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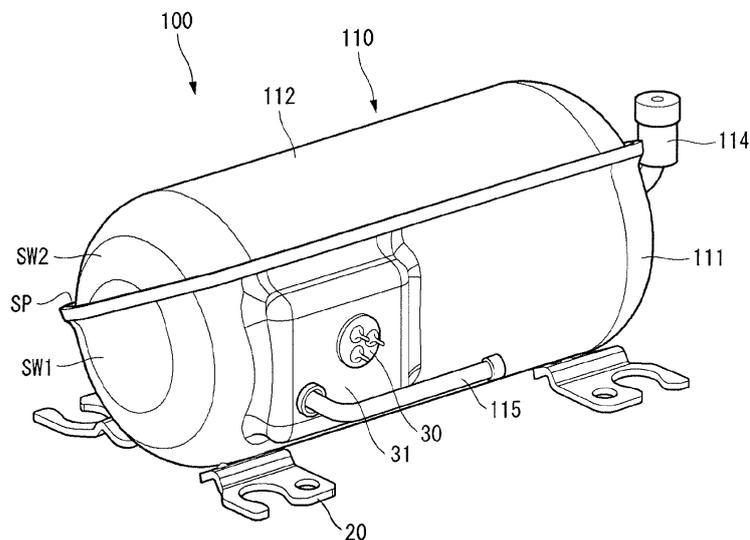
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(54) **COMPRESSOR**

(57) A compressor is disclosed. According to an embodiment, a compressor comprises a compressor main body including a cylinder, a piston reciprocating in an axial direction of a casing in the cylinder, and a driving unit for driving the piston, the casing surrounding the compressor main body, a first support supporting an suction side of the compressor main body in the casing, and

a second support supporting an discharge side of the compressor main body in the casing. The casing may include a lower shell and an upper shell fixed to the lower shell. A separation plane where the lower shell and the upper shell are fixed may be inclined from a horizontal center line of the casing as viewed in the axial direction of the casing.

[FIG. 1]



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Description**BACKGROUND OF THE DISCLOSURE****(a) Field of the Disclosure**

[0001] The disclosure relates to compressors. More specifically, the disclosure relates to linear compressors that compress a coolant by piston reciprocation.

(b) Description of the Related Art

[0002] A compressor refers to a device configured to receive power from a power generating device, such as a motor or a turbine, and compress a working fluid, such as air or coolant.

[0003] Such compressors may be divided into reciprocating compressors, rotary compressors, and scroll compressors depending on how to compress the coolant.

[0004] In the reciprocating compressor, a compression space where working gas is sucked in and discharged is formed between the piston and the cylinder, and the piston compresses the coolant while linearly reciprocating within the cylinder. In the rotary compressor, a compression space where working gas is sucked in and discharged is formed between a roller that rotates eccentrically and the cylinder, and the roller rotates eccentrically along an inner wall of the cylinder to compress the coolant. In the scroll compressor, a compression space where working gas is sucked in and discharged between an orbiting scroll and a fixed scroll is formed, and the orbiting scroll rotates along the fixed scroll to compress the coolant.

[0005] Among reciprocating compressors, a number of linear compressors with a simplified structure have been recently developed in which a piston is directly connected to a driving motor, which linearly reciprocates, to thereby improve compression efficiency without mechanical loss due to motion conversion.

[0006] Korean Patent Application No. 10-2017-0124889 (hereinafter, "Applicant's prior application"), filed by the applicant of the instant application, discloses

[0007] a linear compressor that includes a main body including a mechanism structure, a casing for protecting the main body from the outside, and a support for supporting the main body between the main body and the casing.

[0008] The support includes a pair of support springs disposed at the front and back of the main body and a structure for fixing the support springs.

[0009] The casing includes a cylindrical shell in which a terminal for transferring external power to the motor assembly of the linear compressor is installed. A receptacle is formed at an end of a lead wire connected with the motor of the compressor main body and is coupled to the terminal inside the cylindrical shell.

[0010] In the linear compressor, the lead wire needs

to be prevented from disconnection due to the vibration of the compressor and is supposed to have a proper length not to contact the cylindrical shell and the compressor main body.

5 [0011] It needs to be checked with the naked eye whether the support has been correctly assembled with the cylindrical shell.

[0012] Thus, in the conventional linear compressor, the cylindrical shell has openings in both ends along the length direction of the shell, and the casing further includes a pair of shell covers to finish the front and back ends along the length direction of the shell.

10 [0013] In the linear compressor, the compressor main body is slightly pushed in the cylindrical shell, and a support on one side (e.g., a first support including a leaf spring) is assembled to a shell cover on one side (e.g., a first shell cover), and then, the first shell cover is assembled to the cylindrical shell while the first shell cover and the compressor main body are pushed in.

15 [0014] Thereafter, the receptacle and the lead wire from the motor is connected to the terminal which is located in the cylindrical shell, and wiring is performed so that the lead wire does not contact the cylindrical shell and the compressor main body.

20 [0015] Next, the other shell cover (e.g., a second shell cover) is assembled to the cylindrical shell, and the separation plane between the first shell cover and the cylindrical shell and the separation plane between the second shell cover and the cylindrical shell are welded together, thereby finishing the assembly of the casing.

25 [0016] As described above, since the linear compressor of Applicant's prior application separately has two shell covers for dealing with the lead wire and assembling the receptacle, assembly time and man hour may be increased due to the increase in the number of components.

30 [0017] To reduce the assembly time and man hour, there is an attempt to configure the casing of the linear compressor with two shells, which are separated from each other in the upper and lower directions, as is the casing of the sealed compressor. However, in such a case, the terminal ends up being fixed to the upper shell.

35 [0018] Thus, if the casing of the compressor is made up of the two shells, separated from each other in the upper and lower directions, a quality issue with receptacle assembly and lead wire line contact may occur, and it is not easy to configure the casing with the two shells.

[PRIOR TECHNICAL DOCUMENTS]

40 [0019] (Patent Document 1) Korean Patent Application Publication No. 10-2017-0124889 A (published on November 13, 2017)

SUMMARY OF THE DISCLOSURE

45 [0020] The disclosure aims to provide a compressor with a casing made up of two shells which are separated

from each other in the upper and lower directions.

[0021] The disclosure aims to provide a compressor in which the upper shell and the lower shell have an inclined separation plane so that the terminal may be installed in the lower shell.

According to an embodiment, a compressor comprises a compressor main body including a cylinder, a piston reciprocating in an axial direction of a casing in the cylinder, and a driving unit for driving the piston, the casing surrounding the compressor main body, a first support supporting a suction side of the compressor main body in the casing, and a second support supporting a discharge side of the compressor main body in the casing.

[0022] The casing may include a lower shell and an upper shell fixed to the lower shell. A separation plane where the lower shell and the upper shell are fixed may be inclined from a horizontal center line of the casing as viewed in the axial direction of the casing.

[0023] The inclination angle of the separation plane may be set within a range in which a terminal and a PTC cover may be mounted and a second support may be installed.

[0024] As an example, the inclination angle of the separation plane may range from 20° to 70°.

[0025] The lower shell and the upper shell each may include side walls on both sides thereof in the axial direction of the casing.

[0026] The side wall may replace the conventional shell cover.

[0027] As viewed in the axial direction of the casing, at least one of two opposite ends of the separation plane may be positioned above the horizontal center line of the casing.

[0028] The lower shell may include a terminal for transferring external power to a motor assembly of the compressor. The terminal may be installed in the lower shell at an end, positioned relatively higher, of the two opposite ends of the separation plane.

[0029] Each of the first support and the second support may include a leaf spring.

[0030] In contrast, the first support may include a leaf spring. The second support may include an axial supporting unit elastically deforming in the axial direction or a direction adjacent to the axial direction and a radial supporting unit elastically deforming in a radial direction perpendicular to the axial direction or a direction adjacent to the radial direction.

[0031] The axial supporting unit may be interposed between the compressor main body and one side wall of the lower shell.

[0032] The axial supporting unit may include a first side supported by the compressor main body and a second side supported by a side wall of the lower shell. The radial supporting unit may include a first side supported by the compressor main body and a second side supported by a body portion of the lower shell.

[0033] The compressor main body may include an outlet cover assembly. An suction pipe through which a coolant is sucked may be connected to a side in the axial direction of the outlet cover assembly, and a discharge pipe through which the coolant compressed in the cylinder may be discharged to another side in the axial direction of the outlet cover assembly.

[0034] The axial supporting unit may be supported to the outlet cover assembly in the axial direction or the direction adjacent to the axial direction. The radial supporting unit may be supported to the outlet cover assembly in the radial direction or the direction adjacent to the radial direction.

[0035] An outlet cover of the outlet cover assembly may form a supporting unit coupling part projecting in the axial direction. An end of the axial supporting unit may be seated in a groove formed in a side of the supporting unit coupling part. The radial supporting unit may be seated on an outer surface of the supporting unit coupling part.

[0036] In this case, the axial supporting unit may include a coil spring. An end of the coil spring may be seated in the groove of the supporting unit coupling part.

[0037] The radial supporting unit may include a coupling member coupled to the supporting unit coupling part, a leg unit connected to the coupling member and extending in the axial direction or the direction adjacent to the axial direction, a spring support provided in an end of the leg unit, and a coil spring supported by the spring support and compressed in the radial direction or the direction adjacent to the radial direction.

[0038] In this case, the spring may be prepared so that a compressible length thereof is larger than an outer diameter thereof.

[0039] The axial supporting unit may include a coil spring prepared so that the outer diameter is equal to or smaller than the compressible length thereof.

[0040] The radial supporting unit may include a coil spring compressed in a direction parallel to a direction of the load of the compressor main body as viewed in the axial direction.

[0041] In this case, the coil spring may be prepared so that a compressible length thereof is larger than an outer diameter thereof.

[0042] The axial supporting unit may include a coil spring compressed in a direction parallel to a driving direction of the compressor main body as viewed from thereabove.

[0043] The radial supporting unit may include a plurality of coil springs compressed in a direction inclined by a predetermined angle from a load direction of the compressor main body as viewed in the axial direction. The plurality of coil springs may be disposed at angles symmetrical to each other with respect to the load direction.

[0044] The radial supporting unit may include a coupling member coupled to the compressor main body, a leg unit connected to the coupling member and extending in the axial direction or the direction adjacent to the axial

direction, a spring support provided in an end of the leg unit, and a coil spring supported by the spring support and compressed in the radial direction or the direction adjacent to the radial direction.

[0045] The radial supporting unit may include a pair of supporting units disposed at angles symmetrical to each other with respect to the load direction.

[0046] The leg unit may include a first side connected to the coupling member and a second side branching into two legs and extending at angles symmetrical to each other with respect to the load direction. The spring supporting unit and the coil spring may be formed corresponding to each of the two legs of the leg unit.

[0047] According to an embodiment, a compressor may include a lower shell and an upper shell. A separation plane where the lower shell and the upper shell are fixed to each other is inclined from a horizontal center line as viewed in an axial direction. Thus, a compressor main body, a first support and a second support supporting the compressor main body, a terminal for supplying power to a motor assembly of the compressor main body, or other components may be mounted in the lower shell.

[0048] Thus, the number of the components of the casing may be reduced, and the assembly time and man hour may be decreased.

BRIEF DESCRIPTION OF THE DRAWINGS

[0049]

FIG. 1 is a perspective view illustrating an outer appearance of a compressor according to an embodiment;

FIG. 2 is a left side view of the compressor of FIG. 1, as viewed from a discharge side;

FIG. 3 is a view illustrating an example in which a partition wall is removed from the compressor of FIG. 2;

FIG. 4 is a cross-sectional view illustrating an internal structure of a compressor according to an embodiment;

FIG. 5 is a cross-sectional view illustrating an internal structure of a compressor according to an embodiment;

FIG. 6 is a perspective view illustrating a first support spring according to an embodiment;

FIG. 7 is a front view illustrating a second support spring according to an embodiment;

FIG. 8 is a cross-sectional view illustrating a coupling structure of an axial supporting unit;

FIG. 9 is an exploded perspective view illustrating a second support spring;

FIG. 10 is a view illustrating a radial supporting unit according to a first embodiment;

FIG. 11 is a view illustrating a modification to the embodiment of FIG. 10;

FIG. 12 is a front view illustrating a second support spring for describing a radial supporting unit accord-

ing to a second embodiment;

FIG. 13 is a front view illustrating a radial supporting unit according to the second embodiment;

FIG. 14 is a front view illustrating a second support spring for describing a radial supporting unit according to a third embodiment; and

FIG. 15 is a view illustrating the vibration level according to the rigidity of a support spring.

10 DETAILED DESCRIPTION OF THE EMBODIMENTS

[0050] Hereinafter, embodiments of the disclosure are described in detail with reference to the accompanying drawings. The same references may be used to denote the same or similar elements throughout the drawings and the specification, and no duplicate description is given of the elements.

[0051] It will be understood that when an element or layer is referred to as being "on," "connected to," "coupled to," or "adjacent to" another element or layer, it can be directly on, connected, coupled, or adjacent to the other element or layer, or intervening elements or layers may be present.

[0052] When determined to make the subject matter of the disclosure unclear, the detailed description of the known art or functions may be skipped.

[0053] The accompanying drawings are provided merely for a better understanding of the disclosure and the technical spirit or the scope of the disclosure are not limited by the drawings.

[0054] As used herein, the term "disclosure" may be replaced with other terms, such as "disclosure," "document," "specification," or "description."

[0055] Described below is an example linear compressor that sucks in and compresses a fluid and discharges the compressed fluid as a piston linearly reciprocates according to an embodiment.

[0056] The linear compressor may be a component for a cooling cycle, and the fluid compressed by the linear compressor may be a coolant circulating along the cooling cycle.

[0057] The cooling cycle may further include a condenser, an expander, and an evaporator. The linear compressor may be used as a component of a cooling system of a refrigerator but, without limitations thereto, may be used in the overall industry.

[0058] FIG. 1 is a perspective view illustrating an outer appearance of a compressor according to an embodiment. FIG. 2 is a left side view of the compressor of FIG. 1, as viewed from a discharge side. FIG. 3 is a view illustrating an example in which a partition wall is removed from the compressor of FIG. 2.

[0059] Referring to FIGS. 1 to 3, according to an embodiment, a linear compressor 100 includes a casing 110 surrounding the compressor main body.

[0060] The casing 110 may include a lower shell 111 and an upper shell 112 fixed to the lower shell 111. As viewed along the axial direction of the casing 110, a sep-

aration plane SP where the lower shell 111 and the upper shell 112 are fixed to each other may be formed to be inclined from a horizontal center line HCL of the casing 110.

[0061] The inclination angle θ of the separation plane SP from the horizontal center line HCL may be set within a range in which a terminal 30 and a PTC cover may be mounted and a second support may be installed.

[0062] As an example, the inclination angle θ of the separation plane SP may be 20° to 70° from the horizontal center line HCL of the casing 110.

[0063] As viewed along the axial direction of the casing 110, at least one of two opposite ends of the separation plane SP may be positioned higher than the horizontal center line HCL of the casing 110.

[0064] In other words, although FIGS. 1 to 3 illustrate an example in which the right end of the two opposite ends of the separation plane SP is positioned higher than the horizontal center line HCL, and the left end is positioned lower than the horizontal center line HCL, the left end of the separation plane SP may also be positioned higher than the horizontal center line HCL.

[0065] Legs 20 may be coupled to the bottom of the lower shell 111. The legs 20 may be coupled to the base of the product in which the linear compressor 100 is installed.

[0066] For example, the product includes a refrigerator, and the base may include a mechanical chamber base of the refrigerator. As another example, the product may include the outdoor unit of an air conditioner, and the base may include a base for the outdoor unit.

[0067] Referring to FIG. 1, the lower shell 111 may extend in the horizontal direction, and the center axis in the length direction of the lower shell 111 is consistent with the center axis of the compressor main body described below, and the center axis of the compressor main body is consistent with the center axis of the cylinder and piston constituting the compressor main body.

[0068] A terminal 30 may be installed on an outer surface of the lower shell 111, where the height of the separation plane SP is relatively large, and a receptacle LW1 connected to an end of a lead wire LW is connected to the terminal 30.

[0069] Here, the "height" may be appreciated as a distance, in the vertical direction, from the legs 20.

[0070] The terminal 30 is appreciated as a component that transfers external power to a motor assembly (refer to the driving unit 130 of FIG. 4) of the linear compressor 100. In particular, the terminal 30 may be connected to the lead line of a coil (refer to 132b of FIG. 4).

[0071] A PTC cover 31 is installed outside the terminal 30, protecting the terminal 30.

[0072] The lower shell 111 may have side walls SW1 on both sides along the axial direction of the casing 110, and the upper shell 112 may have side walls SW2 on both sides along the axial direction of the casing 110.

[0073] The side walls SW1 and SW2 may replace the conventional shell covers. In other words, the right side

wall SW1 of the lower shell 111 and the right side wall SW2 of the upper shell 112 may replace the conventional shell cover on the suction side, and the left side wall SW1 of the lower shell 111 and the left side wall SW2 of the upper shell 112 may replace the conventional shell cover on the discharge side.

[0074] Thus, the top of the lower shell 111, which faces the upper shell 112, may be open, and the bottom of the upper shell 112, which faces the lower shell 111, may be open.

[0075] Thus, when the lower shell 111 and the upper shell 112 are fixed together to the separation plane SP by, e.g., welding, the internal space of the casing 110 may be sealed off.

[0076] One side wall SW1, e.g., the right side wall SW1 in FIG. 1, may be positioned on the suction side of the coolant, and the other side wall SW1, e.g., the left side wall SW1 in FIG. 1, may be positioned on the discharge side of the coolant.

[0077] The linear compressor 100 may further include a plurality of pipes 114 and 115 provided on the lower shell 111 to suck in, discharge, or inject the coolant.

[0078] The plurality of pipes 114 and 115 include a suction pipe 114 for sucking the coolant into the inside of the linear compressor 100, and a discharge pipe 115 for discharging the compressed coolant from the linear compressor 100.

[0079] Although not shown, the compressor may further include a supplementing pipe for supplementing the coolant to the linear compressor 100.

[0080] The suction pipe 114 may be coupled to a right side wall of the lower shell 111. The coolant may be sucked into the inside of the linear compressor 100 through the suction pipe 114 along the axial direction.

[0081] The discharge pipe 115 may be coupled to the outer circumferential surface of the lower shell 111. The coolant sucked in through the suction pipe 114 may be compressed while flowing along the axial direction of the compressor.

[0082] The compressed coolant may be discharged through the discharge pipe 115. The discharge pipe 115 may be disposed in a position adjacent to the left side wall, rather than the right side wall, of the lower shell 111.

[0083] A device for supporting the compressor main body may be provided inside the lower shell 111. Here, the compressor main body means a component provided inside the shell 111 and may include, e.g., a driver moving back and forth and a support supporting the driver.

[0084] FIG. 4 is a cross-sectional view illustrating an internal structure of a compressor 100 according to an embodiment.

[0085] Referring to FIG. 4, the compressor main body includes a frame 120, a cylinder 140 fixed to the frame 120, a piston 150 linearly reciprocating inside the cylinder 140, and a driving unit 130 fixed to the frame 120 to give driving power to the piston 150. The cylinder 140 and the piston 150 may also be referred to as a compression unit 140 and 150.

[0086] The compressor 100 may have a bearing means to reduce friction between the cylinder 140 and the piston 150. The bearing means may be an oil bearing or a gas bearing. A mechanical bearing may be used as the bearing means.

[0087] The compressor main body may be elastically supported by support springs 116 and 117 installed at both ends inside the casing 110.

[0088] The support springs may include a first support spring 116 supporting the back (suction side) of the main body and a second support spring supporting the front (discharge side) of the main body and may be prepared as leaf springs.

[0089] The support springs 116 and 117 may absorb vibration and shocks that are caused as the piston 150 reciprocates.

[0090] The sealed space formed by the casing 110 includes a receiving space 101 for receiving the coolant sucked in, a suction space 102 which is filled with the pre-compression coolant, and a discharge space 104 which is filled with the compressed coolant.

[0091] In other words, the coolant sucked from the suction pipe 114 connected to the back side of the casing 110 fills the receiving space 101, the coolant in the suction space 102 communicating with the receiving space 101 is compressed in the compression space 103 and is discharged to the discharge space 104, and is discharged out through the discharge pipe 115 connected to the front side of the casing 110.

[0092] The casing 110 may be formed of a thermal conductive material. Thus, the heat generated from the internal space of the casing 110 may be rapidly radiated out.

[0093] The suction pipe 114 is inserted and coupled to the center of the right side wall of the lower shell 111.

[0094] The back side of the compressor main body may be elastically supported against the right side wall by the first support spring 116 in the radial direction.

[0095] The first support spring 116 may be provided as a circular leaf spring. An edge of the first support spring 116 may be supported against a back cover 123 in the forward direction via a supporting bracket 123a, and the center portion with an opening, of the first support spring 116, may be supported against the right side wall of the lower shell 111 in the backward direction via a suction guide 116a.

[0096] The suction guide 116a is formed in a cylindrical shape with a through passage thereinside. The center opening of the first support spring 116 is coupled to the outer circumferential surface, on the front side, of the suction guide 116a, and the end on the back side of the suction guide 116a may be supported against the right side wall of the lower shell 111.

[0097] In this case, a separate suction-side supporting member 116b may be interposed between the suction guide 116a and the inner surface of the right side wall of the lower shell 111.

[0098] The back side of the suction guide 116a may

communicate with the suction pipe 114, and the coolant sucked in via the suction pipe 114 may be introduced to a muffler unit 160 through the suction guide 116a.

[0099] A damping member 116c formed of, e.g., rubber, may be installed between the suction guide 116a and the suction-side supporting member 116b.

[0100] Thus, the vibration generated while the coolant is sucked in through the suction pipe 114 may be blocked from being delivered to the right side wall of the lower shell 111.

[0101] The discharge pipe 115 may be inserted and coupled through a loop pipe 115a to the lower shell 111. The coolant discharged from the compression space 103 may pass through an outlet cover assembly 180 and be then discharged to the cooling cycle through the loop pipe 115a and the discharge pipe 115.

[0102] The front side of the compressor main body may be elastically supported against the lower shell 111 or the left side wall of the lower shell 111 by the second support spring 117 in the radial direction.

[0103] The second support spring 117 may be provided as a circular leaf spring. The open center portion of the second support spring 117 may be supported against the outlet cover assembly 180 in the backward direction by the first supporting guide 117b, and an edge of the second support spring 117 may be supported against the inner circumferential surface of the lower shell 111 adjacent to the left side wall of the lower shell 111 or the inner surface of the lower shell 111 in the radial direction by the supporting bracket 117a.

[0104] Alternatively, unlike shown in the drawings, the edge of the second support spring 117 may be supported against the left side wall of the lower shell 111 in the forward direction via a bracket (not shown).

[0105] The first supporting guide 117b is formed in a continuous cylindrical shape with different diameters, and a front side of the first supporting guide 117b may be inserted into the center opening of the second support spring 117, and a back side of the first supporting guide 117b may be inserted into the center opening of the outlet cover assembly 180.

[0106] The supporting cover 117c may be coupled to the front side of the first supporting guide 117b, with the second support spring 117 disposed therebetween.

[0107] A cup-shaped second supporting guide 117d depressed forwards may be coupled to the front side of the supporting cover 117c, and a cup-shaped third supporting guide 117e depressed backwards and corresponding to the second supporting guide 117d may be coupled to the inside of the left side wall of the lower shell 111.

[0108] The second supporting guide 117d may be inserted to the inside of the third supporting guide 117e and be supported in the axial direction and radial direction. In this case, a gap may be formed between the second supporting guide 117d and the third supporting guide 117e.

[0109] A frame 120 includes a body portion 121 sup-

porting the outer circumferential surface of the cylinder 140 and a flange portion 122 connected to one side of the body portion 121 and supporting the driving unit 130.

[0110] The frame 120, along with the driving unit 130 and the cylinder 140, may be elastically supported against the casing 110 by the first support spring 116 and the second support spring 117.

[0111] The body portion 121 may be formed in a cylindrical shape surrounding the outer circumferential surface of the cylinder 140, and the flange portion 122 may extend from a front-side end of the body portion 121 in the radial direction.

[0112] The cylinder 140 may be coupled to the inner circumferential surface of the body portion 121, and an inner stator 134 may be connected to the outer circumferential surface.

[0113] For example, the cylinder 140 may be press-fitted and fixed to the inner circumferential surface of the body portion 121, and the inner stator 134 may be fixed to the outer circumferential surface of the body portion 121 using a fixing ring.

[0114] An outer stator 131 may be coupled to the back surface of the flange portion 122, and the outlet cover assembly 180 may be coupled to the front surface of the flange portion 122. The outer stator 131 and the outlet cover assembly 180 may be fixed to the flange portion 122 via a mechanical coupling means.

[0115] A bearing inlet hole forming a portion of a gas bearing may be formed in a front side of the flange portion 122, a bearing communication hole may be formed to penetrate from the bearing inlet hole to the inner circumferential surface of the body portion 121, and a gas hole may be formed in the inner circumferential surface of the body portion 121 to communicate from the bearing communication hole.

[0116] The bearing inlet hole may be depressed to a predetermined depth in the axial direction, and the bearing communication hole may be a hole with a smaller cross sectional area than the bearing inlet hole and be formed to be inclined toward the inner circumferential surface of the body portion 121.

[0117] The gas hole may be formed in a ring shape with a predetermined depth and a length along the axial direction, in the inner circumferential surface of the body portion 121.

[0118] Unlike this, the gas hole may be formed in the outer circumferential surface of the cylinder 140, which the inner circumferential surface of the body portion 121 abuts, or in each of the inner circumferential surface of the body portion 121 and the outer circumferential surface of the cylinder 140.

[0119] A gas inlet 142 corresponding to the gas hole may be formed in the outer circumferential surface of the cylinder 140. The gas inlet 142 forms a sort of nozzle in the gas bearing.

[0120] The frame 120 and the cylinder 140 may be formed of aluminum or an aluminum alloy.

[0121] The cylinder 140 may be formed in a cylindrical

shape with openings in two opposite ends, the piston 150 may be inserted through the back end of the cylinder 140, and the front end of the cylinder 140 may be closed off by a discharge valve assembly 170.

[0122] The compression space 103 may be formed in a space surrounded by the cylinder 140, the front end (head portion 151) of the piston 150, and the discharge valve assembly 170.

[0123] The compression space 103 increases in volume when the piston 150 moves backward and decreases in volume as the piston 150 moves forward.

[0124] In other words, the coolant sucked into the inside of the compression space 103 may be compressed as the piston 150 moves forward and be discharged via the discharge valve assembly 170.

[0125] The front end of the cylinder 140 may be bent out, forming a flange portion 141. The flange portion 141 of the cylinder 140 may be coupled to the frame 120.

[0126] For example, a flange hole corresponding to the flange portion 141 of the cylinder 140 may be formed in the front end of the frame 120, and the flange portion 141 of the cylinder 140 may be inserted to the flange hole and coupled via a mechanical coupling member.

[0127] A gas bearing means may be provided which may supply a discharging gas to the gap between the outer circumferential surface of the piston 150 and the outer circumferential surface of the cylinder 140 to thereby enable gas lubrication between the cylinder 140 and the piston 150.

[0128] The discharging gas between the cylinder 140 and the piston 150 may provide a floating force to the piston 150, reducing friction, to the cylinder 140, of the piston 150.

[0129] For example, a gas inlet 142 may be formed in the cylinder 140. The gas inlet 142 may communicate with the gas hole formed in the inner circumferential surface of the body portion 121 and guide the compressed coolant, passing through the cylinder 140 in the radial direction and introduced to the gas hole, to the space between the inner circumferential surface of the cylinder 140 and the outer circumferential surface of the piston 150.

[0130] Given convenient processing, the gas hole may be formed in the outer circumferential surface of the cylinder 140.

[0131] The entrance of the gas inlet 142 may be formed in a relatively large size, and the exit of the gas inlet 142 may be formed as a tiny (or fine) through hole to function as a nozzle.

[0132] A filter (not shown) may be added at the entrance of the gas inlet 142 to block off influx of a foreign body. The filter may be a net filter formed of metal or may be formed by winding a thin thread therearound.

[0133] A plurality of independent gas inlets 142 may be formed. The entrance of the gas inlet 142 may be a ring-shaped hole, and a plurality of exits spaced apart from one another along the ring-shaped hole may be formed in the gas inlet 142.

[0134] The gas inlet 142 may be formed only at the front side of the center, in the axial direction, of the cylinder 140 or, considering a sagging of the piston 150, the gas inlet 142 may also be formed in the back side of the cylinder 140.

[0135] The piston 150 is inserted from the open back end of the cylinder 140 to the inside of the cylinder 140 and seals off the back side of the compression space 103.

[0136] The piston 150 includes a head portion 151, which is shaped as a circular plate and partitions the compression space 103, and a cylindrical guide portion 152 extending backwards from the outer circumferential surface of the head portion 151.

[0137] The head portion 151 is provided to be partially open, and the guide portion 152 is hollow. The front side of the guide portion 152 is partially sealed off by the head portion 151 but the back side of the guide portion 152 is open and connected to the muffler unit 160.

[0138] The head portion 151 and the guide portion 152 may be prepared as separate members coupled together, or the head portion 151 and the guide portion 152 may be integrally formed with each other.

[0139] A suction port 154 is formed to pass through the head portion 151.

[0140] The suction port 154 enables the suction space 102 inside the piston 150 to communicate with the compression space 103.

[0141] Thus, the coolant introduced from the receiving space 101 to the suction space 102 inside the piston 150 may pass through the suction port 154 and be sucked into the compression space 103 between the piston 150 and the cylinder 140.

[0142] The suction port 154 may extend in the axial direction of the piston 150. Or, the suction port 154 may be formed to be inclined from the axial direction of the piston 150.

[0143] For example, the suction port 154 may extend, inclined to go away from the center axis toward the back end of the piston 150.

[0144] The suction port 154 may be formed as a circular opening, and the inner diameter of the suction port 154 may be constant.

[0145] Alternatively, the suction port 154 may be formed as a long hole-shaped opening which extends in the radial direction of the head portion 151, and the inner diameter of the suction port 154 may increase toward the back end thereof.

[0146] A plurality of suction ports 154 may be formed in any one or more of the radial direction and circumferential direction of the head portion 151.

[0147] A suction valve 155 may be mounted on the head portion 151 of the piston 150 adjacent to the compression space 103, selectively opening or closing the suction port 154.

[0148] The suction valve 155 may be elastically deformed and operated, opening or closing the suction port 154.

[0149] In other words, the suction valve 155 may be

elastically deformed to open the suction port 154 by the pressure of the coolant flowing through the suction port 154 to the compression space 103.

[0150] The piston 150 may be connected to a mover 135, and the mover 135 reciprocates back and forth as the piston 150 moves.

[0151] The inner stator 134 and the cylinder 140 may be positioned between the mover 135 and the piston 150.

[0152] The mover 135 and the piston 150 may be connected together by a magnet frame 136 formed around to the back sides of the cylinder 140 and the inner stator 134.

[0153] The muffler unit 160 may be coupled to the back side of the piston 150 and attenuates the noise caused while the coolant is sucked to the piston 150.

[0154] The coolant sucked in through the suction pipe 114 flows through the muffler unit 160 to the suction space 102 inside the piston 150.

[0155] The muffler unit 160 includes a suction muffler 161 communicating with the receiving space 101 of the casing 110 and an inner guide 162 connected to the front side of the suction muffler 161 and guiding the coolant to the suction port 154.

[0156] The suction muffler 161 is positioned at the back side of the piston 150, and the back-side opening of the suction muffler 161 is disposed adjacent to the suction pipe 114, and the front-side end of the suction muffler 161 is coupled to the back side of the piston 150.

[0157] The suction muffler 161 includes a flow path formed in the axial direction and may guide the coolant in the receiving space 101 to the suction space 102 inside the piston 150.

[0158] A plurality of noise spaces partitioned by a baffle may be formed in the suction muffler 161.

[0159] The suction muffler 161 may be formed as two or more members are coupled together. For example, a plurality of noise spaces may be formed as a second suction muffler is press-fitted into a first suction muffler. Given weight and insulation, the suction muffler 161 may be formed of plastic.

[0160] The inner guide 162 may be formed in a pipe shape which has one end communicating with the noise space of the suction muffler 161 and another end deeply inserted into the inside of the piston 150.

[0161] The inner guide 162 may be formed in a cylindrical shape two opposite ends thereof have the same inner diameter. However, in some cases, the front end on the discharge side may be larger in inner diameter than its opposite side end, i.e., back end.

[0162] The suction muffler 161 and the inner guide 162 may be provided in various shapes and may thus adjust the pressure of the coolant passing through the muffler unit 160. The suction muffler 161 and the inner guide 162 may be integrally formed with each other.

[0163] The discharge valve assembly 170 may include a discharge valve 171 and a valve spring 172 provided on the front side of the discharge valve 171 to elastically support the discharge valve 171.

[0164] The discharge valve assembly 170 may selectively discharge the coolant compressed in the compression space 103. The compression space 103 may be appreciated as a space formed between the suction valve 155 and the discharge valve 171.

[0165] The discharge valve 171 may be disposed to be supported on the front surface of the cylinder 140 and may be mounted to selectively open or close the front opening of the cylinder 140.

[0166] The discharge valve 171 may be elastically deformed and operated, opening or closing the compression space 103.

[0167] The discharge valve 171 may be elastically deformed to open the compression space 103 by the pressure of the coolant flowing through the compression space 103 to the discharge space 104.

[0168] For example, in the state where the discharge valve 171 is supported on the front surface of the cylinder 140, the compression space 103 may remain sealed-off and, in the state where the discharge valve 171 is spaced apart from the front surface of the cylinder 140, the compressed coolant in the compression space 103 may be discharged through the opened space.

[0169] The valve spring 172 may be provided between the discharge valve 171 and the outlet cover assembly 180, providing an elastic force in the axial direction.

[0170] The valve spring 172 may be prepared as a compression coil spring and, in light of occupied space or reliability, the valve spring 172 may be prepared as a leaf spring.

[0171] If the pressure of the compression space 103 is a discharge pressure or more, the valve spring 172 may be deformed forward to thereby open the discharge valve 171, and the coolant may be discharged from the compression space 103 to a first discharge space of the outlet cover assembly 180.

[0172] If the discharge of the coolant is complete, the valve spring 172 provides a restorative force to the discharge valve 171, closing the discharge valve 171.

[0173] Described below is a process in which the coolant is introduced through the suction valve 155 to the compression space 103, and the coolant is discharged from the compression space 103 through the discharge valve 171 to the discharge space 104.

[0174] If the pressure of the compression space 103 becomes a predetermined suction pressure or less while the piston 150 linearly reciprocates inside the cylinder 140, the suction valve 155 is open, and the coolant is sucked into the compression space 103.

[0175] In contrast, if the pressure of the compression space 103 goes over the predetermined suction pressure, the coolant in the compression space 103 is compressed, with the suction valve 155 closed.

[0176] If the pressure of the compression space 103 is the predetermined discharge pressure or more, the valve spring 172 may be deformed forward to thereby open the discharge valve 171 connected thereto, and the coolant may be discharged from the compression space

103 to the discharge space 104 of the outlet cover assembly 180.

[0177] If the discharge of the coolant is complete, the valve spring 172 provides a restorative force to the discharge valve 171, closing the discharge valve 171 and hence sealing off the front side of the compression space 103.

[0178] The outlet cover assembly 180 is installed on the front side of the compression space 103, forming the discharge space 104 for receiving the coolant discharged from the compression space 103. The outlet cover assembly 180 is coupled to the front side of the frame 120, attenuating the noise generated while the coolant is discharged from the compression space 103.

[0179] The outlet cover assembly 180 may receive the discharge valve assembly 170 and be coupled to the front side of the flange portion 122 of the frame 120.

[0180] For example, the outlet cover assembly 180 may be coupled to the flange portion 122 via a mechanical coupling member.

[0181] A gasket for thermal insulation and an O-ring for preventing the coolant from leaking from the discharge space 104 may be provided between the outlet cover assembly 180 and the frame 120.

[0182] The outlet cover assembly 180 may be formed of a thermal conductive material. Thus, if a hot coolant is introduced to the outlet cover assembly 180, the heat of the coolant may be transferred through the outlet cover assembly 180 to the casing 110 and be radiated to the outside of the compressor.

[0183] The outlet cover assembly 180 may be configured of one discharge cover or may be formed of a plurality of discharge covers to sequentially communicate.

[0184] Where there are provided a plurality of discharge covers, the discharge space 104 may include a plurality of space portions partitioned by each discharge cover. The plurality of space portions may be disposed back and forth and may communicate with one another.

[0185] For example, when there are three discharge covers, the discharge space 104 may include a first discharge space formed between the frame 120 and a first discharge cover 181 coupled to the front side of the frame 120, a second discharge space communicating with the first discharge space and formed between the first discharge cover 181 and a second discharge cover 182 coupled to the front side of the first discharge cover 181, and a third discharge space communicating with the second discharge space and formed between the second discharge cover 182 and a third discharge cover 183 coupled to the front side of the second discharge cover 182.

[0186] The first discharge space may selectively communicate with the compression space 103 by the discharge valve 171, the second discharge space may communicate with the first discharge space, and the third discharge space may communicate with the second discharge space.

[0187] Thus, the discharge noise may be attenuated while the coolant discharged from the compression

space 103 sequentially passes through the first discharge space, second discharge space, and third discharge space, and the coolant may then be discharged through the loop pipe 115a communicating with the third discharge cover 183 and the discharge pipe 115 to the outside of the casing 110.

[0188] The driving unit 130 may include the outer stator 131 disposed to surround the body portion 121 of the frame 120 between the casing 110 and the frame 120, the inner stator 134 disposed to surround the cylinder 140 between the outer stator 131 and the cylinder 140, and the mover 135 disposed between the outer stator 131 and the inner stator 134.

[0189] The outer stator 131 may be coupled to the back side of the flange portion 122 of the frame 120, and the inner stator 134 may be coupled to the outer circumferential surface of the body portion 121 of the frame 120.

[0190] The inner stator 134 may be spaced internally of the outer stator 131, and the mover 135 may be disposed in the space between the outer stator 131 and the inner stator 134.

[0191] A winding coil may be mounted on the outer stator 131, and the mover 135 may have a permanent magnet. The permanent magnet may be formed of one single-pole magnet or of a combination of a plurality of magnets with three poles.

[0192] The outer stator 131 includes a coil winding body 132 surrounding the axial direction in the circumferential direction and a stacked state core 133 surrounding the coil winding body 132.

[0193] The coil winding 132 may include a hollow, cylindrical bobbin 132a and a coil 132b wound around the bobbin 132a in the circumferential direction.

[0194] The coil 132b may have a circular or polygonal, e.g., hexagonal, cross section.

[0195] The state core 133 may have a plurality of lamination sheets stacked radially or may have a plurality of lamination blocks stacked along the circumferential direction.

[0196] The front side of the outer stator 131 may be supported by the flange portion 122 of the frame 120, and the back side thereof may be supported by the state cover 137.

[0197] For example, the state cover 137 may be prepared as a hollow circular plate, and the outer stator 131 may be supported against the front surface of the state cover 137, and a resonant spring may be supported against the back surface of the state cover 137.

[0198] The inner stator 134 may have a plurality of laminations stacked radially on the outer circumferential surface of the body portion 121.

[0199] One side of the mover 135 may be coupled to the magnet frame 136 and be supported. The magnet frame 136 may have a substantially cylindrical shape and be disposed to be inserted in the space between the outer stator 131 and the inner stator 134.

[0200] The magnet frame 136 may be coupled to the back side of the piston 150 and is moved together with

the piston 150.

[0201] As an example, the back end of the magnet frame 136 may be bent inward in the radial direction and extend, forming a coupling portion 136a. The coupling portion 136a may be coupled to the flange portion 153 formed at the back of the piston 150.

[0202] The coupling portion 136a of the magnet frame 136 and the flange portion 153 of the piston 150 may be coupled together via a mechanical coupling member.

[0203] A flange portion 161a formed on the front side of the suction muffler 161 may be interposed between the flange portion 153 of the piston 150 and the coupling portion 136a of the magnet frame 136.

[0204] Thus, the piston 150, the muffler unit 160, and the mover 135 may be integrally coupled together and be linearly moved back and forth.

[0205] If a current is applied to the driving unit 130, a magnetic flux may be formed around the coil winding, and an electromagnetic force may be generated by the interaction between the magnetic flux formed around the coil winding of the outer stator 131 and the magnetic flux formed around the permanent magnet of the mover 135, moving the mover 135.

[0206] While the mover 135 moves back and forth along the axial direction, the piston 150 connected to the magnet frame 136 is simultaneously moved along the axial direction, together with the mover 135.

[0207] Meanwhile, the driving unit 130 and the compression unit 140 and 150 may be supported in the axial direction by the support springs 116 and 117 and the resonant spring.

[0208] The resonant spring 118 may amplify the vibration generated by the reciprocation of the mover 135 and the piston 150, thereby allowing for effective compression of the coolant.

[0209] Specifically, the resonant spring 118 may be adjusted to the frequency corresponding to the natural frequency of the piston 150, allowing the piston 150 to perform resonant motion.

[0210] Further, the resonant spring 118 triggers stable movement of the piston 150, thereby reducing vibration and noise.

[0211] The resonant spring 118 may be a coil spring extending in the axial direction. Both ends of the resonant spring 118 may be connected to a vibrating body and a fixture.

[0212] For example, one end of the resonant spring 118 may be connected to the magnet frame 136, and the other end may be connected to the back cover 123.

[0213] Thus, the resonant spring 118 may be elastically deformed between the vibrating body and the fixture.

[0214] The natural frequency of the resonant spring 118 may be designed to be consistent with the resonance frequency of the mover 135 and the piston 150 when the compressor 100 is operated, allowing the reciprocation of the piston 150 to be amplified.

[0215] However, since the back cover 123, prepared as the fixture, is elastically supported against the casing

110 by the first support spring 116, it-strictly speaking-may be not fixed.

[0216] The resonant spring 118 may include a first resonant spring 118a supported on the back side of a spring supporter 119 and a second resonant spring 118b supported on the front side thereof.

[0217] The spring supporter 119 may include a body portion 119a surrounding the suction muffler 161, a coupling portion 119b bent in the inner radial direction from the front side of the body portion 119a, and a support 119c bent in the outer radial direction from the back side of the body portion 119a.

[0218] The front surface of the coupling portion 119b of the spring supporter 119 may be supported on the coupling portion 136a of the magnet frame 136.

[0219] The inner diameter of the coupling portion 119b of the spring supporter 119 may be prepared to surround the outer diameter of the suction muffler 161.

[0220] For example, the coupling portion 119b of the spring supporter 119, the coupling portion 136a of the magnet frame 136, and the flange portion 153 of the piston 150 may be disposed in order and be then integrally coupled together via a mechanical member.

[0221] In this case, as described above, the flange portion 161a of the suction muffler 161 may be interposed between the flange portion 153 of the piston 150 and the coupling portion 136a of the magnet frame 136 and it may be fixed together.

[0222] The first resonant spring 118a may be provided between the front surface of the back cover 123 and the back surface of the spring supporter 119, and the second resonant spring 118b may be provided between the back surface of the stator cover 137 and the front surface of the spring supporter 119.

[0223] A plurality of first resonant springs 118a and second resonant springs 118b may be arranged along the circumferential direction of the center axis.

[0224] The first resonant spring 118a and the second resonant spring 118b may be arranged side-by-side along the axial direction or to cross each other.

[0225] The first and second resonant springs 118a and 118b may be arranged at predetermined intervals radially from the center axis.

[0226] For example, there may be provided three first resonant springs 118a and three second resonant springs 118b, which are disposed radially at 120 degrees from the center axis.

[0227] The compressor 100 may include a plurality of sealing members for increasing the coupling force between the frame 120 and its surrounding components.

[0228] For example, the plurality of sealing members may include a first sealing member interposed where the frame 120 and the outlet cover assembly 180 are coupled together and inserted to the installation hole provided in the front end of the frame 120 and a second sealing member provided where the frame 120 and the cylinder 140 are coupled together and inserted to the installation hole provided in the outer surface of the cylinder 140.

[0229] The second sealing member may prevent the coolant from leaking from the gas hole formed between the inner circumferential surface of the frame 120 and the outer circumferential surface of the cylinder 140 to the outside and increase the coupling force of the frame 120 and the cylinder 140.

[0230] The plurality of sealing member may further include a third sealing member provided where the frame 120 and the inner stator 134 are coupled together and inserted to the installation hole provided in the outer surface of the frame 120. The first to third sealing members may have a ring shape.

[0231] The above-described linear compressor 100 is operated as described below.

[0232] If a current is applied to the driving unit 130, a magnetic flux may be formed around the outer stator 131 by the current flowing through the coil 132b.

[0233] The magnetic flux formed around the outer stator 131 may generate an electromagnetic force, and the mover 135, which has a permanent magnet, may be linearly moved back and forth by the generated electromagnetic force.

[0234] The electromagnetic force may be generated in the direction in which the piston 150 is oriented to the top dead center (TDC) (forward) upon the compression stroke and, upon the suction stroke, the electromagnetic force may be generated in the direction in which the piston 150 is oriented to the bottom dead center (BDC) (backward).

[0235] In other words, the driving unit 130 may generate thrust which is a force to push the mover 135 and piston 150 in the moving direction.

[0236] The piston 150 which linearly reciprocates inside the cylinder 140 may alternately and repetitively increase and decrease the volume of the compression space 103.

[0237] If the piston 150 moves in the direction (backward direction) in which the volume of the compression space 103 is increased, the pressure of the compression space 103 reduces.

[0238] Thus, the suction valve 155 mounted on the front side of the piston 150 is open, and the coolant, which stays in the suction space 102, may be sucked into the compression space 103 along the suction port 154.

[0239] The suction stroke proceeds until the piston 150 is positioned at the BDC while maximally increasing the volume of the compression space 103.

[0240] Upon arriving at the BDC, the piston 150 switches its motion direction and moves in the direction (forward direction) in which the volume of the compression space 103 is reduced, performing the compression stroke. Upon the compression stroke, the pressure of the compression space 103 is increased so that the coolant sucked is compressed.

[0241] If the pressure of the compression space 103 reaches a predetermined pressure, the discharge valve 171 is pushed away by the pressure of the compression space 103 and is thus open from the cylinder 140, so that the coolant is discharged through the separated space

to the discharge space 104.

[0242] The compression stroke continues while the piston 150 moves up to the TDC at which the volume of the compression space 103 is minimized.

[0243] While the suction stroke and compression stroke of the piston 150 are repeated, the coolant introduced through the suction pipe 114 to the receiving space 101 inside the compressor 100 sequentially passes the suction guide 116a, the suction muffler 161, and the inner guide 162 and is introduced to the suction space 102 inside the piston 150 and, upon the suction stroke, the coolant in the suction space 102 is introduced to the compression space 103 inside the cylinder 140.

[0244] Upon the compression stroke of the piston 150, the coolant in the compression space 103 is compressed and discharged to the discharge space 104. Thereafter, the coolant is discharged through the loop pipe 115a and the discharge pipe 115 to the outside of the compressor 100.

[0245] FIG. 5 is a cross-sectional view illustrating a structure of a compressor 100-1 according to an embodiment.

[0246] Referring to FIG. 5, a compressor 100-1 includes an outlet cover assembly 190 and a discharge valve assembly.

[0247] The outlet cover assembly 190 forms a discharge space 104 for the coolant discharged from the compression space 103. The outlet cover assembly 190 includes a discharge cover 184 coupled to the front surface of the frame 120 and a discharge plenum 185 disposed inside the discharge cover 184.

[0248] The outlet cover assembly 190 may further include a cylindrical fixing ring 186 brought in tight contact with the inner circumferential surface of the discharge plenum 185.

[0249] The discharge valve assembly is coupled to the inner side of the outlet cover assembly 190 and discharges the coolant compressed in the compression space 103 to the discharge space 104.

[0250] The discharge valve assembly may include a discharge valve 171 and a spring assembly 175 providing an elastic force in the direction in which it comes in tight contact with the front end of the cylinder 140.

[0251] The spring assembly 175 may include a valve spring 172 in the form of a leaf spring, a spring support 173 positioned on the edge of the valve spring 172 to support the valve spring 172, and a frictional ring 174 fitted to the outer circumferential surface of the spring support 173.

[0252] The front center of the discharge valve 171 is fixed and coupled to the center of the valve spring 172. The back surface of the discharge valve 171 is brought in tight contact with the front surface (or front end) of the cylinder 140 by the elastic force of the valve spring 172.

[0253] If the pressure of the compression space 103 becomes the discharge pressure or more, the valve spring 172 is elastically deformed in the direction of the discharge plenum 185.

[0254] The discharge valve 171 is spaced from the front end of the cylinder 140, so that the coolant may be discharged from the compression space 103 to the discharge space 104 which is formed inside the discharge plenum 185.

[0255] In other words, if the discharge valve 171 is supported against the front surface of the cylinder 140, the compression space 103 maintains the sealed state and, if the discharge valve 171 is spaced from the front surface of the cylinder 140, the compression space 103 is open so that the coolant compressed inside the compression space 103 may be discharged.

[0256] The compression space 103 may be appreciated as a space formed between the suction valve 155 and the discharge valve 171.

[0257] The suction valve 155 may be formed on one side of the compression space 103, and the discharge valve 171 may be provided on the other side of the compression space 103, i.e., the opposite side of the suction valve 155.

[0258] If the pressure of the compression space 103 becomes not more than the suction pressure of the coolant while the piston 150 linearly reciprocates inside the cylinder 140, the suction valve 155 is open, so that the coolant is introduced into the compression space 103.

[0259] In contrast, if the pressure of the compression space 103 exceeds the coolant suction pressure, the suction valve 155 is closed and, as the piston 150 advances, the coolant in the compression space 103 is compressed.

[0260] If the pressure of the compression space 103 becomes larger than the pressure (discharge pressure) in the discharge space 104, the valve spring 172 is deformed forward so that the discharge valve 171 is separated from the cylinder 140.

[0261] The coolant in the compression space 103 is discharged through the space between the discharge valve 171 and the cylinder 140 to the discharge space 104 formed inside the discharge plenum 185.

[0262] If the discharge of the coolant is complete, the valve spring 172 provides a restorative force to the discharge valve 171, so that the discharge valve 171 is again brought in tight contact with the front end of the cylinder 140.

[0263] The linear compressor 100-1 may further include a loop pipe 115a connected to the discharge pipe 115.

[0264] The loop pipe 115a discharges the coolant, which has flown into the outlet cover assembly 190, to the outside.

[0265] In this case, one end of the loop pipe 115a is coupled to the discharge cover 184, and the other end thereof is coupled to the discharge pipe 115. At least a portion of the loop pipe 115a may be formed of a flexible material and bend and extend along the inner circumferential surface of the casing 110.

[0266] The linear compressor 100-1 may further include an axial supporting unit 210 and a radial supporting unit 200 that support the front end of the compressor

main body.

[0267] The axial supporting unit 210 may be disposed in parallel with the left partition wall of the lower shell 111 and the discharge cover 184.

[0268] One end of the axial supporting unit 210 is supported in the mounting hole 113a depressed forward from the back of the left side wall of the lower shell 111, and the other end thereof is supported in the mounting hole depressed backward from the front of the discharge cover 184.

[0269] The axial supporting unit 210 is prepared to be compressed and extended in the axial direction and may support loads and reduce vibration in the axial direction.

[0270] The radial supporting unit 200 may be disposed in the direction perpendicular to the axial direction between the discharge cover 184 and the casing 110.

[0271] One end of the radial supporting unit 200 is supported against the outer circumferential surface of the supporting unit coupling part 184b protruding forward of the discharge cover 184, and the other end thereof may be supported against the lower shell 111 or the inner circumferential surface of the left side wall of the lower shell 111.

[0272] The radial supporting unit 200 is prepared to be compressed and extended in the radial direction and may support loads and reduce vibration in the vertical direction.

[0273] Unlike shown in the drawings, the radial supporting unit 200 may be disposed in a direction which is tilted to some degree from the direction perpendicular to the axial direction.

[0274] In other words, the radial supporting unit 200 may be disposed so that the lower portion thereof is positioned forward of the upper portion thereof.

[0275] The radial supporting unit 200 may include supporting units disposed in multiple directions.

[0276] For example, a pair of supporting units 200 may be disposed apart from each other at an angle ranging from 90 degrees to 120 degrees, supporting the outlet cover assembly 190.

[0277] The left side wall of the lower shell 111 may be provided in a shape to prevent interference with the supporting unit 200.

[0278] The linear compressor 100-1 may include a frame 120 and a plurality of sealing members to increase the coupling force between the frame 120 and its surrounding components. For example, the plurality of sealing members may have a ring shape.

[0279] FIG. 6 is a perspective view illustrating a first support spring 116 according to an embodiment.

[0280] According to an embodiment, the first support spring 116 may be prepared as a leaf spring.

[0281] The first support spring 116 may support one side of the compressor main body, thereby mitigating the sagging phenomenon. If a sagging of the compressor main body is mitigated, the main body may be prevented from colliding with the casing 110 while the compressor is operated.

[0282] The first support spring 116 may be coupled to the right side wall of the lower shell 111 via the suction-side supporting member 116b and the suction guide 116a.

5 **[0283]** The suction guide 116a may be coupled to the center of the first support spring 116, and the suction-side supporting member 116b may be coupled to the back of the suction guide 116a and be fixed to the right side wall of the lower shell 111.

10 **[0284]** The center axis of the first support spring 116 is disposed in parallel with the axial direction of the compressor main body and is mounted so that the leaf spring is disposed in the direction perpendicular to the axial direction.

15 **[0285]** The leaf spring, by its nature, may have large lateral stiffness (stiffness in a direction perpendicular to the axial direction of the compressor main body) and small longitudinal stiffness (stiffness in the axial direction of the compressor main body).

20 **[0286]** For example, the leaf spring may have a longitudinal stiffness-to-lateral stiffness ratio of 1:10. Here, longitudinal stiffness means stiffness in the axial direction of the leaf spring, and lateral stiffness means stiffness in the width direction of the leaf spring.

25 **[0287]** As such, as the leaf spring has the characteristics of large lateral stiffness, it may negatively affect vibration and noise characteristics. This is why a better vibration and noise characteristic may be obtained as the stiffness of spring reduces.

30 **[0288]** A rub packing member may be press-fitted into the inside of the leaf spring. As there is no structure to prevent rotation of the leaf spring and the rubber packing member, the rubber packing member has a chance of rotating relative to the leaf spring.

35 **[0289]** Thus, the compressor main body may be rotated, and the vibration in the radial direction of the compressor main body may increase. If the vibration in the radial direction of the compressor main body increases, the compressor main body may collide with the casing.

40 **[0290]** FIG. 7 is a front view illustrating a second support spring 117 according to an embodiment. FIG. 8 is a cross-sectional view illustrating a coupling structure of an axial supporting unit 210. FIG. 9 is an exploded perspective view illustrating a second support spring 117.

45 **[0291]** Referring to FIGS. 7 to 9, according to an embodiment, the second support spring 117 is prepared in a structure including a coil spring. As such, use of the coil spring may address the above-described issues with the leaf spring.

50 **[0292]** Although varied depending on its design, the coil spring is prepared typically in a longitudinal stiffness-to-lateral stiffness ranging from 1:0.3 to 1:1.2. Here, longitudinal stiffness means stiffness in the direction along which the coil spring is compressed, and lateral stiffness means stiffness in the circumferential direction of the coil spring.

[0293] If a leaf spring is applied to the second support spring 117, the vibration characteristics in the direction

of the load of the compressor main body may worsen due to the large lateral stiffness of the leaf spring.

[0294] However, if a coil spring is applied to the second support spring 117, the vibration characteristics in the direction of the loads may get better due to the small longitudinal stiffness of the coil spring.

[0295] The second support spring 117 may include an axial supporting unit 210 and a radial supporting unit 200.

[0296] The axial supporting unit 210 may be disposed in parallel with the left side wall of the lower shell 111 and the discharge cover 184.

[0297] One end of the axial supporting unit 210 is supported in the mounting hole 113a depressed forward from the back of the left side wall of the lower shell 111, and the other end thereof is supported in the mounting hole depressed backward from the front of the discharge cover 184.

[0298] The axial supporting unit 210 is prepared to be compressed and extended in the axial direction and may support loads and reduce vibration in the axial direction.

[0299] The axial supporting unit 210 may be disposed adjacent to the axial direction. For example, the axial supporting unit 210 may be disposed to be inclined from the upper and lower directions.

[0300] However, if the axial supporting unit 210 is tilted off the upper and lower directions as viewed from the front of the axial direction, it is not preferable because the vibration in the width direction may worsen.

[0301] The front side of the discharge cover 184 may have a mounting hole 184a for receiving the back end of the axial supporting unit 210.

[0302] For example, the mounting hole 184a may be prepared as a hole depressed in a circular shape corresponding to the outer diameter of the back side of the axial supporting unit 210.

[0303] The mounting hole 184a may be formed in the front surface of the supporting unit coupling part 184b which projects forward from the discharge cover 184. One end of the axial supporting unit 210 is inserted and supported in the mounting hole 184a of the discharge cover 184 and its movement in the radial direction may be limited.

[0304] The back side of the left side wall of the lower shell 111 may have a mounting hole 113a for receiving the front end of the axial supporting unit 210.

[0305] For example, the mounting hole 113a may be prepared as a hole depressed in a circular shape corresponding to the outer diameter of the front side of the axial supporting unit 210.

[0306] The axial supporting unit 210 may be selected to have the optimized length and stiffness in the axial direction.

[0307] The length and stiffness in the axial direction may be selected to be able to reduce vibrations and support the loads of the main body while preventing the left side wall of the lower shell 111 from colliding with the discharge cover 184 when compressed.

[0308] The radial supporting unit 200 may be disposed

in the direction perpendicular to the axial direction between the discharge cover 184 and the lower shell 111.

[0309] One end of the radial supporting unit 200 is supported against the outer circumferential surface of the supporting unit coupling part 184b protruding forward of the discharge cover 184, and the other end thereof may be supported against the inner circumferential surface of the lower shell 111.

[0310] The radial supporting unit 200 is prepared to be compressed and extended in the radial direction and may support loads and reduce vibration in the vertical direction.

[0311] Unlike shown in the drawings, the radial supporting unit 200 may be disposed in a direction which is tilted to some degree from the direction perpendicular to the axial direction. In other words, the radial supporting unit 200 may be disposed so that the lower portion thereof is positioned forward of the upper portion thereof.

[0312] The radial supporting unit 200 may be disposed adjacent to the radial direction. For example, the radial supporting unit 200 may be disposed to be tilted to the axial direction and, as viewed from the side surface, it may be disposed to be tilted forward.

[0313] However, in the case where only one radial supporting unit 200 is prepared, if the radial supporting unit 200 is tilted off the vertical direction as viewed from the front of the axial direction, it is not preferable because the vibration in the width direction may worsen.

[0314] However, such issue may be addressed if a plurality of radial supporting units 200 are prepared symmetrically in the width direction.

[0315] The radial supporting unit 200 may include a plurality of supporting units disposed in upper and lower directions symmetrical to each other.

[0316] For example, a pair of supporting units may be disposed apart from each other at an angle ranging from 90 degrees to 120 degrees as viewed from the axial direction, supporting the outlet cover assembly.

[0317] The left side wall of the lower shell 111 may be provided in a shape to prevent interference with the radial supporting unit 200.

[0318] The front side of the discharge cover 184 may have a supporting unit coupling part 184b to which one end of the radial supporting unit 200 is coupled.

[0319] For example, the supporting unit coupling unit 184b may protrude in a cylindrical shape from the front surface of the discharge cover 184, and the diameter of the supporting unit coupling part 184b may be larger than the diameter of the axial supporting unit 210.

[0320] There may be provided a pair of radial supporting units 200. First ends of the pair of radial supporting units 200 may be coupled to the outer circumferential surface of the supporting unit coupling part 184b of the discharge cover 184, and second ends thereof may be brought in tight contact with the inner circumferential surface of the lower shell 111.

[0321] For example, the pair of radial supporting units 200 may be coupled to the supporting unit coupling part

184b of the discharge cover 184, disposed apart from each other at an angle ranging from 90 degrees to 120 degrees.

[0322] The angle between the pair of radial supporting units 200 may be set to be able to support horizontal shakes while supporting the loads in the vertical direction.

[0323] For example, if the angle between the pair of radial supporting units 200 reduces, the loads in the vertical direction may be supported more properly and, if the angle between the pair of radial supporting units 200 increases, the shakes in the width direction may be supported more properly.

[0324] FIG. 10 is a view illustrating a radial supporting unit 200 according to a first embodiment.

[0325] Referring to FIG. 10, according to the first embodiment, the radial supporting unit 200 may include a leg unit 201 extending in the radial direction of the axial direction, a support 202 supported by the supporting unit coupling part 184b of the discharge cover 184, spring supports 203a and 203b prepared in a tip of the leg unit 201, and a coupling protrusion 205 coupled to the supporting unit coupling part 184b.

[0326] When mounted, the leg unit 201 extends in the direction perpendicular to the axial direction and extends outward from one end of the leg unit 201. Thus, the supporting area may be increased, so that stable support may be obtained.

[0327] The support 202 may be prepared in a concave shape corresponding to the convex surface of the supporting unit coupling part 184b. A reinforcing rib may be formed between the leg unit 201 and the support 202.

[0328] The coupling protrusion 205 may protrude from one surface of the support 202, which faces the leg unit 201 and may be prepared in a shape, corresponding to the coupling hole 184c depressed from the outer circumferential surface of the supporting unit coupling part 184b of the discharge cover 184, to be fitted to the coupling hole 184c. The coupling protrusion 205 may be detachably provided to the discharge cover 184.

[0329] An anti-vibration member 202a may be prepared in the inner surface of the support 202 to prevent transfer of vibration and impacts between the support 202 and the supporting unit coupling part 184b.

[0330] A force in the axial direction and twist in the circumferential direction, as well as the loads in the radial direction, may be exerted to the radial supporting unit 200.

[0331] Thus, the coupling protrusion 205 may be formed of a material that may be elastically deformed.

[0332] For example, the coupling protrusion 205 may be formed of rubber, e.g., a fluorine-based rubber material.

[0333] In this case, the coupling protrusion 205 and the anti-vibration member 202a may be integrally formed with each other. For example, the coupling protrusion 205 and the anti-vibration member 202a may be formed of rubber by injection molding.

[0334] The spring supports 203a and 203b may be pro-

vided at an end of the leg unit 201 supported on the inner circumferential surface of the lower shell 111 when mounted.

[0335] The spring supports 203a and 203b may include a fixed spring support 203a connected to the leg unit 201 and supporting one end of the spring 204 and a variable spring support 203b supporting the other end of the spring 204 and moved as the spring 204 extends and contracts.

[0336] The fixed spring support 203a may form a supporting surface that expands outward from the end of the leg unit 201 and supports the end of the spring 204.

[0337] To prevent the spring 204 from escaping off, the fixed spring support 203a may have a fixed protrusion that has an outer diameter corresponding to the inner diameter of the spring 204 and protrudes in the length direction of the spring 204.

[0338] The variable spring support 203b has one surface supporting the other end of the spring 204 and another surface supporting the inner circumferential surface of the lower shell 111.

[0339] To prevent the spring 204 from escaping off, the variable spring support 203b may have a fixed protrusion that has an outer diameter corresponding to the inner diameter of the spring 204 and protrudes in the length direction of the spring 204.

[0340] The other surface of the variable spring support 203b supported by the lower shell 111 may form a curved surface, e.g., a curved surface corresponding to the radius of curvature of the inner circumferential surface of the lower shell 111.

[0341] The term "fixed" as in the fixed spring support 203a and the term "variable" as in the variable spring support 203b may be appreciated as a relative movement.

[0342] In other words, fixed spring support 203a means that it maintains a fixed position with respect to the discharge cover 184 to which the radial supporting unit 200 is coupled, and variable spring support 203b means that it approaches or moves away from the discharge cover 184 in the radial direction.

[0343] When movement is described with respect to the lower shell 111, it may be appreciated that the variable spring support 203b may be prepared in a fixed position in the lower shell 111, and the position of the fixed spring support 203a may be varied.

[0344] The spring 204 may be a coil spring, and both ends thereof may be supported by the spring supports 203a and 203b.

[0345] According to the first embodiment, the radial supporting unit 200 may cause the spring 204 to buckle.

[0346] If the compressor main body significantly vibrates or a force is applied from the outside, an external force exceeding the force set for the spring 204 may be exerted, so that the spring 204 may be buckled and lose the function of supporting the main body.

[0347] If the spring 204 is formed to have an increased length to reduce the stiffness (longitudinal stiffness) in

the direction of gravity, the resistance to buckling may be reduced. Thus, reducing the longitudinal stiffness is limited.

[0348] FIG. 11 is a view illustrating a modification to the embodiment of FIG. 10.

[0349] Referring to FIG. 11, according to a modified embodiment, a radial supporting unit 200-1 is provided to address the buckling issue with the spring 204. The spring support may include a guide portion 203c, which has an end connected to the variable spring support 203b and another end movably inserted to the fixed spring support 203a, in addition to the fixed spring support 203a and the variable spring support 203b.

[0350] The guide portion 203c may extend through the center the coil spring 204 and be prepared in a length larger than the free length of the spring 204. The guide portion 203c may be prepared to be movable in the direction of compression of the spring 204.

[0351] The guide portion 203c absorbs the force applied in the direction off the compressing direction of the spring 204, preventing the spring 204 from buckling.

[0352] However, since a twist in the circumferential direction is exerted to the radial supporting unit 200-1, the guide portion 203c may be broken.

[0353] FIG. 12 is a front view illustrating a second support spring for describing a radial supporting unit 200-2 according to a second embodiment. FIG. 13 is a front view illustrating a radial supporting unit 200-2 according to the second embodiment.

[0354] Referring to FIGS. 12 and 13, according to the second embodiment, the radial supporting unit 200-2 includes two leg units 201-1 spaced apart from each other at a predetermined angle. The two leg units 201-1 are connected to two sides of one support extension 202-1.

[0355] In other words, unlike in the first embodiment in which the radial supporting unit 200 has a pair of supporting units each having one leg unit 201 and installed at a predetermined angle, described above in connection with FIGS. 7 to 10, in the second embodiment of the disclosure, the radial supporting unit 200-2 has two leg units 201-1 extending from one supporting unit.

[0356] As such, as the two leg units 201-1 are integrated with each other, structural stiffness may be secured, and the assembly tolerance may be reduced.

[0357] The radial supporting units 200, 200-1, and 200-2 described above in connection with FIGS. 7 to 12 are disposed, rather than in the direction of the load of the main body 200, but a predetermined angle apart from the direction of the load to the circumferential direction.

[0358] FIG. 14 is a front view illustrating a radial supporting unit 200-3 according to a third embodiment of the disclosure.

[0359] The support springs 116 and 117 may serve as a path along which vibration is transferred between the compressor main body and the casing 110. Thus, to effectively attenuate the transferred vibration, the longitudinal stiffness and lateral stiffness of the support springs 116 and 117 need to be small.

[0360] The supporting force of the spring structure may be represented as the product of the stiffness and the compressed length. Thus, the same supporting force may be obtained with smaller stiffness by increasing the compressed length.

[0361] Referring to FIG. 14, the third embodiment of the disclosure differs from the first and second embodiments in that there is only one radial supporting unit 200-3 that extends from the center axis downward in the six o'clock direction.

[0362] According to the third embodiment, the second support spring may reduce both the lateral stiffness and longitudinal stiffness, stably supporting the main body while reducing noise and vibration.

[0363] If the radial supporting unit 200, 200-1, and 200-2 is disposed a predetermined angle apart in the circumferential direction, from the vertical direction, reducing the longitudinal stiffness may be limited.

[0364] To reduce the longitudinal stiffness, the compressed length of the spring needs to be increased. However, in the case where the spring is disposed to be tilted from the direction of the load, if the length of the spring is increased, a buckling of the spring may be more likely.

[0365] However, if the radial supporting unit 200-3 is disposed downward in the vertical direction (the six o'clock direction), the direction of the elastically restorative force becomes consistent with the direction of the load, so that the likelihood of a buckling of the spring may be reduced, and the spring may support the load of the main body while reducing the longitudinal stiffness by increasing the compressed length of the spring.

[0366] Further, the second support spring needs to exert a supporting force not only in the direction of the load of the compressor main body but also in directions off the direction of the load.

[0367] To that end, according to the third embodiment, the second support spring may further include an axial supporting unit 210 disposed in parallel with the axial direction between the left side wall of the lower shell 111 and the discharge cover 184.

[0368] In such a structure, one radial supporting unit 200-3 may support the load of the main body with reduced longitudinal stiffness, and one axial supporting unit 210 may support the rotation or twist of the main body 200.

[0369] The axial supporting unit 210 may be prepared so that the free length (compressible length) of the spring is equal to, or smaller than, the outer diameter of the spring, preventing the spring from buckling. This is why in the case of the axial supporting unit 210, the load is exerted in the lateral direction of the spring.

[0370] The radial supporting unit 200-3 may be prepared so that the free length (compressible length) of the spring is larger than the outer diameter of the spring, reducing the longitudinal stiffness.

[0371] According to the third embodiment, the second support spring 117 uses one axial supporting unit 210 and one radial supporting unit 200-3. Thus, it is possible to reduce the number of support springs, as media for

transferring vibration, and to increase the effect of reducing vibration using low-stiffness springs as described above.

[0372] FIG. 15 is a view illustrating the vibration level according to the rigidity of a support spring.

[0373] FIG. 15 shows differences in vibration level when springs with different spring constants are used in structures with the same weight.

[0374] FIG. 15(a) shows an example in which the vibration level is 100 gal (mm/sec²) when the spring constant is 7,000 N/m, and FIG. 15(b) shows an example in which the vibration level is 55 gal (mm/sec²) when the spring constant is 4,000 N/m. In other words, if the spring stiffness reduces from 7,000 to 4,000, the vibration level reduces substantially in half.

[0375] Therefore, it may be identified that the vibration level may be reduced by decreasing the stiffness of the axial supporting unit 210 and the radial supporting unit 200.

Claims

1. A compressor (100), comprising:

a compressor main body including a cylinder (140), a piston (150) reciprocating in an axial direction of a casing (110) in the cylinder (140), and a driving unit (130) for driving the piston (150), wherein the casing (110) surrounds the compressor main body;

a first support (116) supporting a suction side of the compressor main body in the casing (110); and

a second support (117, 200, 210) supporting a discharge side of the compressor main body in the casing (110),

characterized in that

the casing (110) includes a lower shell (111) and an upper shell (112) fixed to the lower shell (111), and

a separation plane (SP) where the lower shell (111) and the upper shell (112) are fixed is inclined from a horizontal center line (HCL) of the casing (110) as viewed in the axial direction of the casing (110).

2. The compressor (100) of claim 1, wherein the inclination angle (θ) of the separation plane (SP) ranges from 20° to 70°.

3. The compressor (100) of claim 1 or 2, wherein the lower shell (111) and the upper shell (112) each include side walls (SW1, SW2) on both sides thereof in the axial direction of the casing (110).

4. The compressor (100) of any one of claims 1 to 3, wherein as viewed in the axial direction of the casing

(110), at least one of two opposite ends of the separation plane (SP) is positioned above the horizontal center line (HCL) of the casing (110).

5. The compressor (100) of any one of claims 1 to 4, wherein the lower shell (111) includes a terminal (30) for transferring external power to a motor assembly of the compressor (100).

6. The compressor (100) of claim 5, wherein the terminal (30) is installed in the lower shell (111) at an end, positioned relatively higher, of the two opposite ends of the separation plane (SP).

7. The compressor (100) any one of claims 1 to 6, wherein each of the first support (116) and the second support (117) includes a leaf spring.

8. The compressor (100) any one of claims 1 to 6, wherein the first support (116) includes a leaf spring, and

wherein the second support (117) includes an axial supporting unit (210) elastically deforming in the axial direction or a direction adjacent to the axial direction and a radial supporting unit (200) elastically deforming in a radial direction perpendicular to the axial direction or a direction adjacent to the radial direction.

9. The compressor (100) of claim 8, wherein the axial supporting unit (210) includes a first side supported by the compressor main body and a second side supported by a side wall of the lower shell (111), and wherein the radial supporting unit (200) includes a first side supported by the compressor main body and a second side supported by a body portion of the lower shell (111).

10. The compressor (100) of claim 8 or 9, wherein the compressor main body includes an outlet cover assembly (180, 190),

wherein a suction pipe (114) through which a coolant is sucked is connected to a side in the axial direction of the outlet cover assembly (180, 190), and an discharge pipe (115) through which the coolant compressed in the cylinder (140) is discharged to another side in the axial direction of the outlet cover assembly (180, 190),

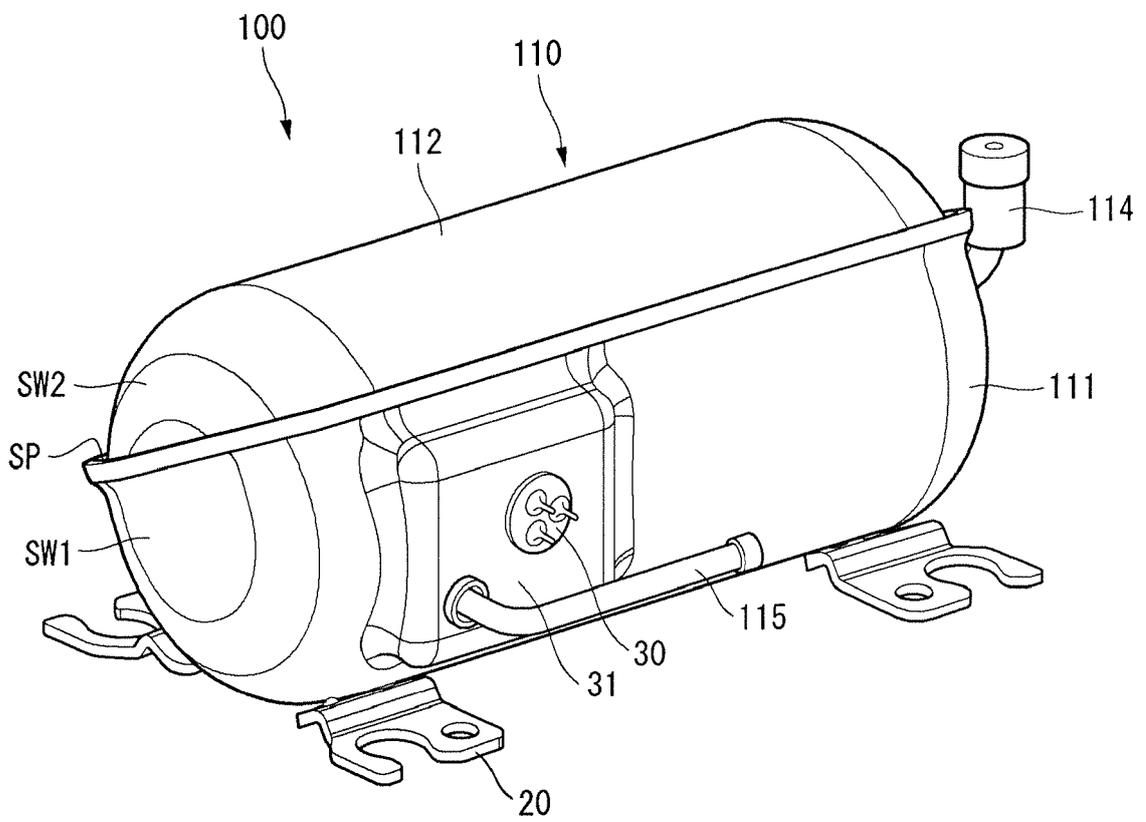
wherein the axial supporting unit (210) is supported to the outlet cover assembly (180, 190) in the axial direction or the direction adjacent to the axial direction, and

wherein the radial supporting unit (200) is supported to the outlet cover assembly (180, 190) in the radial direction or the direction adjacent to the radial direction.

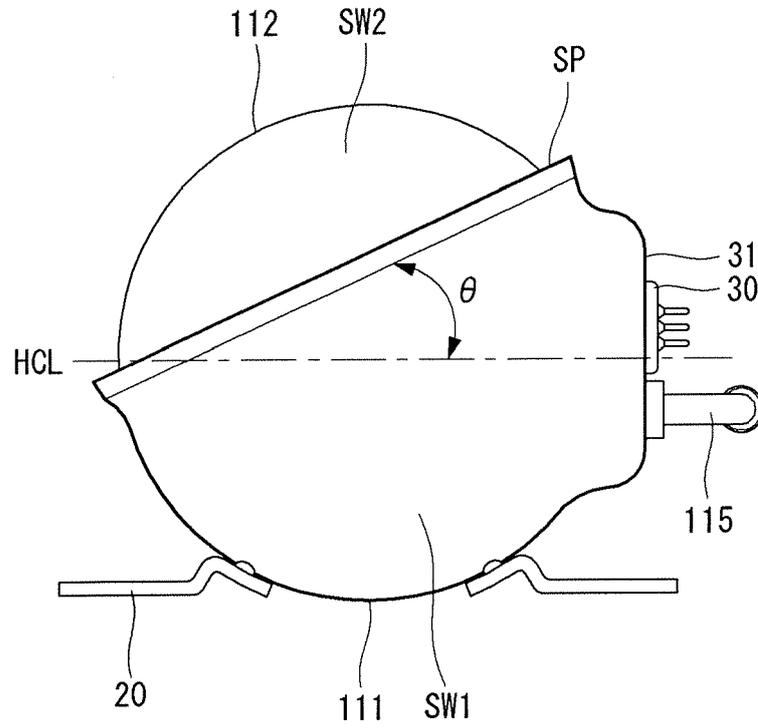
11. The compressor (100) of claim 10, wherein an outlet

- cover (181, 182, 183, 184) of the outlet cover assembly (180) forms a supporting unit coupling part (184b) projecting in the axial direction, wherein an end of the axial supporting unit (210) is seated in a groove (184a) formed in a side of the supporting unit coupling part (184b), wherein the radial supporting unit (200) is seated on an outer surface of the supporting unit coupling part (184b), wherein the axial supporting unit (210) includes a coil spring, and wherein an end of the coil spring is seated in the groove of the supporting unit coupling part (184b). 5 10
- 12.** The compressor (100) of claim 11, wherein the radial supporting unit (200) includes a coupling member (202, 205) coupled to the supporting unit coupling part (184b), a leg unit (201, 201-1) connected to the coupling member (205) and extending in the axial direction or the direction adjacent to the axial direction, a spring support (203a, 203b) provided in an end of the leg unit (201, 201-1), and a coil spring (204) supported by the spring support (203a, 203b) and compressed in the radial direction or the direction adjacent to the radial direction. 15 20 25
- 13.** The compressor (100) of claim 8, wherein the radial supporting unit (200) includes a plurality of coil springs (204) compressed in a direction inclined by a predetermined angle from a load direction of the compressor main body as viewed in the axial direction, and wherein the plurality of coil springs (204) are arranged at angles opposite to the load direction. 30 35
- 14.** The compressor (100) of claim 13, wherein the radial supporting unit (200) includes a coupling member (202, 205) coupled to the compressor main body, a leg unit (201, 201-1) connected to the coupling member and extending in the axial direction or the direction adjacent to the axial direction, a spring support (203a, 203b) provided in an end of the leg unit (201, 201-1), and wherein each of the plurality of coil springs (204) is supported by the spring support (203a, 203b) and compressed in the radial direction or the direction adjacent to the radial direction. 40 45
- 15.** The compressor (100) of claim 14, wherein the leg unit (201-1) includes a first side connected to the coupling member (202, 205) and a second side branching into two legs and extending at angles symmetrical to each other with respect to the load direction, and wherein the spring supporting unit (203a, 203b) and the each of the plurality of coil springs (204) are formed corresponding to each of the two legs of the leg unit (201-1). 50 55

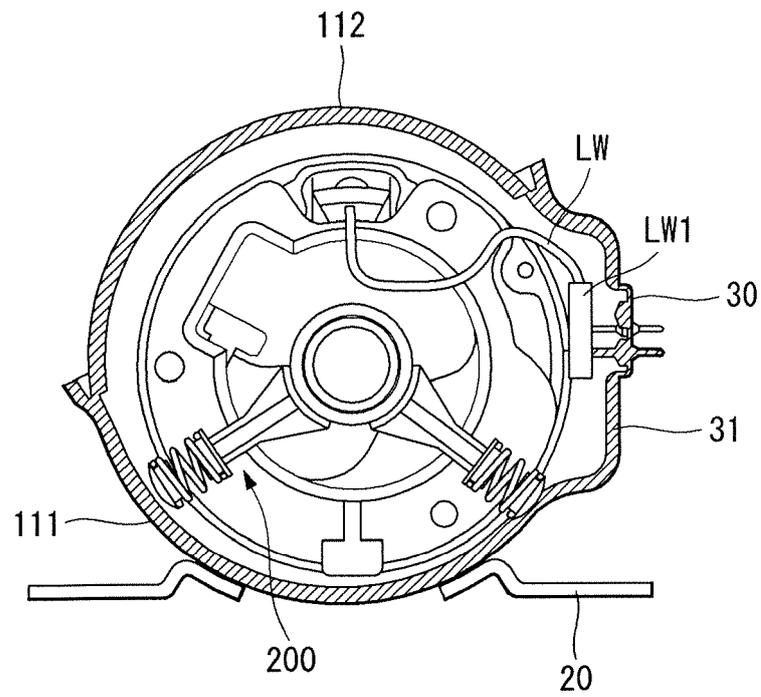
【FIG. 1】



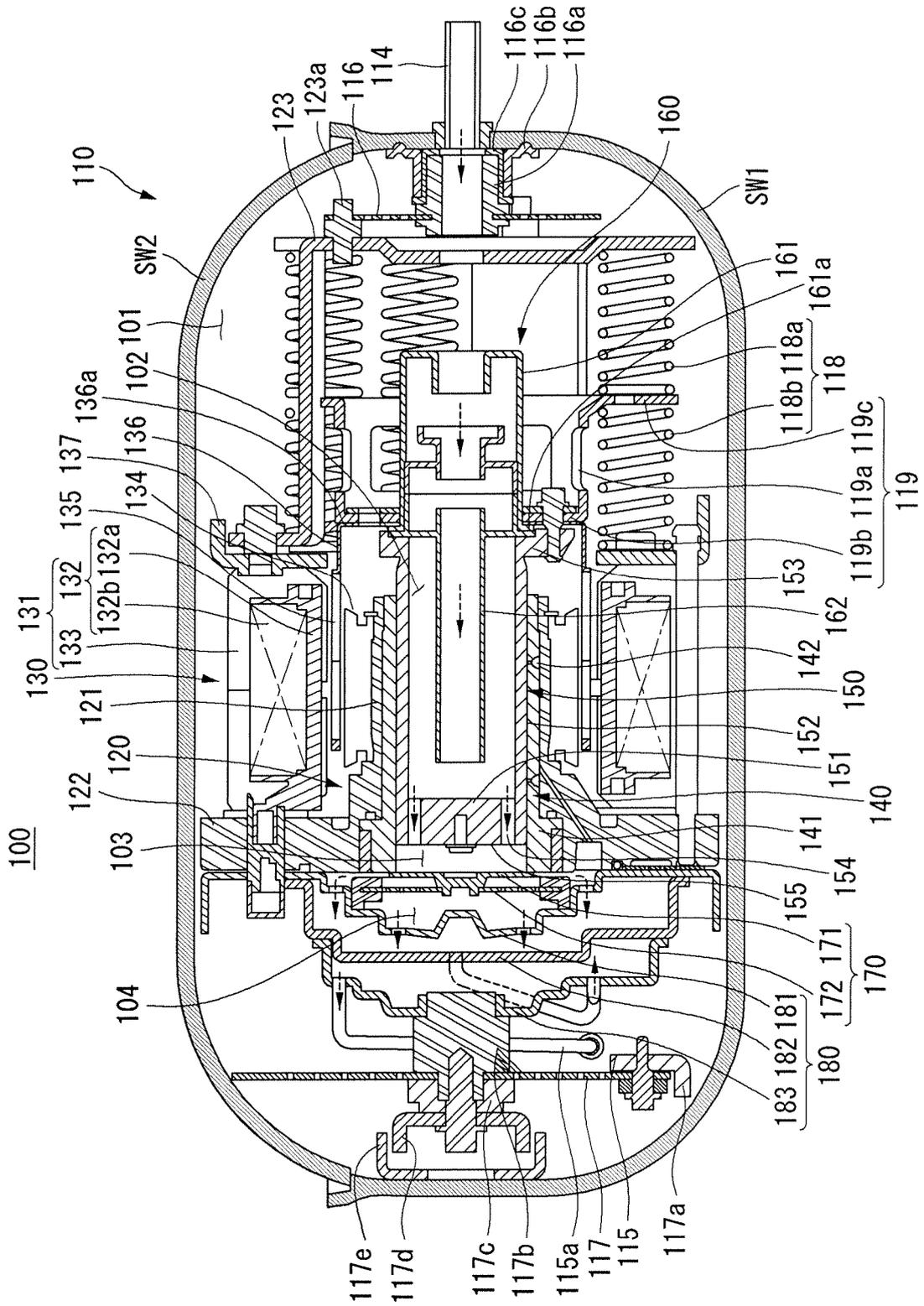
【FIG. 2】



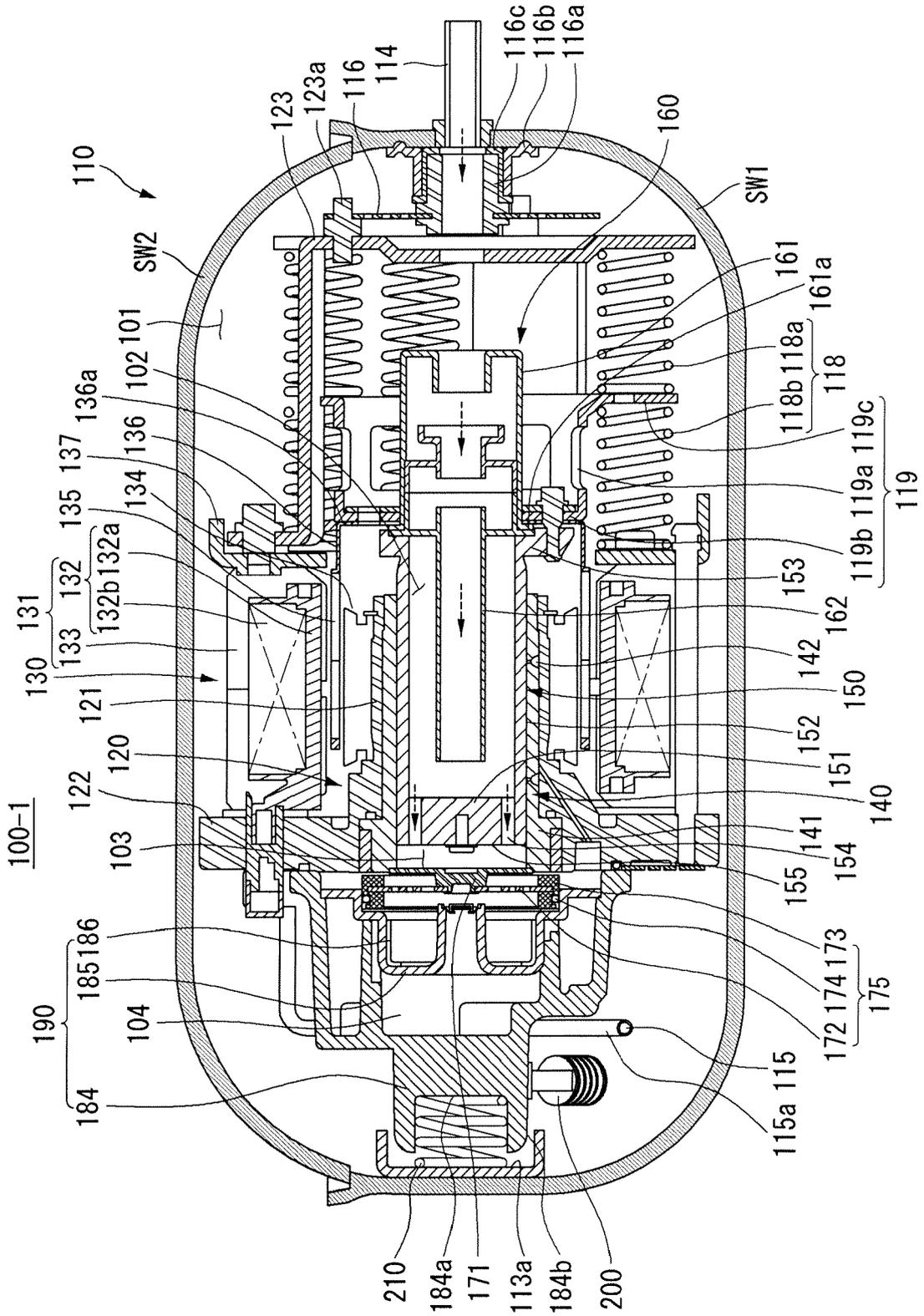
【FIG. 3】



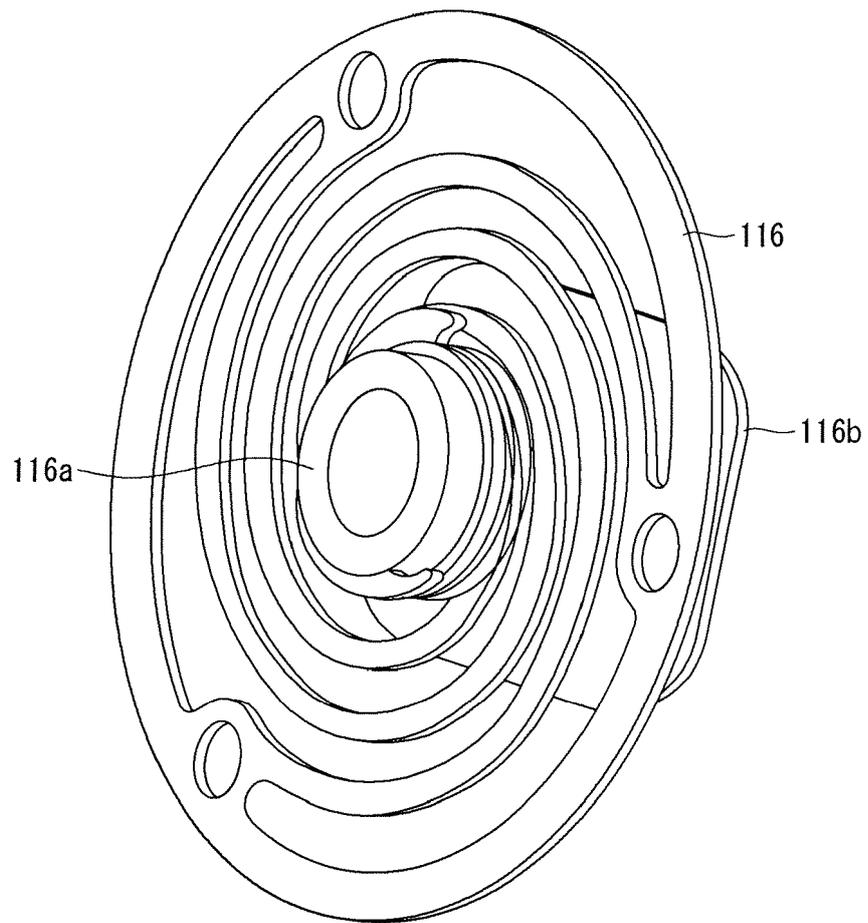
【FIG. 4】



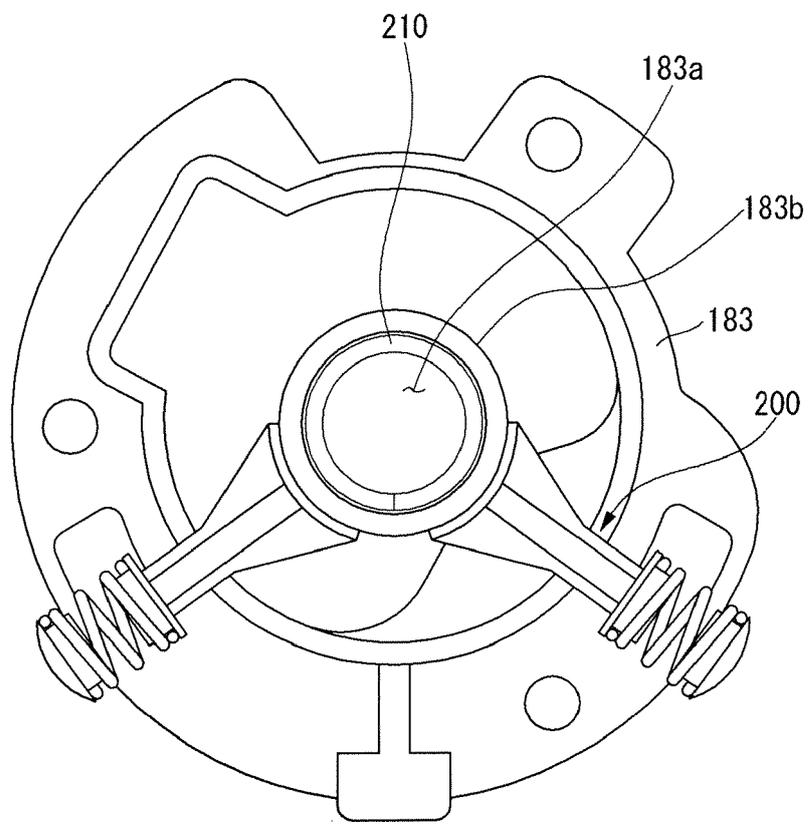
【FIG. 5】



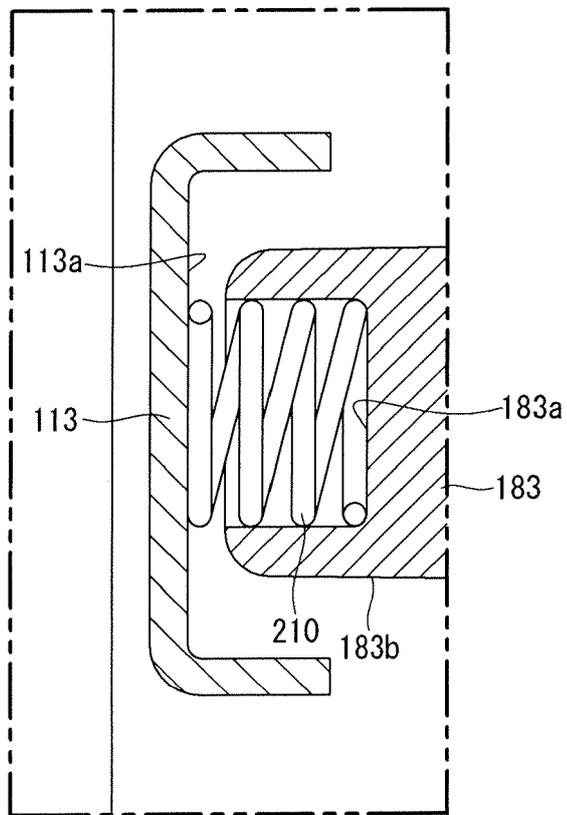
【FIG. 6】



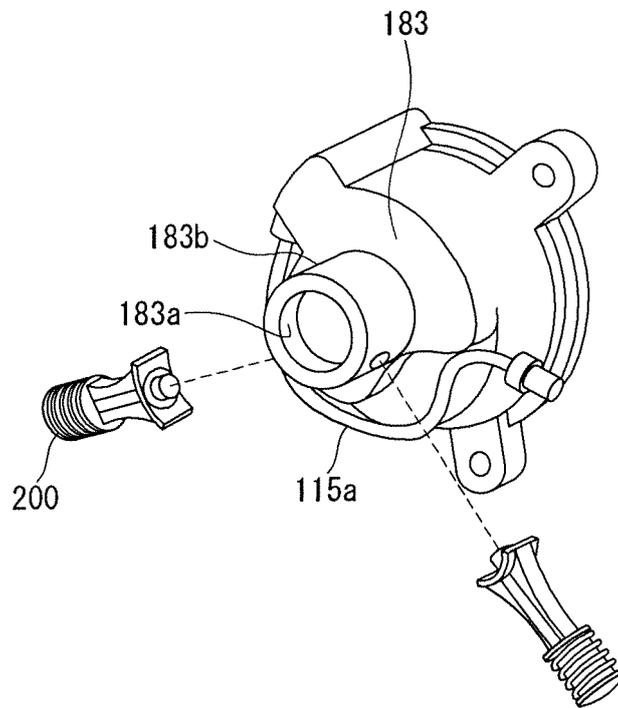
【FIG. 7】



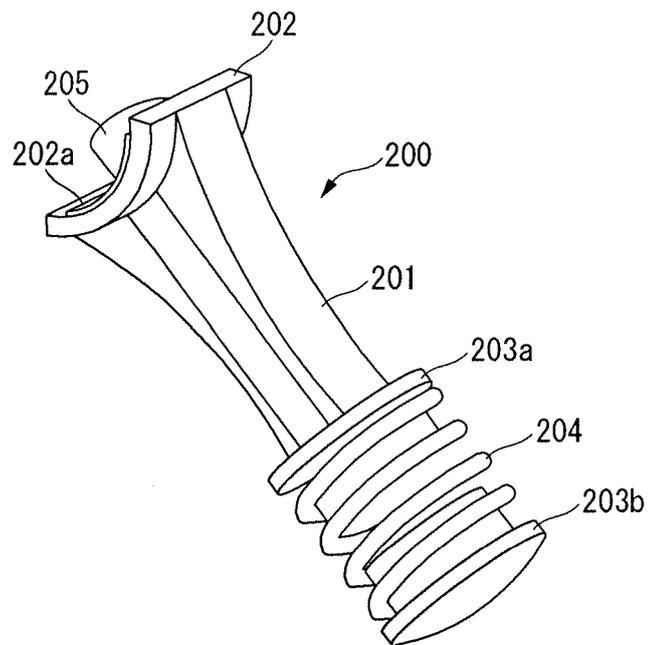
【FIG. 8】



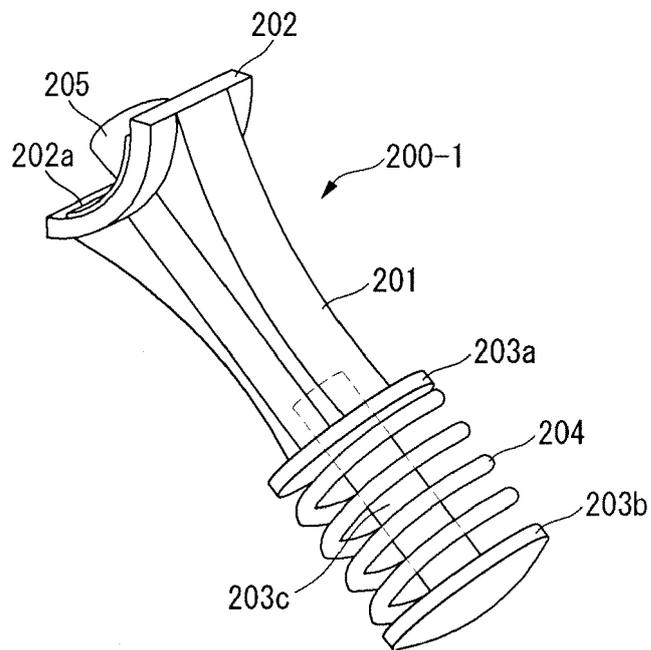
【FIG. 9】



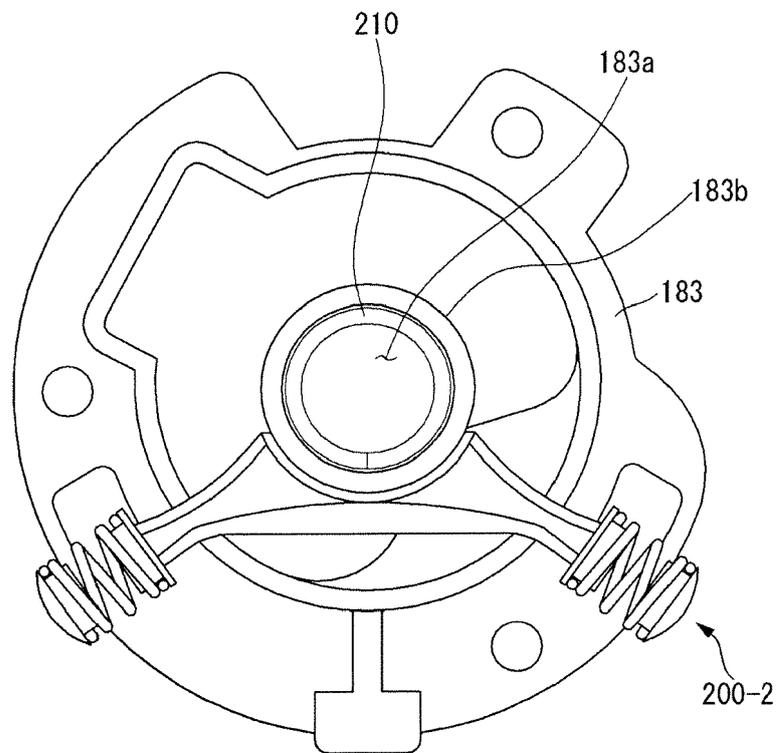
【FIG. 10】



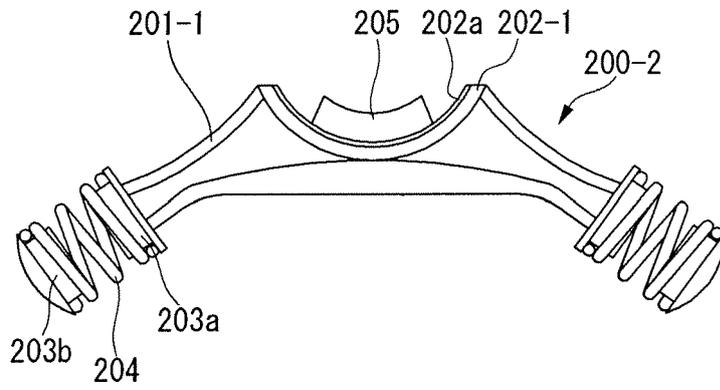
【FIG. 11】



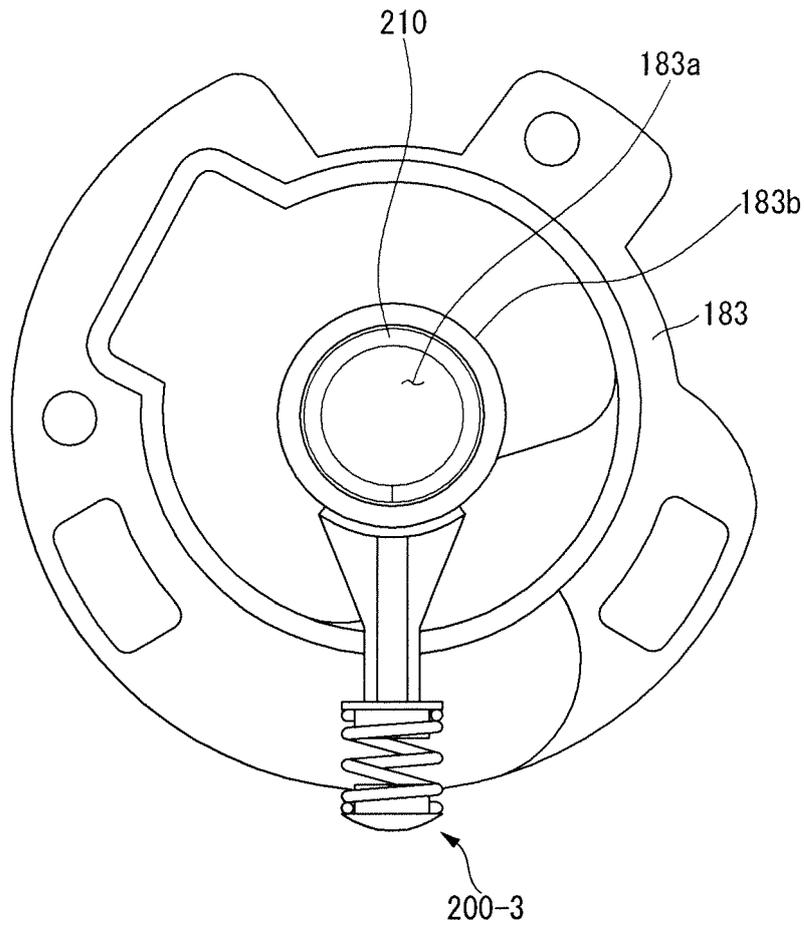
【FIG. 12】



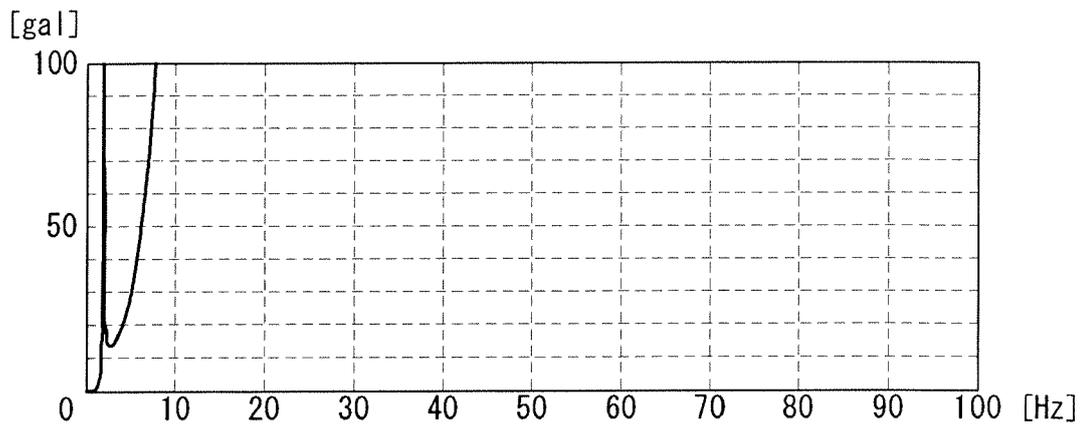
【FIG. 13】



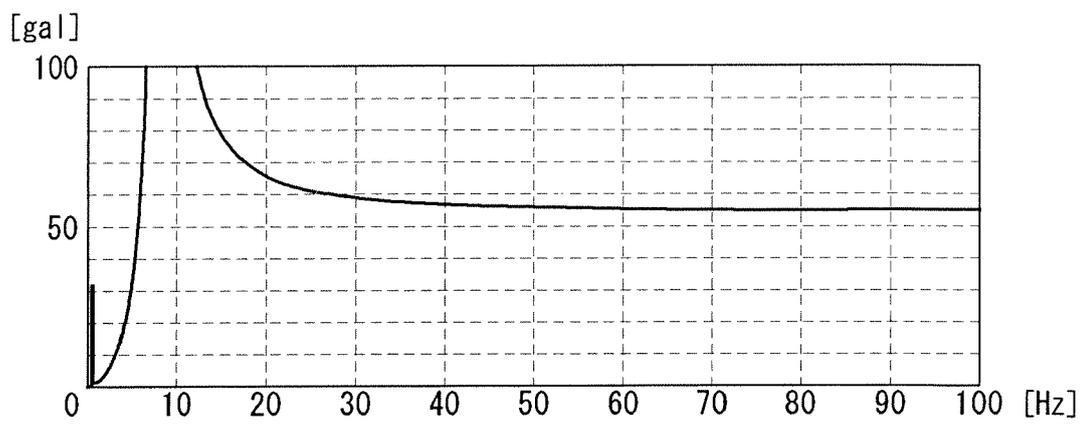
【FIG. 14】



【FIG. 15】



(a)



(b)



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Application Number
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A	* figures 1-9 * * paragraph [0021] - paragraph [0112] *	1-6,8-15	
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Place of search Munich		Date of completion of the search 25 November 2020	Examiner Ricci, Saverio
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