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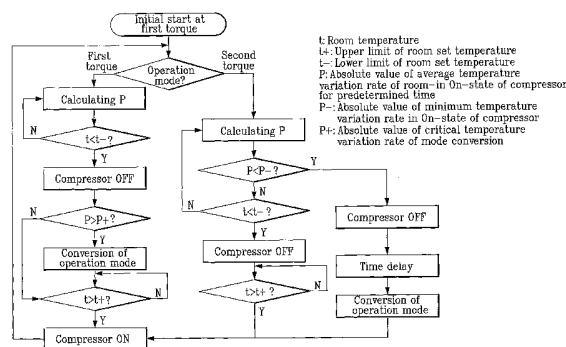
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(54) Title: SYSTEM FOR CONTROLLING COMPRESSOR OF COOLING SYSTEM AND METHOD FOR CONTROLLING THE SAME



(57) Abstract: Disclosed is a system for controlling a compressor of a cooling system. The system includes: the compressor having a driving shaft that is rotatable clockwise and counterclockwise and operated by a power of a motor outputting different torque characteristics depending on the rotational directions of the driving shaft; a selector for selecting an output torque characteristic of the motor; a switching part for turning on or off the motor; and a control unit for controlling the selector to drive the compressor in a torque characteristic suitable for an object to be cooled. In an aspect of the invention, there is provided a method for controlling an operation of a compressor in a cooling system. The method includes the steps of: (a) an initial starting step of starting the compressor equipped with a motor different torque characteristics depending on rotary directions of a driving shaft at a first torque characteristic; (b) determining the operation torque characteristic of the motor; (c) when it is determined that the motor operates at the first torque characteristic in consequence of performing the step (b), if a first condition is met during an operation of the compressor, stopping the compressor; (d) determining whether it is suitable to continuously operate the motor at the first torque characteristic in a state that the compressor is stopped, and if it is determined that it is suitable, maintaining the operation torque characteristic of the motor, while if it is determined that it is not suitable, converting the operation torque characteristic of the motor from the first torque characteristic to a second torque characteristic, and if a second condition is met, operating the compressor.

WO 2004/102006 A1



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- 1 -

SYSTEM FOR CONTROLLING COMPRESSOR OF COOLING SYSTEM AND METHOD FOR CONTROLLING THE SAME

5 Technical Field

The present invention relates to a cooling system and a method for controlling a compressor thereof, and more particularly, to a cooling system using a compressor in which a motor is rotatable in forward/reverse directions, and a method for controlling the compressor.

10 Background Art

In general, compressors are machines that are supplied power from a power generator such as electric motor, turbine or the like and apply compressive work to a working fluid, such as air or refrigerant to elevate the pressure of the working fluid. Such compressors are widely used in a variety of applications, from electric home
15 appliances such as air conditioners, refrigerators and the like to industrial plants.

The compressors are classified into two types according to their compressing methods: a positive displacement compressor, and a dynamic compressor (a turbo compressor). The positive displacement compressor is widely used in industry fields and configured to increase pressure by reducing its volume. The positive
20 displacement compressors can be further classified into a reciprocating compressor and a rotary compressor.

The reciprocating compressor is configured to compress the working fluid using a piston that linearly reciprocates in a cylinder. The reciprocating compressor is configured to compress the working fluid using a piston that linearly reciprocates in
25 a cylinder. The reciprocating compressor has an advantage of providing high compression efficiency with a simple structure. The rotary compressor is configured to compress working fluid using a roller eccentrically revolving along an inner circumference of the cylinder, and has an advantage of obtaining high compression

- 2 -

efficiency at a low speed compared with the reciprocating compressor, thereby reducing noise and vibration.

Meanwhile, the reciprocating or rotary compressor used in the cooling system requires different torques according to various environmental conditions.

5 In other words, since an inner pressure of a refrigeration pipe is very high at an initial start operation having high temperature of a refrigerant and high temperature of an object to be cooled (for example, a food containing chamber in case of a refrigerator, or an indoor space in case of an air conditioner), a large torque is required for driving the compressor.

10 In addition, when a temperature of the object to be cooled is increased after the cooling system stops its operation for a long time and thus the cooling system again operates, the inner pressure of the refrigeration pipe is high, so that a large torque is required for driving the cooling system.

 Meanwhile, if the cooling system operates for a long time, frost is formed on a
15 surface of a heat exchanger absorbing adjacent heat, resulting in a degradation of heat exchange efficiency. Therefore, a defrost operation should be carried out periodically. In this case, temperatures of the heat exchanger and the refrigerant increase so that a large torque is necessary for driving the compressor.

 On the contrary, there is also a case of requiring a small torque when driving
20 the compressor. In other words, in case an inner pressure of the refrigeration pipe is in a low state when the compressor is driven, for example, in case a temperature of the refrigerant is maintained in a low state by maintaining the object at a low temperature, a small torque is required. In addition, a small torque is required when the compressor is operated intermittently with a short period while driving the cooling
25 system.

As described above, when driving the compressor, the cooling system requires different driving torques according to different conditions. However, although different torques are required according to different conditions, the torque of the compressor of the cooling system is unchangeable. Accordingly, the compressor

- 3 -

must have the largest of the torques meeting the above conditions. In this case, if using a large-capacity compressor, it causes problems of unnecessary power consumption and increase in a size of the compressor. Meanwhile, two or more compressors may be used in order to obtain desired driving torques according to
5 conditions. However, in this case, the structure of the cooling system is very inefficient and installation costs are expended excessively.

Disclosure of Invention

Accordingly, the present invention is directed to a cooling system and a system for controlling a compressor that substantially obviate one or more problems due to
10 limitations and disadvantages of the related art.

An object of the present invention is to provide a cooling system using one compressor to generate two different torques according to operation conditions of the cooling system, and a system for controlling the compressor.

Another object of the present invention is to provide a method for controlling a
15 compressor, which can generate two different torques, with suitable driving torques and efficiency according to operation conditions of a cooling system.

Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned
20 from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, a system for
25 controlling a compressor of a cooling system includes: the compressor having a driving shaft that is rotatable clockwise and counterclockwise and operated by a power of a motor outputting different torque characteristics depending on the rotational directions of the driving shaft; a selector for selecting an output torque characteristic of the motor; a switching part for turning on or off the motor; and a

- 4 -

control unit for controlling the selector to drive the compressor in a torque characteristic suitable for an object to be cooled.

To achieve another object of the present invention, a method for controlling an operation of a compressor in a cooling system includes the steps of: (a) an initial
5 starting step of starting the compressor equipped with a motor different torque characteristics depending on rotary directions of a driving shaft at a first torque characteristic; (b) determining the operation torque characteristic of the motor; (c) when it is determined that the motor operates at the first torque characteristic in consequence of performing the step (b), if a first condition is met during an operation
10 of the compressor, stopping the compressor; (d) determining whether it is suitable to continuously operate the motor at the first torque characteristic in a state that the compressor is stopped, and if it is determined that it is suitable, maintaining the operation torque characteristic of the motor, while if it is determined that it is not suitable, converting the operation torque characteristic of the motor from the first
15 torque characteristic to a second torque characteristic, and if a second condition is met, operating the compressor.

It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

20 Brief Description of Drawings

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

25 FIG. 1 is a schematic view illustrating a structure of a cooling system;

FIG. 2 is a schematic view of a system for controlling a compressor according to an embodiment of the present invention;

FIG. 3 is a schematic view of a system for controlling a compressor according to another embodiment of the present invention;

- 5 -

FIG. 4 is a schematic view illustrating an embodiment of the compressor of FIGs. 2 and 3;

FIG. 5 is an exploded perspective view illustrating a compressing unit of the compressor of FIG. 4;

5 FIGs. 6A to 6C are cross-sectional views illustrating an inside of the cylinder when the roller of the compressor shown in FIG. 4 revolves counterclockwise;

FIGs. 7A to 7C are cross-sectional views illustrating an inside of the cylinder when the roller of the compressor shown in FIG. 4 revolves clockwise;

10 FIG. 8 is a schematic view illustrating another embodiment of the compressor of FIGs. 2 and 3;

FIG. 9 is an exploded perspective view illustrating a compressing unit of the compressor of FIG. 8;

FIG. 10 is a sectional view of the compressing unit shown in FIG. 9;

15 FIG. 11 is a sectional view illustrating an inside of the cylinder of the compressor shown in FIG. 8;

FIGs. 12A and 12B are plan views illustrating an embodiment of a control means of the valve assembly in the compressing unit of FIG. 9;

FIGs. 13A to 13C are sectional views illustrating an inside of the cylinder when the roller of the compressor shown in FIG. 8 revolves counterclockwise;

20 FIGs. 14A to 14C are sectional views illustrating an inside of the cylinder when the roller of the compressor shown in FIG. 8 revolves clockwise;

FIG. 15 is a flowchart illustrating a method for controlling a compressor of a cooling system according to an embodiment of the present invention; and

25 FIG. 16 is a flowchart illustrating a method for controlling a compressor of a cooling system according to another embodiment of the present invention.

Best Mode for Carrying Out the Invention

Reference will now be made in detail to the preferred embodiments of the present invention to achieve the objects, with examples of which are illustrated in the

- 6 -

accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

FIG. 1 is a schematic view illustrating a structure of a cooling system according to the present invention. Referring to FIG. 1, the cooling system of the present invention includes a compressor 510, a first heat exchanger 520, a second heat exchanger 530, and an expansion unit 540. Of course, there is provided a compressor control unit (not shown) for controlling the compressor 510.

The compressor 510 has a driving shaft which is rotatable in clockwise or counterclockwise directions. The compressor 510 is supplied with a power generated by a motor which outputs torque characteristics variably according to rotation directions of the driving shaft, which will be described later. The compressor control unit includes a selector for selecting the output torque characteristics of the motor, a switching unit for switching on/off the motor, and a micom for controlling the selector to drive the compressor according to the torque characteristic suitable for states of an object to be cooled. The compressor control unit constructed as above will be described later.

The compressor 510 compresses sucked refrigerant at high pressure and discharges it. Therefore, the refrigerant is supplied with a flowing force to pass through respective elements through a pipe 550 of the cooling system. The compressed refrigerant is transferred to the first heat exchanger 520. The first heat exchanger 520 changes heat between an object to be cooled and an adiabatic air, thereby condensing the compressed refrigerant. At this time, a first fan 525 blows an outdoor air to the first heat exchanger 520. The refrigerant compressed at the first heat exchanger 520 moves to the expansion unit 540 through the pipe 550. The expansion unit 540 expands the condensed high-pressure and low-temperature refrigerant to generate low-pressure and low-temperature refrigerant. The expanded refrigerant is introduced into the second heat exchanger 530. The second heat exchanger 530 absorbs and evaporates heat of the object through heat exchange with an indoor heat exchanger. At this time, a second fan 535 discharges the air, which is

- 7 -

cooled due to the heat exchange with the second heat exchanger 530, toward the object to be cooled so that the object is cooled. The low-temperature and low-pressure gaseous refrigerant evaporated at the second heat exchanger 530 is introduced into the compressor 510. The object continues to be cooled through a repetition of the above procedures.

Meanwhile, although not shown, the cooling system according to the present invention can further include several bypasses to make the object warm. A brief description on that will be made. Although not shown, the bypass directly guide the refrigerant discharged from the compressor 510 to the second heat exchanger 530. At this time, the refrigerant guided by the bypass is directly introduced into the second heat exchanger 530 through a side which is not connected to the expansion unit 540. The refrigerant introduced into the second heat exchanger 530 by the bypass is condensed through heat exchange with the object to be cooled. At this time, high-temperature and high-pressure refrigerant emits heat toward the object to be cooled and is changed into low-temperature and low-pressure refrigerant. The heat emitted from the second heat exchanger 530 is discharged to the object through the second fan 535, thus making the object warm. The refrigerant heat-exchanged at the second heat exchanger 530 is introduced into the expansion unit 540 to be changed into low-temperature and low-pressure refrigerant, and then introduced into the first heat exchanger 520. At the first heat exchanger 520, the refrigerant absorbs heat of an outdoor air and is evaporated. Then, the refrigerant is introduced into the compressor 510. Through repetition of the above procedures, the cooling system of the present invention can make the object warm.

The cooling system of the present invention is applicable to an air conditioning system for cooling or heating an indoor space, a refrigerator for cooling a predetermined chamber so as to keeping foods in a fresh state, and the like. Meanwhile, the cooling system requires different operation characteristics in various environmental conditions, more particularly torque characteristics of the motor. The compressor of the present invention provides an optimum torque characteristic in

- 8 -

various environmental conditions requiring different torque characteristics. Further, the present invention provides a system and a method for controlling the compressor.

Hereinafter, the system and the method for controlling the compressor will be described in detail with reference to the accompanying drawings.

5 FIG. 2 is a schematic view of a system for controlling the compressor according to an embodiment of the present invention, and FIG. 3 is a schematic view of a system for controlling the compressor according to another embodiment of the present invention. Each embodiment of the present invention will be described with reference to FIGs. 2 and 3.

10 Referring to FIG. 2, the system for controlling the compressor according to an embodiment of the present invention includes a compressor, a selector 620, a switching unit 650, and a control unit 610. The compressor is provided with a power generator (i.e., a motor) for generating power, and a compressing unit being supplied with the power to compress a refrigerant and discharge the compressed refrigerant.
15 A structure of the compressing unit will be described later in detail with reference to FIGs. 4 to 14C, and a brief description on the motor will be described herein.

 The motor used in the compressor of the present invention has a driving shaft 13 which is rotatable counterclockwise and clockwise and outputs different torque characteristics depending on rotation directions of the driving shaft 13. To achieve
20 this, the motor includes: a first winding 634 connecting a first terminal 632 and a common terminal 631 and rotating the drive shaft 13 in a first torque characteristic; and a second winding 635 connecting a second terminal 632 and the common terminal 631 and rotating the drive shaft 13 in a second torque characteristic. Here, for the convenience of explanation, it is assumed that the first torque is greater than the
25 second torque, and the driving shaft 13 rotates counterclockwise when the first torque can be obtained, i.e., when the power is supplied to the first winding side. According to the compressor of the present invention, in order to obtain a large torque when the driving shaft 13 rotates counterclockwise, the first winding 634 should have a thick coil whose diameter is large and also have a large number of turns. On the contrary,

- 9 -

when the driving shaft 13 rotates clockwise, an efficiency in operation should be high although the torque is small. Therefore, the second winding 635 should have a diameter smaller than the first winding 634 and also have a small number of turns. By doing so, the first winding 634 is used to rotate the driving shaft 13 counterclockwise in an initial start operation requiring a large torque, or when a pressure of a refrigerant circulation line is in a high state due to a high temperature of the object to be cooled or the refrigerant. When a relatively small torque is required, in other words, when a pressure of the refrigerant circulation line is in a low state due to a low temperature of the object to be cooled or the refrigerant, the second winding 635 is used to rotate the driving shaft 13 clockwise. Compared with the case of using the first winding 634 to rotate the driving shaft 13, the case of using the second winding 635 to rotate the driving shaft 13 has a smaller output torque and reduces power consumption, so that the cooling system can be operated very economically.

The selector 620 selects the output torque characteristics of the motor under a control of the control unit 610. To achieve this, the selector includes a first contact point 623 connected with the first terminal 633, a second contact point 622 connected with the second terminal 632, and a common contact point 621 connected to the first contact point 623 or the second contact point 622. If the selector 620 is constructed as above, the control unit 620 can control the selector 620 to output the torque characteristics suitable for the adjacent environment of the motor. In other words, if the adjacent environment requires for the compressor to output a large torque, the control unit 610 transmits a control signal to the selector 620 to thereby connect the common contact point 621 with the second contact point 622.

The switching unit 650 turns on/off the motor of the compressor. In the system for controlling the compressor of the cooling system according to the present invention, the switching unit 650 is controlled by the control unit 610. In other words, based on external information, the control unit 610 determines whether the cooling system operates or not. If the control unit 620 intends to operate the cooling system, the control unit 610 transmits the control signal to the switching unit 650 to

- 10 -

thereby turn on the switching unit 650. Then, a circuit for supplying a power to the motor is turned on and thus the power is supplied to the motor from a winding side selected by the selector 620. As a result, the driving shaft 13 is driven by either of the first and second torques. On the other hand, if the control unit 620 intends to stop
5 the cooling system, the control unit 620 transmits the control signal to the switching unit 650 to thereby turn off the switching unit 650. Then, the circuit for supplying the power to the motor is turned off and thus the power is supplied to the motor. As a result, the motor stops its operation.

In the system for controlling the compressor according to the present invention,
10 the control unit 610 controls the selector 620 and the switching unit 650 on the basis of information on the object to be cooled. Here, the information on the object to be cooled can be obtained through a sensing means, e.g., a temperature sensor for measuring a temperature of the object to be cooled. In FIG. 2, the temperature sensor senses temperatures of the food containing chamber or the indoor space and transmits
15 the temperature information to the control unit 610. Then, the control unit 620 controls the selector 620 and the switching unit 650 on the basis of the temperature information transmitted from the sensing means, e.g., the temperature sensor.

Meanwhile, an overload protector is connected in series between the switching unit 650 and the motor in order to prevent the motor from being damaged due to an
20 overload phenomenon. A plurality of capacitors 645 are connected in parallel between the motor and the selector 620. An undescribed reference numeral "646" is a positive temperature coefficient (P.T.C), which serves to effectively protect the circuit by limiting an excess current in an initial stage, or to effectively support the start of the compressor by improving an initial start torque at a start circuit of the
25 compressor.

Hereinafter, an operation of the system for controlling the compressor according to the present invention will be described in brief.

When the control unit 610 performs an operation of starting the compressor on the basis of the temperature measured by the temperature sensor 60, the control unit

- 11 -

610 transmits the control signal to the switching unit 650 to thereby turn on the switching unit 650. Then, the circuit for supplying the power to the motor is turned on and thus the power is supplied to the motor. As a result, the driving shaft 13 rotates so that the cooling system is driven. Here, the common contact point 621 of the selector 620 is connected to either of the first and second contact points 623 and 622 before the switching unit 650 is turned on. To achieve this, the control unit 610 may control the selector 620 before the switching unit 650 is turned on, or may continuously maintain the previous state when the cooling system is stopped. Meanwhile, in a state that the common contact point 621 is connected to the first contact point 623, if the switching unit 650 is turned on, the motor start to operate with the first torque. In a state that the common contact point 621 is connected to the second contact point 622, if the switching is turned on, the motor starts to operate with the second torque.

If the motor is driven, the cooling system starts to operate. If the cooling system operates for a predetermined time, the temperature of the room is also changed. The temperature of the room is detected by the temperature sensor 660, and the detected information is transmitted to the control unit 610. Then, the control unit 610 determines an operation method of the cooling system, i.e., whether to continue to operate the cooling system with a current torque, whether to stop the cooling system, or whether to operate the cooling system with a changed torque. At this time, in case the control unit 610 determines to operate the cooling system with the changed torque, the control unit 610 transmits the control signal to the switching unit 650 to thereby turn off the switching unit 650. Then, the control unit 610 transmits the control signal to the selector 620 to thereby change the connection state between the common contact point 621 and other contact points 622 and 623. After the connection state is changed, the switching unit 650 is turned on. Then, the compressor operates according to the changed torque characteristic. Accordingly, in an embodiment of the present invention, the cooling system can be operated suitably according to the state of the object to be cooled. A method for controlling the compressor of the

- 12 -

cooling system according to an embodiment of the present invention will be described later.

Meanwhile, referring to FIG. 3, a system for controlling the compressor according to another embodiment of the present invention includes a control unit 610, a selector 620, a power generator 10, and a switching unit 670. Here, since the structures of the control unit 610, the selector 620 and the power generator 10 are identical to those of FIG. 2, their detailed description will be omitted.

In the system for controlling the compressor according to another embodiment of the present invention, as shown in FIG. 3, the switching unit 670 includes a thermostat, of which contact points are on/off according to temperatures of the object to be cooled. Here, the thermostat is provided with, e.g., a bimetal. For example, the switching unit 670 is configured to switch on the contact point when the temperature of the indoor space or the food containing chamber is above a predetermined level, and to switch off when the temperature is below the predetermined level. The switching unit 670 constructed as above drives or stops the motor according to conditions of the room without any control of the control unit 610. In this case, the control unit 610 controls the selector 620 by checking an elapse of time, so that the cooling system is effectively operated.

Meanwhile, the system for controlling the compressor according to another embodiment of the present invention further includes means for determining whether the motor is turned on or off. Here, the determining means is provided with a current sensor 690 for sensing a current through the switching unit 670. In this case, when the temperature of the room increases or decreases to thereby turn on or off the switching unit 670, the current sensor 690 senses whether or not the motor operates and transmits corresponding information to the control unit 610. With the information on the operation of the motor, the control unit 610 checks an elapse of time and controls the selector 620, so that the cooling system is controlled more effectively.

- 13 -

Meanwhile, the system according to another embodiment of the present invention further includes a second switching unit 680 connected in series to the switching unit 370. Unlike the switching unit 670, the second switching unit 680 is turned on/off by the control unit 610. In this case, the control unit 610 can control
5 the selector 620 on the basis of the elapse of time, and can control the second switching unit 680 to forcibly stop the motor. Here, during the driving of the motor, the control unit 610 can forcibly stop the motor by opening the contact point of the second switching unit 680. However, during the stopping of the motor, the control unit 610 cannot forcibly operate the motor. Here, the case of not driving the motor is
10 the case that either of the switching unit 670 and the second switching unit 680 is opened. If the switching unit 670 is opened, the motor is not driven even when the control unit 610 closes the contact point of the second switching unit 680. Thus, in the system according to another embodiment of the present invention, the control unit 610 checks the elapse of time and controls the compressor on the basis of information
15 on the elapse of time during the driving of the motor.

Hereinafter, an operation of the system according to another embodiment of the present invention will be described in brief.

For example, if the temperature of the room increases, the switching unit 670 is automatically turned on to drive the motor. Of course, like the embodiment
20 described above with reference to FIG. 2, the common contact point 621 is connected to any one of other contact points before the motor is driven. If it is assumed that the common contact point 621 is connected to the first contact point 623, the motor is driven with the first torque as soon as the switching unit 670 is turned on. If the motor is driven, the current sensor 690 informs the control unit 610 that the motor is
25 driven. The control unit 610 checks an elapse of time while recognizing the driving of the motor. The control unit 610 can change the torque characteristic by transmitting the control signal to the second switching unit 680 after a predetermined time, or by transmitting the control signal to the selector 620 after stopping the motor. After the torque characteristic of the motor is changed by the selector 620, the control

- 14 -

unit 610 can control the second switching unit 680 to drive the motor again. Of course, after a predetermined time, the contact point of the switching unit 670 may be automatically opened due to an operation of the thermostat, so that the motor is stopped. According to the present invention, the system for controlling the
5 compressor operates suitably according to the conditions since the cooling system immediately responds to the temperature of the room. Of course, the system for controlling the compressor according to another embodiment of the present invention requires an elaborate control algorithm based on the driving of the motor and the elapse of time. An operation of the system for controlling the compressor according
10 to another embodiment of the present invention will be described below in more detail.

Hereinafter, a structure of a compressor in the cooling system according to the present invention will be described in detail with reference to the accompanying drawings.

FIG. 4 is a schematic view of the compressor of FIG. 2 or 3 according to an
15 embodiment of the present invention. FIG. 5 is an exploded perspective view illustrating a compressing unit of the compressor of FIG. 4.

As shown in FIG. 4, the rotary compressor of the present invention includes a case 1, a power generator 10 positioned in the case 1, i.e., a motor, and a compressing unit 20. Referring to FIG. 4, the power generator 10 is positioned on the upper
20 portion of the compressor and the compressing unit 20 is positioned on the lower portion of the compressor. However, their positions may be changed if necessary. An upper cap 3 and a lower cap 5 are installed on the upper portion and the lower portion of the case 1 respectively to define a sealed inner space. A suction pipe 7 for sucking working fluid is installed on a side of the case 1 and connected to an
25 accumulator 8 for separating lubricant from refrigerant. A discharge tube 9 for discharging the compressed fluid is installed on the center of the upper cap 3. A predetermined amount of the lubricant "O" is filled in the lower cap 5 so as to lubricate and cool members that are moving frictionally. Here, an end of a driving shaft 13 is dipped in the lubricant.

- 15 -

The power generator 10 includes a stator 11 fixed in the case 1, a rotor 12 rotatable supported in the stator 11 and the driving shaft 13 inserted forcibly into the rotor 12. The rotor 12 is rotated due to electromagnetic force, and the driving shaft 13 delivers the rotation force of the rotor to the compressing unit 20. To supply
5 external power to the stator 20, a terminal 4 is installed in the upper cap 3.

The compressing unit 20 includes a cylinder 21 fixed to the case 1, a roller 22 positioned in the cylinder 21 and upper and lower bearings 24 and 25 respectively installed on upper and lower portions of the cylinder 21. The compressing unit 20 will be described in more detail with reference to FIGs. 2, 3 and 4.

10 The cylinder 21 has a predetermined inner volume and a strength enough to endure the pressure of the fluid. The cylinder 21 accommodates an eccentric portion 13a formed on the driving shaft 13 in the inner volume. The eccentric portion 13a is a kind of an eccentric cam and has a center spaced by a predetermined distance from its rotation center. The cylinder 21 has a groove 21b extending by a predetermined
15 depth from its inner circumference. A vane 23 to be described below is installed on the groove 21b. The groove 21b is long enough to accommodate the vane 23 completely. As shown in FIGs. 4 and 5, the suction ports 27 communicating with the fluid chamber 29 are formed at the cylinder 21. The suction ports 27 guide the compressed fluid to the fluid chamber 29. The suction ports 27 are connected to the
20 suction pipe 7 so that the fluid outside of the compressor can flow into the chamber 29. More particularly, the suction pipe 7 is connected to the suction ports 27 through a connection pipe 7 so that prior-to-compressed fluid can be supplied to the fluid chamber 29.

The roller 22 is a ring member that has an outer diameter less than the inner
25 diameter of the cylinder 21. As shown in FIG. 4, the roller 22 contacts the inner circumference of the cylinder 21 and rotatably coupled with the eccentric portion 13a. Accordingly, the roller 22 performs rolling motion on the inner circumference of the cylinder 21 while spinning on the outer circumference of the eccentric portion 13a when the driving shaft 13 rotates. The roller 22 revolves spaced apart by a

- 16 -

predetermined distance from the rotation center 'O' due to the eccentric portion 13a while performing the rolling motion. Since the outer circumference of the roller 22 always contacts the inner circumference due to the eccentric portion 13a, the outer circumference of the roller 22 and the inner circumference of the cylinder form a
5 separate fluid chamber 29 in the inner volume. The fluid chamber 29 is used to suck and compress the fluid in the rotary compressor.

The vane 23 is installed in the groove 21b of the cylinder 21 as described above. An elastic member 23a is installed in the groove 21b to elastically support the vane 23. The vane 23 continuously contacts the roller 22. In other words, the
10 elastic member 23a has one end fixed to the cylinder 21 and the other end coupled with the vane 23, and pushes the vane 23 to the side of the roller 22. Accordingly, the vane 23 divides the fluid chamber 29 into two separate spaces 29a and 29b as shown in FIG. 4. While the driving shaft 13 rotate or the roller 22 revolves, the volumes of the spaces 29a and 29b change complementarily. In other words, if the
15 roller 22 rotates clockwise, the space 29a gets smaller but the other space 29b gets larger. However, the total volume of the spaces 29a and 29b is constant and approximately same as that of the predetermined fluid chamber 29. One of the spaces 29a and 29b works as a suction chamber for sucking the fluid and the other one works as a compression chamber for compressing the fluid relatively when the driving
20 shaft 13 rotates in one direction (clockwise or counterclockwise). Accordingly, as described above, the compression chamber of the spaces 29a and 29b gets smaller to compress the previously sucked fluid and the suction chamber expands to suck the new fluid relatively according to the rotation of the roller 22. If the rotation direction of the roller 22 is reversed, the functions of the spaces 29a and 29b are exchanged.
25 In the other words, if the roller 22 revolves counterclockwise, the right space 29b of the roller 22 becomes a compression chamber, but if the roller 22 revolves clockwise, the left space 29a of the roller 22 becomes a discharge unit.

The upper bearing 24 and the lower bearing 25 are, as shown in FIG. 4, installed on the upper and lower portions of the cylinder 21 respectively, and rotatably

- 17 -

support the driving shaft 12 using a sleeve and the penetrating holes 24b and 25b formed inside the sleeve. More particularly, the upper bearing 24, the second bearing 25 and the cylinder 21 include a plurality of coupling holes 24a, 25a and 21a formed to correspond to each other respectively. The cylinder 21, the upper bearing
5 24 and the lower bearing 25 are coupled with one another to seal the cylinder inner volume, especially the fluid chamber 29 using coupling members such as bolts and nuts.

The discharge ports 26a and 26b are formed on the upper bearing 24. The discharge ports 26a and 26b communicate with the fluid chamber 29 so that the
10 compressed fluid can be discharged. The discharge ports 26a and 26b can communicate directly with the fluid chamber 29 or can communicate with the fluid chamber 29 through a predetermined fluid passage 21d formed in the cylinder 21 and the first bearing 24. Discharge valves 26c and 26d are installed on the upper bearing 24 so as to open and close the discharge ports 26a and 26b. The discharge valves
15 26c and 26d selectively open the discharge ports 26a and 26b only when the pressure of the chamber 29 is greater than or equal to a predetermined pressure. To achieve this, it is desirable that the discharge valves 26c and 26d are leaf springs of which one end is fixed in the vicinity of the discharge ports 26a and 26b and the other end can be deformed freely. As shown, retainers 26e and 26f for limiting the deformation of the
20 valves in order for the valves to operate stably can be installed on upper portions of the discharge valves 26c and 26d. The retainer 26e and 26f are provided so as to secure the stable operations of the discharge valves 26c and 26d and disposed contacting the discharge valves 26c and 26d to control the opening extents of the discharge valves 26c and 26d. If there are no retainers 26e and 26f, the discharge
25 valves 26c and 26d may be deformed due to the high pressure, whereby the reliability of the discharge valves 26c and 26d may be deteriorated.

A muffler 140 is disposed above the upper bearing 24. The muffler 140 reduces noise generated when the compressed fluid is discharged. For this, the

- 18 -

muffler 140 encloses an upper space of the discharge ports 26a and 26b, and an additional discharge 141 is formed at one side of the muffler 140.

Meanwhile, the revolution direction of the roller 22 and the location of the suction port 27 are very important factors for determining the compression capacity in a preferred embodiment of the present invention. Their relationship will be described in more detail hereinafter.

FIG. 6A is a sectional view illustrating an inside of the cylinder when the roller of the compressor of FIG. 4 revolves counterclockwise. As shown in the drawing, the fluid chamber 29 is divided into the two spaces 29a and 29b by the vane 23 and the roller 22. The discharge ports 26a and 26b are respectively located on each side of the vane 23 to continuously compress fluid regardless of the revolution direction of the roller 22. In other words, regardless of the revolution direction of the roller, at least one of the discharge ports 26a and 26b is opened between the suction port 27 and the vane 23. At this point, it is preferable that a distance between the vane 23 and the discharge port 26a is identical to that between the vane 23 and the discharge port 27b.

Here, the compression chamber 200 is divided into a suction portion for sucking gas through the suction port 27 by the vane 23 and the roller 22, and a discharge portion for discharging the fluid gas through one of the discharge ports 26a and 26b. At this point, the suction portion and the discharge portion are determined according to the revolution direction of the roller 22. In other words, when the roller 22 revolves counterclockwise, a right space 210 with respect to the roller 22 becomes the discharge portion, and when the roller 22 revolves clockwise, a left space 220 becomes the discharge portion.

Meanwhile, the compression capacity of the compressor is determined by volumes of the discharge portions 29a and 29b. The volumes of the discharge portions 29a and 29b are determined by spaces enclosed by the cylinder 50 and the roller 22 from the suction port 27 to the vane 23. Accordingly, the compression capacity is determined by the location of the suction port 27.

- 19 -

For example, when the suction port 27 is located on a phantom line extending from a longitudinal axis of the vane 23, in other words, when the suction port 27 is located spaced away from the vane 23 by an angular distance of about 180° , the volume of the discharge portion 29a becomes identical to that of the discharge portion 29b. Therefore, an identical capacity can be obtained from the compressor regardless of the revolution direction of the roller 22.

However, when the suction port 27 is located on one side of the phantom line extending from the longitudinal axis of the vane 23, the discharge portions 29a and 29b of the compression chamber 29 become different in their volumes. That is, as shown in FIG. 6A, the compression chamber 29 is divided in the left and right spaces 29a and 29b. The left space 29a is defined by a counterclockwise angular distance between the vane 23 and the suction port 26, and the right space 29b is defined by a clockwise angular distance between the vane 23 and the suction port 26, the counterclockwise angular distance being less than the clockwise angular distance. At this point, the spaces 29a and 29b become low and high capacity discharge portions 29b and 29a in accordance with the revolving direction of the roller 22. This shows that the rotary compressor of the present invention has a dual-capacity.

The location of the suction port 27 is then determined by a compression ratio between the high and low capacity discharge portions 29b and 29a. For example, the present invention proposes a clockwise angular distance of about $180\text{--}300^\circ$ between the vane 23 and the suction port 27. When the clockwise angular distance between the vane 23 and the suction port 26 is 180° , the compression ratio between the spaces 29b and 29a becomes 50:50. When the clockwise angular distance between the vane 23 and the suction port 27 is about 270° , the compression ratio between the spaces 29b and 29a is about 75:25.

The operation of the rotary compressor of the present invention will now be described in more detail.

FIGs. 6A to 6C show consecutive operating steps of the rotary compressor when the roller revolves counterclockwise. FIG. 6A shows an initial fluid intake step,

- 20 -

FIG. 6B shows a fluid compression/discharge step, and FIG. 6C shows a discharge completion step.

As the driving shaft 13 rotates, the roller 22 rotates and revolves counterclockwise along the inner circumference of the cylinder 50. During this process, the suction port 27 is opened so that fluid is sucked into the fluid chamber through the suction port 27. The fluid is then directed to the high capacity discharge portion 29b by the roller 22 as shown in FIG. 6A.

As the roller 22 further revolves, the volume of the high capacity discharge portion 29b is reduced to compress the fluid. During this process, the vane 23 maintains the seal of the high capacity discharge portion 29b while elastically reciprocating by the spring 23a and the roller 22, at the same time of which fluid is continuously fed into the high capacity discharge portion 29b through the suction port 27.

After the above, when pressure of the high capacity discharge portion 29b is increased above a predetermined level, the discharge valve 26d of the high capacity discharge portion 29b is opened. Accordingly, the fluid in the high capacity discharge portion 29b starts being discharged to the muffler through the discharge port 26b, as shown in FIG. 6B.

Then, when the roller further revolves, the fluid in the high capacity discharge portion 29b is completely discharged to the muffler through the discharge port 26b, after which the discharge valve 26d closes the discharge port 26b using its self-elastic force, as shown in FIG. 6C.

FIGs. 7A and 7B show consecutive operating steps of the rotary compressor when the roller revolves clockwise. FIG. 7A shows an initial fluid intake step, and FIG. 7B shows a fluid compression/discharge step.

As the driving shaft 13 rotates, the roller 22 rotates and revolves clockwise along the inner circumference of the cylinder 21. During this process, the suction port 27 is opened so that fluid is sucked into the compression chamber through the

- 21 -

suction port 27. At this point, the fluid is directed to the low capacity discharge portion 29a by the roller 22.

As the roller 22 further revolves, the volume of the low capacity discharge portion 29a is reduced to compress the fluid, at the same time of which fluid is
5 continuously fed through the suction port 27.

After the above, when pressure of the low capacity discharge portion 29a is increased above a predetermined level, the discharge valve 26c of the low capacity discharge portion 29a is opened. Accordingly, the fluid in the low capacity discharge portion 29a starts being discharged to the muffler through the discharge port 26a, as
10 shown in FIG. 7B.

Then, when the roller 22 further revolves, the fluid in the low capacity discharge portion 29a is completely discharged to the muffler through the discharge port 26a, after which the discharge valve 26c closes the discharge port 26a using its self-elastic force.

15 After the above, as the roller 22 further revolves clockwise, the fluid is further discharged to the muffler through the above-described intake, compression, and discharge steps.

As shown in FIG. 4, the compressed gas in the muffler 140 is discharged into the case 1 through the discharge port 141, and is then further directed to a desired
20 destination through a space between the rotor 12 and the stator 11 or a space between the stator 11 and the case 1.

Meanwhile, in FIG. 8, there is shown a compressor of the compressor control system according to another embodiment of the present invention. The compressor according to another embodiment of the present invention will be described in detail
25 hereinafter. FIG. 8 is a longitudinal sectional view illustrating a construction of the compressor, FIG. 9 is an exploded perspective view illustrating a compressing unit of the compressor, and FIG. 10 is a sectional view of the compressing unit.

Referring to FIG. 8, the compressor according to another embodiment of the present invention includes a power generator 10 and a compressing unit 20, and the

- 22 -

compressing unit 20 includes a cylinder 21, upper and lower bearings 24 and 25, and a valve assembly 100. In this embodiment, the same structure as the embodiment of FIGs. 4 to 7c will be omitted.

The upper bearing 24 is provided with discharge ports 26a and 26b, communicating with the fluid chamber 29 to discharge the compressed fluid out of the fluid chamber 29. The discharge ports 26a and 26b may be directly communicated with the fluid chamber 29, or be communicated with the same through a fluid passage 21d formed on the cylinder 21 and the upper bearing 24. An opening/closing operation of the discharge ports 26a and 26b is controlled by discharge valves 26c and 26d, installed on the upper bearing 24. The discharge valves 26c and 26d selectively open the discharge ports 26a and 26b only when the pressure of the fluid chamber 29 is increased to above a predetermined level. To achieve this, it is desirable that the discharge valves 26c and 26d are leaf springs of which one end is fixed in the vicinity of the discharge ports 26a and 26b and the other end can be deformed freely. Although not shown, retainers for limiting the deformation of the valves in order for the valves to operate stably can be installed on upper portions of the discharge valves 26c and 26d. In addition, a muffler (not shown) can be installed on the upper portion of the upper bearing 24 to reduce a noise generated when the compressed fluid is discharged.

The suction ports 27a, 27b and 27c communicating with the fluid chamber 29 are formed on the lower bearing 25. The suction ports 27a, 27b and 27c guide the compressed fluid to the fluid chamber 29. The suction ports 27a, 27b and 27c are connected to the suction pipe 7 so that the fluid outside of the compressor can flow into the chamber 29. More particularly, the suction pipe 7 is branched into a plurality of auxiliary tubes 7a and is connected to suction ports 27 respectively. If necessary, the discharge ports 26a, and 26b may be formed on the lower bearing 25 and the suction ports 27a, 27b and 27c may be formed on the upper bearing 24.

- 23 -

Meanwhile, it is preferable to provide a plenum 200 communicating with the suction ports 27a, 27b and 27c and preliminarily storing fluid so that the fluid can be supplied to the fluid chamber 29 of the cylinder 21.

The suction plenum 200 directly communicates with all of the suction ports 27a, 27b and 27c so as to supply the fluid. Accordingly, the suction plenum 200 is installed in a lower portion of the lower bearing 25 in the vicinity of the suction ports 27a, 27b and 27c. Although there is shown in the drawing that the suction ports 27a, 27b and 27c are formed at the lower bearing 25, they can be formed at the upper bearing 24 if necessary. In this case, the suction plenum 200 is installed in the upper bearing 24. The suction plenum 200 can be directly fixed to the lower bearing 25 by a welding. In addition, a coupling member can be used to couple the suction plenum 200 with the cylinder 21, the upper and lower bearings 24 and 25 and the valve assembly 100. In order to lubricate the driving shaft 13, a sleeve 25d of the lower bearing 25 should be soaked into a lubricant which is stored in a lower portion of the case 1. Accordingly, the suction plenum 200 includes a penetration hole 200a for the sleeve. Preferably, the suction plenum 200 has one to four times a volume as large as the fluid chamber 29 so as to supply the fluid stably. The suction plenum 200 is also connected with the suction pipe 7 so as to store the fluid. In more detail, the suction plenum 200 can be connected with the suction pipe 7 through a predetermined fluid passage. In this case, as shown in FIG. 10, the fluid passage penetrates the cylinder 21, the valve assembly 100 and the lower bearing 25. In other words, the fluid passage includes a suction hole 21c of the cylinder 21, a suction hole 122 of the second valve, and a suction hole 25c of the lower bearing 25.

Such a suction plenum 200 forms a space in which a predetermined amount of fluid is always stored, so that a compression variation of the sucked fluid is buffered to stably supply the fluid to the suction ports 27a, 27b and 27c. In addition, the suction plenum 200 can accommodate oil extracted from the stored fluid and thus assist or substitute for the accumulator 8.

- 24 -

The suction and discharge ports 26 and 27 become the important factors in determining compression capacity of the rotary compressor and will be described referring to FIG. 11. FIG. 11 illustrates a cylinder coupled with the lower bearing 25 without a valve assembly 100 to clearly show the suction ports 27.

5 First, the compressor of the present invention includes at least two discharge ports 26a and 26b. As shown in the drawing, even if the roller 22 revolves in any direction, one discharge port should exist between the suction port and vane 23 positioned in the revolution path to discharge the compressed fluid. Accordingly, one discharge port is necessary for each rotation direction. It causes the compressor
10 of the present invention to discharge the fluid independent of the revolution direction of the roller 22 (that is, the rotation direction of the driving shaft 13). Meanwhile, as described above, the compression chamber of the spaces 29a and 29b gets smaller to compress the fluid as the roller 22 approaches the vane 23. Accordingly, the discharge ports 26a and 26b are preferably formed facing each other in the vicinity of
15 the vane 23 to discharge the maximum compressed fluid. In other word, as shown in the drawings, the discharge ports 26a and 26b are positioned on both sides of the vane 23 respectively. The discharge ports 26a and 26b are preferably positioned in the vicinity of the vane 23 if possible.

The suction port 27 is positioned properly so that the fluid can be compressed
20 between the discharge ports 26a and 26b and the roller 22. Actually, the fluid is compressed from a suction port to a discharge port positioned in the revolution path of the roller 22. In other words, the relative position of the suction port for the corresponding discharge port determines the compression capacity and accordingly two compression capacities can be obtained using different suction ports 27 according
25 to the rotation direction. Accordingly, the compression of the present invention has first and second suction ports 27a and 27b corresponding to two discharge ports 26a and 26b respectively and the suction ports are separated by a predetermined angle from each other with respect to the center 0 for two different compression capacities.

- 25 -

Preferably, the first suction port 27a is positioned in the vicinity of the vane 23. Accordingly, the roller 22 compresses the fluid from the first suction port 27a to the second discharge port 26b positioned across the vane 23 in its rotation in one direction (counterclockwise in the drawing). The roller 22 compresses the fluid due to the first suction port 27a by using the overall chamber 29 and accordingly the compressor has a maximum compression capacity in the counterclockwise rotation. In other words, the fluid as much as overall volume of the chamber 29 is compressed. The first suction port 27a is actually separated by an angle θ_1 of 10° clockwise or counterclockwise from the vane 23. The drawings of the present invention illustrate the first suction port 27a separated by the angle θ_1 counterclockwise. At this separating angle θ_1 , the overall fluid chamber 29 can be used to compress the fluid without interference of the vane 23.

The second suction port 27b is separated by a predetermined angle from the first suction port 27a with respect to the center. The roller 20 compresses the fluid from the second suction port 27b to the first discharge port 26a in its rotation in counterclockwise direction. Since the second suction port 27b is separated by a considerable angle clockwise from the vane 23, the roller 22 compresses the fluid by using a portion of the chamber 29 and accordingly the compressor has the less compression capacity than that of counterclockwise rotary motion. In other words, the fluid as much as a portion volume of the chamber 29 is compressed. The second suction port 27b is preferably separated by an angle θ_2 of a range of $90 - 180^\circ$ clockwise or counterclockwise from the vane 23. The second suction port 27b is preferably positioned facing the first suction port 27a so that the difference between compression capacities can be made properly and the interference can be avoided for each rotation direction.

As shown in FIG. 11, the suction ports 27a and 27b are generally in circular shapes. In order to increase a suction amount of fluid, the suction ports 27a and 27b can also be provided in several shapes, including a rectangle. Further, as shown in FIGs. 12A and 12B, the suction ports 27a and 27b can be in rectangular shapes having

- 26 -

predetermined curvature. In this case, an interference with adjacent other parts, especially the roller 22, can be minimized in operation.

Meanwhile, in order to obtain desired compression capacity in each rotation direction, suction ports that are available in any one of rotation directions should be single. If there are two suction ports in rotation path of the roller 22, the compression does not occur between the suction ports. In other words, if the first suction port 27a is opened, the second suction port 27b should be closed, and vice versa. Accordingly, for the purpose of electively opening only one of the suction ports 27a and 27b according to the revolution direction of the roller 22, the valve assembly 100 is installed in the compressor of the present invention.

The valve assembly 100 includes first and second valves 110 and 120, which are installed between the cylinder 21 and the lower bearing 25 so as to allow it to be adjacent to the suction ports. If the suction ports 27a, 27b and 27c are formed on the upper bearing 24, the first and second valves 110 and 120 are installed between the cylinder 21 and the upper bearing 24.

The first valve 110 is a disk member installed so as to contact the eccentric portion 13a more accurately than the driving shaft 13. Accordingly, if the driving shaft 13 rotates (that is, the roller 22 revolves), the first valve 110 rotates in the same direction. Preferably, the first valve 110 has a diameter larger than an inner diameter of the cylinder 21. The cylinder 21 supports a portion (i.e., an outer circumference) of the first valve 110 so that the first valve 110 can rotate stably.

The first valve 110 includes first and second openings 111 and 112 respectively communicating with the first and second suction ports 27a and 27b in specific rotation direction, and a penetration hole 110a into which the driving shaft 13 is inserted. In more detail, when the roller 22 rotates in any one of the clockwise and counterclockwise directions, the first opening 111 communicates with the first suction port 27a by the rotation of the first valve 110, and the second suction port 27b is closed by the body of the first valve 110. When the roller 22 rotates in the other of the clockwise and counterclockwise directions, the second opening 112 communicates

- 27 -

with the second suction port 27b. At this time, the first suction port 27a is closed by the body of the first valve 110. These first and second openings 111 and 112 can be in circular or polygonal shapes. Additionally, as shown in FIGs. 12A and 12B, the openings 111 and 112 can be rectangular shapes having predetermined curvature.

5 As a result, the openings are enlarged, such that fluid is sucked smoothly. If these openings 111 and 112 are formed adjacent to a center of the first valve 110, a probability of interference between the roller 22 and the eccentric portion 13a becomes increasing. In addition, there is the fluid's probability of leaking out along the driving shaft 13, since the openings 111 and 112 communicate with a space

10 between the roller 22 and the eccentric portion 13a. For these reasons, it is preferable that the openings 111 and 112 are positioned in the vicinity of the outer circumference of the first valve. Meanwhile, the first opening 111 may open each of the first and second suction ports 27a and 27b at each rotation direction by adjusting the rotation angle of the first valve 110. In other words, when the driving shaft 13

15 rotates in any one of the clockwise and counterclockwise directions, the first opening 111 communicates with the first suction port 27a while closing the second suction port 27b. When the driving shaft 13 rotates in the other of the clockwise and counterclockwise directions, the first opening 111 communicates with the second suction port 27b while closing the first suction port 27a. It is desirable to control the

20 suction ports using such a single opening 111, since the structure of the first valve 110 is simplified much more.

The second valve 120 is fixed between the cylinder 21 and the lower bearing 25 so as to guide a rotary motion of the first valve 110. The second valve 120 is a ring-shaped member having a site portion 121 which receives rotatably the first valve

25 110. The second valve 120 further includes a coupling hole 120a through which it is coupled with the cylinder 21 and the first and second bearings 24 and 25 by a coupling member. Preferably, the second valve 120 has the same thickness as the first valve 110 in order for a prevention of fluid leakage and a stable support. In addition, since the first valve 110 is partially supported by the cylinder 21, the first valve 110 may

- 28 -

have a thickness slightly smaller than the second valve 120 in order to form a gap for the smooth rotation of the second valve 120.

Meanwhile, referring to FIG. 11, in the case of the clockwise rotation, the fluid's suction or discharge between the vane 23 and the roller 22 does not occur while the roller 22 revolves from the vane 23 to the second suction port 27b. Accordingly, a region V becomes a vacuum state. The vacuum region V causes a power loss of the driving shaft 13 and a loud noise. Accordingly, in order to overcome the problem in the vacuum region V, a third suction port 27c is provided at the lower bearing 25. The third suction port 27c is formed between the second suction port 27b and the vane 23, supplying fluid to the space between the roller 22 and the vane 23 so as not to form the vacuum state before the roller 22 passes through the second suction port 27b. Preferably, the third suction port 27c is formed in the vicinity of the vane 23 so as to remove quickly the vacuum state. However, the third suction port 27c is positioned to face the first suction port 27a since the third suction port 27c operates at a different rotation direction from the first suction port 27a. In reality, the third suction port 27c is positioned spaced by an angle (θ_3) of approximately 10° from the vane 23 clockwise or counterclockwise. In addition, as shown in FIGs. 5A and 5B, the third suction port 27c can be circular shapes or curved rectangular shapes.

Since such a third suction port 27c operates along with the second suction port 27b, the suction ports 27b and 27c should be simultaneously opened while the roller 22 revolves in any one of the clockwise and counterclockwise directions. Accordingly, the first valve 110 further includes a third opening configured to communicate with the third suction port 27c at the same time when the second suction port 27b is opened. According to the present invention, the third opening 113 can be formed independently. However, since the first and third suction ports 27a and 27c are adjacent to each other, it is desirable to open both the first and third suction ports 27a and 27c according to the rotation direction of the first opening 111 by increasing the rotation angle of the first valve 110.

- 29 -

The first valve 110 may open the suction ports 27a, 27b and 27c according to the rotation direction of the roller 22, but the corresponding suction ports should be opened accurately in order to obtain desired compression capacity. The accurate opening of the suction ports can be achieved by controlling the rotation angle of the first valve. Thus, it is preferable that the valve assembly 100 further includes means for controlling the rotation angle of the first valve 110, which will be described in detail with reference to FIGs. 12A and 12B. FIGs. 12A and 12B illustrate the valve assembly connected with the second bearing 25 in order to clearly explain the control means.

The control means can be provided with a projection 115 formed on the first valve 110 and projecting in a radial direction of the first valve, and a groove 123 formed on the second valve 220 and receiving the projection movably. Here, the groove 123 is formed on the second valve 220 so as not to be exposed to the inner volume of the cylinder 21. Therefore, a dead volume is not formed inside the cylinder. In addition, although not shown, the control means can be provided with a projection formed on the second valve 120 and projecting in a radial direction of the second valve 120, and a groove formed on the first valve 110 and receiving the projection 124 movably.

In the case of using such a control means, as shown in FIG. 12A, the projections 115 and 124 are latched to one end of each groove 123 and 116 if the driving shaft 13 rotates counterclockwise. Accordingly, the first opening 111 communicates with the first suction port 27a so as to allow the suction of fluid, and the second and third suction ports 27b and 27c are closed. On the contrary, as shown in FIG. 12, if the driving shaft 13 rotates clockwise, the projections 115 and 124 are latched to the other end of each groove 123 and 116, and the first and second openings 111 and 112 simultaneously open the third and second suction ports 27c and 27b so as to allow the suction of fluid. The first suction port 27a is closed by the first valve 110.

- 30 -

Hereinafter, an operation of a rotary compressor according to the present invention will be described in more detail.

FIGs. 13A to 13C are cross-sectional views illustrating an operation of the rotary compressor when the roller revolves in the counterclockwise direction.

5 First, in FIG. 13A, there are shown states of respective elements inside the cylinder when the driving shaft 13 rotates in the counterclockwise direction. First, the first suction port 27a communicates with the first opening 111, and the remainder second suction port 27b and third suction port 27c are closed. Detailed description on the state of the suction ports in the counterclockwise direction will be omitted since
10 it has been described above.

In a state that the first suction port 27a is opened, the roller 22 revolves counterclockwise with performing a rolling motion along the inner circumference of the cylinder due to the rotation of the driving shaft 13. As the roller 22 continues to revolve, the size of the space 29b is reduced and the fluid that has been sucked is
15 compressed. In this stroke, the vane 23 moves up and down elastically by the elastic member 23a to thereby partition the fluid chamber 29 into the two sealed spaces 29a and 29b. At the same time, new fluid is continuously sucked into the space 29a through the first suction port 27 so as to be compressed in a next cycle.

When the fluid pressure in the space 29b is above a predetermined value, the
20 second discharge valve 26d is opened. Accordingly, the fluid in the space 29b is discharged through the second discharge port 26b. As the roller 22 continues to revolve, all the fluid in the space 29b is discharged through the second discharge port 26b. After the fluid is completely discharged, the second discharge valve 26d closes the second discharge port 26c by its self-elasticity.

25 Thus, after a single cycle is ended, the roller 22 continues to revolve counterclockwise and discharges the fluid by repeating the same cycle. In the counterclockwise cycle, the roller 22 compresses the fluid with revolving from the first suction port 27a to the second discharge port 26b. As aforementioned, since the first suction port 27a and the second discharge port 27b are positioned in the vicinity

- 31 -

of the vane 23 to face each other, the fluid is compressed using the overall volume of the fluid chamber 29 in the counterclockwise cycle, so that a maximal compression capacity is obtained.

FIGs. 14A to 14C are cross-sectional views an operation sequence of a rotary compressor according to the present invention when the roller revolves clockwise.

First, in FIG. 14A, there are shown states of respective elements inside the cylinder when the driving shaft 13 rotates in the clockwise direction. The first suction port 27a is closed, and the second suction port 27b and third suction port 27c communicate with the second opening 112 and the first opening 111 respectively. If the first valve 110 has the third opening 113 additionally, the third suction port 27c communicates with the third opening 113. Detailed description on the state of the suction ports in the clockwise direction will be omitted since it has been described above.

In a state that the second and third suction ports 27b and 27c are opened, the roller 22 begins to revolve clockwise with performing a rolling motion along the inner circumference of the cylinder due to the clockwise rotation of the driving shaft 13. In such an initial stage revolution, the fluid sucked until the roller 22 reaches the second suction port 27b is not compressed but is forcibly exhausted outside the cylinder 21 by the roller 22 through the second suction port 27b as shown in FIG. 14A. Accordingly, the fluid begins to be compressed after the roller 22 passes the second suction port 27b as shown in FIG. 14B. At the same time, a space between the second suction port 27b and the vane 23, i.e., the space 29b is made in a vacuum state. However, as aforementioned, as the revolution of the roller 22 starts, the third suction port 27c communicates with the first opening 111 and thus is opened so as to suck the fluid. Accordingly, the vacuum state of the space 29b is removed by the sucked fluid, so that generation of a noise and power loss are constrained.

As the roller 22 continues to revolve, the size of the space 29a is reduced and the fluid that has been sucked is compressed. In this compression stroke, the vane 23 moves up and down elastically by the elastic member 23a to thereby partition the fluid

- 32 -

chamber 29 into the two sealed spaces 29a and 29b. Also, new fluid is continuously sucked into the space 29b through the second and third suction ports 27b and 27c so as to be compressed in a next stroke.

When the fluid pressure in the space 29a is above a predetermined value, the
5 first discharge valve 26c shown in FIG. 15 is opened and accordingly the fluid is discharged through the first discharge port 26a. After the fluid is completely discharged, the first discharge valve 26c closes the first discharge port 26a by its self-elasticity.

Thus, after a single stroke is ended, the roller 22 continues to revolve
10 clockwise and discharges the fluid by repeating the same stroke. In the counterclockwise stroke, the roller 22 compresses the fluid with revolving from the second suction port 27b to the first discharge port 26a. Accordingly, the fluid is compressed using a part of the overall fluid chamber 29 in the counterclockwise stroke, so that a compression capacity smaller than the compression capacity in the
15 clockwise direction.

In the aforementioned strokes (i.e., the clockwise stroke and the counterclockwise stroke), the discharged compressed fluid moves upward through the space between the rotator 12 and the stator 11 inside the case 1 and the space between the stator 11 and the case 1. As a result, the compressed fluid is discharged through
20 the discharge tube 9 out of the compressor.

Hereinafter, a method for controlling the compressor of the cooling system constructed as above will be described in detail with reference to the accompanying drawings. FIG. 15 is a flowchart illustrating a method for controlling the compressor of the cooling system according to an embodiment of the present invention. In this
25 embodiment, the control unit receives information on the temperature change of the room from the temperature sensor installed in the room and controls the compressor. Of course, the motor installed in the compressor has different torque characteristics depending on rotation directions of the driving shaft. In the following description, a phrase "to operate with the first torque" means that the compressor is driven with a

- 33 -

large torque and also generates a large output (or a large cooling force), and a phrase “to operate with the second torque” means that the compressor is driven a small torque and generates a small output (or, a small cooling force).

Referring to FIG. 15, the compressor starts to operate with the first torque
5 characteristic at an initial start step. In the embodiment of FIG. 2, at the initial start stage, if the control unit 610 receives the information on the temperature of the room from the temperature sensor 660 installed in the room and determines to operate the cooling system, the control unit 610 transmits the control signal to the switching part 650 to thereby close the contact point of the switching part 650. The power is
10 supplied to the motor, and the driving shaft 13 operates with the first torque. Of course, the switching part 650 is closed in a state that the common contact point 621 of the selector 620 is connected to the first contact point 623. Like the above, there are two methods for connecting the common contact point 621 of the selector 620 to the first contact point 623 before the motor is driven. One method is that the control
15 unit 610 receiving the information from the temperature sensor 660 controls the selector 620 before the contact point of the switching part 650 is closed. The other method is that the common contact point 621 of the selector 620 is designed to always maintain the connection state with the first contact point 623 at the initial start stage. Of course, in the latter case, if the motor is opened in a state that the connection states
20 of the contact points of the selector 620 are changed, it can be configured to maintain the connection states as they are. The reason why the compressor operates with the first driving torque at the initial start stage is that the compressor is in a relatively high load because a compressor of a refrigerant line becomes high due to a high temperature of the object to be cooled, i.e., the food containing chamber of the
25 refrigerator or the indoor space, and a high temperature of the refrigerant of the cooling system at the initial start stage. It is desirable that the compressor is driven with a very high torque characteristic, i.e., the first torque, at the initial start stage when the compressor is in the high load state. At this time, if the compressor is driven with the second torque smaller than the first torque, the start operation fails, or

- 34 -

a cooling force of the refrigerant becomes insufficient even if it operates for a long time, so that the object is not cooled well.

After the initial start with the first torque, as shown in FIG. 15, the driving mode of the motor is checked. Of course, it is checked that the compressor is operated with the first torque mode at the initial start stage. The driving mode determining step, which will be described later, is carried out in order to determine if the driving mode of the compressor is changed in operation, at which mode the compressor operates when the compressor starts to operate after it stops, and by which operation method the compressor operates according to the state of the room.

As the determination result of the driving mode, if the compressor is driven with the first torque characteristic, it is checked whether a first condition is met while the compressor operates. If the first condition is met, the compressor is stopped. Here, when checking whether the first condition is met or not, as shown in FIG. 15, it is desirable to compute an absolute value (P) of an average temperature variation rate of the room for a predetermined time. The reason is that the absolute value (P) is used as the basis of determining whether or not the driving mode of the compressor is changed. Of course, if using other factors, for example, elapse of time, to determine the driving mode of the compressor, it is unnecessary to compute the absolute value (P). Meanwhile, in this embodiment, the first condition is whether the temperature of the object, i.e., the temperature (t) of the room is below a lower limit (t-) of the set temperature. Here, if the temperature (t) is greater than the lower limit (t-) of the set temperature, as shown in FIG. 15, the absolute value (P) is continuously computed. If the temperature (t) is less than the lower limit (t-) of the set temperature, the compressor is stopped. In the embodiment of FIG. 2, if the temperature of the room provided from the temperature sensor 660 is less than the lower limit (t-) of the set temperature while the control unit 610 continues to compute the absolute value (P), the control unit 610 transmits the control signal to the switching part 650 to stop the motor.

- 35 -

It is determined whether it is adaptable to continue to operate the compressor with the first torque characteristic in a state that the compressor is stopped. As the determination result, if adaptable, the driving torque characteristic of the motor is maintained, and if not adaptable, the driving torque characteristic is changed into the
5 second torque characteristic. If satisfying the second condition, the compressor is again driven. Detailed description on that will be made with reference to FIG. 2.

First, the control unit 610 determines the torque characteristic change condition of the motor in a state that the compressor is stopped. In this embodiment, the torque characteristic change condition of the motor, as shown in FIG. 15, is
10 whether the absolute value (P) is greater than a critical value (P+) of the temperature variation rate absolute value for the torque characteristic change. In other words, if the computed absolute value (P) is greater than the critical value (P+), the control unit 610 transmits the control signal to the selector 620 to connect the common contact point 621 with the second contact point 623, so that the driving torque characteristic
15 of the motor changes from the first torque characteristic to the second torque characteristic. Here, that the absolute value (P) is greater than the critical value (P+) means that it is unnecessary to drive the motor with stronger cooling force since the temperature variation rate of the room is high, that is, the temperature is dropped much more while the compressor operates. Accordingly, in this case, it is necessary
20 to stop the first driving torque mode operation having much energy consumption and operate the compressor at the second driving torque mode. For this reason, the control unit 610 controls the selector 620 to change the driving torque characteristic. Meanwhile, if the torque characteristic change condition is not met, the temperature variation rate of the room is small. In other words, it means that a drop in the
25 temperature of the room is small. Therefore, in this case, the room should continue to be cooled with a strong cooling force. Accordingly, the first torque characteristic is maintained as it is without changing the driving torque characteristic.

The driving mode is changed after determining the driving torque change characteristic, and then it is determined whether or not the second condition is met.

- 36 -

Here, the second condition is whether the temperature of the object to be cooled, i.e., the temperature (t) of the room is greater than the upper limit (t+) of the set temperature of the room. In other words, the cooling system does not operate for a predetermined time since the compressor is in the stopped state. Accordingly, with
5 the passage of time, the temperature of the room is gradually increasing. If the temperature (t) of the room exceeds the upper limit (t+) of the set temperature, the control unit 610 transmits the control signal to the switching part 650 to close the contact point, thereby driving the motor. In this case, although the torque is small, the motor is driven at the second driving torque having a high energy efficiency. At
10 this time, the motor can be driven at the second driving torque since the temperature of the room is dropped much more and the compressor is burdened with a load having allowable range within which the compressor can be driven at the second driving torque. When the motor is driven at the second driving torque, an energy efficiency of the cooling system is improved. Meanwhile, even if the torque characteristic is
15 maintained since the driving torque change condition is not met, the temperature of the room is checked to drive the compressor in the same manner. If the temperature (t) of the room is less than the upper limit (t+) of the set temperature, it continues to check the temperature.

If the compressor operates after the above procedures are completed, as shown
20 in FIG. 15, the driving mode of the compressor is again determined. In this case, the driving mode of the compressor can be determined with two cases. One case is to change the driving mode when the temperature of the room is dropped much while the above procedures are executed, and the other case is to maintain the driving mode since the temperature of the room is dropped less. After the driving mode is
25 maintained, the compressor is driven, the driving mode of the compressor is determined, and then the above procedures are repeated. Another method for controlling the compressor after determining the driving mode of the compressor will be described below.

- 37 -

Referring to FIG. 15, if it is determined that the motor is driven at the second torque characteristic, the control unit 610 determines whether it is adaptable to operate the motor at the second torque characteristic on the basis of the state of the object to be cooled, i.e., the temperature of the room and the absolute value of the variation rate. Then, the compressor is stopped. A description on that will be described with reference to FIG. 2.

First, the control unit 610 receives the temperature of the room from the temperature sensor 660 in real time, and computes the absolute value (P) of the average temperature variation rate for a predetermined time while the compressor is operating. It is determined whether the absolute value (P) is less than an absolute value (P-) of the minimum temperature variation rate.

Here, if the absolute value (P) is less than the absolute value (P+), the control unit 610 transmits the control signal to the switching part 650 to open the contact points of the switching part 650, thereby stopping the motor. That the absolute value (P) is less than the absolute value (P+) means that the temperature of the room is not dropped as much as the minimum necessary level due to the lack of the cooling force although the cooling system operates at the second torque for a predetermined time. In this case, if the cooling system operates at the second torque, necessary cooling force is not supplied to the room, so that the room is not cooled effectively. Accordingly, if it is determined that the absolute value (P) is the absolute value (P+), it is not suitable to operate the motor at the second torque characteristic. Therefore, the driving torque characteristic is changed into the first torque characteristic in order to cool the room at larger cooling force. In this case, as shown in FIG. 15, the control unit 610 controls the switching part 650 to stop the compressor.

If the compressor is stopped, the control unit 610 transmits the control signal to the selector 620 after a delay of predetermined time, so that the common contact point 621 and the first contact point 623 are connected to each other. As a result, the driving torque characteristic of the motor is changed into the first torque characteristic. If the torque characteristic change of the motor is completed, the control unit 610

- 38 -

transmits the control signal to the switching part 650 to close the contact points of the switching part 650, thereby driving the motor. The compressor is driven at the first driving torque, so that the room is cooled at a large cooling force. If the compressor is driven at the first driving torque, as shown in FIG. 15, it is again
5 determined at which driving mode the compressor is operating.

Meanwhile, if the absolute value (P) is greater than the absolute value (P+), the control unit 610 determines whether it is suitable to operate the motor at the second torque characteristic on the basis of the temperature information provided from the temperature sensor 660. The determination condition, as shown in FIG. 15, is that it
10 is whether the temperature of the object to be cooled, i.e., the temperature (t) of the room, is less than the lower limit (t-) of the set temperature. If the temperature (t) of the room is less than the lower limit (t-) of the set temperature, the control unit 610 determines whether it is suitable to operate the motor at the second torque characteristic, and then transmits the control signal to the switching part 650 to stop
15 the motor. Here, that the temperature (t) of the room is less than the lower limit (t-) of the set temperature means that a large cooling force is not necessary since the temperature (t) is sufficiently low although the temperature variation rate of the room is very small, and that the cooling system can continue to operate at a small cooling force. Accordingly, in this case, the motor is stopped in a state that the driving
20 characteristic of the motor is maintained. Meanwhile, if the temperature (t) of the room is greater than the lower limit (t-) of the set temperature, the control unit 610 continues to compute the absolute value (P), compares the two absolute values (P)(P+), and repeats the above procedures according to the comparison result.

After stopping the compressor since the temperature (t) of the room is less than
25 the lower limit (t-) of the set temperature, as shown in FIG. 15, it is determined whether the temperature of the object to be cooled, i.e., the temperature (t) of the room satisfies the upper limit (t+) of the set temperature. If the temperature (t) satisfies the upper limit (t+) of the set temperature, the motor is driven, and the process proceeds to the step of determining the driving mode.

- 39 -

In the method for controlling the compressor according to the present invention, the control unit controls the compressor to check the temperature variation of the room in real time and output the torques necessary for the cooling force of the room and the driving of the compressor on the basis of the checked
5 temperature variation, thereby always obtaining the optimum operation of the compressor.

FIG. 16 is a flowchart illustrating a method for controlling the compressor in the cooling system according to another embodiment of the present invention. In this embodiment, the control unit controls the compressor on the basis of the driving of the
10 motor and the elapse degree of time. This embodiment of the present invention will be described in detail with reference to FIG. 3. The same contents as the embodiment of FIG. 15 will be omitted.

Referring to FIG. 16, the compressor starts to operate at the first torque at the initial start stage. Referring again to FIG. 3, the motor is automatically driven by the
15 switching part 670 for turning on/off the contact points according to the temperature of the room. In other words, the switching part 670 including the thermostat operated by the bimetal is configured to close the contact points above the first temperature and open them below the second temperature. If the temperature of the room increases above the first temperature, the contact points of the switching part
20 670 are closed so that the compressor operates. After the compress is initially operated, the process proceeds to the step of determining the driving mode.

As the determination result of the driving mode, if the compressor operates at the first torque characteristic, it is determined whether the compressor satisfies the first condition while it is operating. At this time, if the first condition is met, the
25 compressor is stopped. In this embodiment, the first condition is whether the compressor is stopped or not. Referring to FIG. 3, the compressor is automatically turned on or off by the switching part 670 which is turned on/off according to the temperature of the room. Accordingly, if the compressor operates for a long time so that the temperature of the room is dropped below the second temperature, the contact

- 40 -

points of the switching part 670 are opened to stop the compressor. The current sensor 690 connected in series to the switching part 670 checks the stopping of the compressor and informs the control unit 610 of it. In other words, if the current is not sensed by the current sensor 690, the control unit 610 determines that the motor is
5 stopped.

Meanwhile, in order to determine the driving mode change condition, which will be described later, the elapse time (T) is counted while the compressor is operating. If the compressor is not stopped, the elapse time (T) continues to be counted. Of course, if the compressor is stopped, the counting of the elapse time (T)
10 is stopped.

If it is determined that the compressor is stopped, it is determined whether it is suitable to continue to operate the compressor at the first torque characteristic in a state that the compressor is stopped. If suitable, the driving torque characteristic is maintained, and if not suitable, the driving characteristic is changed into the second
15 torque characteristic. After maintaining or changing the driving torque characteristic of the motor, it is determined whether the second condition is met. If met, the compressor is operated. Detailed description on that will be made in detail with reference to FIG. 2.

First, the control unit 610 determines the condition for changing the torque
20 characteristic of the motor in a state that the compressor is stopped. Here, the torque characteristic change condition is whether or not the elapse time (T) is less than the preset minimum time (T₋). In other words, if the elapse time (T) is less than the minimum time (T₋), the control unit 610 determines that it is not suitable to drive the compressor at the first driving mode. That the elapse time (T) is less than the
25 minimum time (T₋) means that the temperature of the room is dropped to desired temperature within a very short time due to the sufficiency of the cooling force or the low temperature of the room. Therefore, it is unnecessary to drive the compressor at large cooling force. At this time, it is necessary to efficiently drive the system by reducing the energy consumption through the change of the torque characteristic. On

- 41 -

the contrary, if the elapse time (T) exceeds the minimum time (T-), the control unit 610 determines that it is suitable to drive the compressor at the first driving mode, and thus maintains the driving torque characteristic. In this embodiment, the minimum time (T-) can be set to about 10 minutes.

5 If the elapse time (T) is less than the minimum time (T-), the control unit 610 transmits the control signal to the selector 620 to connect the common contact point 621 with the second contact point 622, thereby changing the driving torque characteristic of the motor into the second torque characteristic. After changing the driving torque characteristic of the motor, the control unit 610 resets the elapse time
10 (T). On the contrary, if the elapse time is less than the minimum time (T-), the control unit 610 resets the elapse time (T) in a state that the driving torque characteristic is maintained as it is, as shown in FIG. 16.

After resetting the elapse time (T), the control unit 610 determines the second condition, i.e., whether the compressor is driven or not. Of course, the current sensor
15 690 is used to determine the second condition. If it is determined that the compressor is driven, as shown in FIG. 15, the process proceeds to the step of determining the driving mode of the motor. On the other hand, if it is determined that the compressor is not driven, the control unit 610 continues to determine the second condition.

20 Meanwhile, like the embodiment of FIG. 15, two results are provided at the step of determining the driving mode of the compressor after the above procedures. If it is determined that the compressor is driven at the first torque, the above procedures are repeatedly carried out, and if it is determined that the motor is driven at the second torque, the compressor operates in a different method. The case that the
25 motor is driven at the second torque will be described below.

First, if it is determined that the motor is driven at the second torque characteristic, it is determined whether it is suitable to operate the motor at the second torque characteristic on the basis of the elapse time. Here, the determination is carried out by comparing the elapse time while the compressor operates and the preset

- 42 -

time. After completing the determination, the compressor is stopped, which will be described in detail with reference to FIG. 3.

The control unit 610 counts the elapse time (T) while the compressor is driven as shown in FIG. 16. Then, the control unit 610 determines the driving torque change condition of the compressor. Here, the driving torque change condition is provided with two cases. One case is whether the elapse time (T) exceeds the maximum limit time (T+), and the other case is whether the elapse time (T) is less than a start success determining time (Tt) of the compressor. In this embodiment, the maximum limit time (T+) can be set to about 30 minutes, and the start success determining time (Ty) can be set to about 10 minutes. If one of two conditions is met, the control unit 610 determines that it is not suitable to operate the compressor at the second torque characteristic. The reasons are as follows.

First, that the elapse time (T) exceeds the maximum limit time (T+) means that the compressor operates at the second torque characteristic unnecessarily for a long time. Due to an insufficiency of the cooling force of the cooling system or the high temperature of the surroundings or the room, the compressor operates at the second torque characteristic for a long time. Therefore, the temperature is dropped enough to open the switching part 670 installed in the room. In this case, since it is more effective to drive the cooling system at large cooling force, it is determined that it is not suitable to operate the compressor at the second torque characteristic

If the elapse time (T) is less than the start success determining time (Tt), the compressor does not operate normally. In addition, it means that the compressor is stopped just after the compressor is driven at the second torque characteristic. In other words, when the compressor operates at the second torque characteristic, if the torque outputted at the second torque start is smaller than the torque necessary for the driving, the motor is overloaded. Therefore, the motor is automatically stopped by, for example, the overload protector 640. In this case, since it means that the torque of the driving shaft 13 is weak when driving the motor at the second torque characteristic, the motor should be driven at larger torque.

- 43 -

As described above, if it is determined that it is not suitable to drive the motor at the second torque characteristic, the control unit 610 transmits the control signal to the second switching part 680 to open the contact points, thereby forcibly stopping the motor. After the compressor is stopped, as shown in FIG. 16, the control unit 610 delays a predetermined time and controls the selector 620 to change the driving torque characteristic of the compressor into the first torque characteristic. After changing the torque characteristic, the elapse time (T) is reset. The control unit 610 controls the second switching part 680 to drive the compressor, and then the process proceeds to the step of determining the mode.

Meanwhile, if the compressor operating at the second torque does not satisfies the torque change condition, in other words, if the elapse time exceeds the start success determining time (T_t) and is less than the maximum limit time (T_+), the control unit 610 determines that it is suitable to drive the compressor at the second torque. This means that the start at the second torque is succeeded and the temperature of the room is dropped below the second temperature. After such a determination, the current sensor 690 senses whether or not the compressor is turned on. At this time, if the compressor is operating, the torque change condition is again determined while checking the elapse time (T), and then a corresponding process is carried out.

If it is determined that the compressor is stopped, it means that the driving at the second torque is succeeded and the temperature of the room is dropped to a desired target temperature, i.e., the second temperature, while the compressor operates at the second torque. After the compressor is stopped, the control unit 610 resets the elapse time (T). In addition, since the cooling system does not operate after the compressor is stopped, the temperature of the room increases gradually. If the temperature of the room is above the first temperature, the switching part 670 is automatically closed and the motor rotates, thereby driving the compressor. If the temperature is less than the first temperature, the switching part 670 maintains the opened state and thus the compressor maintains the stopped state. Meanwhile, as

- 44 -

shown in FIG. 16, after the compressor is driven, the process proceeds to the step of determining the driving mode of the compressor.

According to the system for controlling the cooling system, the compressor is controlled by automatically turning on/off the motor according to the temperature of the room on the basis of the time elapse. Therefore, it is possible to provide the torque and the cooling force which is sensitive to the temperature condition of the room and suitable for the condition of the room.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

For example, the method for controlling the compressor of the cooling system according to the present invention is not limited to only the above-described compressors. In other words, the present invention can be applied to any compressor used in the cooling system and having the motor that outputs two different torques. However, unlike the compressors of the present invention, these compressors has a disadvantage that they cannot provide the two different torques and two different capacities or cooling forces at the same time. In this case, if the method of the present invention is applied to the compressors, the compressors can output torque suitable for the state of the object to be cooled, thereby obtaining an improved energy efficiency. Meanwhile, the present invention provides a method for controlling the compressors that can output two different torques and dual capacity.

Industrial Applicability

The rotary compressor constructed as above has following effects.

First, according to the related art, several devices are combined in order to achieve the dual-capacity compression. For example, an inverter and two compressors having different compression capacities are combined in order to obtain the dual compression capacities. In this case, the structure becomes complicated and

- 45 -

the cost increases. However, according to the present invention, the dual-capacity compression can be achieved using only one compressor. Particularly, the present invention can achieve the dual-capacity compression by changing parts of the conventional rotary compressor to the minimum.

5 Second, the conventional compressor having a single compression capacity cannot provide the compression capacity that is adaptable for various operation conditions of air conditioner or refrigerator. In this case, a power consumption may be wasted unnecessarily. However, the present invention can provide a compression capacity that is adaptable for the operation conditions of equipments.

10 Third, according to the rotary compressor of the present invention, the conventional designed fluid chamber can be used to provide the dual-compression capacity. It means that the compressor of the present invention has at least the same compression capacity as the conventional rotary compressor having the same cylinder and fluid chamber in size. In other words, the rotary compressor of the present
15 invention can substitute for the conventional rotary compressor without modifying designs of basic parts, such as a size of the cylinder. Accordingly, the rotary compressor of the present invention can be freely applied to required systems without any consideration of the compression capacity and any increase in unit cost of production.

20 Fourth, according to the method for controlling the compressor of the present invention, all the compressors which can output different torques as well as the double-capacity compressors can operate at the optimum torque according to the conditions of the objects to be cooled. Therefore, the cooling system can be operated more economically and efficiently compared with the related art.

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- 46 -

Claims

1. A system for controlling a compressor of a cooling system, the controlling system comprising:

the compressor having a driving shaft that is rotatable clockwise and
5 counterclockwise and operated by a power of a motor outputting different torque characteristics depending on the rotational directions of the driving shaft;

a selector for selecting an output torque characteristic of the motor;

a switching part for turning on or off the motor; and

a control unit for controlling the selector to drive the compressor in a torque
10 characteristic suitable for an object to be cooled.

2. The system of claim 1, further comprising means for sensing information on the object to be cooled, wherein the control unit controls the selector and the switching part on the basis of information transmitted from the sensing means.

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3. The system of claim 2, wherein the sensing means comprises a temperature sensor for measuring the temperature of the object to be cooled.

4. The system of claim 1, further comprising an overload protector provided
20 between the motor and the switching part.

5. The system of claim 1, wherein the motor comprises:

a first winding connecting a first terminal and a common terminal and rotating the driving shaft in a first torque characteristic; and

25 a second winding a second terminal and the common terminal and rotating the driving shaft in a second torque characteristic.

6. The system of claim 5, wherein the selector comprises:

a first contact point connected with the first terminal;

- 47 -

a second contact point connected with the second terminal; and

a common contact point connected with a power and selected connected to the first contact point or the second contact point.

5 7. The system of claim 1, wherein the switching part comprises a thermostat of which contact point is turned on or off depending on the temperature of the object to be cooled.

8. The system of claim 7, further comprising means for determining whether
10 the motor is turned on or off.

9. The system of claim 8, wherein the determining means comprises a current sensor for sensing a current through the switching part.

15 10. The system of claim 8, wherein the control unit controls the selector on the basis of whether the motor is turned on or off and an elapse of time.

11. The system of claim 7, further comprising a second switching part connected in series with the switching part, wherein the control unit controls the
20 selector and the second switching part on the basis of the elapse degree of time.

12. The system of claim 1, wherein the compressor comprises:
the driving shaft having a predetermined sized eccentric part and being rotatable clockwise and counterclockwise;
25 a cylinder forming a predetermined inner volume;
a roller rotating in contact with an inner circumference of the cylinder, installed rotatably on an outer circumference of the eccentric part, performing a rolling motion along the inner circumference and forming a fluid chamber to suck and compress fluid along with the inner circumference;

- 48 -

a vane installed elastically in the cylinder so as to be in contact with the roller continuously, and partitioning the fluid chamber into two independent spaces;

upper and lower bearings installed respective at upper and lower sides of the cylinder, for rotatably supporting the driving shaft and sealing the inner volume;

5 discharge ports communicating with the fluid chamber;

discharge valves for opening the respective discharge ports at a predetermined pressure or more; and

at least one suction port communicating with the fluid chamber.

10 13. The system of claim 12, wherein the suction and discharge ports are formed in the cylinder.

14. The system of claim 13, wherein the discharge ports are spaced apart by a predetermined distance to face with each other with respect to the vane.

15

15. The system of claim 14, wherein the suction port is one that is located to face with the vane on an imaginary line passing on the vane.

16. The system of claim 14, wherein the suction port is located at a side on an imaginary line passing on the vane.

20

17. The system of claim 12, wherein the suction and discharge ports are formed in the bearing, further comprising a valve assembly for selectively opening one of the suction ports depending on the rotary direction of the driving shaft.

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18. The system of claim 17, wherein the discharge ports comprise first and second discharge ports that are located to face with each other about the vane.

19. The system of claim 17, wherein the suction port comprises:

- 49 -

a first suction port located adjacent to the vane; and

a second suction port spaced apart by a predetermined angle from the first suction port with respect to a center of the cylinder.

5 20. The system of claim 17, wherein the roller compresses the fluid by using the overall fluid chamber when the driving shaft rotates only in either the clockwise direction or counterclockwise direction.

21. The system of claim 17, wherein the roller compresses the fluid by using a
10 part of the fluid chamber when the driving shaft rotates only in either the clockwise direction or counterclockwise direction.

22. The system of claim 19, wherein the valve assembly comprises:

a first valve installed rotatably between the cylinder and the bearing and
15 having a penetration hole through which the driving shaft is inserted; and
a second valve fixed between the cylinder and the bearing, having a site portion accommodating the first valve, and for guiding a rotary motion of the first valve.

20 23. The system of claim 22, wherein the first valve is comprised of a circular plate member that is in contact with the eccentric part of the driving shaft to rotate in the rotary direction of the driving shaft.

24. The system of claim 22, wherein the first valve comprises:

25 a first opening communicating with the first suction port when the driving shaft rotates in one of the clockwise direction or the counterclockwise direction; and
a second opening communicating with the second suction port when the driving shaft rotates in the other the clockwise direction or the counterclockwise direction.

- 50 -

25. The system of claim 24, wherein the suction port further comprises a third suction port located on the second suction port and the vane, and the first opening no sooner opens the third suction port than the second suction port is opened.

5

26. The system of claim 22, wherein the valve assembly further comprises means for controlling a rotary angle of the first valve so as to precisely open the corresponding suction port with respect to each rotary direction.

10

27. The system of claim 26, wherein the control means comprises:
a protruded portion protruded in a radius direction of the first valve; and
a groove formed in the second valve and accommodating the protruded portion movably.

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28. A cooling system comprising:

a compressor having a driving shaft that can be rotatable clockwise and counterclockwise and operated by a power of a motor outputting different torque characteristics depending on the rotational directions of the driving shaft;

a compressor control part including a selector for selecting an output torque characteristic of the motor; a switching part for turning on or off the motor; and a micom for controlling the selector to operate the compressor at a torque characteristic suitable for an object to be cooled;

20 first and second heat exchangers which heat-exchange coolant forcibly delivered from the compressor with an indoor or an outdoor respectively; and

25 an expansion unit provided in a coolant tube connecting the first and second heat exchangers.

29. A method for controlling an operation of a compressor in a cooling system, the method comprising the steps of:

- 51 -

(a) an initial starting step of starting the compressor equipped with a motor different torque characteristics depending on rotary directions of a driving shaft at a first torque characteristic;

(b) determining the operation torque characteristic of the motor;

5 (c) when it is determined that the motor operates at the first torque characteristic in consequence of performing the step (b), if a first condition is met during an operation of the compressor, stopping the compressor;

(d) determining whether it is suitable to continuously operate the motor at the first torque characteristic in a state that the compressor is stopped, and if it is
10 determined that it is suitable, maintaining the operation torque characteristic of the motor, while if it is determined that it is not suitable, converting the operation torque characteristic of the motor from the first torque characteristic to a second torque characteristic, and if a second condition is met, operating the compressor.

15 30. The method of claim 29, wherein the first torque characteristic has a torque greater than the second torque characteristic.

31. The method of claim 30, wherein the first condition is a question 'Is the temperature of an object to be cooled below a lower limit of a set temperature?'.
20

32. The method of claim 31, wherein the step (c) comprises the step of (c0) computing an absolute value (P) of an average temperature variation rate of the object to be cooled during a predetermined time period while the compressor operates.

25 33. The method of claim 32, wherein the step (d) comprises the steps of:

(d1) determining a conversion condition of the torque characteristic in the state that the compressor is stopped, and if the conversion condition is met, converting the torque characteristic of the motor to the second torque characteristic;

(d2) determining the conversion condition of the torque characteristic in the

- 52 -

state that the compressor is stopped, and if the conversion condition is not met, maintaining the torque characteristic of the motor at the first torque characteristic; and

(d3) after the step (d1) or (d2), if the second condition is met, operating the
5 compressor while if the second condition is not met, continuing to determining whether the second condition is met or not.

34. The method of claim 33, wherein the conversion condition of the torque
characteristic is a question "Does an absolute value (P) of average temperature
10 variation rate of the object to be cooled exceed a critical value (P+) of an absolute value of temperature variation rate for torque characteristic conversion of the motor?".

35. The method of claim 33, wherein the second condition is a question "Does
the temperature of the object to be cooled exceed an upper limit of a set temperature?".
15

36. The method of claim 29, wherein the step (b) is performed after the step
(d).

37. The method of claim 36, further comprising, when it is determined that the
20 motor operates at the second torque characteristic as a result of performing the step (b), the step (e) determining whether or not it is proper to operate the motor at the second torque characteristic based on the state of the object to be cooled and stopping the compressor.

25 38. The method of claim 37, wherein the step (e) comprises the steps of:

(e1) measuring an absolute value (P) of an average temperature variation rate
of the object to be cooled for a selected time interval while the compressor operates;

(e2) determining whether the absolute value (P) of the average temperature
variation rate of the object to be cooled is less than an absolute value (P-) of a preset

- 53 -

minimum temperature variation rate for a selected time interval; and

(e3) if the step (e2) is met, determining that it is not proper to operate the motor at the second torque characteristic and stopping the compressor.

5 39. The method of claim 38, further comprising the step (e4) of, determining whether the temperature of the object to be cooled is less than the lower limit of the set temperature, if so, determining that it is proper to operate the motor at the second torque characteristic and stopping the compressor.

10 40. The method of claim 39, when in the step (e4), it is determined that the temperature of the object to be cooled is equal to or greater than the lower limit of the set temperature, further comprising the step of returning to the step (e1).

41. The method of claim 38, further comprising the steps of:

15 (f) if a compression key is stopped by the step (e3), after a time delay, converting the torque characteristic of the motor to the first torque characteristic; and

(g) after the step (f), driving the motor to operate the compressor, and going to the step (b).

20 42. The method of claim 39, further comprising the step of, if the compressor is stopped by the step (e4), driving the motor and operating the compressor when the temperature of the object to be cooled meets an upper limit of the set temperature, and going to the step (b).

25 43. The method of claim 30, wherein the first condition is a question "Is the compressor turned off?".

44. The method of claim 43, wherein whether or not the compressor is stopped is determined by On or Off of a motor switching part which is automatically turned on

- 54 -

or off by a condition of the object to be cooled.

45. The method of claim 44, wherein whether or not the compressor is stopped is determined by whether or not current is sensed by a current sensor connected in series to the motor switching part.

46. The method of claim 43, wherein the step (c) comprises the step (c5) of counting an elapse time.

47. The method of claim 46, wherein the step (d) comprises the steps of:

(d5) determining the conversion condition of the torque characteristic in a stop state of the compressor, and if the conversion condition is met, converting the torque characteristic to the second torque characteristic;

(d6) determining the conversion condition of the torque characteristic in the stop state of the compressor, and if the conversion condition is not met, maintaining the first torque characteristic;

(d7) resetting the elapse time after the step (d5) or (d6); and

(d8) after the step (d7), if the second condition is met, operating the compressor, and if the second condition is not met, continuing to determining whether or not the second condition is met.

48. The method of claim 47, wherein the conversion condition of the torque characteristic is a question "Doesn't the elapse time reach a minimum limit time?"

49. The method of claim 47, wherein the second condition is a question "Is the compressor turned on?"

50. The method of claim 47, wherein the step (b) is performed after the step (c).

- 55 -

51. The method of claim 50, after the step (b), when it is determined that the motor operates at the second torque characteristic, determining whether or not it is proper to operate the motor at the second torque characteristic based on whether or not a predetermined time elapses, and stopping the compressor the compressor.

5

52. The method of claim 51, wherein the step (k) comprises the steps of:

(k1) counting an elapse time (T) while the compressor operates;

(k2) determining whether the elapse time (T) exceeds a preset maximum limit time (T+) or the elapse time (T) is under a preset start success determining time (Tt) of the compressor; and

10

(k3) if the step (k2) is met, determining that it is not proper to operate the motor at the second torque characteristic and stopping the compressor.

53. The method of claim 52, further comprising the step of (k4), if the step (k2) is not met, determining whether or not the compressor is in Off-state, and if the compressor is in Off-state, determining that it is proper to operate the motor at the second torque characteristic.

15

54. The method of claim 53, further comprising the step of (l) after the step (k4), resetting the elapse time (T).

20

55. The method of claim 53, further comprising the step of, in the step (k4), if it is determined that the compressor is not in Off-state, returning to the step (k1).

56. The method of claim 54, after the step (l), determining whether the compressor is turned on, if it is determined that the compressor is turned on, returning to the step (b), and if it is determined that the compressor is not turned on, returning to the step (l).

25

- 56 -

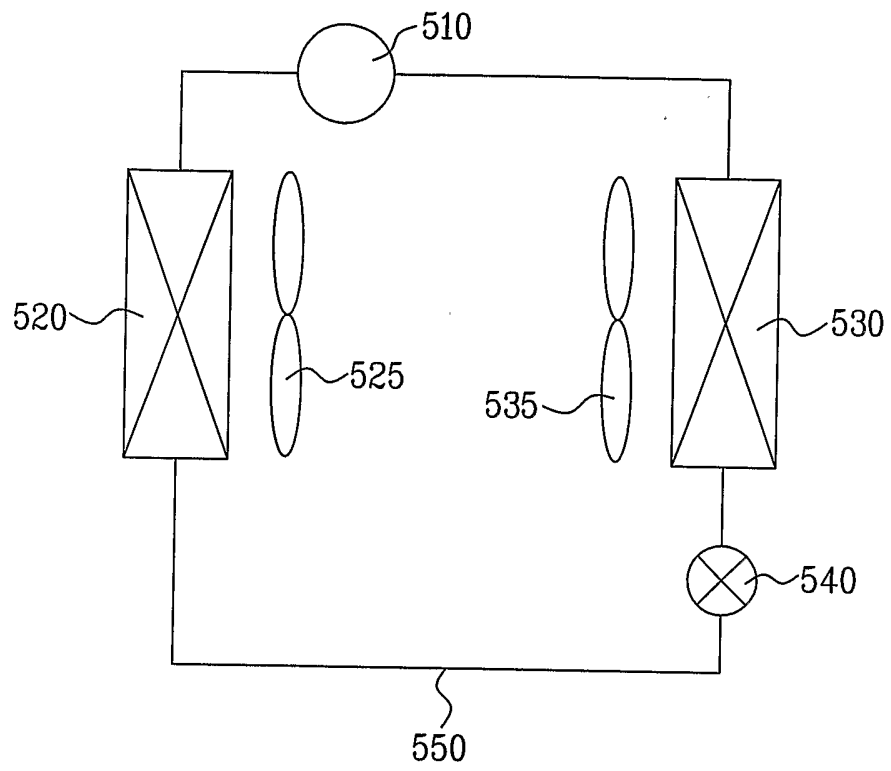
57. The method of claim 52, further comprising the steps of:

(n) if the compressor is stopped by the step (k3), after a predetermined time delay, converting the torque characteristic of the motor to the first torque characteristic; and

- 5 (o) after the step (n), resetting the elapse time (T), operating the compressor and then returning to the step (b).

1/21

FIG.1



3/21

FIG. 3

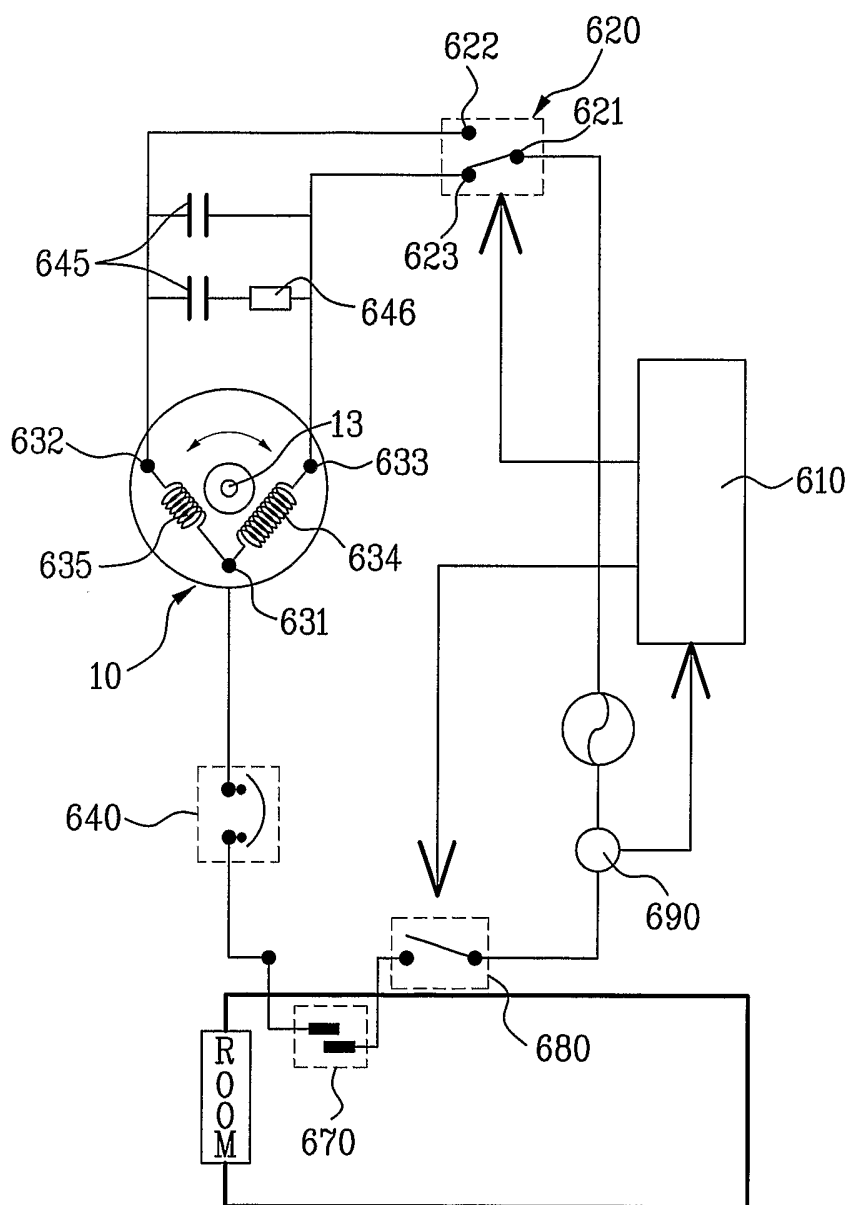
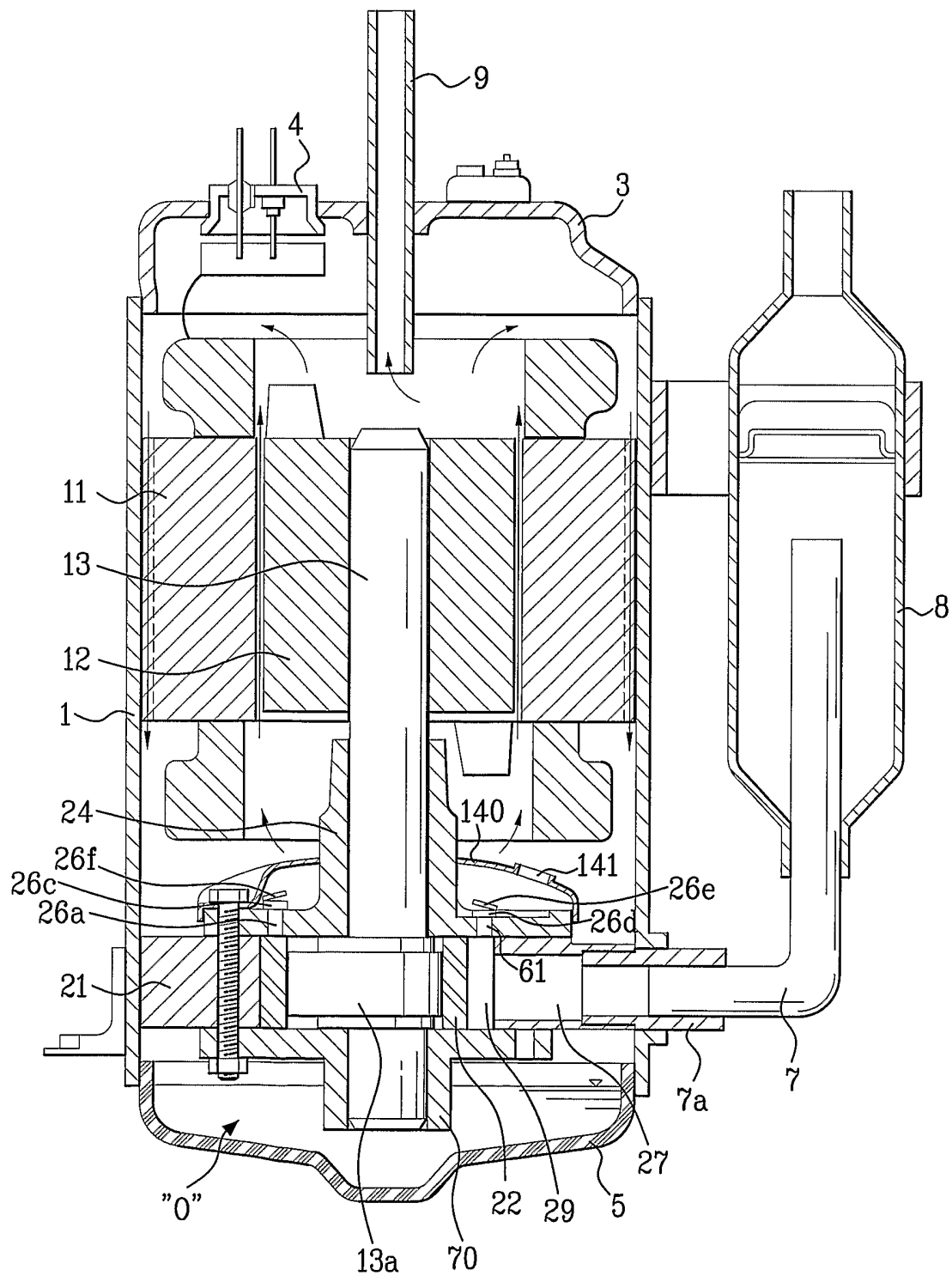
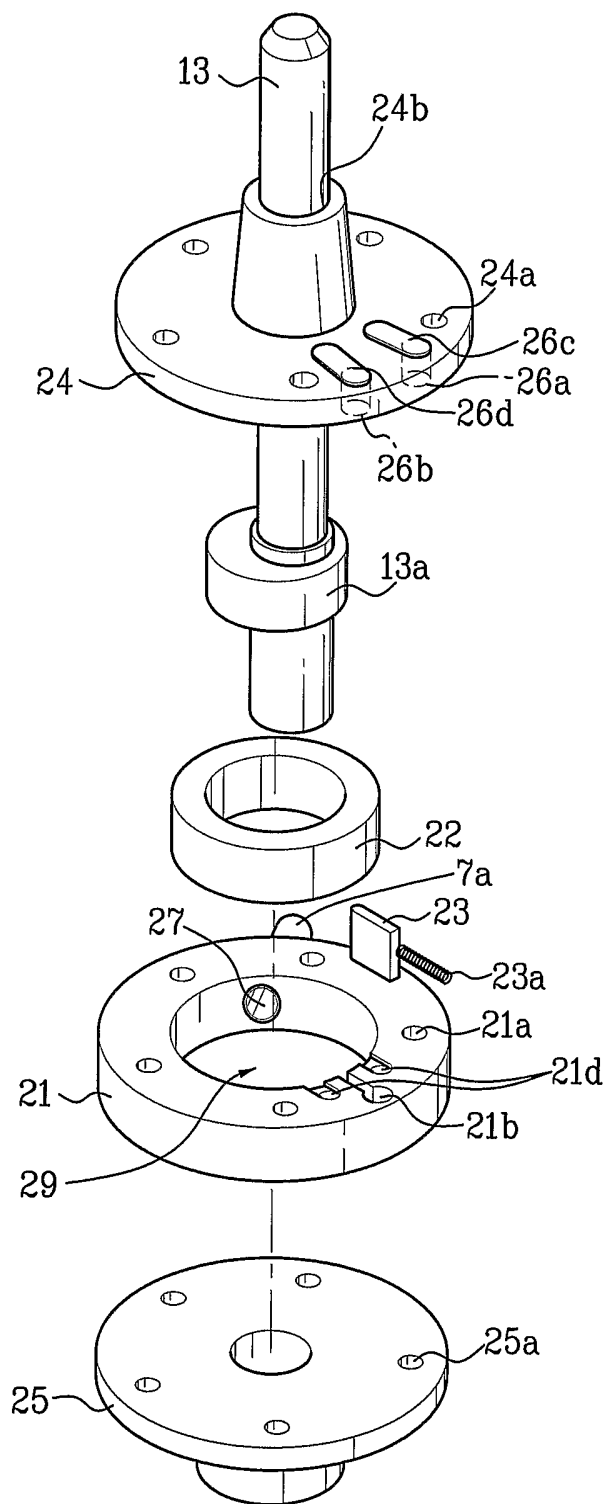


FIG. 4



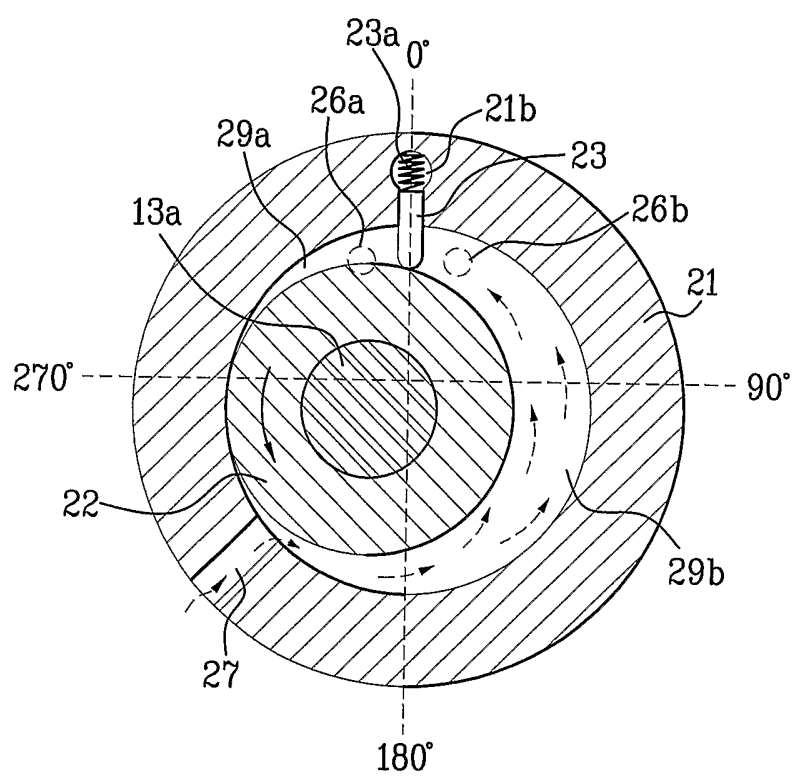
5/21

FIG. 5



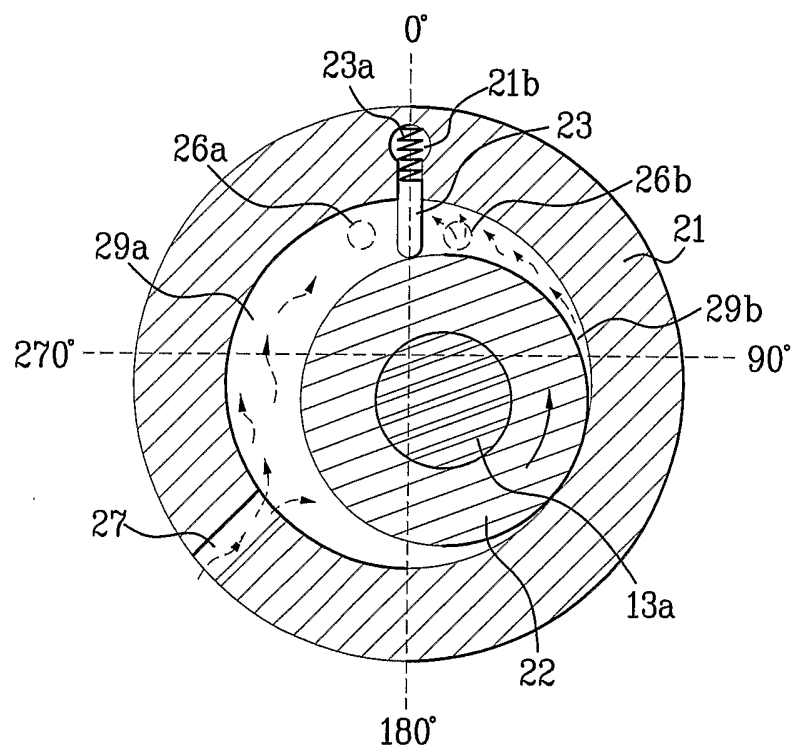
6/21

FIG. 6A



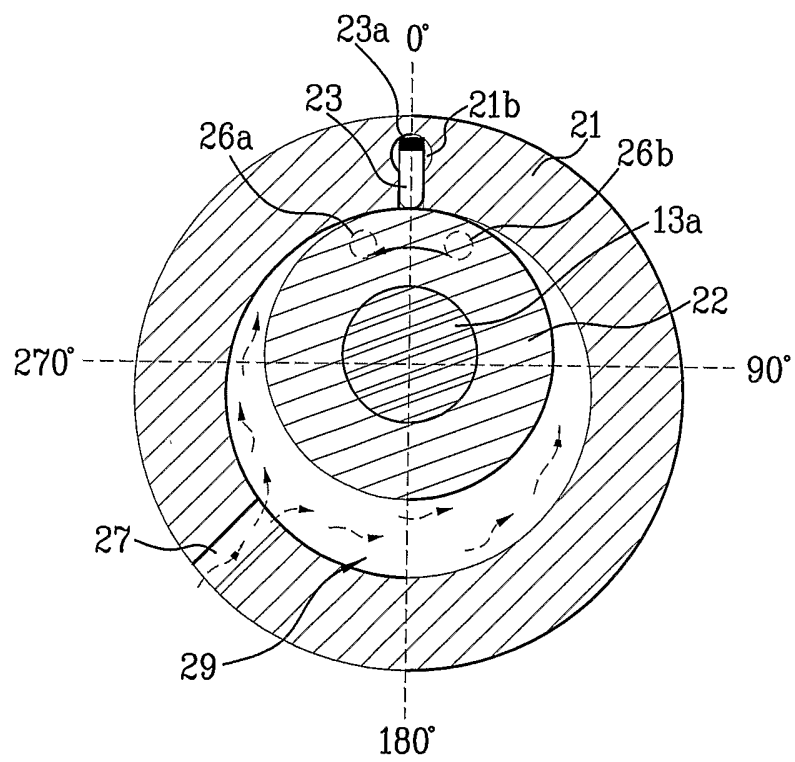
7/21

FIG. 6B



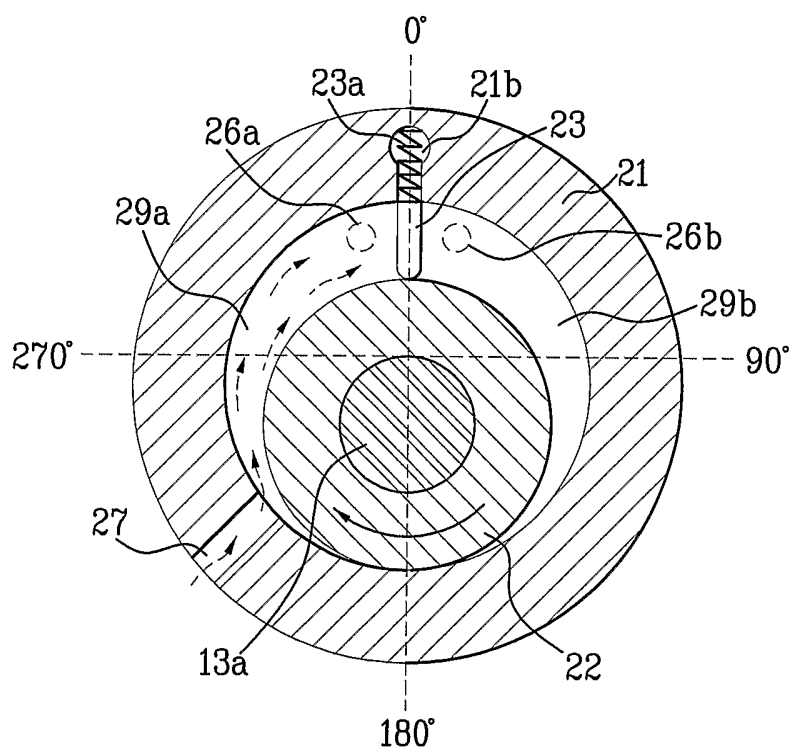
8/21

FIG. 6C

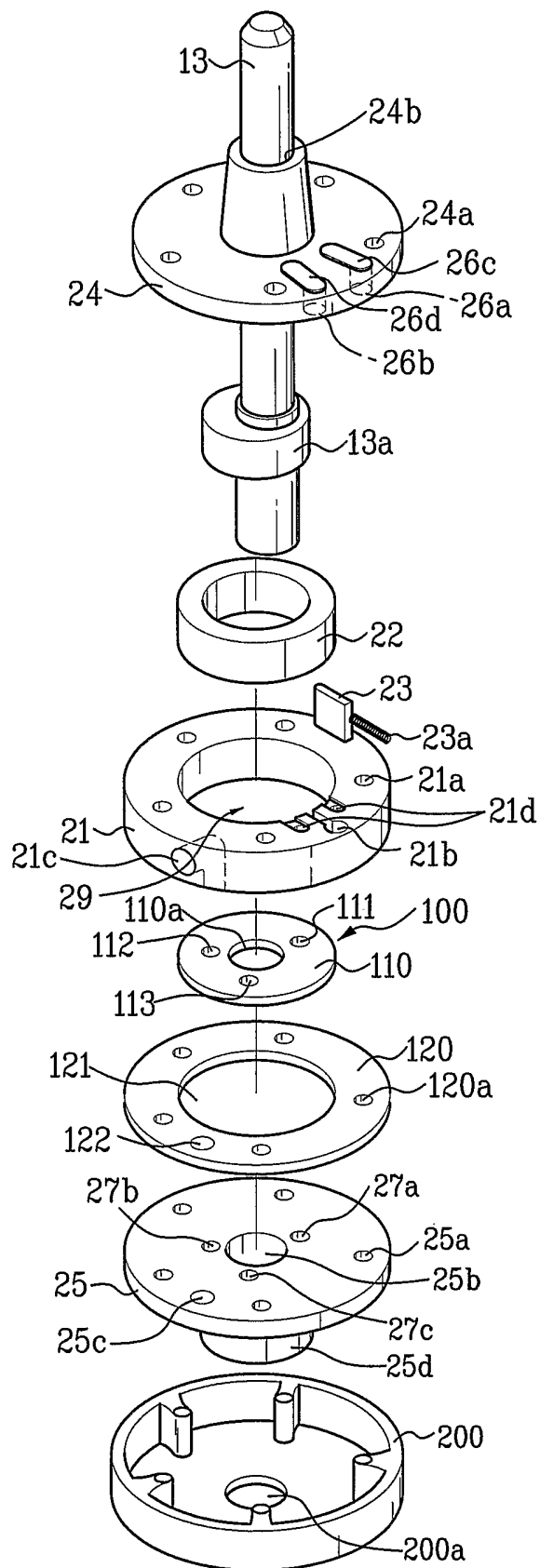


9/21

FIG. 7A

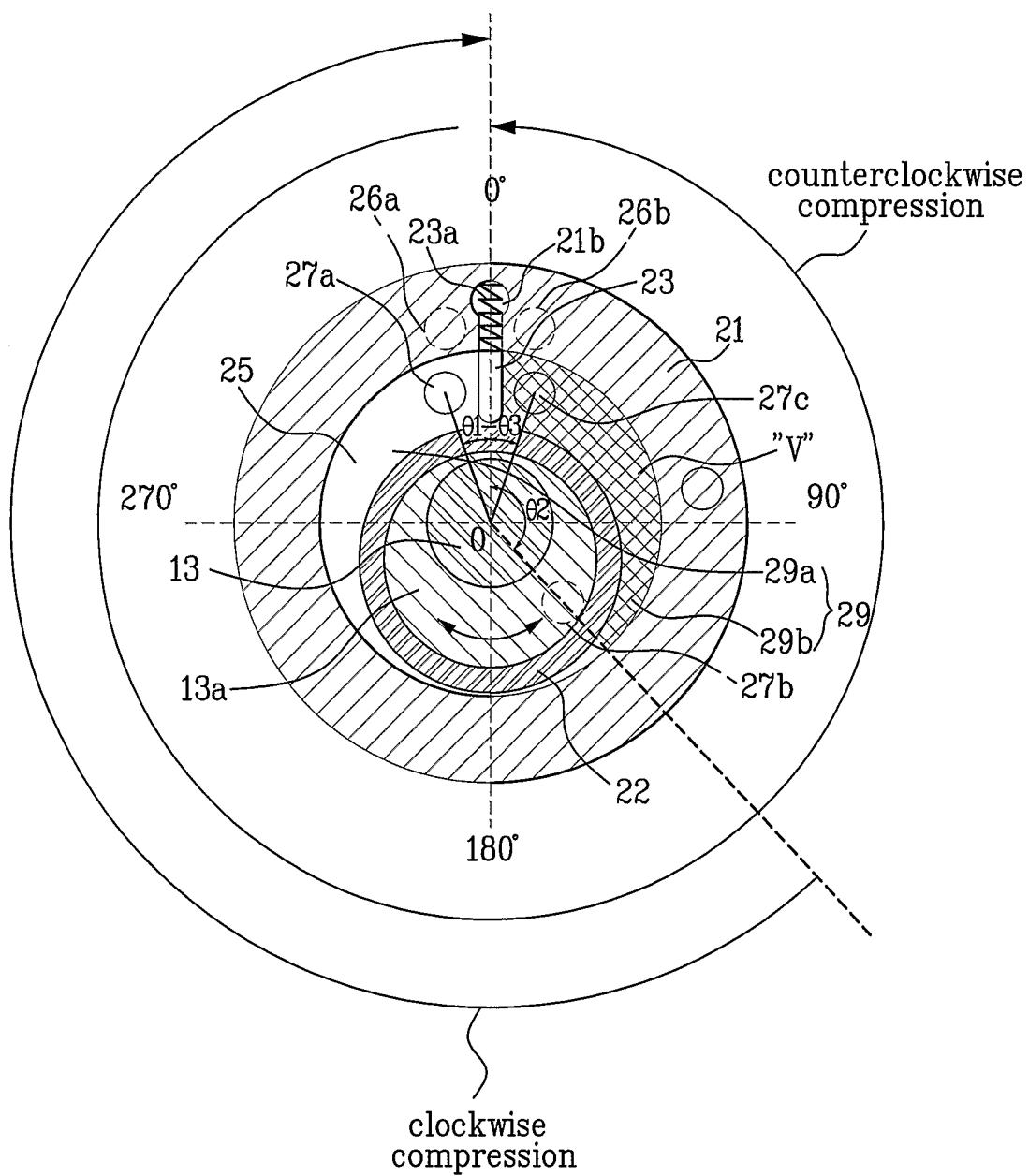


12/21

FIG. 9

14/21

FIG. 11



15/21

FIG.12A

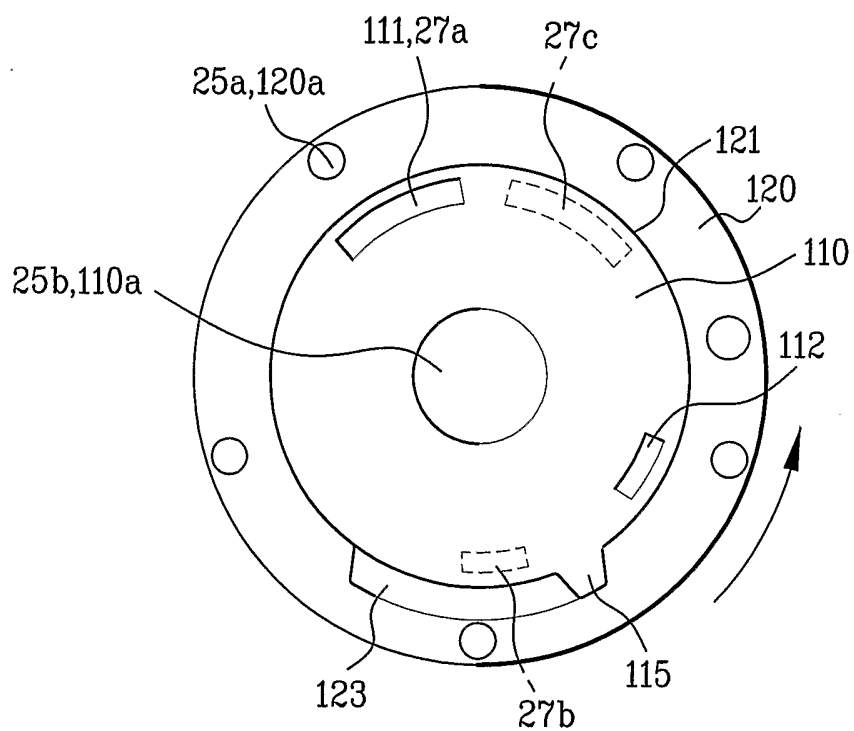
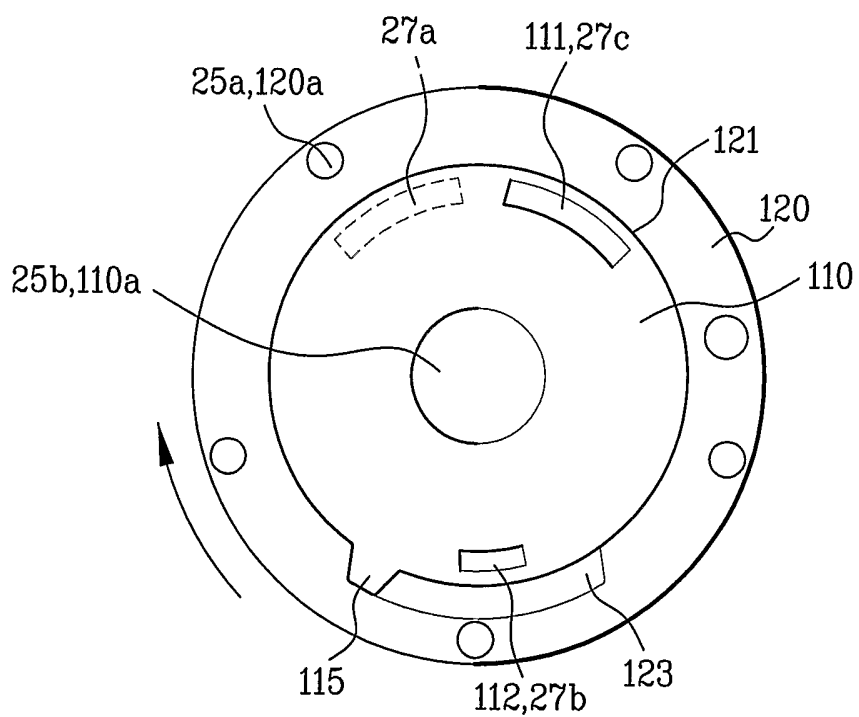


FIG.12B



17/21

FIG.13C

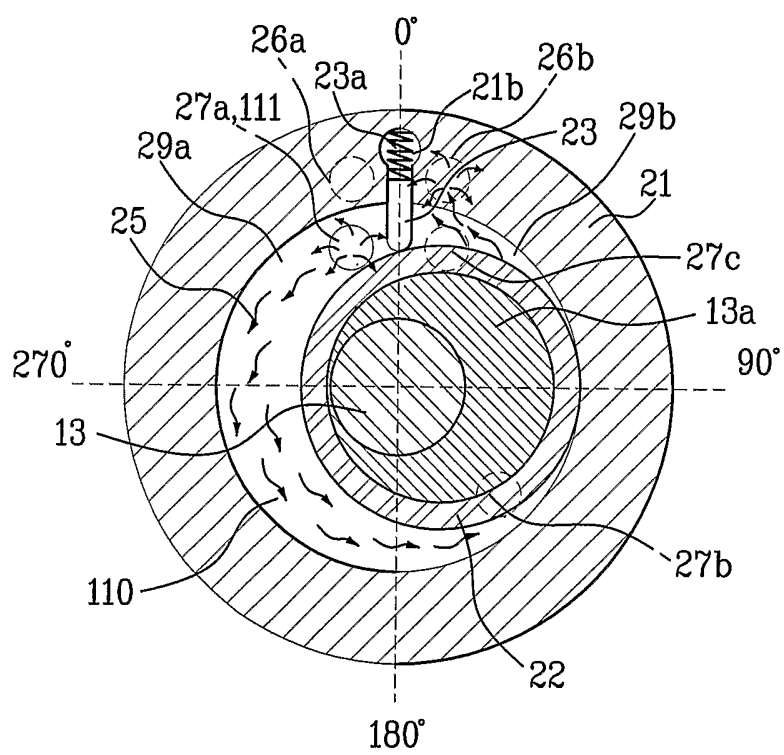


FIG. 14A

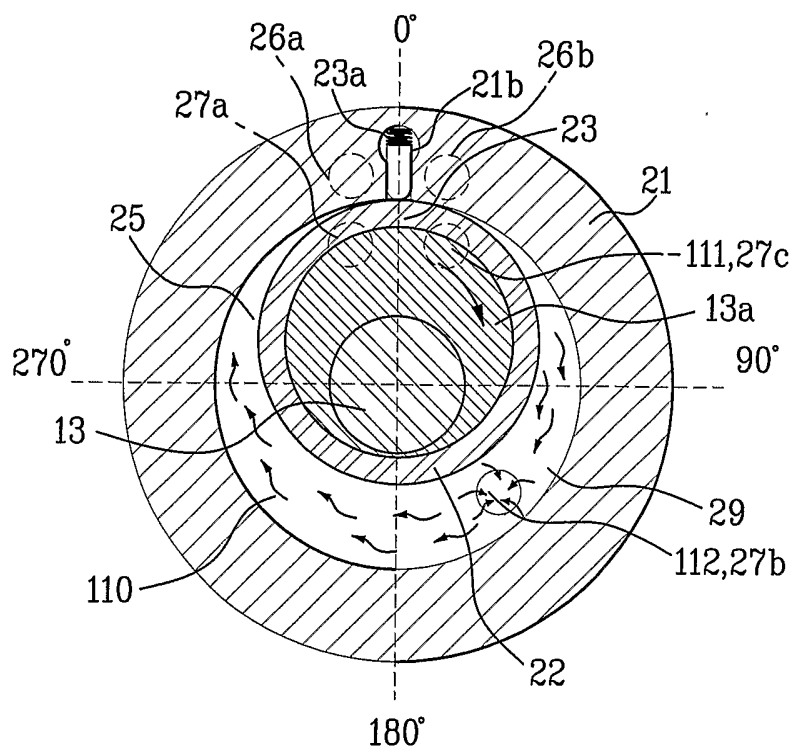


FIG.14B

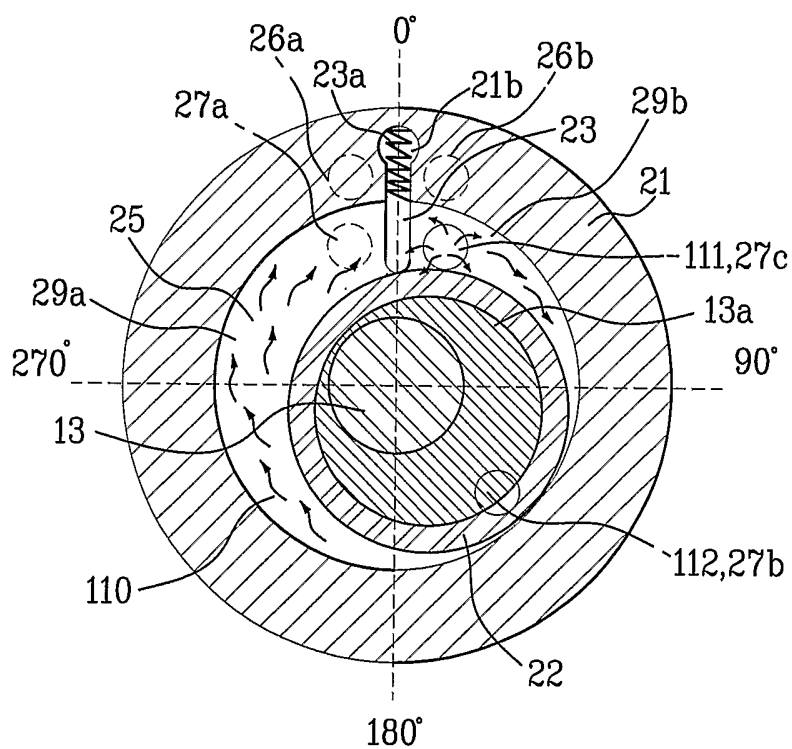


FIG.15

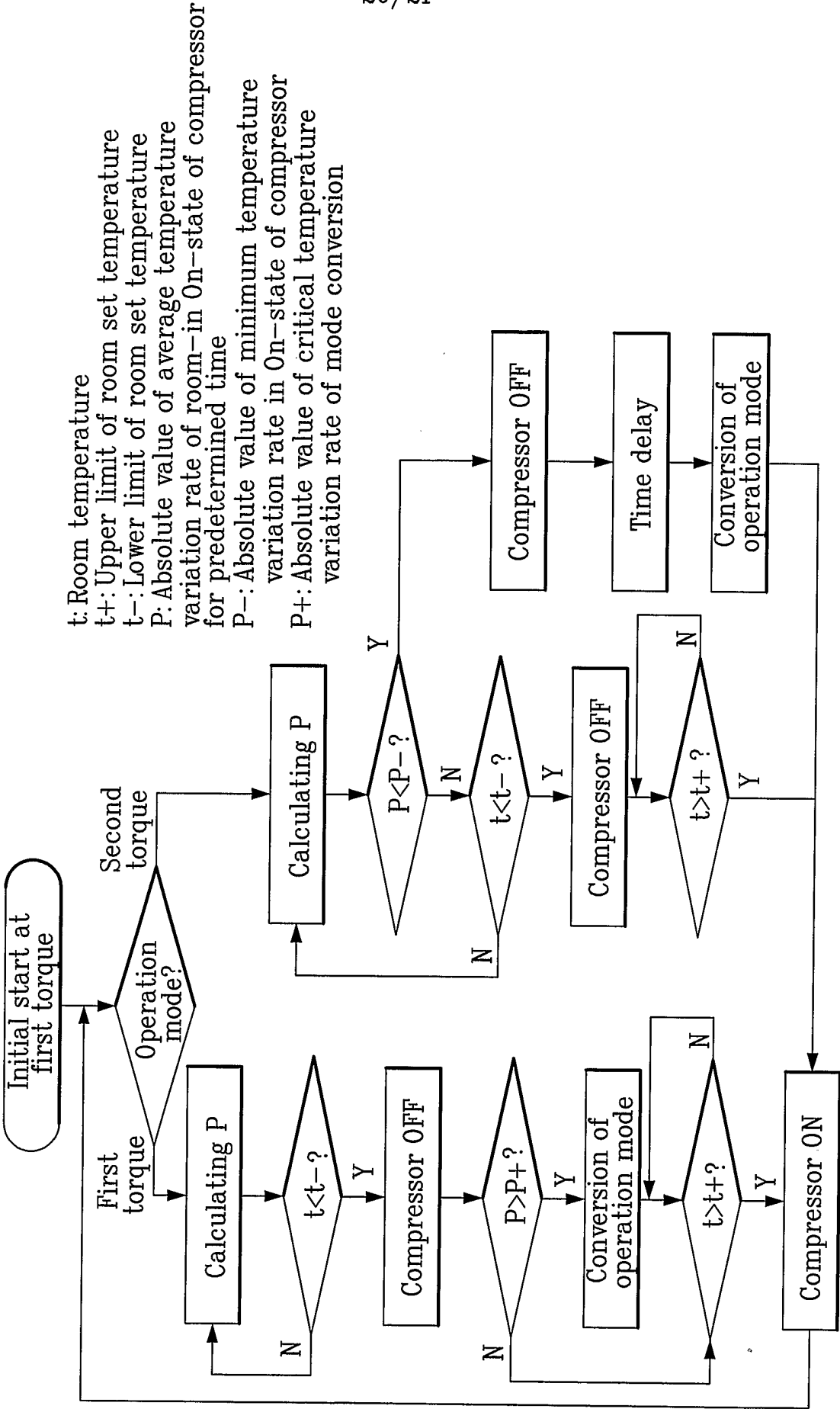
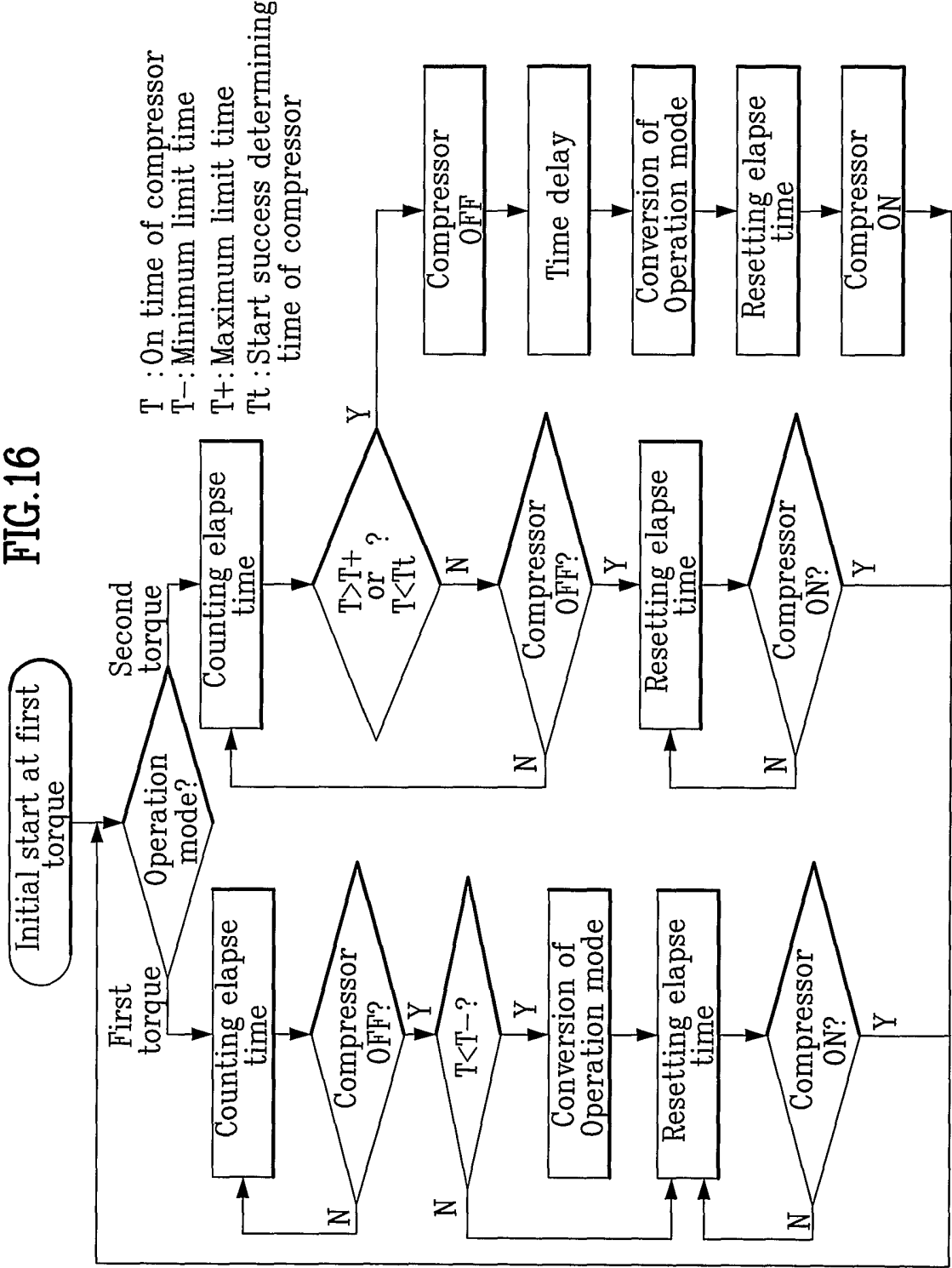


FIG.16



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 2004/000965

A. CLASSIFICATION OF SUBJECT MATTER IPC ⁷ : F04C 29/10; F25B 1/04; <u>F25B 49/02</u> ; F04B 49/06; F24F 11/00; G05D 23/19; G05D 27/02; H02K 7/14 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) IPC ⁷ : F04C; F25B; F04B; F24F; G05D Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) WPI, EPODOC, PAJ		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2001/0029743 A1 (HERRICK et al.) 18 October 2001 (18.10.2001) <i>abstract, fig. 1.</i>	1, 2, 3, 12, 28
A	<i>fig. 1, fig. 4.</i> —	2, 3, 8
Y	JP 58 110880 A (SHARP KK) 1 July 1983 (01.07.1983) <i>abstract, fig. 1.</i>	1, 2, 3, 12, 28
A	<i>abstract.</i> —	5, 6, 10, 36
Y	US 4598559 A (TOMAYKO et al.) 8 July 1986 (08.07.1986) <i>the whole document.</i>	12, 28
A	<i>abstract, fig. 2, fig. 4.</i> —	14, 16, 18, 26
☒ 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 30 June 2004 (30.06.2004)		Date of mailing of the international search report 31 August 2004 (31.08.2004)
Name and mailing address of the ISA/ AT Austrian Patent Office Dresdner Straße 87, A-1200 Vienna Facsimile No. +43 / 1 / 534 24 / 535		Authorized officer KUTZENBERGER T. Telephone No. +43 / 1 / 534 24 / 577

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 2004/000965

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	<i>abstract, fig. 2.</i>	29, 36
A	-- GB 2086615 A (WESTINGHOUSE ELECTRIC CORP.) 12 May 1982 (12.05.1982) <i>description page 1, lines 120-125; page 2, lines 80-90; fig. 2; abstract.</i>	1, 2, 3, 7, 12, 28

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR 2004/000965

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				US	A	4843834	1989-07-04
				KR	B	9503789	1995-04-18
				EP	A	0275045	1988-07-20
				DE	T	3882151T	1993-11-18
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JP	A	58110880		none			
		A2					
US	A	20010029		none			
		743					