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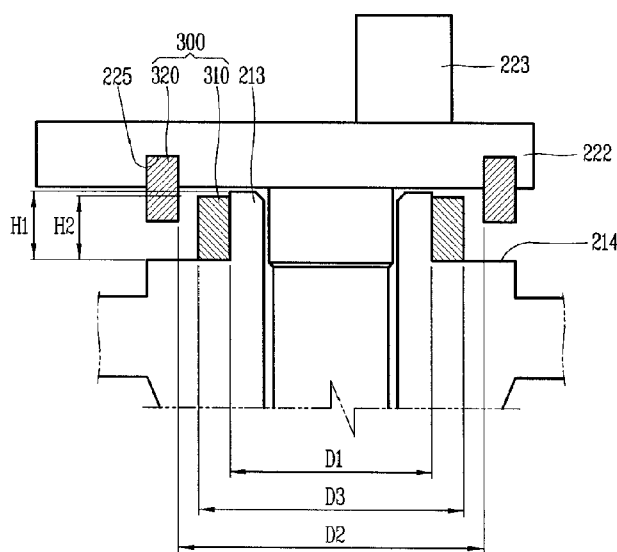
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(54) Title: RECIPROCATING COMPRESSOR AND REFRIGERATING MACHINE HAVING THE SAME

[Fig. 3]



(57) Abstract: Disclosed are a reciprocating compressor and a refrigerating apparatus having the same, wherein a magnet bearing is inserted between facing surfaces between a cylinder block and a crank shaft and the magnet bearing so as to generate a magnetic force both in a shaft direction and in a radial direction, so that the cylinder block and the crank shaft can be supported both in the shaft direction and in the radial direction, thereby reducing a frictional loss due to an eccentric load of the crank shaft, and also, both magnets are disposed to overlap each other so as to prevent an increase in an input load due to the magnetic force between the magnets, resulting in further improvement of energy efficiency of the compressor.

## Description

### Title of Invention: RECIPROCATING COMPRESSOR AND REFRIGERATING MACHINE HAVING THE SAME

#### Technical Field

- [1] The present invention relates to a reciprocating compressor and a refrigerating (cooling) apparatus (machine) having the same, and more particularly, a reciprocating compressor having a magnet bearing installed at thrust surfaces between a cylinder block and a crank shaft, and a refrigerating apparatus having the same.

#### Background Art

- [2] In general, a hermetic compressor is a compressor provided with a motor unit disposed in a hermetic container for generating a driving force, and a compression unit operated by receiving the driving force from the motor unit. The hermetic compressors may be categorized into a reciprocating type, a rotary type, a vane type and a scroll type according to the compression mechanism with respect to a refrigerant as a compressible fluid.
- [3] The reciprocating compressor is configured such that a crank shaft is coupled to a rotor of a motor unit, a connecting rod is coupled to the crankshaft of the motor unit and a piston is coupled to the connecting rod, so that the piston linearly reciprocates within a cylinder to thereby compress a refrigerant.
- [4] The reciprocating compressor is configured such that a shaft portion of a crank shaft is inserted into a cylinder block to be supported in a radial direction and simultaneously an eccentric mass portion is laid on the cylinder block to be supported in a shaft direction as well, thereby forming a journal bearing surface and a thrust bearing surface between the crank shaft and the cylinder block. Hence, how to reduce the frictional loss between the crank shaft and the cylinder block as much as possible acts as an important factor on enhancing energy efficiency of the compressor. To this end, an oil passage is formed at the crank shaft so that oil pumped from an oil feeder can evenly be supplied to each bearing surface via the oil passage.
- [5] However, the related art reciprocating compressor has limitation on the reduction of frictional loss due to the surface-contact of the thrust surfaces. Taking into account of this, a technology has recently been proposed in which magnets are installed at the thrust surfaces to prevent the contact between the thrust surfaces so as to minimize the frictional loss.

#### Disclosure of Invention

#### Technical Problem

- [6] However, in the reciprocating compressor in which the magnets are installed at the

thrust surfaces so as to generate a repulsive force against each other, the magnets installed at both the thrust surfaces have almost the same diameter and are disposed to face each other with a predetermined interval in a shaft direction, accordingly the crank shaft can be supported by the magnetic force in the shaft direction without friction while not supported by the magnetic force in a radial direction.

### **Solution to Problem**

- [7] Therefore, to overcome the limitation of the related art reciprocating compressor, an object of the present invention is to provide a reciprocating compressor capable of supporting a crank shaft both in a shaft direction and in a radial direction by use of a magnetic force of magnets installed at the thrust surfaces, and a refrigerating apparatus having the same.
- [8] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is provided a reciprocating compressor including, a cylinder block having a shaft accommodation hole to form a journal bearing surface, a crank shaft including a shaft portion inserted into the shaft accommodation hole of the cylinder block, and a plate-shaped extending portion extending from an outer circumferential surface of the shaft portion to be formed wider than the shaft accommodation hole of the cylinder block, and a magnet bearing including a first magnet installed at a thrust surface of a periphery of the shaft accommodation hole of the cylinder block, and a second magnet installed at a thrust surface corresponding to the thrust surface of the cylinder block, wherein the magnets of the magnet bearing are disposed to generate a repulsive force both in a shaft direction and in a radial direction.
- [9] In another aspect of the present invention, there is provided a refrigerating apparatus including, a compressor, a condenser connected to a discharge side of the compressor, an expansion apparatus connected to the condenser, and an evaporator connected to the expansion apparatus and to a suction side of the compressor, wherein the compressor is provided with a magnet bearing installed between a cylinder block and a crank shaft and configured to support the same both in a shaft direction and in a radial direction.

### **Advantageous Effects of Invention**

- [10] In the reciprocating compressor and a refrigerating apparatus having the same according to the present invention, a magnet bearing is inserted between facing surfaces of the cylinder block and the crank shaft and the magnet bearing generates a magnetic force both in the shaft direction and in the radial direction so as to support the crank shaft and the cylinder block in the shaft direction and the radial direction, thereby reducing a frictional loss due to an eccentric load of the crank shaft. Also, both magnets of the magnet bearing are disposed to overlap each other so as to prevent the

increase in an input load due to the magnetic force between the magnets, thereby further enhancing energy efficiency ratio (EER) of the compressor.

### **Brief Description of Drawings**

- [11] FIG. 1 is a longitudinal sectional view showing an embodiment of a reciprocating compressor in accordance with the present invention;
- [12] FIG. 2 is a disassembled perspective view of a cylinder block, a crank shaft and a ball bearing in the reciprocating compressor of FIG. 1;
- [13] FIG. 3 is a longitudinal sectional view showing an assembled state of a magnet bearing according to FIG. 1;
- [14] FIG. 4 is an enlarged schematic view of the magnet bearing of FIG. 3;
- [15] FIG. 5 is a graph showing a comparison result of magnetic forces with respect to an overlapping distance of the magnet bearing according to FIG. 1;
- [16] FIG. 6 is a graph showing a comparison result of magnetic forces with respect to an interval in a radial direction of the magnet bearing according to FIG. 1;
- [17] FIG. 7 is a distribution view of magnetic lines of the magnet bearing according to FIG. 1;
- [18] FIG. 8 is a schematic view showing magnetic poles of the magnet bearing according to FIG. 7;
- [19] FIG. 9 is a table showing testing results of comparing input, cooling capacity and energy efficiency between the reciprocating compressor having the magnet bearing according to the present invention and a reciprocating compressor having the related art sliding-contact bearing;
- [20] FIG. 10 is a longitudinal sectional view showing another embodiment of the shape of magnets of the magnet bearing according to FIG. 1;
- [21] FIGS. 12 and 13 are longitudinal sectional views showing another embodiment of arranged positions of the magnets of the magnet bearing according to FIG. 1;
- [22] FIG. 14 is a longitudinal sectional view showing another embodiment of installed positions of the magnets of the magnet bearing according to FIG. 1; and
- [23] FIG. 15 is a schematic view showing an embodiment of a refrigerator having the reciprocating compressor in accordance with the present invention.

### **Best Mode for Carrying out the Invention**

- [24] Hereinafter, with reference to the accompanying drawings, description will be made in detail of a reciprocating compressor and a refrigerating apparatus having the same in accordance with embodiments of the present invention.
- [25] As shown in FIG. 1, a reciprocating compressor according to the present invention may include a motor unit 100 installed inside a hermetic container 1 and performing a rotation motion, and a compression unit 200 disposed above the motor unit 100 and

- compressing refrigerant by a rotational force received from the motor unit 100.
- [26] The motor unit 100 may be implemented as a constant-speed motor which is rotatable in a forward direction, a constant-speed motor which is rotatable both in forward and reverse direction, or an inverter motor. The motor unit 100 may include a stator 110 elastically installed in the hermetic container 1 with being supported by a cylinder block 210 to be explained later, and a rotor 120 rotatably installed inside the stator 110.
- [27] The compression part 200 may include a cylinder block 210 having a cylinder 211 forming a compression space and elastically supported by the hermetic container 1, a crank shaft 220 inserted into the cylinder block 210 to be supported in a radial direction and a shaft direction and coupled to the rotor 120 of the motor unit 100 for transferring a rotational force, a connecting rod 230 rotatably coupled to the crank shaft 220 for converting a rotation motion into a linear motion, a piston 240 rotatably coupled to the connecting rod 230 and linearly reciprocating within the cylinder 211 so as to compress a refrigerant, a valve assembly 250 coupled to an end of the cylinder block 210 and having a suction valve and a discharge valve, a suction muffler 260 coupled to a suction side of the valve assembly 250, a discharge cover 270 coupled to accommodate a discharge side of the valve assembly 250, and a discharge muffler 280 communicating with the discharge cover 270 for attenuating discharge noise of a discharged refrigerant.
- [28] With the configuration of the reciprocating compressor according to the present invention, when power is applied to the stator 110 of the motor unit 100, the rotor 120 is rotated with the crank shaft 220 by interaction with the stator 110, and the connecting rod 230 coupled to a cam portion 223 of the crank shaft 220 performs an orbiting motion. The piston 240 coupled to the connecting rod 230 then linearly reciprocates within the cylinder 211 to compress a refrigerant and discharges the compressed refrigerant via the discharge cover 270. The refrigerant discharged via the discharge cover 270 then flows into a refrigerating cycle via the discharge muffler 280. The series of processes are repeated.
- [29] Simultaneously, the crank shaft 220 is rotated in a state of being supported both in the radial and shaft directions so that the oil feeder O installed at a lower end of the crank shaft 220 pumps up oil contained in an oil storing unit. Such oil is sucked up via the oil passage of the crank shaft 220 so as to be supported to each bearing surface. Here, the oil is partially dispersed at the upper end of the crank shaft 220 so as to cool the motor unit 100.
- [30] Here, the crank shaft 220 may be inserted into a shaft accommodation hole 212 of the cylinder block 210 so as to be supported in a radial direction and simultaneously rotated in a state of being supported in the shaft direction and the radial direction by

magnets disposed at facing surfaces in the shaft direction between the cylinder block 210 and the crank shaft 220. This configuration will now be described in detail.

- [31] As shown in FIGS. 2 and 3, the shaft accommodation hole 212, which forms a journal bearing surface so that the crank shaft 220 is inserted therein so as to be supported in the radial direction, may be formed at a center of the cylinder block 210. A magnet bearing 300 may be installed between the periphery of the shaft accommodation hole 212 of the cylinder block 210 and the eccentric mass portion 222 of the crank shaft 220 so that the crank shaft 220 can be supported by the cylinder block 210 not only in the shaft direction but also in the radial direction due to a repulsive force generated by a magnetic force. That is, a first magnet 310 may be installed on an upper surface of the cylinder block 210 while a second magnet 320 may be installed on a lower surface of the eccentric mass portion 222 of the crank shaft 220 so that the same polarity to that of the first magnet 310 faces each other approximately in a diagonal direction.
- [32] To this end, a bearing supporting portion 213 may be protruded by a predetermined height from the periphery of the upper end of the shaft accommodation hole 212 formed at the cylinder block 210 so as to form a thrust surface and allow insertion of the first magnet 310. Preferably, the bearing supporting portion 213 may be formed so that a height H1 thereof up to its upper surface, namely, a height from a magnet mounted surface 214 on which the first magnet is mounted 310 may not be lower than a height H2 in a radial direction, namely, a thickness of the first magnet 310 from the magnet mounted surface 214, more preferably, be slightly higher than the height H2. Accordingly, the first magnet 310 can be prevented from being collided against the eccentric mass portion 222 of the crank shaft 220. The bearing supporting portion 213 may be formed in an annular shape as shown in the drawing. Alternatively, the bearing supporting portion 213 may be formed in a form of protrusion protruded with a uniform interval along a circumferential direction.
- [33] Also, the eccentric mass portion 222 of the crank shaft 220 may be eccentrically formed at an upper end of the shaft portion 221 coupled to the rotor 120. A magnet insertion groove 225 formed in an annular shape in which the second magnet 320 is inserted may be formed at the thrust surface facing the thrust surface of the cylinder block 210.
- [34] The magnet insertion groove 225 may have a depth as deep as partially exposing the second magnet 320, namely, a depth in which the second magnet 320 can overlap the first magnet 310 but the first and second magnets 310 and 320 can have the same polarity in the radial direction even when the thrust surfaces of the cylinder block 210 and the crank shaft 220 come in contact with each other. In other words, as shown in FIG. 4, an interval t1 between an upper end of the first magnet 310 and a middle

portion of the second magnet 320 is at least not shorter than an interval  $t_2$  between the thrust surfaces. Consequently, the generation of the attractive force at the magnet bearing 300 can be prevented beforehand.

- [35] The first magnet 310 may be formed in an annular shape having a predetermined diameter, namely, an inner diameter  $D_2$  greater than an outer diameter  $D_1$  of the bearing supporting portion 213 of the cylinder block 210, and forms a polarity in the shaft direction. That is, as shown in FIG. 4, N-pole is magnetized to an upper side of the first magnet 310 in the shaft direction, S-pole is magnetized to a lower side thereof in the shaft direction
- [36] The second magnet 320 may be formed in an annular shape with a diameter as great as overlapping the first magnet 310 outside the first magnet 310, and forms a polarity in the shaft direction to face the same polarity of the first magnet 310. That is, the polarities of the second magnet 320 may be symmetrically opposite polarities to those of the first magnet 310. For instance, as shown in FIG. 4, if the upper side of the first magnet 310 is N-pole, the lower side of the magnet 320 is magnetized to N-pole and the upper side thereof is magnetized to S-pole.
- [37] The first magnet 310 and the second magnet 320 may be disposed to overlap each other by a predetermined height in the shaft direction. For example, as shown in FIGS. 3 and 4, an upper end of the first magnet 310 is located higher than a lower end of the second magnet 320, thereby rendering the first and second magnets 310 and 320 overlap each other in the shaft direction. Here, an overlapped distance  $t_3$  between the first magnet 310 and the second magnet 320 may preferably be less than a half height of the second magnet 320, namely, have a height at which the upper side polarity of the first magnet 310 does not correspond to the upper side polarity of the second magnet 320 in the radial direction. For example, referring to FIG. 4, the overlapped distance  $t_3$  may be approximately in the range of 0.4 to 1.0mm, in which the repulsive force between the magnets 310 and 320 can be maximized.
- [38] The first and second magnets 310 and 320 may also preferably be disposed to be slightly spaced apart from each other in the radial direction. For example, as shown in FIG. 3, if an outer diameter  $D_3$  of the first magnet 310 is smaller than an inner diameter  $D_2$  of the second magnet 320, an interval between the outer diameter  $D_3$  of the first magnet 310 and the inner diameter  $D_2$  of the second magnet 310, namely, as shown in FIG. 4, an interval  $t_4$  between the first magnet 310 and the second magnet 320, may be approximately less than 1.0mm, so as to generate the repulsive force between the first and second magnets 310 and 320 as much as possible.
- [39] With such configuration, when the crank shaft 220 is inserted into the shaft accommodation hole 212 of the cylinder block 210, the crank shaft 220 may be slightly raised from the cylinder block 210 due to the repulsive force generated between the first

magnet 310 and the second magnet 320, each disposed on the thrust surfaces of the cylinder block 210 and the crank shaft 220.

[40] That is, referring to FIG. 7, as the first and second magnets 310 and 320 are disposed so that the same polarity is located at surfaces facing each other in a diagonal direction, the first magnet 310 and the second magnet 320 generate a repulsive force thrusting each other. Accordingly, the crank shaft 220 is pushed away from the cylinder block 210 in the shaft direction so as to be slightly raised, thereby reducing a frictional loss due to a load of the crank shaft 220 in the shaft direction.

[41] Here, referring to FIG. 8, between the first magnet 310 and the second magnet 320, the repulsive force is generated not only in the shaft direction (x-direction) but also in the radial direction (y-direction), resulting in generation of the repulsive force in the diagonal direction as well. Consequently, the crank shaft 220 and the cylinder block 210 can be supported by the magnet bearing 300 in the radial direction as well as in the shaft direction, which enables the reduction of frictional loss due to an eccentric load of the crank shaft 220.

[42] Especially, the first magnet 310 and the second magnet 320 are disposed so as to overlap each other within a preset range, namely, within a range that the same polarities of both the magnets 310 and 320 do not face (correspond to) each other in the radial direction. Accordingly, an increase in an input load caused by the magnetic force between the first magnet 310 and the second magnet 320 can be prevented, which allows further improvement of the energy efficiency of the compressor.

[43] FIG. 9 is a table showing results of comparing input, cooling capacity and energy efficiency between the reciprocating compressor having the magnet bearing according to the present invention and a reciprocating compressor having the related art sliding-contact bearing. As shown in FIG. 9, for reciprocating compressors with the same capacity, if the magnet bearing is employed to support the crank shaft 220 in the radial direction and the shaft direction as shown in the present invention, the input is 125.2W. To the contrary, if the conventional sliding-bearing is employed, the input is 126W. Accordingly, it can be seen that the present invention has been improved even in terms of the input. In addition, a cooling capacity of the present invention is 233.08W while the cooling capacity of the related art is just 229.4W. It can consequently be noticed that an energy efficiency ratio (EER) of the compressor according to the present invention is about 6.4 while that of the related art is about 6.25. That is, the EER of the present invention has been remarkably improved as great as about 0.15, compared to the related art.

### **Mode for the Invention**

[44] Hereinafter, description will be given of another embodiment of the shapes of first

and second magnets configuring the magnet bearing of the reciprocating compressor according to the present invention.

[45] That is, the previous embodiment has illustrated that the first and second magnets have a square section, e.g., a rectangular or perfect square section. However, this embodiment illustrates that first and second magnets 310 and 320 may be formed in a shape having a tilt surface, for example, having a section in a half-trapezoid shape or lozenge shape.

[46] In this case, facing surfaces between the first and second magnets 310 and 320 in the shaft direction may be inclined to be symmetrical about each other. As shown in FIG. 10, the facing surfaces between the first and second magnets 310 and 320 in the shaft direction may be located so that their sectional centers in the shaft direction are aligned with each other. Alternatively, as shown in FIG. 11, the magnet bearing 300 may be more preferably disposed so that the sectional centers between the first and second magnets 310 and 320 in the shaft direction have a preset interval  $t$  therebetween so as to generate the repulsive force both in the shaft direction and in the radial direction.

[47] Here, this embodiment may be implemented so that the facing surfaces between the first and second magnets 310 and 320 in the shaft direction are inclined with respect to each other and the sectional centers thereof in the shaft direction have the preset interval, which renders the first and second magnets 310 and 320 overlap each other in the shaft direction. Therefore, the structure that the first magnet 310 is inserted into the second magnet 320 or vice versa may not be needed. That is, in this embodiment, since an uppermost point of the first magnet 310 and the lowermost point of the second magnet 320 may be disposed at positions overlapping in the shaft direction, an outer diameter of the first magnet 310 does not have to be smaller than an inner diameter of the second magnet 320. Accordingly, if the diameter of the second magnet 320 is the same to that in the previous embodiment, the diameter of the first magnet 310 can be formed greater than that in the previous embodiment, thereby enhancing the bearing effect. On the other hand, if the diameter of the first magnet 310 is the same to that in the previous embodiment, the diameter of the second magnet 320 may be made to become smaller so as to reduce a material cost for the magnets that much. Other configuration and the thusly obtained operation effects are similar or the same to those in the previous embodiment, so the detailed description thereof will be omitted.

[48] Hereinafter, description will be given of another embodiment in which the magnet bearing for the reciprocating compressor according to the present invention is installed at the thrust surface of the cylinder block 210 and the thrust surface of the crank shaft 220.

[49] That is, the previous embodiment has illustrated that the bearing supporting portion 213 of the cylinder block 210 is formed at the periphery of the shaft accommodation

hole 212, wherein an inner circumferential surface of the first magnet 310 comes in contact with an outer circumferential surface of the shaft accommodation hole 212. However, this embodiment may implement, as shown in FIG. 12, that the bearing supporting portion 213 is formed at an edge of the upper surface of the cylinder block 210 so that an outer circumferential surface of the first magnet 310 is inserted in a contact state with an inner circumferential surface of the bearing supporting portion 213.

[50] Even in this case, the height of the bearing supporting portion 213 may be formed the same to that in the previous embodiment. The magnet insertion groove 225 may be formed at the thrust surface of the crank shaft 220, and the second magnet 320 may be inserted into the magnet insertion groove 225 for coupling. Other basic configuration and the thusly obtained operation effects are similar or the same to those in the previous embodiment, so the detailed description will be omitted.

[51] Here, in this embodiment, since the first magnet 310 is located inside the bearing supporting portion 213, the second magnet 320 is located inside the first magnet 310, namely, at the inner diameter of the first magnet 310. Accordingly, the diameters of the first and second magnets 310 and 320 are shortened, so as to relatively reduce the material cost for the first and second magnets 310 and 320 that much, as compared to the previous embodiment.

[52] As another embodiment, as shown in FIG. 13, a bearing supporting portion 226 may be formed at a lower surface of the eccentric mass portion 222 of the crank shaft 220, and the second magnet 320 may be coupled to the bearing supporting portion 226 so that an inner circumferential surface of the second magnet 320 can come in contact with an outer circumferential surface of the bearing supporting portion 226. Here, a magnet insertion groove 215 formed in an annular shape for allowing the first magnet 310 to be inserted therein may be formed at an upper surface of the bearing supporting portion 226 of the crank shaft 220, namely, at a thrust surface of the cylinder block 210 facing (corresponding to) a thrust surface of the crank shaft 220. Although not shown in the drawing, in this case, an outer circumferential surface of the second magnet 320 may be contacted by an inner circumferential surface of the bearing supporting portion 226.

[53] Even in these cases, the basic configurations, such as the height of the bearing supporting portion 226 or the depth of the magnet insertion groove 215, and the thusly obtained operation effects are similar or the same to those in the previous embodiment, so the detailed description thereof will be omitted.

[54] The magnet bearing of the reciprocating compressor according to the present invention may alternatively be installed at a lower surface of the cylinder block and an upper surface of a rotor corresponding to the lower surface.

- [55] That is, the previous embodiment has illustrated that the first magnet 310 is installed at the thrust surface of the cylinder block 210 while the second magnet 320 is installed at the thrust surface of the crank shaft 220. However, this embodiment illustrates, as shown in FIG. 14, that the first magnet 310 is installed at a lower surface of the cylinder block 210 while the second magnet 320 is installed at an upper surface of the rotor 120 corresponding to the lower surface of the cylinder block 210.
- [56] Even in this case, preferably, the first magnet 310 and the second magnet 320 may have different diameters so that sectional centers thereof in the shaft direction can be located with a predetermined gap therebetween. Accordingly, the first and second magnets 310 and 320 may be disposed to be spaced apart from each other by a predetermined gap even in the shaft direction or overlap each other by a predetermined height in the shaft direction. Here, regarding the installation space of the magnet bearing 300 upon assembling the magnet bearing 300, a diameter of the second magnet 320 may preferably be formed greater than that of the first magnet 310.
- [57] In this case, the first and second magnets 310 and 320 may preferably be disposed so that their facing surfaces have different polarities, thereby attracting each other. That is, as the rotor 120 and the crank shaft 220 are integrally coupled to each other, the crank shaft 220, namely, the rotor 120 should be pulled up toward the cylinder block 210 in order to reduce the frictional loss between the crank shaft 220 and the cylinder block 120. Accordingly, when the magnet bearing 300 is installed between the rotor 120 and the cylinder block 210, the magnet bearing 300 should be magnetized to generate an attractive force.
- [58] As another embodiment, the magnet bearing may be disposed so as to use a repulsive force or an attractive force depending on the structure of the compressor.
- [59] That is, as illustrated in the previous embodiments, in case where the compression unit 200 is located above the motor unit 100, if the magnet bearing 300 is installed between the cylinder block 210 and the crank shaft 220, the magnet bearing 300 may use the repulsive force generated between the magnets 310 and 320, while using the attractive force between the two magnets 310 and 320 if the magnet bearing 300 is installed between the rotor 120 and the cylinder block 210.
- [60] On the other hand, in case where the compression unit 200 is located below the motor unit 100, if the magnet bearing 300 is installed between the cylinder block 210 and the crank shaft 220, the magnet bearing 300 may use the attractive force generated between the magnets 310 and 320, while using the repulsive force between the two magnets 310 and 320 if the magnet bearing 300 is installed between the rotor 120 and the cylinder block 210.
- [61] The basic configuration and the thusly obtained operation effect of this embodiment are similar or the same to those in the previous embodiments, so the detailed de-

scription thereof will be omitted.

[62] In the meantime, if the reciprocating compressor according to the present invention is applied to a refrigerating apparatus, the performance of the refrigerating apparatus can be enhanced.

[63] For example, as shown in FIG. 15, inside a refrigerating apparatus 700 having a refrigerant compression type refrigerating cycle including a compressor, a condenser, an expansion apparatus and an evaporator, a reciprocating compressor C in which the magnet bearing 300 without generating a friction is installed at the thrust surfaces as described above may be connected to a main board 710 for controlling an overall operation of the refrigerating apparatus. Also, the magnet bearing 300 of the reciprocating compressor C may be configured so that both magnets facing each other generate a force in the radial direction as well as in the shaft direction, thereby reducing a frictional loss of the crank shaft 220 with respect to the cylinder block 210 not only in the shaft direction but also in the radial direction. Therefore, the refrigerating apparatus having the reciprocating compressor can achieve the effects previously described in association with the reciprocating compressor and additionally enhance its performance.

### **Industrial Applicability**

[64] In association with the reciprocating compressor and the refrigerating apparatus having the same according to the present invention, a single type reciprocating compressor having a single cylinder has been illustrated; however, in some cases, the present invention can also be applied to a multi-type reciprocating compressor having many cylinders and a refrigerating apparatus having the same.

## Claims

- [Claim 1] 1. A reciprocating compressor comprising:  
a casing having a hermetic inner space;  
a driving motor installed in the inner space of the casing;  
a cylinder block installed in the inner space of the casing together with the driving motor, and having a cylinder at one side thereof, a shaft accommodation hole forming a journal bearing surface being formed at one side of the cylinder;  
a crank shaft including a shaft portion coupled to a rotor of the driving motor and inserted into the shaft accommodation hole of the cylinder block, and a plate-shaped extending portion extending from an outer circumferential surface of the shaft portion to be formed wider than the shaft accommodation hole of the cylinder block; and  
a magnet bearing disposed between the cylinder block and the crank shaft to allow generation of a force in a shaft direction and a force in a radial direction so that the crank shaft is supported with respect to the cylinder block in a shaft direction and in a radial direction.
- [Claim 2] The compressor of claim 1, wherein the magnet bearing comprises a first magnet installed at the cylinder block, and a second magnet installed at the crank shaft or the rotor of the driving motor, to which the crank shaft is coupled, to conform with the first magnet, wherein the section of the first magnet and the section of the second magnet are disposed so that centers thereof in the shaft direction have a predetermined interval therebetween.
- [Claim 3] The compressor of claim 1, wherein the magnet bearing comprises a first magnet installed at the cylinder block, and a second magnet installed at the crank shaft or the rotor of the driving motor, to which the crank shaft is coupled, to conform with the first magnet, wherein the first magnet and the second magnet are disposed to overlap each other in the shaft direction.
- [Claim 4] The compressor of claim 3, wherein each of the first magnet and the second magnet is formed in an annular shape, and an outer diameter of one magnet is smaller than another magnet.
- [Claim 5] The compressor of claim 3, wherein an overlapped height between the first and second magnets is adjusted by an interval between a thrust surface of the cylinder block and a thrust surface of the crank shaft.
- [Claim 6] The compressor of claim 1, wherein a magnet insertion groove in

which the first magnet or the second magnet is inserted is formed at at least one of the thrust surface of the cylinder block or the corresponding thrust surface of the crank shaft.

[Claim 7] The compressor of claim 5, wherein the magnet insertion groove is not deeper than the height of the magnet in the shaft direction, the magnet being inserted into the magnet insertion groove.

[Claim 8] The compressor of claim 1, wherein the magnet bearing comprises a first magnet installed at the cylinder block and a second magnet installed at the crank shaft to conform with the first magnet, wherein a bearing supporting portion protruded from a periphery of the shaft accommodation hole of the cylinder block by a predetermined height so that an upper surface thereof forms a thrust surface, an inner circumferential surface of the first magnet coming in contact with an outer circumferential surface of the bearing supporting portion.

[Claim 9] The compressor of claim 8, wherein the thrust surface of the bearing supporting portion is not lower than an upper surface of the first magnet.

[Claim 10] The compressor of claim 8, wherein a magnet insertion groove in which the second magnet is inserted is formed at the thrust surface of the plate-shaped extending portion of the crank shaft, the magnet insertion groove being deep enough that the second magnet overlaps the first magnet in the shaft direction.

[Claim 11] The compressor of claim 1, wherein the magnet bearing comprises a first magnet installed at the cylinder block, and a second magnet installed at the crank shaft or the rotor of the driving motor, to which the crank shaft is coupled, to conform with the first magnet, wherein the first magnet and the second magnet are magnetized so that polarities thereof are symmetrical in the shaft direction.

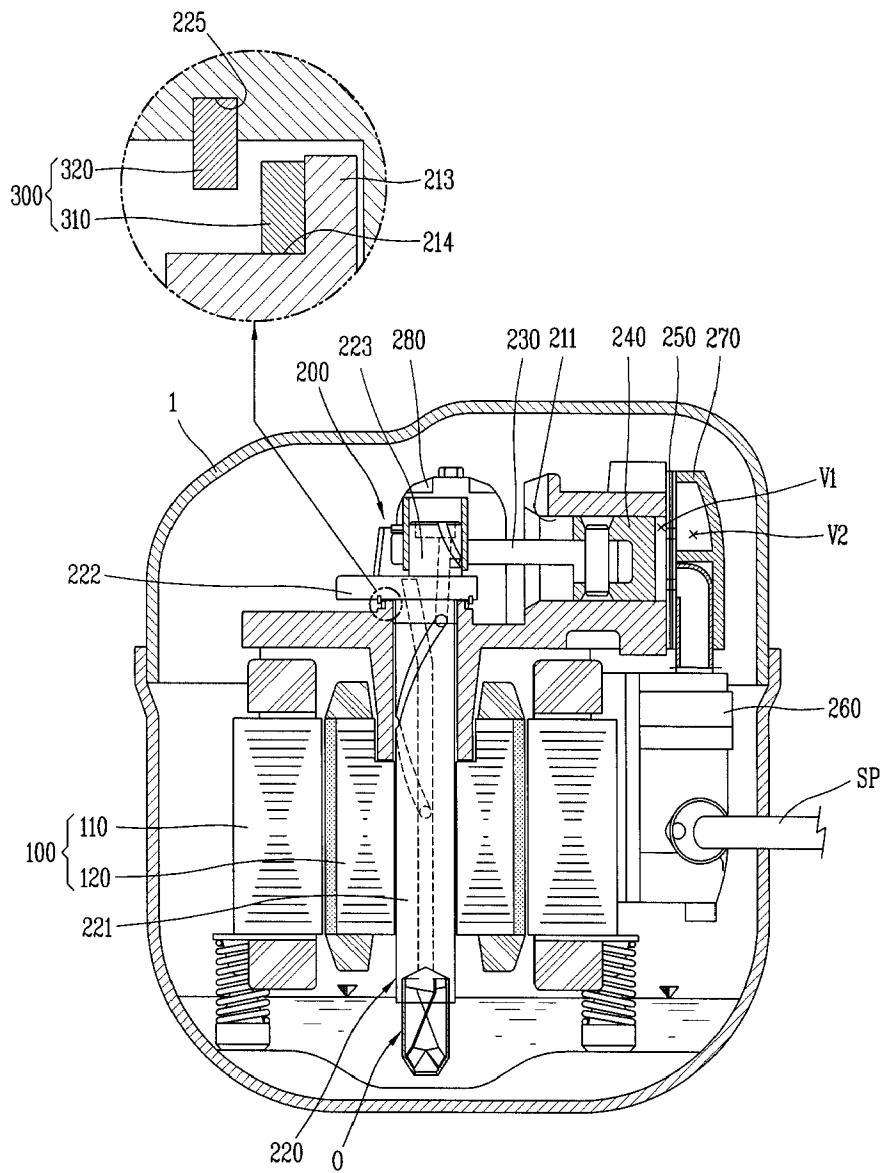
[Claim 12] The compressor of claim 11, wherein the first magnet and the second magnet are disposed to locate the same polarity in the radial direction when the thrust surface of the cylinder block comes in contact with the thrust surface of the crank shaft.

[Claim 13] The compressor of claim 1, wherein the magnet bearing comprises a first magnet installed at the cylinder block, and a second magnet installed at the crank shaft or the rotor of the driving motor, to which the crank shaft is coupled, to conform with the first magnet, wherein the first magnet and the second magnet are formed in a shape having a rectangular or perfect square section.

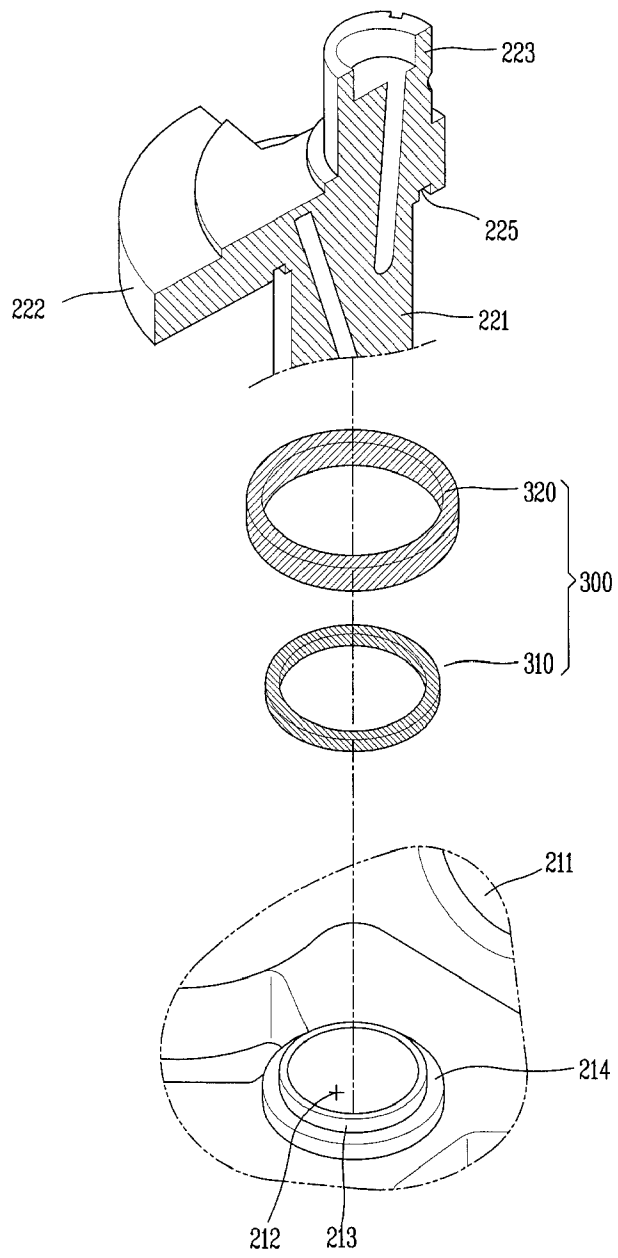
[Claim 14] The compressor of claim 1, wherein the magnet bearing comprises a first magnet installed at the cylinder block, and a second magnet installed at the crank shaft or the rotor of the driving motor, to which the crank shaft is coupled, to conform with the first magnet, wherein the first magnet and the second magnet are inclined so that facing surfaces thereof in the shaft direction are symmetrical about each other in the shaft direction.

[Claim 15] A refrigerating apparatus comprising:  
a compressor;  
a condenser connected to a discharge side of the compressor;  
an expansion apparatus connected to the condenser; and  
an evaporator connected to the expansion apparatus and to a suction side of the compressor,  
wherein the compressor is a compressor according to one of claims 1 to 14.

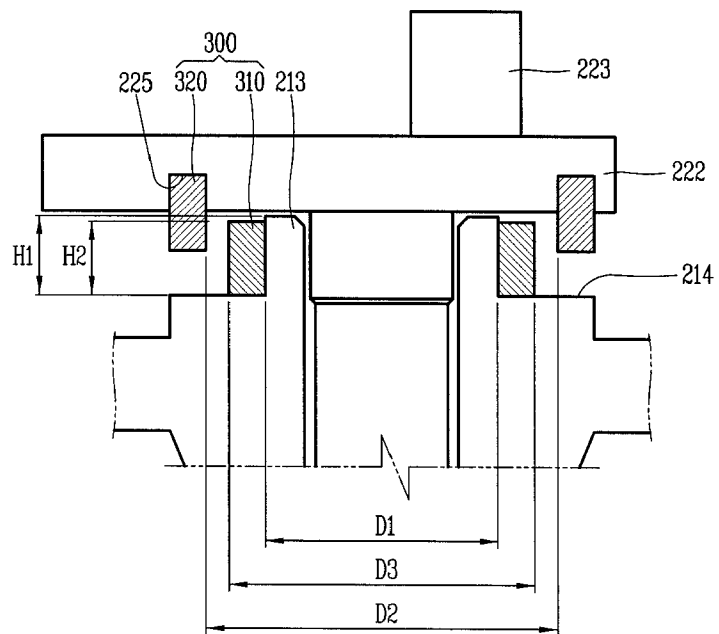
[Fig. 1]



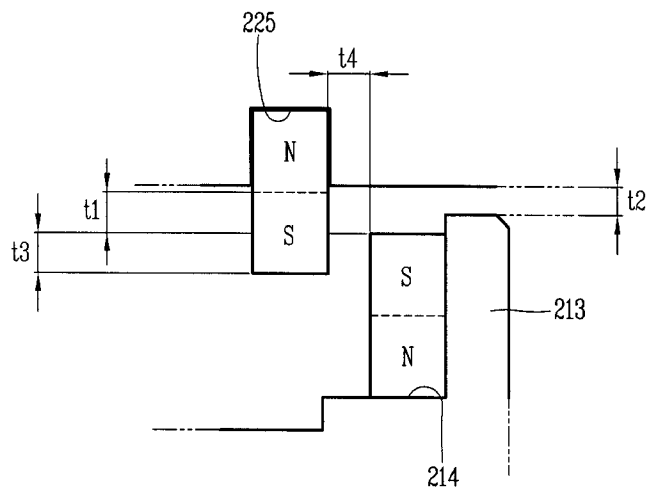
[Fig. 2]



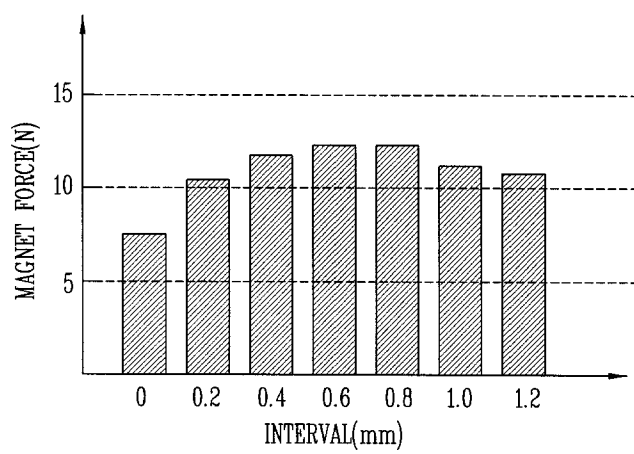
[Fig. 3]



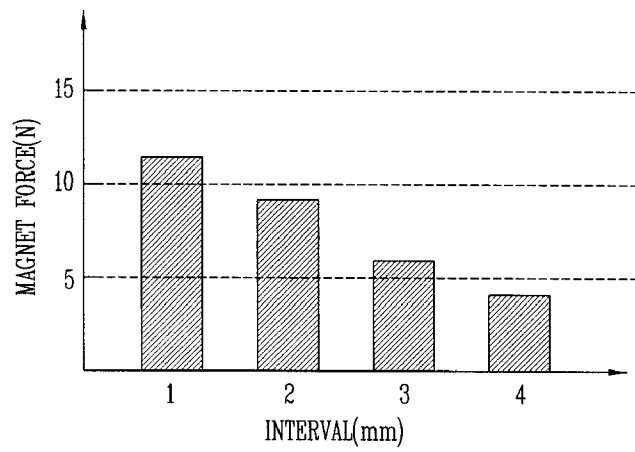
[Fig. 4]



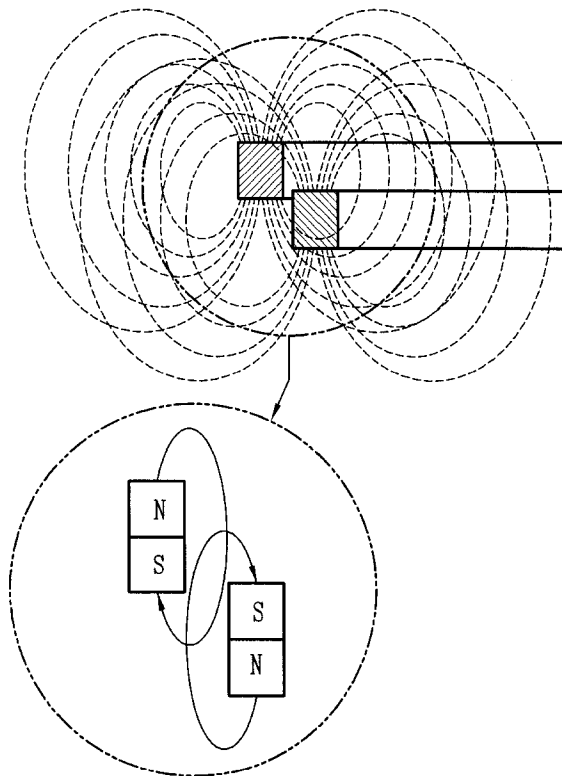
[Fig. 5]



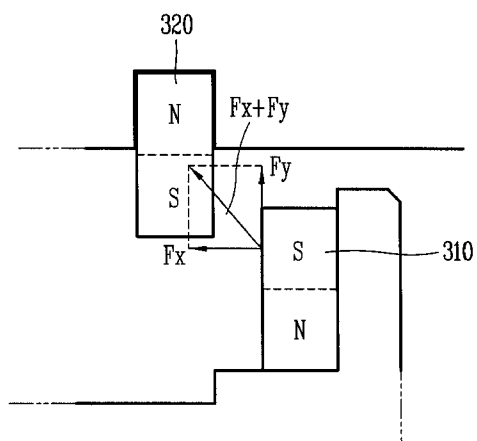
[Fig. 6]



[Fig. 7]



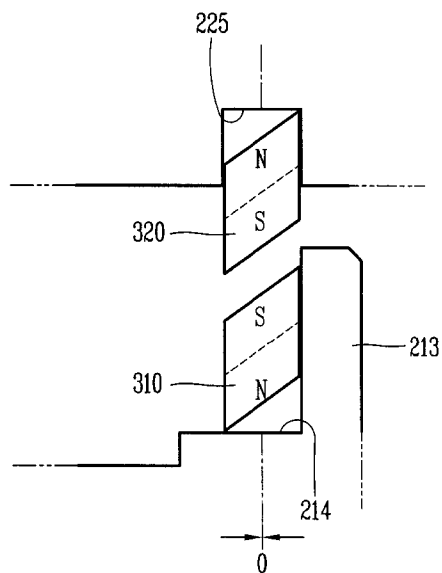
[Fig. 8]



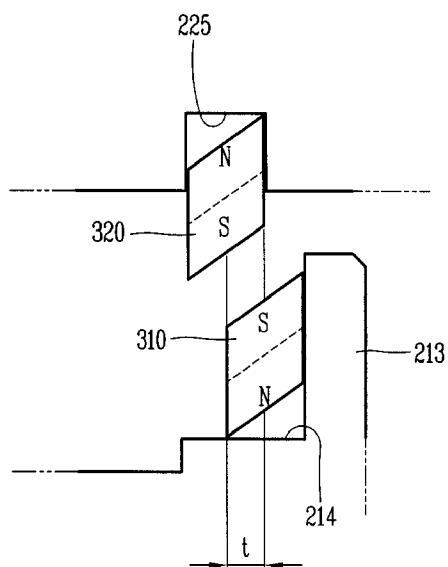
[Fig. 9]

| RESULT \ TYPE    | SLIDING BEARING | MAGNET BEARING |
|------------------|-----------------|----------------|
| INPUT            | 126             | 125.2          |
| COOLING CAPACITY | 229.4           | 233.08         |
| EER              | 6.25            | 6.4            |

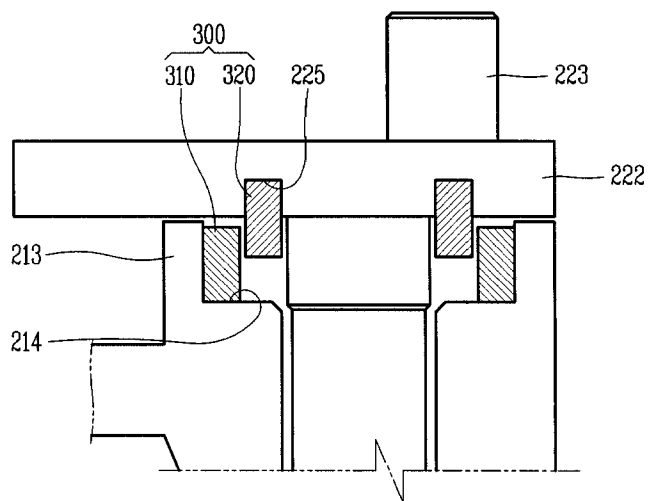
[Fig. 10]



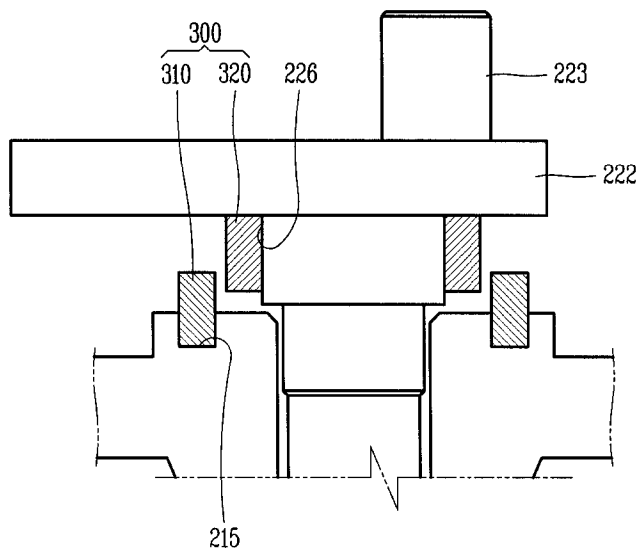
[Fig. 11]



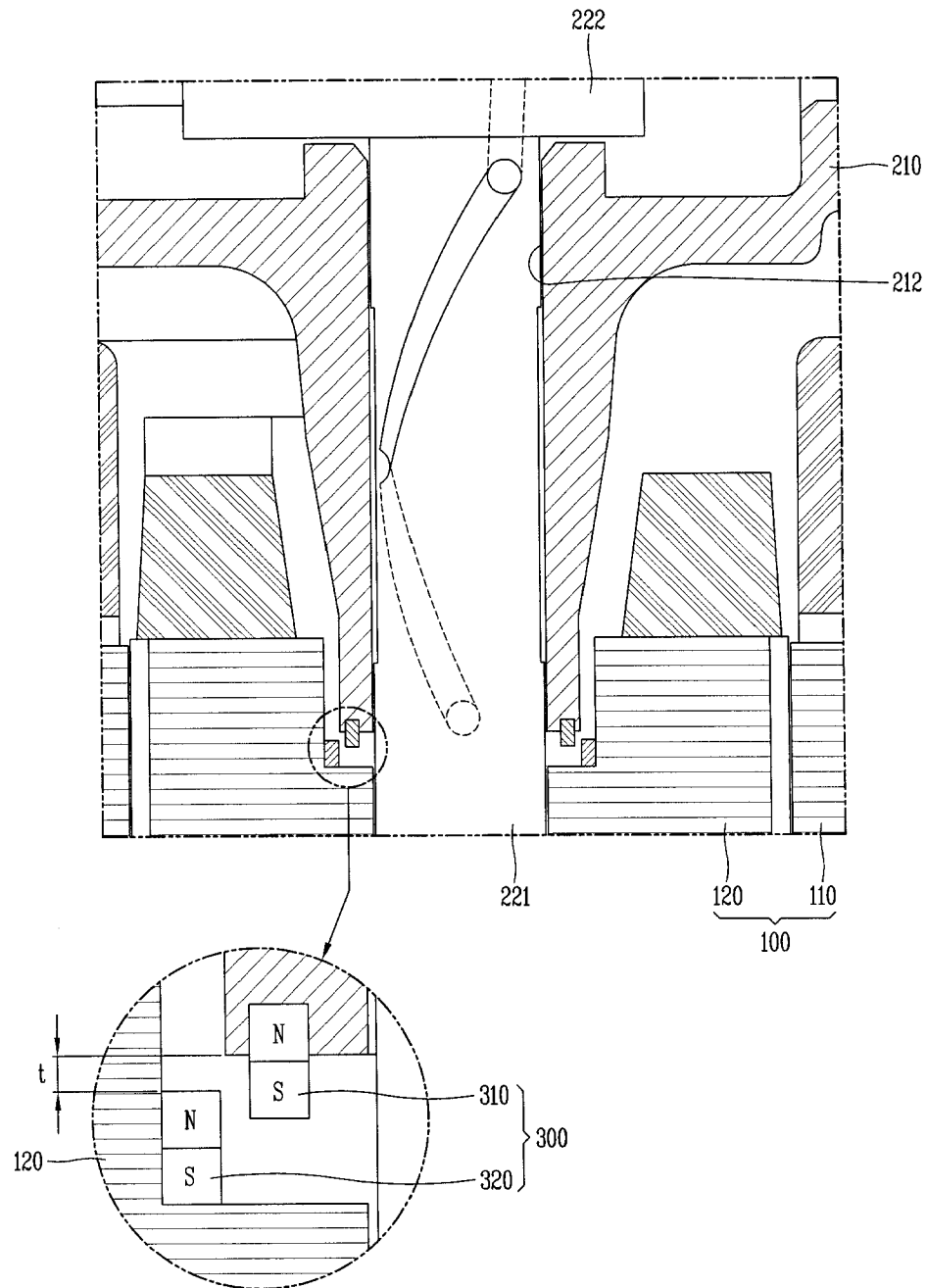
[Fig. 12]



[Fig. 13]



[Fig. 14]



[Fig. 15]

