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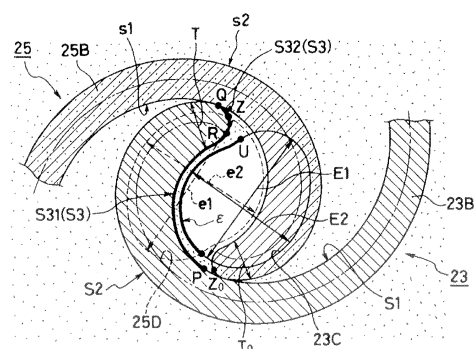
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(54) **SCROLL COMPRESSOR**

(57) Provided is a scroll compressor which can enhance the strength of an end plate facing a through-hole in the vicinity of the base of the lap tip portion of a fixed scroll and hence provide enhanced reliability and durability. A concave curved surface S32 of a non-involute surface S3 formed between the start point P of an inner involute surface S1 constituting a lap 23B of a fixed scroll 23 and the start point Q of an outer involute surface S2 is formed in a curved surface shape having a smaller radius of curvature. The opening shape of the periphery of a through-hole 23C in a close region ε facing the concave curved surface S32 is formed with a curved surface having a smaller radius of curvature than the radius r of curvature of the concave curved surface S32, the through-hole being formed at the spiral center or the tip portion of the lap 23B of the fixed scroll 23. A distance to hole L is ensured to be as long as possible, where the distance to hole L is the length between the base of a vertex Z of the convex curved surface S32 of the non-involute surface S3 and a maximum proximity edge U of the through-hole 23C facing the base of the lap tip portion Z.

FIG. 8



Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to scroll compressors and more particularly, to a scroll compressor which can be increased in the strength of a lap central portion without degradation in compression performance.

BACKGROUND

10 **[0002]** Conventionally, as an example of a compressor for compressing a refrigerant in a refrigeration cycle, for example, a scroll type compressor is known (for example, see Patent Literature 1).

[0003] As shown in Fig. 9, the scroll type compressor 100 includes a compression vessel 110 which is formed in a cylindrical shape extending in the vertical direction and in which there are disposed on the upper side a compression element 114 for compressing a refrigerant and on the lower side an electrical driving element 115 for driving the compression element 114.

15 **[0004]** The compression element 114 includes a fixed scroll 119 and a rocking scroll 120, and laps 132 and 139 of the fixed scroll 119 and the rocking scroll 120 are meshed with each other so as to form a plurality of compression spaces 121 therebetween.

[0005] The fixed scroll 119 is secured to a casing. On the other hand, the movable scroll 120 meshing with the fixed scroll 119 from below is integrally coupled to a driving shaft 123 by fitting an eccentric shaft section 123A of the driving shaft 123 into a bearing portion 122 provided on the lower surface. Then, the movable scroll 120 rotationally driven by drive force from a motor 127 revolves relative to the fixed scroll 119 without rotating, thereby reducing the volume of the compression spaces 121 formed between both the laps 132 and 139 so as to compress a refrigerant therein.

20 **[0006]** In the scroll type compressor 100 configured in this manner, a refrigerant intake pipe 117 is directly connected to an intake port 111 of the compression element 114, and the compression vessel 110 includes a high-pressure side space 113 which is filled with a high-pressure refrigerant compressed by the compression element 114. Furthermore, the compression vessel 110 has a bottom portion serving as an oil reservoir 116 in which a lubricating oil for lubricating the compression element 114 and the like is stored. On the other hand, the compression vessel 110 is provided on the side thereof with a refrigerant intake pipe 117 for drawing the refrigerant into the aforementioned compression element 114 and a refrigerant discharge pipe 118 for discharging the refrigerant compressed by the compression element 114 out of the compressor.

25 **[0007]** Furthermore, in the scroll type compressor, there is formed an oil path 144 for allowing a lubricating oil to pass through a rotation axis 123 in order to supply the lubricating oil to the compression element 114 and bearings 128, 141, and 149 on the rotation axis 123. The oil path 144 is formed in the axial direction of the rotation axis 123 and includes a lubricating oil intake port 145 formed at the lower end of the rotation axis 123 and a paddle 146 formed above the intake port 145. The oil path 144 also includes oil feed ports 147 for supplying the lubricating oil to the position corresponding to the respective bearings.

30 **[0008]** When the rotation axis 123 is rotated, the lubricating oil stored in the oil reservoir 116 enters the oil path 144 through the intake port 145 of the rotation axis 123 and is drawn up along the paddle 146 in the oil path 144. Then, the drawn lubricating oil lubricates each of the bearings 128, 141, and 149 through each oil feed port 147. Furthermore, the lubricating oil drawn up to a boss receiving section 142 is directed to the outer peripheral portion of a mainframe through a return pipe (not shown) formed in the mainframe and then discharged from a discharge port (not shown) formed in the outer peripheral portion, thereby allowing the lubricating oil to be fed back to the oil reservoir 116.

45 PRIOR ART DOCUMENT

Patent Literature

50 **[0009]** Patent Literature 1: Japanese Patent Application Laid-Open No. 2008-50986

SUMMARY OF INVENTION

PROBLEMS TO BE SOLVED BY INVENTION

55 **[0010]** In such a scroll type compressor, the compression portion surrounded by the Lap of the fixed scroll and the lap of the movable scroll is composed of spaces formed by both the laps meshing with each other, where a discharge port that penetrates the end plate of the fixed scroll in the thickness direction is formed at the spiral center or the lap tip portion of the fixed scroll.

[0011] Then, the spiral center at the tip portion surrounded by both the laps of the fixed scroll and the movable scroll is configured such that the refrigerant gas is compressed into a high-pressure state while being fed from peripheral compression portions to central compression portions. Thus, in particular, the vicinity of the base of the spiral center of the lap relatively reduced in thickness on the end plate facing the discharge port is fragile in terms of strength and has

[0012] In other words, this is because the inner surface and the outer surface of the lap of the spiral portion at the center of the fixed scroll receive significantly different pressures from the compressed refrigerant gas, causing stress to act in a concentrated manner upon the root of the inner surface of the lap at the tip portion.

[0013] In this context, in view of the aforementioned circumstances, an object of the present invention is to provide a scroll compressor which can be enhanced in strength in the vicinity of the base of the lap tip portion of the fixed scroll on the end plate facing the through-hole, and hence enhanced in reliability and durability.

MEANS FOR SOLVING PROBLEMS

[0014] The aforementioned object is achieved by the following features.

(1) A scroll compressor of the present invention including a fixed scroll secured inside a casing and a movable scroll to mesh with the fixed scroll, the scroll type compressor compressing a space formed between both laps of these scrolls, the scroll compressor being characterized in that the fixed scroll on a lap tip side is greater in thickness than the movable scroll on a lap tip side.

(2) Furthermore, the scroll compressor according to (1) above characterized in that a non-involute surface which is composed of an inner non-involute surface being a concave curved surface and an outer non-involute surface being a convex curved surface is formed between a start point of an inner involute surface and a start point of an outer involute surface, which constitute the lap of the fixed scroll; the non-involute surface is configured such that the inner non-involute surface being the concave curved surface is formed to be a curved surface having a smaller radius of curvature, and a through-hole constituting a discharge port formed at a spiral center being a lap tip portion of the fixed scroll is formed in a manner such that an opening shape thereof in a close region facing the inner non-involute surface being the concave curved surface has a curved surface having a smaller radius of curvature than that of the inner non-involute surface being the concave curved surface; and a distance to hole between a maximum proximity edge, of a periphery of the through-hole, facing a base of the lap tip portion of the fixed scroll in the closest proximity thereto and the base of the lap tip portion of the fixed scroll is configured to be as long as possible.

(3) Furthermore, the scroll compressor according to (1) or (2) above characterized in that on an end plate in the vicinity of the periphery of the through-hole constituting the discharge port and formed at the spiral center or the lap tip portion of the fixed scroll, a vertical wall erected from a maximum proximity edge of the periphery of the through-hole facing the base of the lap tip portion in the closest proximity thereto is increased in height.

(4) The scroll compressor according to (3) above characterized in that the height of the vertical wall of the through-hole is formed to be approximately two times a thickness of a portion of the lap of the fixed scroll facing a medium-pressure chamber.

(5) The scroll compressor according to any one of (1) to (4) above characterized in that the movable scroll includes a recess at the spiral center being the lap tip portion, the recess forming a dummy port with at least part thereof always overlapping the through-hole of the fixed scroll, and the recess is formed to be greater in size than the through-hole, and the through-hole of the fixed scroll and the recess of the movable scroll are formed to have a positional relation of being 180 degrees out of phase with each other.

(6) The scroll compressor according to any one of (2) to (5) above characterized in that the non-involute surface is formed without changing positions of both the start points of the inner involute surface and the outer involute surface.

EFFECTS OF INVENTION

[0015] According to the scroll compressor of (1) above, an end plate portion facing the through-hole in the vicinity of the base of the lap tip portion of the fixed scroll is formed to have an increased thickness, and by that amount of increase in thickness, the strength of the portion can be enhanced, and hence the reliability and durability of the fixed scroll can be advantageously enhanced.

[0016] According to the scroll compressor of (2) above, it is possible to make, as long as possible, the distance to hole between the maximum proximity edge of the peripheral portion of the through-hole of the fixed scroll, the maximum proximity edge facing the base of the lap tip portion of the fixed scroll in the closest proximity thereto, and the base of the lap tip portion. This can further enhance the strength of the root of the lap tip portion of the fixed scroll on the end plate facing the through-hole and hence advantageously provide further enhanced reliability and durability for the fixed

scroll.

[0017] According to the scroll compressor of (3) above, the vertical wall of the through-hole erected from the peripheral portion facing the base of the lap tip portion of the fixed scroll is formed to have an increased height, whereby the end plate facing the through-hole at the root of the lap tip portion of the fixed scroll is increased in thickness, thus advantageously further enhancing the strength of the fixed scroll by that amount.

[0018] According to the scroll compressor of (4) above, the height of the vertical wall of the through-hole is formed to be approximately two times the thickness of the portion of the lap of the fixed scroll facing the medium-pressure chamber, thus advantageously further enhancing the strength of the end plate facing the through-hole at the root of the lap tip portion of the fixed scroll.

[0019] According to the scroll compressor of (5) above, the movable scroll is provided with the recess that forms the dummy port, thereby advantageously controlling the timing at which the refrigerant gas is discharged from the compression chamber.

[0020] According to the scroll compressor of (6) above, it is possible to provide an enhanced strength to the base of the center tip portion without changing the designed compression ratio of the spiral.

BRIEF DESCRIPTION OF DRAWINGS

[0021]

Fig. 1 is a longitudinal sectional view illustrating a scroll compressor according to an embodiment of the present invention.

Fig. 2 is an explanatory view illustrating the state of the lower surface of the fixed scroll of the scroll compressor shown in Fig. 1.

Fig. 3 is a plan view illustrating the state of the upper surface of the movable scroll of the scroll compressor.

Fig. 4 is a cross-sectional view illustrating the state of the periphery of a communication passage of the scroll compressor.

Fig. 5(A) is an enlarged view illustrating a main portion near the lap tip portion of the fixed scroll of the scroll compressor and Fig. 5(B) is an enlarged view illustrating a main portion near the lap tip portion of the fixed scroll (the fixed scroll according to Specification 1 shown in Table 1) of a generally typical scroll compressor as a comparative example.

Fig. 6 (A) is a cross-sectional view taken along line VIA-VIA in the direction of the arrows in Fig. 5(A) and Fig. 6(B) is a cross-sectional view taken along line VIB-VIB in the direction of the arrows in Fig. 5(B).

Fig. 7 is an explanatory view illustrating a curved surface shape near the lap tip portion of the fixed scroll of the scroll compressor shown in Fig. 1.

Fig. 8 is an explanatory view illustrating the relation between a through-hole and a dummy port of the movable scroll in the vicinity of the lap tip portion of the fixed scroll shown in Fig. 7 as well as the relation between the lap thicknesses of both the scrolls.

Fig. 9 is a cross-sectional view illustrating the configuration of a conventional typical scroll type compressor.

DESCRIPTION OF EMBODIMENTS

[0022] Hereinafter, the present invention will be described below in more detail with reference to the accompanying drawings in accordance with an embodiment.

[0023] Fig. 1 shows a scroll compressor 1 according to an embodiment of the present invention which provides a high internal pressure. The compressor 1 is connected to a refrigerant circuit (not illustrated) in which a refrigerant is circulated to perform a refrigeration cycle and is configured to compress the refrigerant by inverter control.

[0024] The compressor 1 has a vertically elongated cylindrical enclosed dome-shaped casing 3. The casing 3 with a hollow space provided therein has a pressure vessel which is constituted of: a casing body 5 which is a cylindrical barrel section having an axial line extending in the vertical direction; a bowl-shaped upper cap 7 which is hermetically welded to and thereby integrated with the top end thereof and has a convex surface protruded upwardly; and a bowl-shaped lower cap 9 which is hermetically welded to and thereby integrated with the lower end of the casing body 5 and has a convex surface protruded downwardly.

[0025] The casing 3 includes a scroll compressor mechanism 11 for compressing the refrigerant and a driving motor 13 disposed below the scroll compressor mechanism 11. The scroll compressor mechanism 11 and the driving motor 13 are connected to each other by a driving shaft 15 that is disposed to extend through the casing 3 in the vertical direction. There is also formed a high-pressure space 17 or a gap space between the scroll compressor mechanism 11 and the driving motor 13.

[0026] The scroll compressor mechanism 11 includes: a housing 21 being a generally bottomed cylindrical storage

member which is opened upwardly; a fixed scroll 23 which is bolted to the upper surface of the housing 21 in a condition appressed thereto; and a movable scroll 25 disposed between the fixed scroll 23 and the housing 21 and meshing with the fixed scroll 23. The housing 21 is secured, on the outer peripheral surface thereof, to the casing body 5. Furthermore, the casing 3 is partitioned into the high-pressure space 17 below the housing 21 and a discharge space 29 above the housing 21, where the spaces 17 and 29 are in communication with each other through a vertical groove (not illustrated) which is formed to extend vertically through the outer periphery of the housing 21 and the fixed scroll 23.

[0027] The driving motor 13 includes an annular stator 13A secured to the inner wall surface of the casing 3 and a rotor 13B disposed rotatably inside the stator 13A. The motor 13, which is a DC inverter-controlled motor, is configured such that the rotor 13B is drivingly connected with the movable scroll 25 of the scroll compressor mechanism 11 through the driving shaft 15.

[0028] Below the driving motor 13 there is provided a lower space 91 which is maintained at a high pressure, and the inner bottom portion of the lower cap 9 corresponding to the lower end portion thereof serves as an oil reservoir. The driving shaft 15 includes an oil supply path 15B that is formed as part of high-pressure oil supply means, and the oil supply path 15B is in communication with an oil chamber 52 behind the movable scroll 25. The driving shaft 15 is connected at the lower end with a pickup (not illustrated), so that the pickup scoops up the oil stored in the inner bottom portion of the lower cap 9. The scooped oil is supplied through the oil supply path 15B of the driving shaft 15 to the oil chamber 52 behind the movable scroll 25. Then, the oil is supplied from the oil chamber 52 through a communication passage 51 and a communication hole 53 (refer to Fig. 7), to be discussed later, provided in the movable scroll 25, to an oil groove 23D on the side of the fixed scroll 23. Subsequently, the oil is supplied from the oil groove 23D to the respective sliding parts and a compression chamber 27 in the scroll compressor mechanism 11 (refer to Fig. 3).

[0029] The housing 21 includes a support section 21A in which an eccentric shaft section 15A of the driving shaft 15 is rotated and a radial bearing part 21B extending downwardly from the center of the lower surface of the support section 21A. Furthermore, the housing 21 is provided with a radial bearing 21C which penetrates between the lower end of the radial bearing part 21B and the bottom surface of the support section 21A. Furthermore, in the vicinity of the outer peripheral portion of the support section 21A toward the lower surface, a thin plate-shaped oil collector 24 for preventing a lubricating oil from entering into a discharge pipe (not illustrated) is vertically provided along the inner peripheral surface of the casing body 5.

[0030] The upper cap 7 of the casing 3 is provided with an intake pipe (not illustrated) for drawing the refrigerant in the refrigerant circuit into the scroll compressor mechanism 11 and the casing body 5 is provided with a discharge pipe for discharging the refrigerant in the casing 3 out of the casing 3, the pipes each hermetically secured thereto in a penetrating manner. The intake pipe extends in the vertical direction in the discharge space 29, so that the inner end portion thereof penetrates through the fixed scroll 23 of the scroll compressor mechanism 11 so as to communicate with the compression chamber 27. The intake pipe draws the refrigerant into the compression chamber 27.

[0031] As shown in Figs. 1 and 2, the fixed scroll 23 is made up of: an end plate 23A; a spiral (involute) lap 23B formed on the lower surface of the end plate 23A; and a through hole 23C which is pierced through the end plate at the spiral (involute) center of the lap 23B and which forms the discharge port that is opened toward a discharge valve 22. Furthermore, the top end face of the lap 23B of the fixed scroll 23 (a lower surface 233; refer to Fig. 4) particularly toward the refrigerant inlet has the oil groove 23D having a reduced width and engraved on the lower surface 233, the top end face slidingly facing an end surface 250 (refer to Fig. 1) that is the upper surface of the movable scroll 25.

[0032] On the other hand, as shown in Fig. 3, the movable scroll 25 is made up of: an end plate 25A; a spiral (involute) lap 25B formed on the upper surface of the end plate 25A; and a recess 25D that constitutes a dummy port for controlling the timing at which a refrigerant gas in the compression chamber 27 under a high pressure is discharged toward the discharge space 29, the recess 25D being formed in a concave shape at the spiral (involute) center of the lap 25B. Then, the lap 23B of the fixed scroll 23 and the lap 25B of the movable scroll 25 mesh with each other, forming a plurality of compression chambers 27 between both the laps 23B and 25B (refer to Fig. 1).

[0033] As shown in Fig. 4, the movable scroll 25 is configured such that a flow limiting member (pin member) 55 is inserted into the communication passage 51, to be discussed later. The pin 55 is made up of a first pin 55A that is fitted into a pilot hole 51A located downstream of the communication passage 51 and a second pin 55B that is in contact with the first pin 55A and fitted into an insert hole 51B located upstream of the communication passage 51. A screw with a hexagonal hole (not illustrated) is screwed into a female screw hole 51C so as to push the second pin 55B and the first pin 55A integrally against the downstream end, allowing the screw to block one end of the insert hole 51B (the left end in Fig. 4). Furthermore, the screw is secured with an adhesive or the like to prevent the screw from loosening.

[0034] As shown in Fig. 1, the movable scroll 25 is supported by the fixed scroll 23 with an Oldham ring 61 therebetween and provided with a bottomed cylindrical boss section 25C in a protruding manner at the center of the lower surface of the end plate 25A. On the other hand, the driving shaft 15 is provided at the upper end thereof with the eccentric shaft section 15A, and the eccentric shaft section 15A is rotatably fitted into the boss section 25C of the movable scroll 25.

[0035] Furthermore, as shown in Fig. 4, the movable scroll 25 is provided with the communication passage 51 that is formed in the end plate 25A and has one end opened outwardly and extending linearly inwardly. The communication

passage 51 forms the pilot hole 51A of the communication passage that has one end opened outwardly. The pilot hole 51A is reamed from the one end to a predetermined depth so as to form the insert hole 51B of the predetermined depth. Furthermore, the inlet port of the insert hole 51B is threaded to form the female screw hole 51C. The other end (high-pressure opening) 51D of the communication passage 51 is in communication with the oil chamber (the high-pressure section in the hermetically sealed container) 52 behind the movable scroll 25 described above. Furthermore, the communication passage 51 is provided on the inner peripheral surface of the inlet port thereof with the communication hole 53 that is an opening having a perfect circular shape.

[0036] The communication hole 53 is formed in the end plate 25A of the movable scroll 25 near the entrance facing a low-pressure section 27A of the compression chamber so as to penetrate in the thickness direction to the end surface 250, thus being opened to face the fixed scroll 23.

[0037] Furthermore, the driving shaft 15 below the radial bearing part 21B of the housing 21 is provided with a counterweight part 16 to keep the movable scroll 25 and the eccentric shaft section 15A in dynamic balance, so that the driving shaft 15 is rotated while being kept in weight balance by the counterweight part 16, thereby allowing the movable scroll 25 to revolve without rotating. Then, the compression chamber 27 is configured such that as the movable scroll 25 revolves, the volume between both the laps 23B and 25B is contracted toward the center, thereby compressing the refrigerant drawn through the intake pipe.

[0038] The fixed scroll 23 is provided at the center thereof with the through-hole 23C that constitutes the discharge port, so that the gas refrigerant discharged through the through-hole 23C is discharged into the discharge space 29 through the discharge valve 22. Then, the gas refrigerant is allowed to flow into a space out of the oil collector 24 in the high-pressure space 17 below the housing 21 through a vertical groove (not illustrated) provided in the outer periphery of each of the housing 21 and the fixed scroll 23. The high-pressure refrigerant is finally discharged out of the casing 3 through the discharge pipe provided on the casing body 5.

[0039] Next, referring particularly to Figs. 5 to 8, a description will be made to a characteristic structure of the present invention, that is, the structure of the through-hole 23C as well as the spiral (involute) tip Z of the lap 23B of the fixed scroll 23, in other words, the shape near a point Z being the vertex of a convex curve S32 on a non-involute surface S3, to be discussed later, that is, the shape of the portion that faces the through-hole 23C.

[0040] Note that it has been confirmed by the analysis according to the finite element method (FEM) that for example, on an end plate 23'A of a typical fixed scroll 23' shown in Fig. 5(B), a portion facing a through-hole 23'C near a tip portion Z' of a lap 23'B in the closest proximity thereto (refer to Fig. 5(B)) forms the maximum stress bearing portion during the operation of the scroll type compressor. In this regard, as will be discussed in more detail later, the end plate 23A of the fixed scroll 23 shown in Fig. 5 (A) according to this embodiment is configured such that the portion equivalent to that mentioned above is provided with a significantly improved physical strength, the portion facing the through-hole 23C near the tip portion Z of the lap 23B in the closest proximity thereto (refer to Fig. 5(A)).

[0041] Furthermore, in Fig. 8, symbols s1 and s2 denote an inner involute surface and an outer involute surface of the movable scroll 25, respectively. Furthermore, symbols E1 and E2 denote the length of the major axis and the length of the minor axis orthogonal thereto of the through-hole 23C of the fixed scroll 23, respectively. Furthermore, symbols e1 and e2 denote the length of the major axis of the recess 25D of the movable scroll 25 and the length of the orthogonal axis orthogonal thereto, respectively.

[0042] The lap 23B is formed to be greater in height ($h + \Delta h$) than the height (h) of the one according to Specification 1 shown in Table 1, to be discussed later, so as to enable the compressor to provide higher output. Furthermore, as shown in Fig. 7, the tip portion Z of the lap 23B has the non-involute surface S3 which is formed on a region α (refer to Fig. 5(A)) between a start point P of an inner surface of two surfaces that constitute the lap 23B of the fixed scroll 23 (hereafter referred to as the "inner involute surface S1") and a start point Q of the outer surface of the two surfaces (hereafter referred to as the "outer involute surface S2"). Note that the non-involute surface S3 is formed without changing the positions of both the start points of the inner involute surface S1 and the outer involute surface S2.

[0043] The non-involute surface S3 is the region $\alpha (= \alpha_1 + \alpha_2)$ of the curve portion denoted by a line segment from the point P through a point R and the point Z to the point Q in Fig. 5(A), while the point R is equivalent to the point at which a concave curved surface S31 and the convex curved surface S32 of the non-involute surface S3 intersect each other. That is, the region from the point P to the point R is the concave surface portion, forming the concave curved surface S31 that is an inner non-involute surface of the non-involute surface S3. On the other hand, the region from the point R through the point Z to the point Q is the convex surface portion, forming the convex curved surface S32 that is an outer non-involute surface of the non-involute surface S3. Note that the point Z corresponds to the vertex of the convex curved surface S32 that is the outer non-involute surface S3. Furthermore, as described above, the point R is the start point of a common non-involute surface for the concave curved surface S31 being an inner non-involute surface and the convex curved surface S32 being an outer non-involute surface.

[0044] The non-involute surface S3 of the present invention is configured such that the entire concave curved surface S31, particularly from the start point R to the endpoint P of the concave curved surface S31, is formed in the shape of a curved surface having a reduced radius r of curvature ($r < r'$; note that as shown in Fig. 5(B), r' is the radius of curvature

of the inner involute surface S'1 of the fixed scroll according to Specification 1 in Table 1 to be discussed later). That is, the concave curved surface S31 is formed in the shape denoted in Fig. 7 by the solid line which is shifted toward the through-hole 23C (rightward in the figure) with respect to the inner involute surface indicated by the broken line.

[0045] On the other hand, the convex curved surface S32 of the non-involute surface S3, that is, from the point R serving also as the start point of the convex curved surface S32 to the endpoint Q, may have a curved surface which is appropriately shaped to be different from the inner involute surface, for example, any shape such as an arc-shaped curve which is outwardly shifted from the inner involute surface. Note that this embodiment employs an arc having an appropriate radius of curvature. As shown in Fig. 8, this allows the thickness T near the vertex Z of the convex curved surface S32 or the tip portion of the lap 23B of the fixed scroll 23 to be greater at least than a thickness T_0 near a tip portion Z_0 of the lap 25B of the movable scroll 25.

[0046] Next, a description will be made to a method for forming a curved surface that constitutes the non-involute surface S3 mentioned above.

(1) As shown in Fig. 7, desired Cartesian coordinates, i.e., orthogonal X-Y coordinates are set with origin O at a predetermined position, and a base circle β is then drawn with center at the origin O of the two-dimensional coordinates. The base circle β can be any one for each type of compressors; for example, the radius thereof or the like is uniquely determined solely by the size of the fixed scroll and hence by the output from the compressor or the like.

(2) Once the base circle P has been determined at a predetermined position in this manner, an involute curve is drawn with respect to the base circle β , the involute curve having an involute function as a primitive function (in Fig. 5, the curve denoted by a chain double-dashed line is called the primitive involute curve). Then, the primitive involute curve is displaced in both directions by rotation by a certain angle (i.e., by an involute start point angle δ) about the origin. This provides two involute curves that have a certain width t at the start point R. These are the inner involute surface S1 and the outer involute surface S2 of the fixed scroll 23. However, as will be discussed later, a certain region α from the start point R toward the spiral center will be changed to a non-involute surface.

(3) Next, in order to create the inner non-involute surface and the outer non-involute surface, as shown in Fig. 7, which are uniquely determined by a predetermined compression ratio, two straight lines having a slope of a certain angle θ are prepared. Then, using these straight lines, straight lines V and V' being two tangent lines that are tangent to the base circle β are determined. Here, the angle θ serves to determine the involute start angle and is uniquely determined by the compression ratio.

(4) Then, an intersection P at which the aforementioned straight line V intersects the inner involute surface S1 is determined and an intersection Q at which the aforementioned straight line V' intersects the outer involute surface S2 is determined as well.

Note that the intersection P serves as the endpoint of the inner non-involute surface (i.e., the concave curved surface S31) and the start point of the inner involute surface S1, while the intersection Q serves as the endpoint of the outer non-involute surface (i.e., the convex curved surface S32) and the start point of the outer involute surface S2. On the other hand, the start point of the concave curved surface S31 being an inner non-involute surface and the start point of the convex curved surface S32 being an outer non-involute surface are the point R, at which both the curved surfaces intersect each other.

(5) Next, as shown in Fig. 5(A), the curve in the region α denoted by a bold line connecting the four points including the aforementioned two points P and Q, that is, the points P, R, Z, and Q is changed to a curved surface different from an involute, that is, to the non-involute surface S3.

Of the non-involute surface S3 to be changed, the concave curved surface S31 to be formed as the inner non-involute surface particularly within the region α_1 denoted by the two points P and R is configured such that the original involute shape is changed to an arc which is formed as part of the circumference of a circle having a radius r drawn about a given point C on the straight line V that is one of the tangent lines tangent to the base circle P as shown in Fig. 7. Thus, the start point of the inner involute surface S1 is changed to the point P. Note that the center of the circle for forming the arc is not necessarily located within a segment PN on the straight line V being a tangent line but may also be located on an extended line thereof.

(6) In this manner, in the region behind the start point P of the inner involute surface S1 that has been already formed, the involute curve formed in the region α_1 is, in particular, changed to the arc centered at the aforementioned given point C. In particular, the radius r of the circle to be employed in this case is a radius of curvature that is smaller than the corresponding radius r' of the fixed roll 23', i.e., $r < r'$, as shown in Fig. 5(B), the fixed roll 23' being of a type according to Specification 1 (refer to Table 1 to be described later). In this manner, the inner non-involute surface S31 formed in the region α_1 is slightly shifted outwardly from the inner involute curved surface before being changed, that is, toward the through-hole 23C. Note that the arc curve to be employed here passes through both the endpoint P and the start point R at the same time.

(7) Furthermore, in this embodiment, the convex curved surface S32 being an outer non-involute surface which is formed in the region α_2 of the three points Q, Z, and R, of the region α that forms the non-involute surface S3, has

been changed to the arc curve as described above. When compared with the outer involute curved surface that has not yet been changed, this led to a shift causing a slight outward expansion. Note that in this case, the original involute shape is changed to the arc that is part of the circumference of a circle having a radius about a given point, where like the concave curved surface S31, in Fig. 7, the circumference passes through two points N' and Q, N' being the point of contact of the straight line V' being the other tangent line with the base circle β , Q being the intersection of the straight line V' and the aforementioned outer involute surface S2.

[0047] By using the lap 23B of the fixed scroll 23 having the non-involute surface S3 formed in this manner, it is possible to increase the strength of the fixed scroll 23 without changing the compression ratio.

[0048] Next, referring to Figs. 5 to 8, a description will be made to the through-hole 23C that constitutes the discharge port which is formed at the spiral center of the lap 23B of the fixed scroll 23.

[0049] In this embodiment, a length (hereafter referred to as the "distance to hole L") is designed to be as long as possible, where the distance to hole L is the length between the base on the end plate 23A particularly at the point Z being the tip portion of the lap 23B of the fixed scroll 23 (immediately below the portion denoted by the point Z in Fig. 5 (A)), of the inner circumferential edge of the through-hole 23C constituting the discharge port formed at the spiral center being the tip portion of the lap 23B of the fixed scroll 23, and a maximum proximity edge U of the fixed scroll 23 facing the inner circumferential edge of the through-hole 23C in the closest proximity thereto from the base at the point Z being the tip portion of the lap 23B.

[0050] That is, when compared with a length (hereafter referred to as the "distance to hole L'"), at least the distance to hole L of this embodiment is longer than L', that is, $L > L'$, where for a generally typical through-hole, for example, the fixed scroll 23' shown in Fig. 5(B), the distance to hole L' is the length between the base on the end plate 23'A at the point Z' (immediately below the portion denoted by the point Z' in Fig. 5(B)) being the tip portion of the lap 23'B and the maximum proximity edge U' of the fixed scroll 23' facing the inner circumferential edge of the through-hole 23'C in the closest proximity thereto from the base at the tip portion Z' of the lap 23'B.

[0051] As described above, the distance to hole L of the fixed scroll 23 can be increased when compared with the distance to hole L' of the fixed scroll 23' according to Specification 1 because the through hole 23C is reduced, for example, as compared with the through-hole 23'C of the fixed scroll 23' according to Specification 1 in Table 1. By the amount of the reduction, a base surface 232 or the distance to hole L, in particular, can be made longer on the end plate 23A.

[0052] In this context, to narrow the through-hole 23C, this embodiment is configured as follows.

[0053] The through-hole 23C of this embodiment shown in Fig. 5 (A) has an opening area reduced to about 80% to 90% (90% in this embodiment) when compared with the size of the through-hole 23'C opened on the fixed scroll 23' shown in Fig. 5(B) corresponding to Specification 1 in Table 1 (refer to Fig. 5(A) and Fig. 5(B)). That is, the through-hole 23C in a close region (ε) facing the concave curved surface S31 of the non-involute surface S3 is configured to be narrowed in the opening shape when compared with the opening shape of the through-hole 23'C of the fixed scroll 23' in a close region (ε'). For example, in this embodiment, the opening area is reduced by about 10%, thereby increasing the distance to hole L.

[0054] More specifically, in order to narrow the opening of the opening portion of the through-hole 23C in the close region (ε) (refer to Fig. 5(A)) facing the concave curved surface S31, employed is a curved surface which has an inner edge of a radius of curvature smaller than the radius r of curvature of the concave curved surface S31. That is, the opening edge portion in the close region (ε) is shifted and retreated so as to come closer toward the center of the through-hole 23C (in Fig. 7, the portion denoted by an alternate long and short dashed line is shifted rightward to the portion denoted by a bold line). In this manner, the hole is narrowed to thereby reduce the opening area. Note that the curved surface of this portion may be, for example, an arc which has a radius of curvature less than the radius r of curvature of the concave curved surface S31.

[0055] Note that the opening shape of the through-hole 23C is configured such that the inner edge portion in the close region (ε) facing the concave curved surface S31 of the non-involute surface S3 of the fixed scroll 23 is retreated and narrowed so as to be come closer toward the hole center as described above. However, in the remaining region (λ) opposite to the close region (ε) as shown in Fig. 5(A), the opening shape has not been changed and thus the same as the shape of the through-hole 23'C of the fixed scroll 23' according to Specification 1. That is, communication with the compression chamber will start from the remaining region (λ) of the through-hole 23C opposite to the lap. However, since no changes have been made to this side, there is no change to the fact that like the previous one, two pairs of compression chambers discharge at the same timing.

[0056] Furthermore, such a relation regarding the distance to hole L also holds true for a portion slightly apart from the vicinity of the point Z being the tip of the lap 23B of the fixed scroll 23 on a cross-section taken along line VIA-VIA and viewed in the direction of the arrows of Fig. 5(A). That is, as shown in Fig. 6(A), the magnitude of a distance to hole ΔL between the portion slightly apart from the vicinity of the tip portion Z of the lap 23B and the through-hole 23C has also been increased when compared with the distance to hole $\Delta L'$ for the generally typical fixed scroll 23' as shown in

Fig. 6(B) which is a cross-sectional view taken along the corresponding portion of the fixed scroll 23' according to Specification 1 in Table 1.

[0057] As described above, the distance to hole ΔL can be expanded like the aforementioned distance to hole L because as shown in Fig. 6, the width W of the through-hole 23C of the fixed scroll 23 on the cross section is narrowed when compared with the width W' of the corresponding portion of the through-hole 23'C of the fixed scroll 23' (note that $W < W'$).

[0058] Furthermore, the through-hole 23C constituting the discharge port formed at the spiral center being the vertex Z serving also as the tip portion of the lap 23B of the fixed scroll 23 according to this embodiment is configured such that as shown in Fig. 6(A), on the inner circumferential surface of the through-hole 23C, the height H of a vertical wall 231 that is erected vertically particularly from the base surface 232 being a surface portion connected to the base of the lap 23B, of an end face 230 of the end plate 23A of the fixed scroll 23 is increased.

[0059] In particular, the through-hole 23C of this embodiment is configured such that as shown in Figs. 5 (A) and 6 (A), the vertical wall 231 is formed to have a height H generally about two times a lap width t (refer to Fig. 5(A)) except for the tip portion Z of the lap 23B of the fixed scroll 23, that is, $H = 2t$.

[0060] On the other hand, the through-hole 23'C of the fixed scroll 23' according to Specification 1 is configured such that as shown in Figs. 5(B) and 6(B), the vertical wall 231' is formed from the base surface 232' so as to have a height H' generally the same as the width t' except for the tip portion of the lap 23'B of the fixed scroll 23', that is, H' being approximately equal to t'.

[0061] Thus, since the through-hole 23C of this embodiment is formed to have the vertical wall 231 that is higher than that for a generally typical through-hole, that is, the through-hole 23'C of the fixed scroll 23' according to Specification 1, the thickness of the end plate 23A in the vicinity of the point Z or the tip portion of the lap 23B is substantially increased, thus providing a significant increase in the structural strength.

[0062] Next, referring to Fig. 8, a description will be made to the relation between the through-hole 23C of the fixed scroll 23 and the recess 25D of the movable scroll 25.

[0063] The through hole 23C of this embodiment is smaller than the size of the recess 25D constituting the dummy port formed at the spiral center of the lap 25B of the movable scroll 25, that is, so as to satisfy the relation below: $E1 < e1$ and $E2 < e2$.

As described above, the through-hole 23C does not have the same area as that of the recess 25D, but has a narrower area than that.

[0064] Furthermore, the through-hole 23C of the fixed scroll 23 and the recess 25D of the movable scroll 25 are configured to have the relative positional relation of being 180 degrees out of phase with each other so as to be inverted in a point symmetric manner. Here, note that as is known according to the elementary geometry, the "point symmetry" defines the geometric relation between two figures that can be superposed on each other when rotated 180 degrees about a symmetric center position. However, in this embodiment, the expression "in a point symmetric manner" is employed by taking into account the circumstances that the two figures are geometrically similar and have different sizes and thus not exactly superposed on each other.

[0065] By forming the through-hole 23C into such a shape, communication with the compression chamber starts from the remaining region (λ ; refer to Fig. 5) of the through-hole 23C opposite to the lap. Thus, it has not been changed that the two pairs of compression chambers discharge at the same timing. This allows for effectively avoiding generating an unnecessary load on the bearing, and as a result, it is possible to prevent the occurrence of adverse effects on such as noise, vibration, and durability.

[0066] Next, a description will be made to the operation of the scroll compressor 1.

[0067] When the driving motor 13 is driven, the rotor 13B is rotated relative to the stator 13A, thereby rotating the driving shaft 15. When the driving shaft 15 is rotated, the movable scroll 25 of the scroll compressor mechanism 11 revolves without rotating while the attitude thereof is being maintained constant relative to the fixed scroll 23. This causes a low-pressure refrigerant to be drawn through the intake pipe, fed from the periphery of the compression chamber 27 into the compression chamber 27, and compressed with volumetric change of the compression chamber 27.

[0068] The compressed refrigerant, now under a high pressure, is discharged from the compression chamber 27 through the discharge valve 22 into the discharge space 29, and then flows out of the oil collector 24 toward the high-pressure space 17 below the housing 21 through the vertical groove (not illustrated) provided in the outer periphery of each of the housing 21 and the fixed scroll 23. Then, the high-pressure refrigerant is discharged out of the casing 3 through the discharge pipe (not illustrated) provided on the casing body 5. The refrigerant having been discharged out of the casing 3 is circulated through the refrigerant circuit (not illustrated) and after that, drawn back into the compressor 1 through the intake pipe and then compressed, thus allowing the refrigerant to be repeatedly circulated.

[0069] Next, a description will be made to the flow of a lubricating oil.

[0070] The lubricating oil stored in the inner bottom portion of the lower cap 9 of the casing 3 is scooped up with the pickup (not illustrated) provided on the lower end of the driving shaft 15 shown in Fig. 1, so that the resulting lubricating oil is supplied through the oil supply path 15B of the driving shaft 15 into the high-pressure oil chamber 52 behind the

movable scroll 25. Furthermore, the lubricating oil is fed, with the help of a differential pressure, from the oil chamber 52 shown in Fig. 4 through the communication passage 51 and the communication hole 53 provided in the movable scroll 25 into the oil groove 23D (refer to Fig. 2 and Fig. 4) opened on the lower surface 233 being the top end face of the lap 23B of the fixed scroll 23, and then supplied to respective sliding parts of the scroll compressor mechanism 11 and the compression chamber 27.

[0071] Furthermore, for example, in Fig. 1, the oil supplied to the compression chamber 27 moves to the center of both the scrolls which is a high-pressure compression chamber, and then along with the flow of the high-pressure refrigerant compressed here, the oil is discharged through the discharge valve 22 into the discharge space 29. In this manner, the lubricating oil discharged through the discharge valve 22 into the discharge space 29 in conjunction with the high-pressure refrigerant flows into the high-pressure space 17 below the housing 21 through the vertical groove (not illustrated) provided on the outer periphery of each of the housing 21 and the fixed scroll 23. Then, the oil is stored in the inner bottom portion of the lower cap 9 equivalent to the lower space 91 through the inner wall portion of the casing body 5 and a gap of the driving motor 13. In this case, since the high-pressure space 17 has the thin plate-shaped oil collector 24 and a cup 26, it is possible to collect the oil in the inner bottom portion of the lower cap 9 while preventing the oil from entering the discharge pipe.

[0072] Next, when five types of scroll compressors which are provided with each type of fixed scrolls including the fixed scroll 23 according to this embodiment were operated, experiments were conducted to examine the maximum stress acting upon the portion facing the through-hole in the closest proximity thereto in the vicinity of the tip portion of the lap mentioned above. Referring to [Table 1] showing the results of the experiments, a description will be made to the operation and effects of this embodiment. Here, note that of the fixed scrolls according to Specification 1 to Specification 6, the one according to Specification 1 is of a generally typical low output type and the one according to Specification 2 is of a generally typical high output type. Furthermore, the one according to Specification 5 is the fixed scroll 23 that is used for this embodiment.

[Table 1]

SPECIFICATION	CONDITION	MAXIMUM STRESS RATIO
1	SCROLL TOOTH HEIGHT; h DISCHARGE HOLE AREA ; A DISCHARGE HOLE VERTICAL WALL ; H	0.88
2	SCROLL TOOTH HEIGHT ; $h + \Delta h$ DISCHARGE HOLE AREA ; A DISCHARGE HOLE VERTICAL WALL ; H	1
3	SCROLL TOOTH HEIGHT ; $h + \Delta h$ DISCHARGE HOLE AREA ; $0.9 A$ DISCHARGE HOLE VERTICAL WALL ; H	0.86
4	SCROLL TOOTH HEIGHT ; $h + \Delta h$ DISCHARGE HOLE AREA ; $0.9 A$ DISCHARGE HOLE VERTICAL WALL ; H	0.82
5 (THIS EMBODIMENT)	SCROLL TOOTH HEIGHT : $h + \Delta h$ DISCHARGE HOLE AREA ; $0.9A$ DISCHARGE HOLE VERTICAL WALL ; $2.5H$	0.72

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(continued)

SPECIFICATION	CONDITION	MAXIMUM STRESS RATIO
6	SCROLL TOOTH HEIGHT ; $h + \Delta h$ DISCHARGE HOLE AREA ; $0.9 A$ DISCHARGE HOLE VERTICAL WALL ; $2.5 H$	0.72
(Note) The maximum stress ration in the table above indicates the ratio of the maximum stress value of the compressor according to each specification to the maximum stress value of the compressor according to Specification 2, where the maximum stress value acts upon the end plate near the base of the lap tip portion Z of the fixed scroll when operating the scroll type compressor accoding to each specification at a given horsepower.		

[0073] As can be seen from Table 1 above, when compared with the one according to Specification 1 having a generally typical structure (of a low output type), the one according to Specification 5 corresponding to the fixed scroll of this embodiment is configured such that the scroll tooth height is increased by Δh ; the discharge hole area is reduced to 0.9 times; and the discharge hole vertical wall is increased to 2.5 times. This structure provided the finding that it was possible to reduce 28% the force acting on the base of the tip portion Z of the fixed scroll at which the maximum stress occurred. Thus, the compressor 1 of this embodiment that includes the fixed scroll according to Specification 5 showed that the strength of the end plate 23A near the base of the tip portion Z of the lap 23B of the fixed scroll 23 was enhanced.

[0074] Note that the present invention is not limited to the aforementioned embodiment, but may be modified in a variety of ways without departing from the scope of the appended claims. For example, the fixed scroll of the present invention is not limited to the one according to Specification 5 in Table 1 above, but may also be any one according to Specifications 3, 4, and 6.

DESCRIPTION OF REFERENCE SIGNS

[0075]

- 1 scroll compressor
- 11 scroll compressor mechanism
- 13 driving motor
- 13A stator
- 13B rotor
- 15 driving shaft
- 15A eccentric shaft section
- 15B oil supply path
- 16 counterweight part
- 17 high-pressure space
- 21 housing
- 21A support section
- 21B radial bearing part
- 22 discharge valve
- 23 fixed scroll
- 23A end plate
- 23B lap
- 23C through-hole (discharge port)
- 23D oil groove
- 230, 250 end surface
- 231 vertical wall
- 232 base surface
- 24 oil collector
- 25 movable scroll
- 25A end plate
- 25C boss section
- 25D recess (dummy port)
- 27 compression chamber
- 27A low-pressure section

29	discharge space
3	casing
5	casing body
51	communication passage
5 51A	pilot hole
51B	insert hole
51C	female screw hole
52	oil chamber (the high-pressure section in the hermetically sealed container)
53	communication hole
10 55	flow limiting member (pin member)
55A	first pin
55B	second pin
61	Oldham ring
7	upper cap
15 9	lower cap
91	lower space
H	height of vertical wall
L, ΔL	distance to hole
N	point of contact (intersection of base circle and straight line)
20 P	start point of inner involute surface (endpoint of inner non-involute surface)
Q	start point of outer involute surface (endpoint of outer non-involute surface)
R	point at which concave curved surface and convex curved surface of non-involute surface contact each other (start points of both surfaces)
r	radius of curvature of non-involute surface
25 S1	inner involute surface
S2	outer involute surface
S3	non-involute surface
S31	concave curved surface of non-involute surface (inner non-involute surface)
S32	convex curved surface of non-involute surface (outer non-involute surface)
30 T	thickness of lap tip portion of fixed scroll
T_0	thickness of lap tip portion of movable scroll
t	lap width except for lap tip portion of fixed scroll
U	maximum proximity edge (facing the base of lap tip portion of fixed scroll)
V, V'	straight line (tangent to base circle)
35 Z	lap tip portion of fixed scroll (vertex on convex curved surface of non-involute surface)
z	lap tip portion of movable scroll (vertex on convex curved surface of non-involute surface according to Specification 1)
α	region in which non-involute surface is formed
β	base circle
40 ε	close region facing the concave curved surface of non-involute surface of fixed scroll

Claims

- 45 1. A scroll compressor comprising: a fixed scroll secured inside a casing; and a movable scroll to mesh with the fixed scroll, the scroll compressor compressing a space formed between both laps of these scrolls, the scroll compressor being **characterized in that** the fixed scroll on a lap tip side is greater in thickness than the movable scroll on a lap tip side.
- 50 2. The scroll compressor according to claim 1, wherein a non-involute surface which is composed of an inner non-involute surface being a concave curved surface and an outer non-involute surface being a convex curved surface is formed between a start point of an inner involute surface and a start point of an outer involute surface, which constitute the lap of the fixed scroll; the non-involute surface is configured such that the inner non-involute surface being the concave curved surface is formed to be a curved surface having a smaller radius of curvature, and a through-hole constituting a discharge port formed at a spiral center being a lap tip portion of the fixed scroll is formed in a manner such that an opening shape thereof in a close region facing the inner non-involute surface being the concave curved surface has a curved surface having a smaller radius of curvature than that of the inner non-involute surface being the concave curved surface; and a distance to hole between a maximum proximity edge, of a periphery
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of the through-hole, facing a base of the lap tip portion of the fixed scroll in the closest proximity thereto and the base of the lap tip portion of the fixed scroll is configured to be as long as possible.

- 5 **3.** The scroll compressor according to claim 1 or 2, wherein, on an end plate in the vicinity of the periphery of the through-hole constituting the discharge port and formed at the spiral center being the lap tip portion of the fixed scroll, a vertical wall erected from a maximum proximity edge of the periphery of the through-hole facing the base of the lap tip portion in the closest proximity thereto is increased in height.
- 10 **4.** The scroll compressor according to claim 3, wherein the height of the vertical wall of the through-hole is formed to be approximately two times a thickness of a portion of the lap of the fixed scroll facing a medium-pressure chamber.
- 15 **5.** The scroll compressor according to any one of claims 1 to 4, wherein the movable scroll includes a recess at the spiral center being the lap tip portion, the recess forming a dummy port with at least part thereof always overlapping the through-hole of the fixed scroll, and the recess is formed to be greater in size than the through-hole, and the through-hole of the fixed scroll and the recess of the movable scroll are formed to have a positional relation of being 180 degrees out of phase with each other.
- 20 **6.** The scroll compressor according to any one of claims 2 to 5, wherein the non-involute surface is formed without changing positions of both the start points of the inner involute surface and the outer involute surface.

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FIG. 1

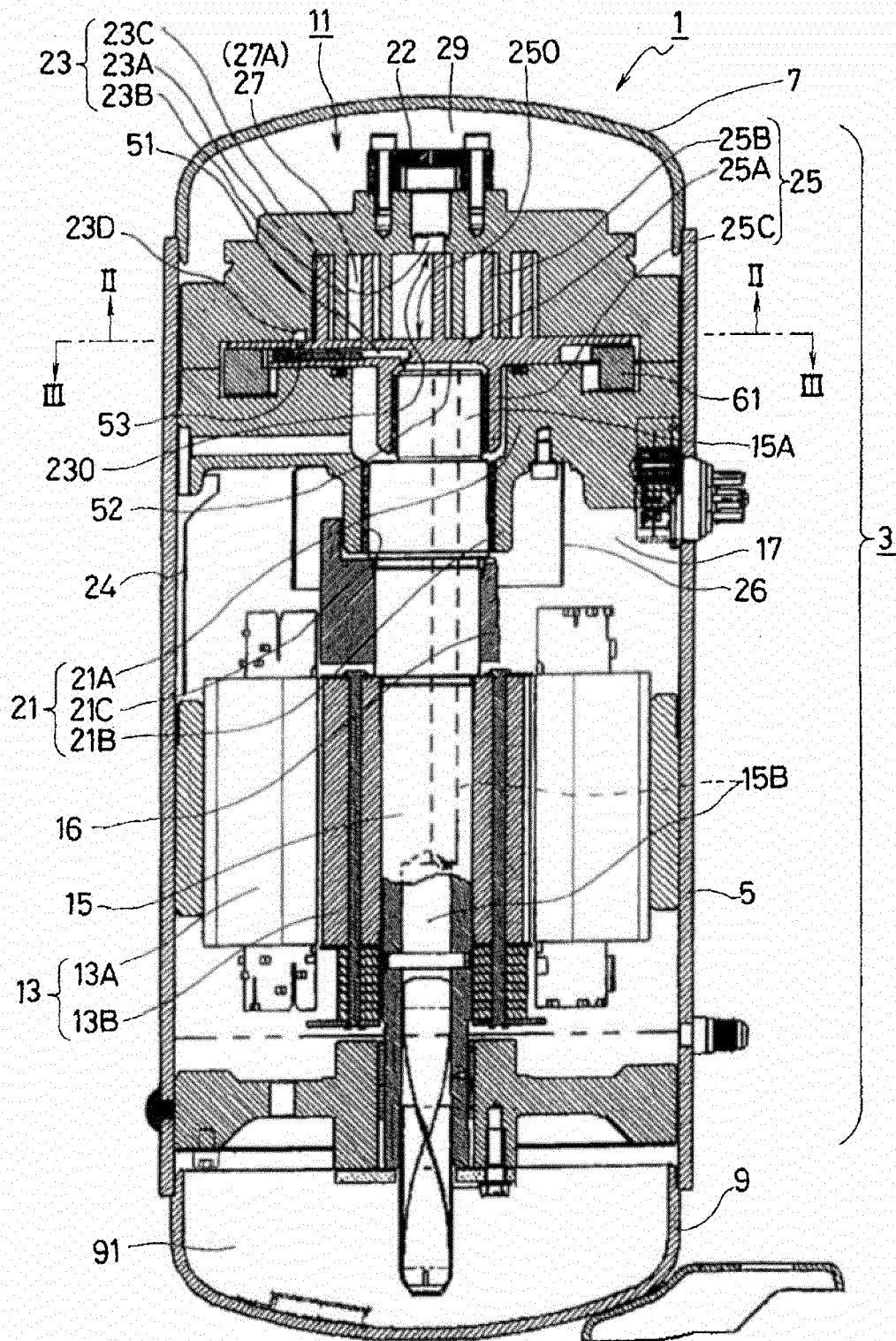


FIG. 2

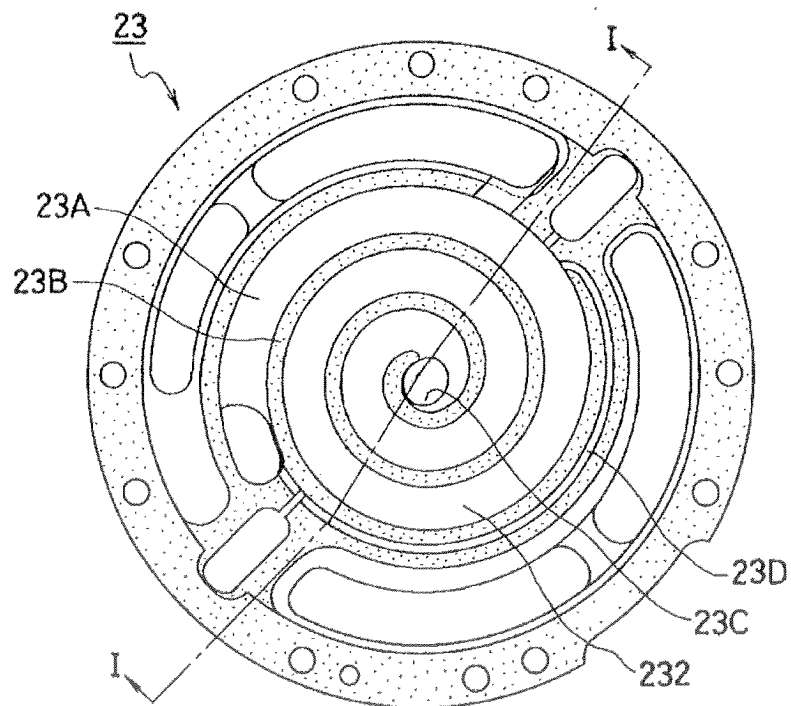


FIG. 3

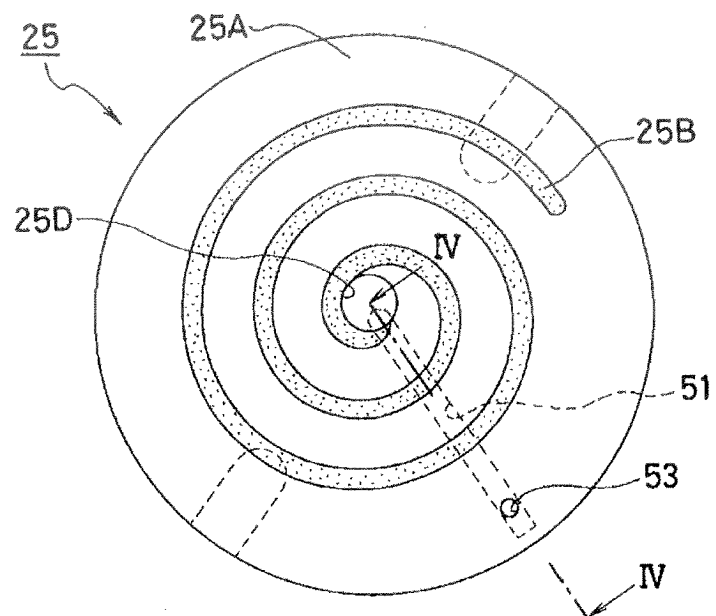


FIG. 4

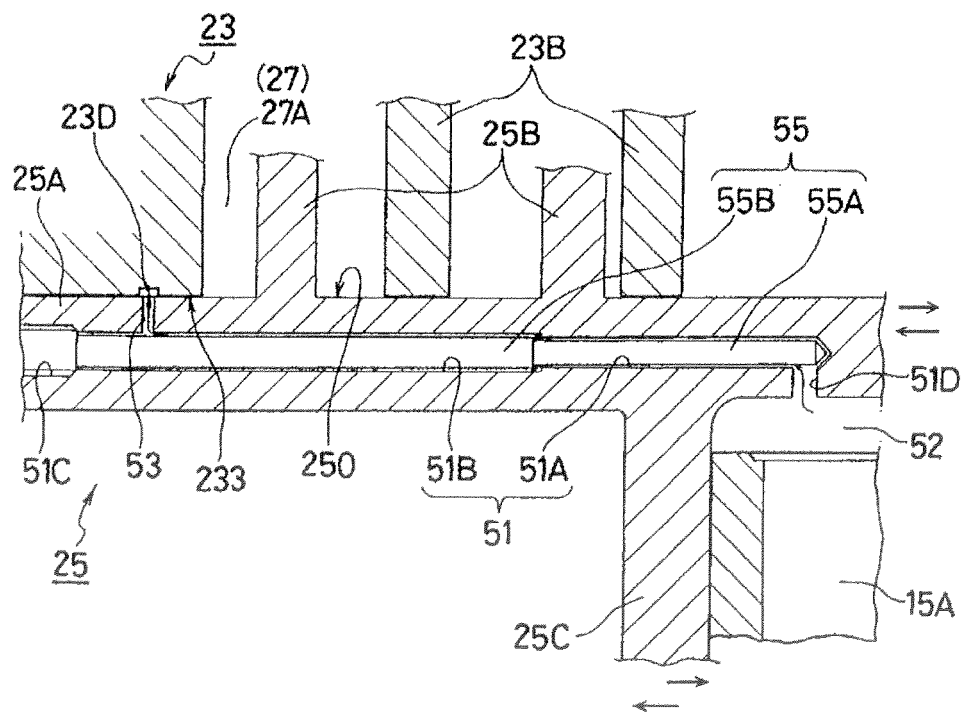


FIG. 5

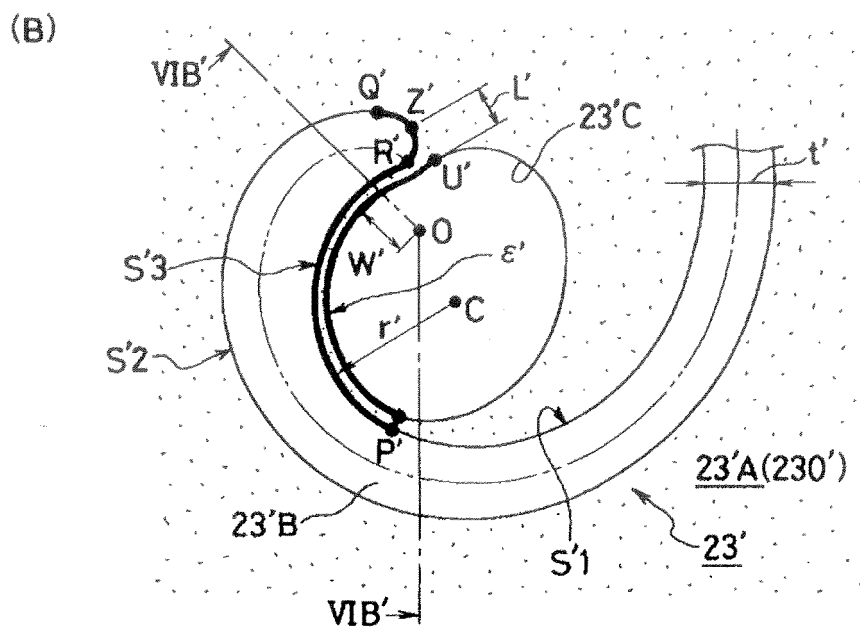
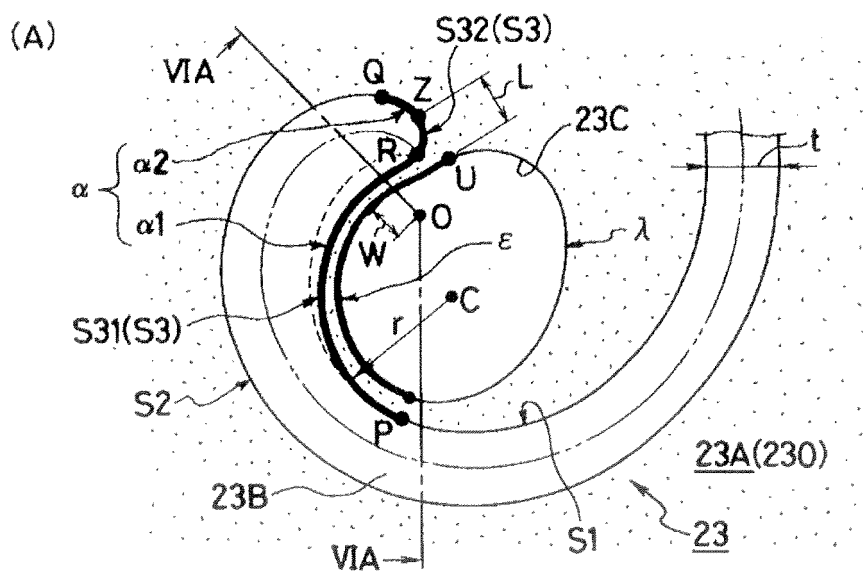


FIG. 6

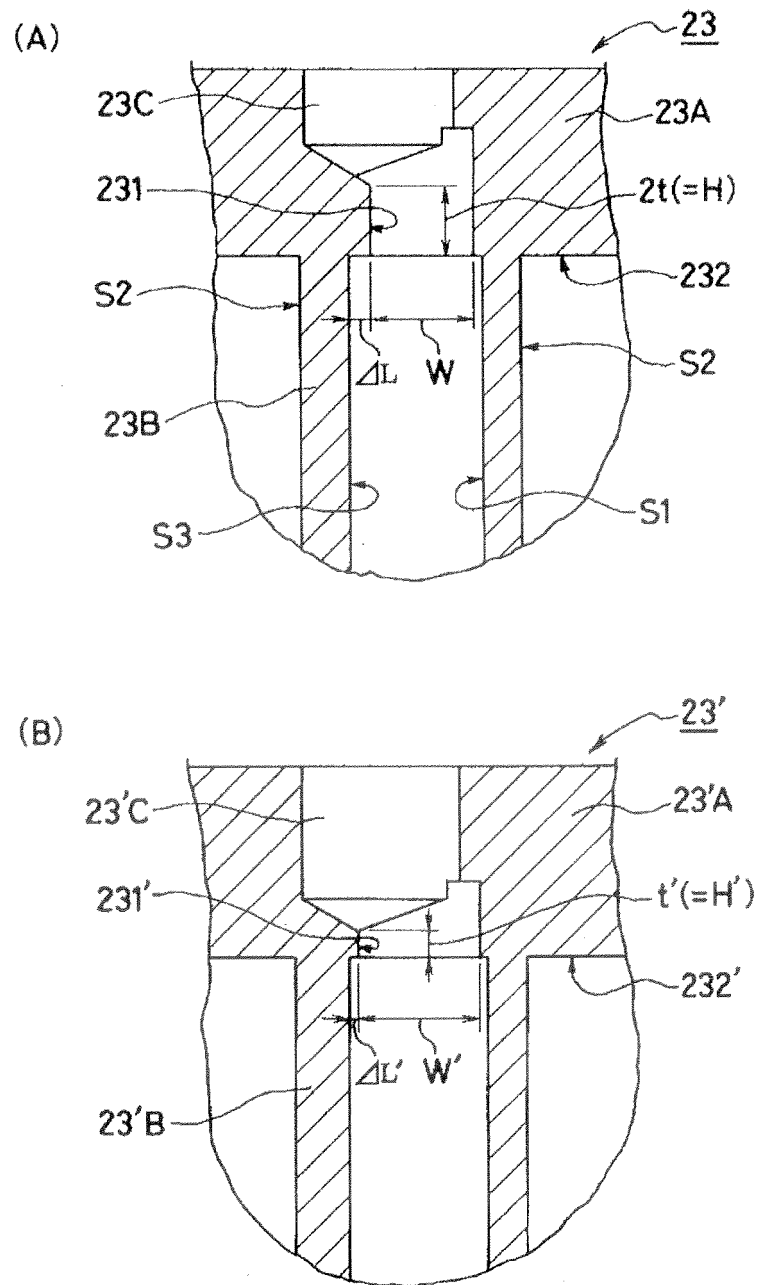


FIG. 7

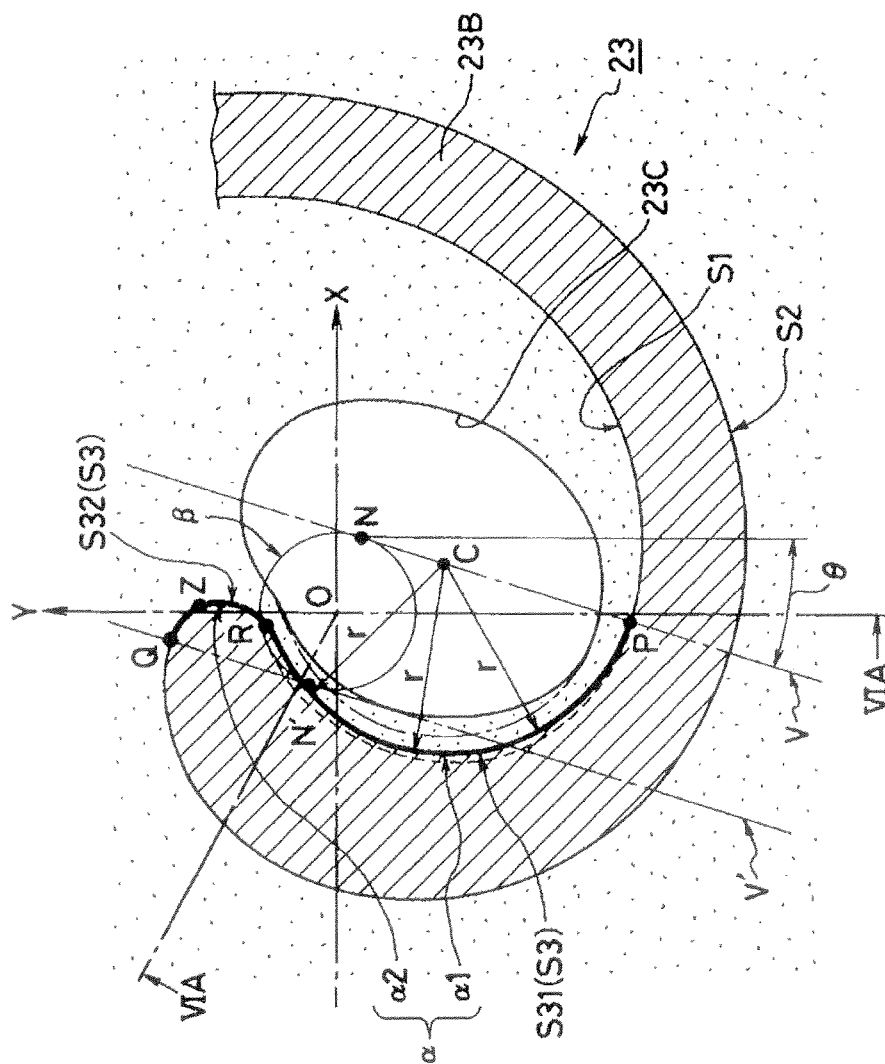


FIG. 8

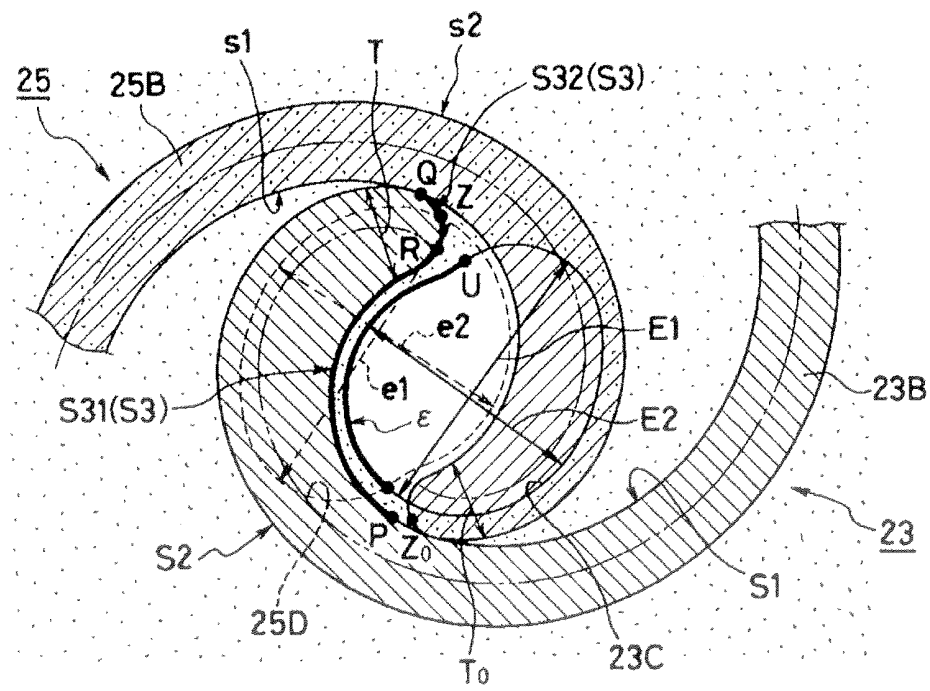
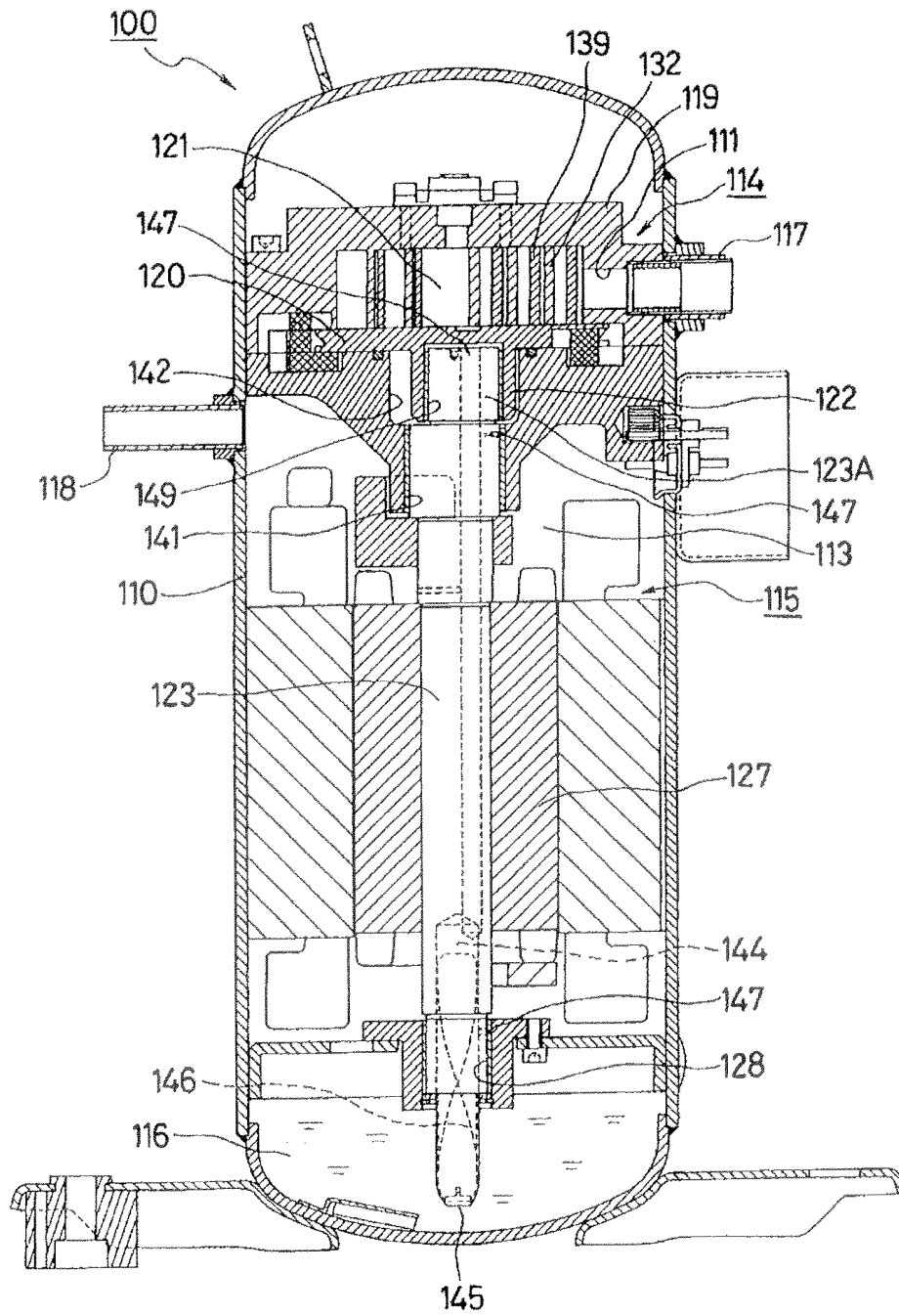


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/080591

A. CLASSIFICATION OF SUBJECT MATTER F04C18/02 (2006.01) i		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) F04C18/02		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012 Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2000-45969 A (Tetsuya ARATA), 15 February 2000 (15.02.2000), paragraphs [0002] to [0003], [0006]; fig. 1, 4, 6, 11 (Family: none)	1 2-6
Y	JP 10-169574 A (Hitachi, Ltd.), 23 June 1998 (23.06.1998), paragraphs [0009] to [0012]; fig. 1 to 2, 5 (Family: none)	2-6
Y	JP 2010-265756 A (Panasonic Corp.), 25 November 2010 (25.11.2010), fig. 4 & CN 101886628 A	2, 6
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 09 April, 2012 (09.04.12)		Date of mailing of the international search report 17 April, 2012 (17.04.12)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/080591

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-273453 A (Aisin Seiki Co., Ltd.), 06 October 2005 (06.10.2005), paragraphs [0015] to [0019]; fig. 1 to 3 & KR 10-2006-0045341 A & CN 1673542 A	5
X	JP 10-122167 A (Mitsubishi Electric Corp.),	1
Y	12 May 1998 (12.05.1998),	5
A	claims 1 to 2; paragraphs [0016] to [0017] (Family: none)	2-4, 6

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REFERENCES CITED IN THE DESCRIPTION

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