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(2) Date: **Apr. 9, 2024**(57) **ABSTRACT**

A scroll compressor includes a shell, a main frame, a fixed scroll, an orbiting scroll, and a crankshaft. The main frame has a suction port for supplying the inside of a compression chamber with the refrigerant swirling around the crankshaft in a lower space below the main frame. The suction port is formed so as to be tilted relative to the axial direction of the crankshaft while running in the direction in which refrigerant flows from the lower space below the main frame to the upper space above the main frame.

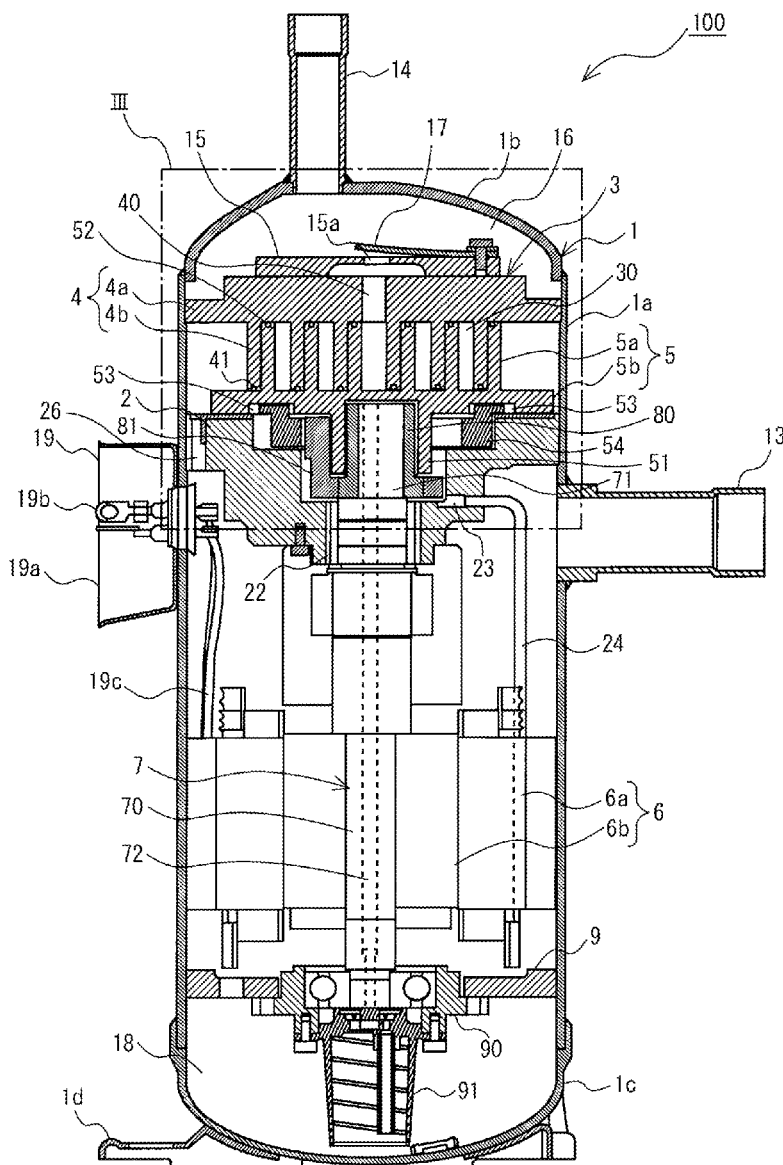


FIG. 2

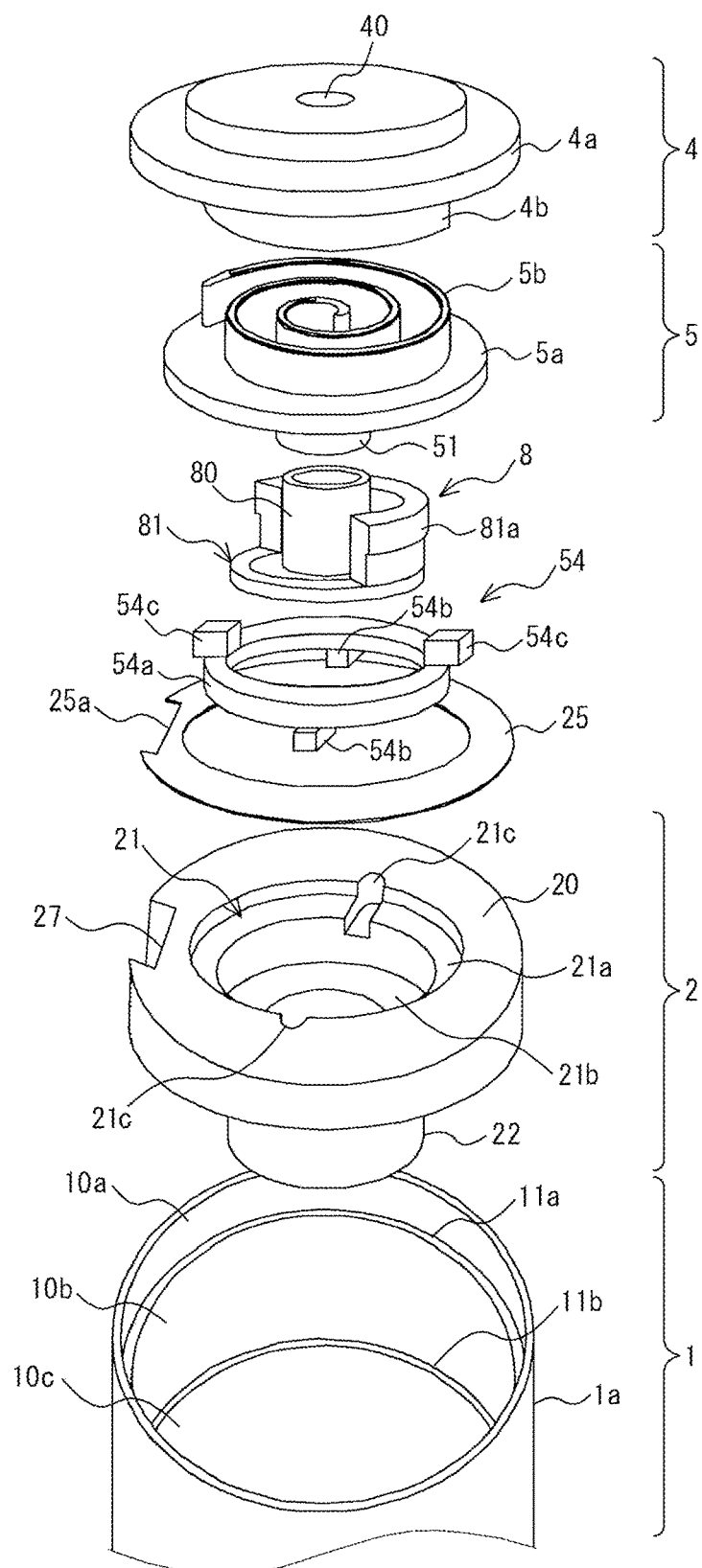


FIG. 3

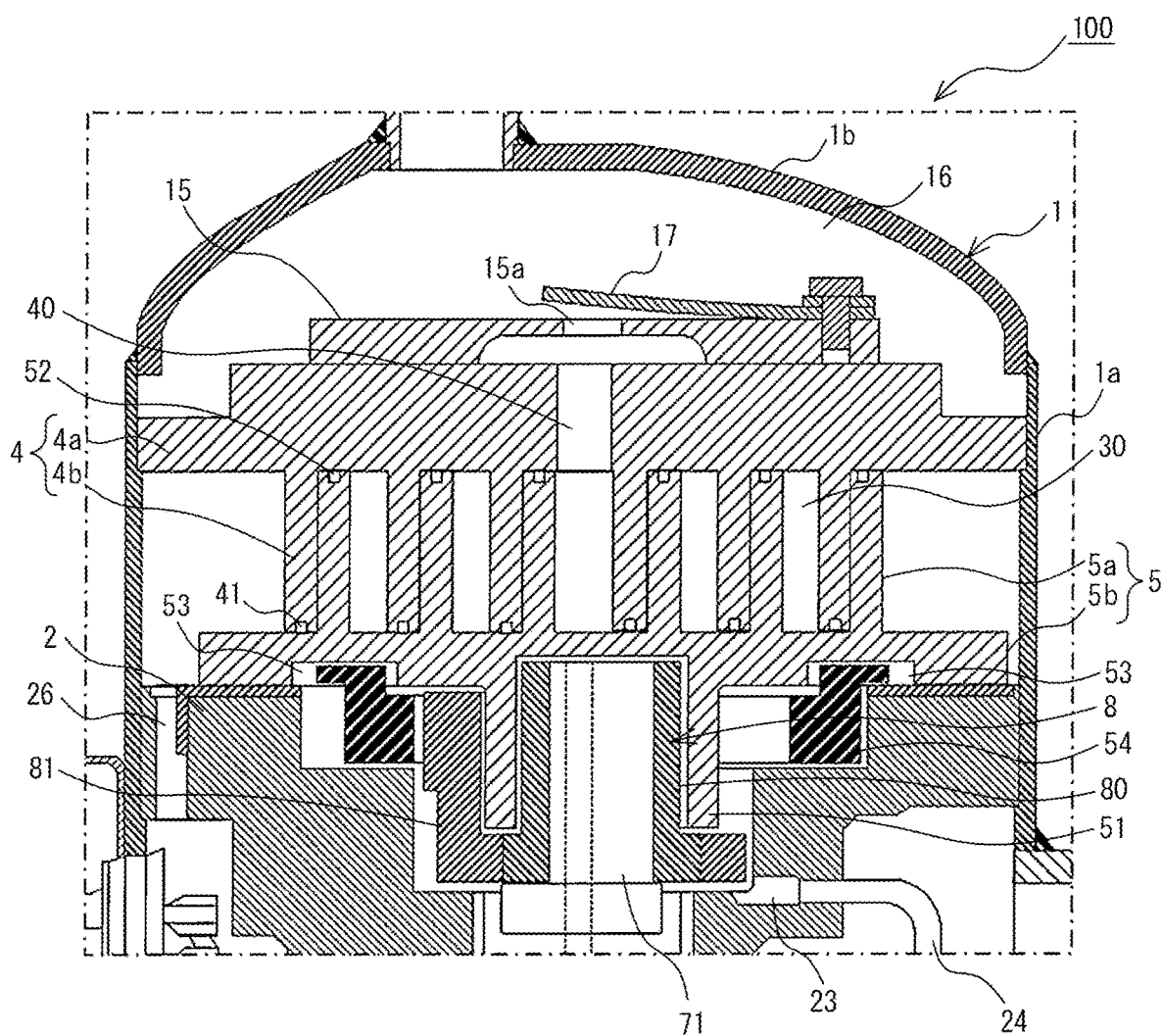


FIG. 4

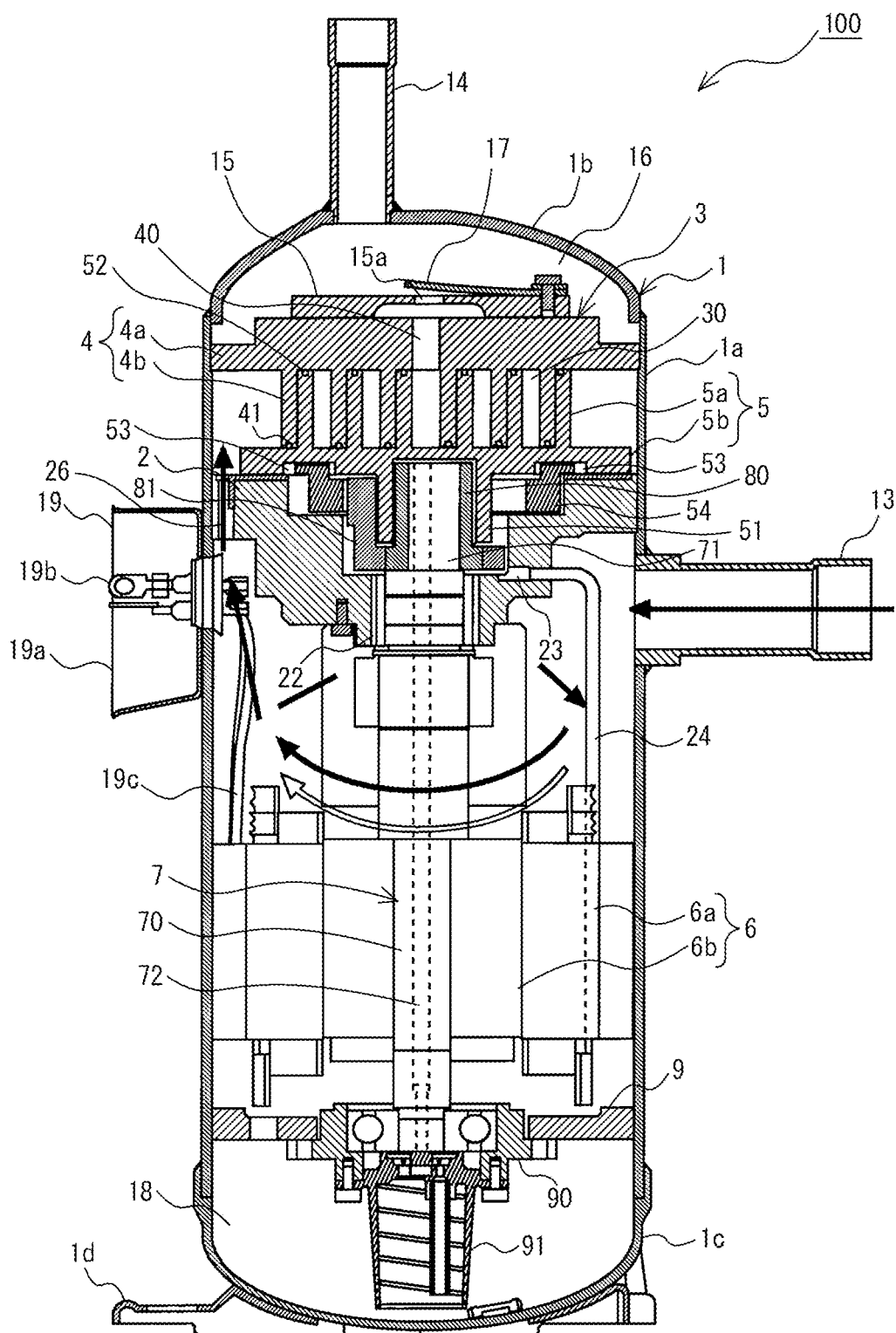


FIG. 5

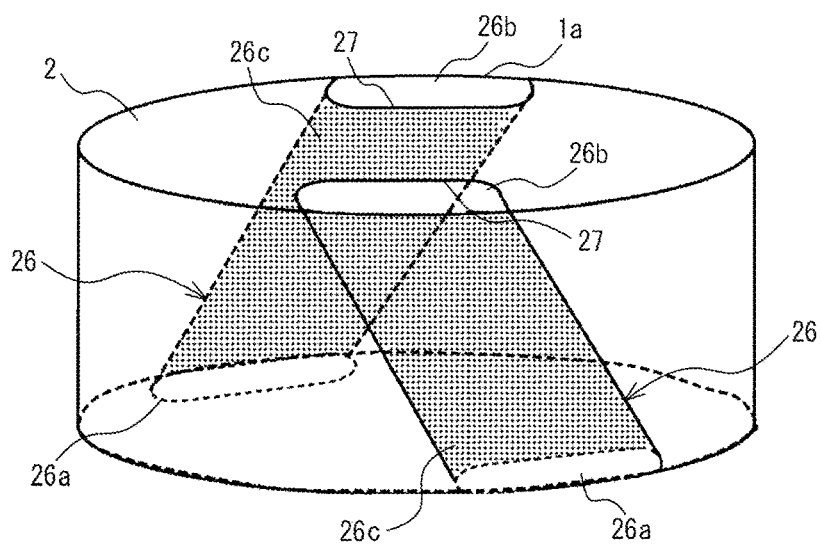


FIG. 6

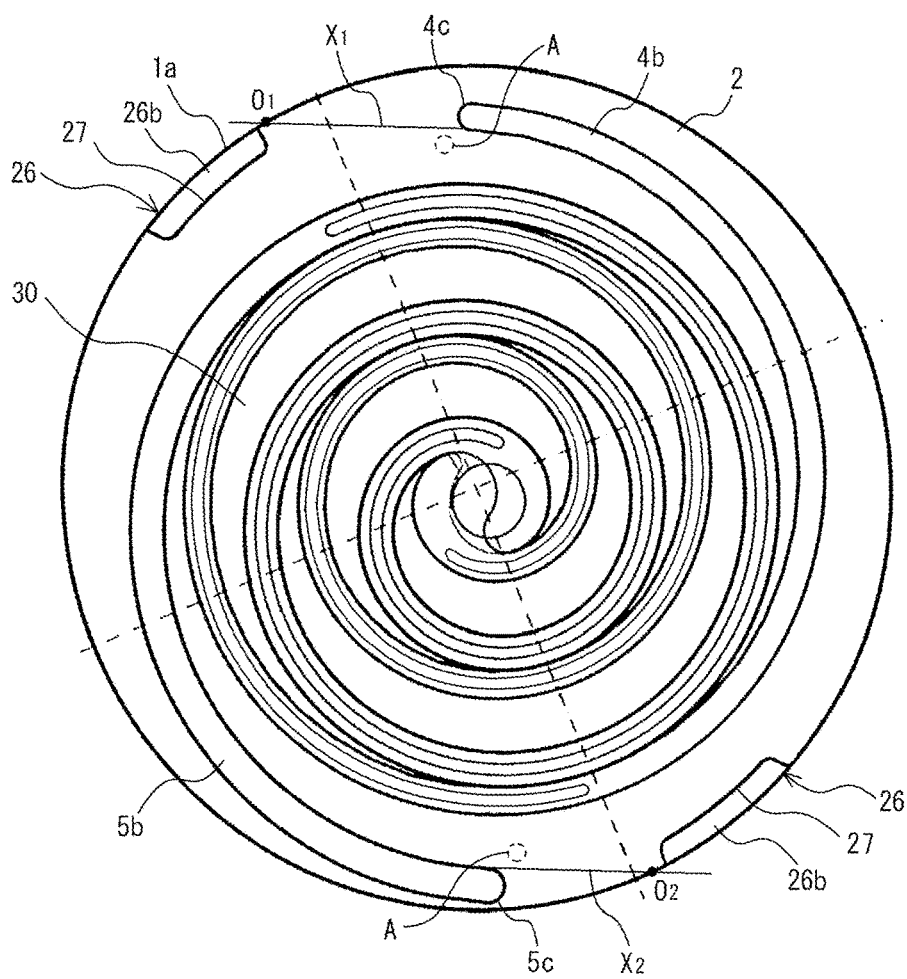


FIG. 7

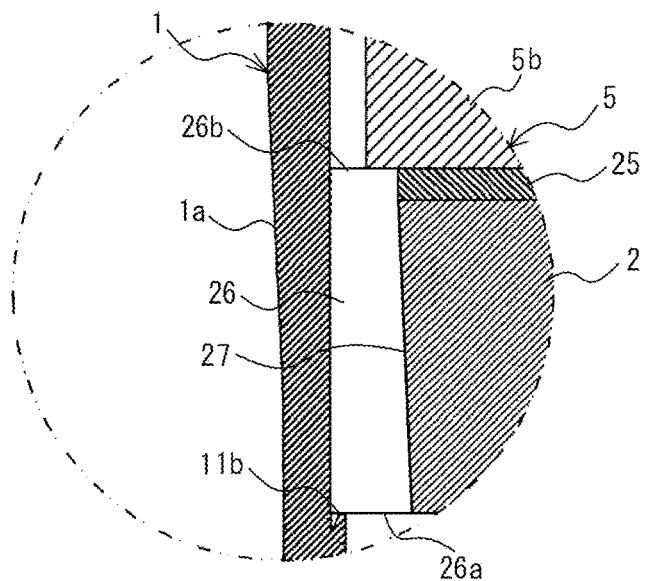


FIG. 8

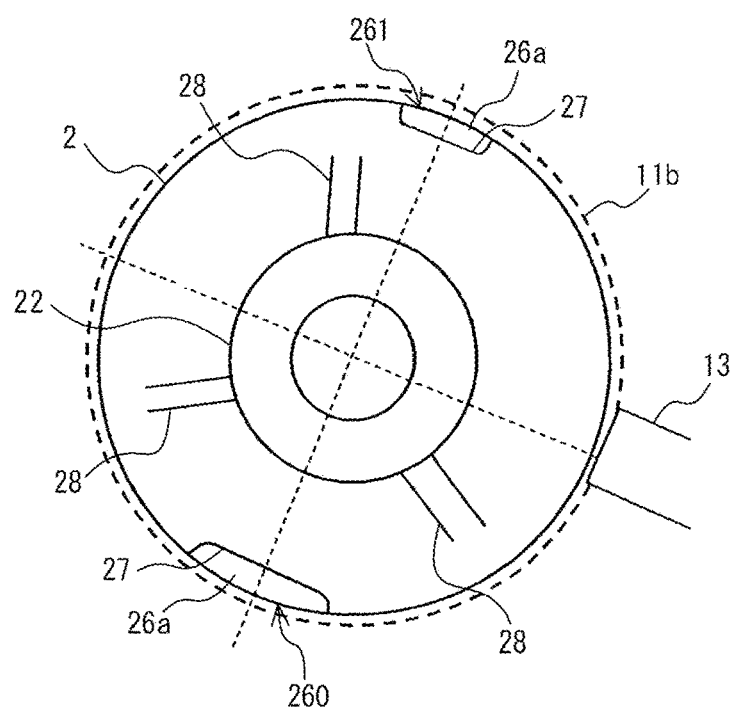
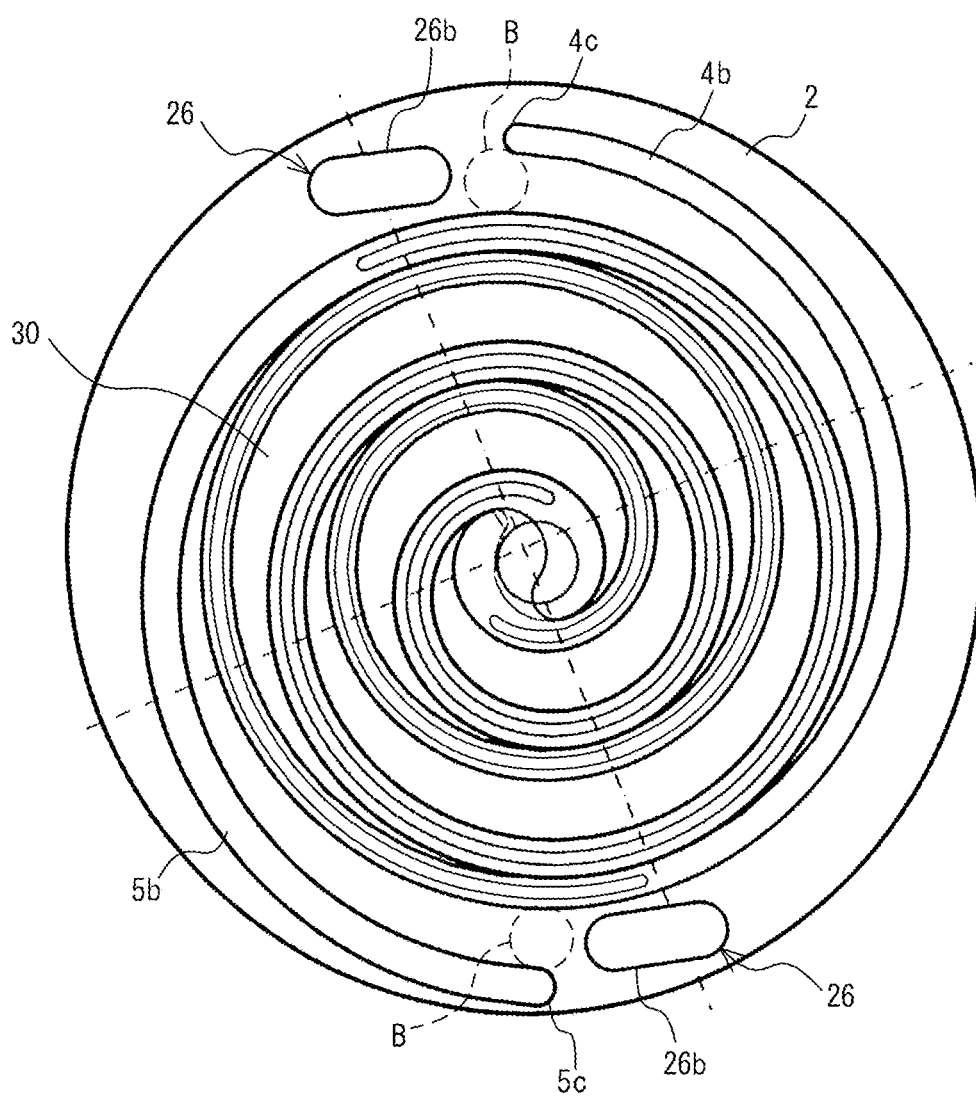


FIG. 10



SCROLL COMPRESSOR

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a U.S. national stage application of PCT/JP2021/048198 filed on Dec. 24, 2021, the contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to a scroll compressor.

BACKGROUND

[0003] There has been known a scroll compressor serving as a compressor used for, for example, an air-conditioning apparatus or a refrigeration apparatus. For example, the scroll compressor disclosed in Patent Literature 1 includes: a shell; a main frame fixed to an inner wall surface of the shell; a fixed scroll fixed to the inner wall surface of the shell and including a fixed base plate provided with a first scroll body; and an orbiting scroll supported by the main frame so as to orbit around the fixed scroll and including an orbiting base plate provided with a second scroll body meshing with the first scroll body. In the scroll compressor, a compression chamber in which refrigerant is compressed is formed between the first scroll body and the second scroll body by meshing the first scroll body and the second scroll body. The main frame has a suction port for introducing refrigerant from a low-pressure space of the shell into the compression chamber. The suction port is a space formed axially along a crankshaft and allows the lower space below the main frame 2 and the upper space above the main frame to communicate with each other. The refrigerant flows into the shell through a suction pipe provided in a side portion of the shell and, while swirling around the axis of the crankshaft in the lower space below the main frame, flows into the compression chamber through the suction port provided in the main frame.

PATENT LITERATURE

[0004] Patent Literature 1: Japanese Patent Application No. 2020-515425

[0005] In the scroll compressor disclosed in Patent Literature 1, the suction port formed in the main frame runs in the vertical direction relative to the direction in which the refrigerant swirls around the axis of the crankshaft. That is, the suction port is not formed along the flow of the refrigerant moving from the lower space below the main frame to the upper space above the main frame. Thus, in the scroll compressor, the refrigerant swirling in the lower space below the main frame is likely to receive resistance when flowing into the suction port, and pressure loss of the refrigerant may thereby be caused. In addition, if, with the increase in the rotational speed of the compressor, the circulation amount of the refrigerant is increased, and the flow rate of the refrigerant is increased, the pressure loss is further increased, thereby causing performance reduction.

SUMMARY

[0006] The present disclosure has been made to solve such an above-described problem, and an object thereof is to provide a scroll compressor enabling reduction of an

increase in the pressure loss of refrigerant and enabling suppression of performance reduction, even if the circulation amount of the refrigerant is increased, and the flow rate of the refrigerant is increased.

[0007] A scroll compressor according to an embodiment of the present disclosure includes: a shell forming a sealed space; a main frame fixed to an inner wall surface of the shell; a fixed scroll including a first base plate provided with a first scroll body; an orbiting scroll supported by the main frame so as to orbit around the fixed scroll, the orbiting scroll including a second base plate provided with a second scroll body meshing with the first scroll body, the orbiting scroll forming, with the fixed scroll, a compression chamber in which refrigerant is compressed; and a crankshaft transmitting rotational driving force to the orbiting scroll. The main frame has a suction port for supplying an inside of the compression chamber with refrigerant swirling around the crankshaft in a lower space below the main frame. The suction port is formed so as to be tilted relative to an axial direction of the crankshaft while running in a direction in which refrigerant flows from the lower space below the main frame to an upper space above the main frame.

[0008] According to an embodiment of the present disclosure, because the suction port is formed so as to be tilted relative to the axial direction of the crankshaft while running in the direction in which the refrigerant flows, the resistance acting on the refrigerant can be reduced when the refrigerant swirling in the lower space below the main frame flows into the suction port. Thus, even if the circulation amount of the refrigerant is increased, and the flow rate of the refrigerant is increased, an increase in the pressure loss of the refrigerant can be reduced, and performance reduction can be suppressed.

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. 1 is a vertical sectional view of the inner structure of a scroll compressor according to Embodiment.

[0010] FIG. 2 is an exploded perspective view of a related part of the scroll compressor according to Embodiment.

[0011] FIG. 3 is an enlarged view of part III in FIG. 1.

[0012] FIG. 4 illustrates the flows of refrigerant in the scroll compressor according to Embodiment.

[0013] FIG. 5 schematically illustrates a suction port of a main frame of the scroll compressor according to Embodiment.

[0014] FIG. 6 is a transverse sectional view of a compression mechanism unit of the scroll compressor according to Embodiment.

[0015] FIG. 7 is a vertical sectional view of the inner structure of the scroll compressor according to Embodiment and an enlarged view of a related part in which the suction port is formed.

[0016] FIG. 8 illustrates the main frame of the scroll compressor according to Embodiment when viewed from below.

[0017] FIG. 9 illustrates the main frame of the scroll compressor according to Embodiment when viewed from below.

[0018] FIG. 10 illustrates a modification of the scroll compressor according to Embodiment and is a transverse sectional view of the compression mechanism unit.

DETAILED DESCRIPTION

[0019] Hereinafter, an embodiment according to the present disclosure will be described with reference to the drawings. Note that, in the drawings, the same or equivalent parts are denoted by the same references, and the description thereof will appropriately be omitted or simplified. In addition, for example, the shapes, the sizes, and the arrangement of the constituents illustrated in the drawings can appropriately be changed.

Embodiment

[0020] FIG. 1 is a vertical sectional view of the inner structure of a scroll compressor 100 according to Embodiment. FIG. 2 is an exploded perspective view of a related part of the scroll compressor 100 according to Embodiment. FIG. 3 is an enlarged view of part III in FIG. 1. Note that the scroll compressor 100, in FIG. 1, according to Embodiment is a so-called vertical scroll compressor that is used with the central axis of a crankshaft 7 being substantially perpendicular to the ground. The scroll compressor 100 is one of the constituting elements of a refrigeration cycle that is used for, for example, a refrigerator, a freezer, an air-conditioning apparatus, a refrigeration apparatus, or a water heater.

[0021] The scroll compressor 100 sucks the refrigerant circulating through the refrigeration cycle, compresses to bring the refrigerant into a high-temperature and high-pressure state, and discharges the refrigerant in such a state. As FIGS. 1 and 2 illustrate, the scroll compressor 100 includes a shell 1 constituting an outer contour, a main frame 2 joined to an inner wall surface of the shell 1, a compression mechanism unit 3 that compresses refrigerant, a driving mechanism unit 6 that drives the compression mechanism unit 3, and the crankshaft 7 coupling the compression mechanism unit 3 and the driving mechanism unit 6 to each other.

[0022] As FIG. 1 illustrates, the shell 1 is constituted by a conductive part such as a metal. The shell 1 has, therein, a sealed space formed by closing both ends of a tubular body. The main frame 2, the compression mechanism unit 3, the driving mechanism unit 6, and the crankshaft 7 are accommodated inside the shell 1.

[0023] The shell 1 includes a main shell 1a having a cylindrical shape, an upper shell 1b closing an upper-side opening of the main shell 1a and having a substantially dome shape, and a lower shell 1c closing a lower-side opening of the main shell 1a and having a substantially dome shape. A portion of a side wall of each of the upper shell 1b and the lower shell 1c is joined to the main shell 1a by, for example, welding. The shell 1 is supported by a fixation base 1d fixed to the lower shell 1c.

[0024] As FIG. 2 illustrates, an inner wall surface of the main shell 1a includes a first inner wall surface 10a formed in an upper end portion and having a large inside diameter, a second inner wall surface 10b formed below the first inner wall surface 10a and having an inside diameter smaller than the inside diameter of the first inner wall surface 10a, and a third inner wall surface 10c formed below the second inner wall surface 10b and having an inside diameter smaller than the inside diameter of the second inner wall surface 10b. A first step part 11a is formed by a lower end of the first inner wall surface 10a and an upper end of the second inner wall surface 10b and protrudes in the radial direction from the inner wall surface of the shell 1, and the first step part 11a

functions as a positioning part for a fixed scroll 4. A second step part 11b is formed by a lower end of the second inner wall surface 10b and an upper end of the third inner wall surface 10c and protrudes in the radial direction from the inner wall surface of the shell 1, and the second step part 11b functions as a positioning part for the main frame 2.

[0025] As FIG. 1 illustrates, the main shell 1a is provided with a suction pipe 13 for introducing refrigerant into the shell 1 and a power supply unit 19 for supplying power to the scroll compressor 100. A portion of the suction pipe 13 is inserted into a hole formed in a side wall of the main shell 1a, and the suction pipe 13 in such a state is connected to the main shell 1a by, for example, welding. The suction pipe 13 communicates with the inner space of the shell 1. The power supply unit 19 includes a cover 19a, a power supply terminal 19b, and a wire 19c. The power supply terminal 19b is a metal part. One end thereof is disposed so as to be surrounded by the cover 19a, and the other end thereof is disposed inside the main shell 1a. One end of the wire 19c is connected to the power supply terminal 19b, and the other end thereof is connected to the driving mechanism unit 6.

[0026] A discharge pipe 14 for discharging the compressed refrigerant outside the shell 1 is connected to the upper shell 1b. The discharge pipe 14 communicates with the inner space of the shell 1. A portion of the discharge pipe 14 is inserted into a hole formed in an upper portion of the upper shell 1b, and the discharge pipe 14 in such a state is connected to the upper shell 1b by, for example, welding. An oil sump 18 for storing a lubricating oil is provided in an inner bottom portion of the shell 1.

[0027] As FIGS. 1 and 2 illustrate, the main frame 2 is a metal frame having a tubular shape tapered downward in a stepwise manner and supports an orbiting scroll 5 such that the orbiting scroll 5 orbits. With an outer peripheral wall of the main frame 2 being supported by the second step part 11b of the main shell 1a, the outer peripheral wall of the main frame 2 is fixed to the second inner wall surface 10b of the main shell 1a by, for example, shrink fitting. A flat surface 20 having an annular shape is formed in an upper surface of the main frame 2. A thrust plate 25 having a ring shape and made of a steel-plate material such as a valve steel is provided on the flat surface 20. The thrust plate 25 functions as a thrust sliding surface of the main frame 2 and supports a thrust load of the compression mechanism unit 3.

[0028] In addition, as FIG. 2 illustrates, a tube inner part of the main frame 2 is constituted by an accommodation part 21 and a main bearing part 22 supporting the crankshaft 7. The accommodation part 21 is provided in an upper portion of the main frame 2. The main bearing part 22 is provided in a lower portion of the main frame 2.

[0029] As FIG. 2 illustrates, the accommodation part 21 is formed such that the inside diameter thereof decreases downward in a stepwise manner. In the accommodation part 21, a step part positioned on the flat surface 20 side serves as an Oldham accommodation part 21a, and a step part positioned on the main bearing part 22 side serves as a bush accommodation part 21b. In addition, a pair of first Oldham grooves 21c is provided in portions of the Oldham accommodation part 21a and portions of the flat surface 20, and the first Oldham grooves 21c are formed so as to face each other with a shaft hole interposed therebetween. Each of the first Oldham grooves 21c is a key groove. A portion of the first Oldham groove 21c overlaps the thrust plate 25 when the main frame 2 is viewed from above.

[0030] In addition, the main frame 2 has a suction port 26 for supplying the compression mechanism unit 3 with the refrigerant swirling around the crankshaft 7 in the lower space below the main frame 2. The suction port 26 is formed in an outer edge portion of the flat surface 20 of the main frame 2 and passes through in an up-down direction such that the lower space below the main frame 2 and the upper space above the main frame 2 communicate with each other. Specifically, the outer peripheral wall of the main frame 2 has a recessed part 27 allowing the lower space below the main frame 2 and the upper space above the main frame 2 to communicate with each other and formed circumferentially along the main frame 2. As FIGS. 1 to 3 illustrate, the suction port 26 is a space surrounded by the recessed part 27 and the inner wall surface of the shell 1. In addition, the thrust plate 25 has, at a position corresponding to the suction port 26 of the main frame 2, a cutout part 25a that is formed by cutting out a portion of the outer periphery of the thrust plate 25. The cutout part 25a has the same shape as the suction port 26 or is formed larger than the suction port 26 such that the suction port 26 is not covered.

[0031] In addition, as FIGS. 1 and 3 illustrate, in the main frame 2, an oil return pipe 24 is inserted into an oil return hole 23 passing through the inside of the main frame 2 to the outside of the main frame 2, and the oil return pipe 24 in such a state is fixed. The oil return hole 23 communicates with the bush accommodation part 21b. The oil return pipe 24 is provided for returning the lubricating oil accumulated in the accommodation part 21 to the oil sump 18 provided in the lower shell 1c. Note that, regarding the oil return hole 23 and the oil return pipe 24, the number thereof is not limited to one and may be more than one.

[0032] The above-described main frame 2 is made of an iron-based metal or an aluminum-based metal. The main frame 2 is shaped by casting when formed by using an iron-based material. In addition, the main frame 2 is formed by machining when formed by using a carbon steel material for machine structures. The main frame 2 is formed by casting or forging when an aluminum-based material is used.

[0033] The compression mechanism unit 3 includes the fixed scroll 4 and the orbiting scroll 5. As FIGS. 2 and 3 illustrate, the fixed scroll 4 includes a first base plate 4a having a disk shape and a first scroll body 4b provided on a lower surface of the first base plate 4a. The orbiting scroll 5 includes a second base plate 5a having a disk shape and a second scroll body 5b provided on an upper surface of the second base plate 5a and meshing with the first scroll body 4b. The orbiting scroll 5 is mounted eccentrically to the fixed scroll 4. The first scroll body 4b of the fixed scroll 4 and the second scroll body 5b of the orbiting scroll 5 are combined to form a compression chamber 30 in which refrigerant is compressed.

[0034] The fixed scroll 4 is formed by a metal such as cast iron. The fixed scroll 4 is joined to the first inner wall surface 10a by, for example, shrink fitting, with an outer peripheral surface of the first base plate 4a being supported by the first step part 11a of the main shell 1a. Note that the configuration in which the fixed scroll 4 is joined to the first inner wall surface 10a is not the only option, and the fixed scroll 4 may be, for example, screwed to the main frame 2.

[0035] A center portion of the first base plate 4a has a discharge port 40 through which the refrigerant that has been compressed into high-temperature and high-pressure refrigerant is discharged. A chamber 15 having a discharge hole

15a communicating with the discharge port 40 is provided on an upper surface of the fixed scroll 4. A discharge valve 17 is screwed to the chamber 15, and the discharge valve 17 opens and closes the discharge hole 15a according to the pressure of the refrigerant. The discharge valve 17 brings the discharge hole 15a into an open state when the pressure of the refrigerant in the compression chamber 30, which communicates with the discharge port 40, reaches a predetermined pressure. The compressed high-temperature and high-pressure refrigerant is sent out from the discharge port 40 into a high-pressure space 16 positioned above the fixed scroll 4 and then passes through the discharge pipe 14 to be discharged outside the shell 1. In addition, a distal end portion of the first scroll body 4b has a groove, and a tip seal 41 made of, for example, a hard plastic is provided for the groove.

[0036] The orbiting scroll 5 is formed by a metal such as aluminum. As FIGS. 1 to 3 illustrate, with an Oldham ring 54 for preventing the orbiting scroll 5 from rotating on its axis, the orbiting scroll 5 performs a revolving motion relative to the fixed scroll 4 without rotating on its axis. Note that a surface of the second base plate 5a (a lower surface in the illustrated example) on the side where the second scroll body 5b is not formed functions as an orbiting-scroll thrust bearing surface. In addition, a boss part 51 having a hollow cylindrical shape is provided at a center portion of the orbiting-scroll thrust bearing surface. An orbiting bearing for supporting a slider 80 of a bush 8 such that the slider 80 rotates is provided in an inner peripheral surface of the boss part 51. The orbiting bearing is a so-called journal bearing. The orbiting bearing is provided such that the central axis thereof is parallel to the central axis of the crankshaft 7. The rotation of an eccentric shaft part 71, of the crankshaft 7, inserted into the boss part 51 causes the orbiting scroll 5 to perform a revolving motion on the thrust sliding surface of the main frame 2.

[0037] In addition, a distal end portion of the second scroll body 5b has a groove, and a tip seal 52 made of, for example, a hard plastic is provided for the groove. In addition, the orbiting-scroll thrust bearing surface has second Oldham grooves 53 in a pair that are formed so as to face each other with the boss part 51 interposed therebetween. Each of the second Oldham grooves 53 is a key groove having an elliptical shape. The paired second Oldham grooves 53 are disposed such that the line connecting the second Oldham grooves 53 to each other is orthogonal to the line connecting the paired first Oldham grooves 21c to each other.

[0038] The Oldham ring 54 includes a ring part 54a, first key parts 54b, and second key parts 54c. The ring part 54a has an annular shape and is accommodated in the Oldham accommodation part 21a of the main frame 2. The first key parts 54b are provided on a lower surface of the ring part 54a. The first key parts 54b are paired and accommodated in the respective paired first Oldham grooves 21c of the main frame 2. The second key parts 54c are provided on an upper surface of the ring part 54a. The second key parts 54c are paired and accommodated in the respective paired second Oldham grooves 53 of the orbiting scroll 5. The position of the second scroll body 5b of the orbiting scroll 5 in the rotation direction is determined by aligning the second Oldham grooves 53 of the orbiting scroll 5 with the second key parts 54c of the Oldham ring 54. That is, the orbiting scroll 5 is positioned, relative to the main frame 2, by the Oldham ring 54, and the phase of the second scroll body 5b

relative to the main frame 2 is determined. When the rotation of the crankshaft 7 causes the orbiting scroll 5 to revolve, the first key part 54b slides in the first Oldham groove 21c, and the second key part 54c slides in the second Oldham groove 53; thus, the Oldham ring 54 prevents the orbiting scroll 5 from rotating on its axis.

[0039] The compression chamber 30 is formed by meshing the first scroll body 4b of the fixed scroll 4 and the second scroll body 5b of the orbiting scroll 5 with each other and by sealing with the tip seal 41, which is provided on the distal end of the first scroll body 4b, and the second base plate 5a and with the tip seal 52, which is provided on the distal end of the second scroll body 5b, and the first base plate 4a. The compression chamber 30 is constituted by plural compression chambers having volumes that are reduced from the outer side to the inner side in the radial direction of the scroll.

[0040] The refrigerant is, for example, a halogenated hydrocarbon having double-bonded carbon in the composition, a halogenated hydrocarbon having no double-bonded carbon in the composition, a hydrocarbon, or a mixture including any one of these hydrocarbons. Examples of the halogenated hydrocarbon having double-bonded carbon include an HFC refrigerant having zero ozone depletion potential, and tetrafluoropropene such as HFO1234yf, HFO1234ze, or HFO1243zf that is a fluorocarbon-based refrigerant, with a low GWP, represented by a chemical formula $C_3H_2F_4$. Examples of the halogenated hydrocarbon having no double-bonded carbon include a refrigerant mixed with, for example, R32 (difluoromethane) represented as CH_2F_2 , or R41. Examples of the hydrocarbon include natural refrigerants such as propane and propylene. Examples of the mixture include mixed refrigerants of, for example, HFO1234yf, HFO1234ze, and HFO1243zf mixed with, for example, R32 or R41.

[0041] As FIG. 1 illustrates, the driving mechanism unit 6 drives the compression mechanism unit 3 coupled thereto by using the crankshaft 7. The driving mechanism unit 6 is constituted by a stator 6a having an annular shape and supported by being joined to the inner wall surface of the shell 1 by, for example, shrink fitting and a rotor 6b attached so as to rotate while facing an inner surface of the stator 6a. The stator 6a has a configuration in which, for example, an iron core formed by layering plural electromagnetic steel sheets is wound with a winding with an insulating layer interposed therebetween, and the stator 6a has a ring shape in plan view. The rotor 6b has a configuration in which a permanent magnet is provided inside an iron core formed by layering plural electromagnetic steel sheets, and the rotor 6b has, at the center, a through hole passing through in the up-down direction. The rotor 6b is disposed with a predetermined gap being maintained between an outer peripheral surface of the rotor 6b and an inner peripheral surface of the stator 6a.

[0042] The crankshaft 7 is a rod-shaped metal part as FIG. 1 illustrates. The crankshaft 7 includes a main shaft part 70 and the eccentric shaft part 71. The main shaft part 70 is a shaft constituting a main part of the crankshaft 7 and is disposed such that the central axis thereof coincides with the central axis of the main shell 1a. The main shaft part 70 is fixed in the through hole positioned at the center of the rotor 6b by, for example, shrink fitting and is supported so as to rotate by the main bearing part 22 provided in a center portion of the main frame 2 and by a sub-bearing part 90

provided in a center portion of a sub-frame 9 joined to a lower portion of the shell 1 by, for example, welding or shrink fitting.

[0043] As FIGS. 1 to 3 illustrate, the eccentric shaft part 71 is provided on an upper end portion of the main shaft part 70 such that the central axis thereof is eccentric to the central axis of the main shaft part 70. The eccentric shaft part 71 is connected to the orbiting scroll 5 with the bush 8 that is a part of a metal, such as iron, interposed therebetween, and the eccentric shaft part 71 is supported by the boss part 51 of the orbiting scroll 5 so as to rotate. The crankshaft 7 rotates with the rotation of the rotor 6b, and the eccentric shaft part 71 of the crankshaft 7 causes the orbiting scroll 5 to revolve. In addition, inside each of the main shaft part 70 and the eccentric shaft part 71, an oil passage 72 is provided and vertically passes through in the axial direction.

[0044] As FIGS. 2 and 3 illustrate, the bush 8 includes the slider 80 and a balance weight 81. The slider 80 is a tubular part on which a collar is formed and is inserted into the boss part 51 so as to rotate. The eccentric shaft part 71 is inserted along a slide surface of the slider 80. That is, the slider 80 is interposed between the orbiting scroll 5 and the eccentric shaft part 71, and the slider 80 makes the radius of orbit of the orbiting scroll 5 variable and supports the orbiting scroll 5 such that the orbiting scroll 5 performs a revolving motion.

[0045] The balance weight 81 is provided for cancelling the centrifugal force of the orbiting scroll 5 generated by an orbital motion. The balance weight 81 is provided eccentrically to the center of rotation. The balance weight 81 has a lower portion having an annular shape and an upper portion in which a weight part 81a having a substantially C shape is provided on the side opposite to the direction of the centrifugal force exerted on the orbiting scroll 5. The scroll compressor 100, with the balance weight 81, can suppress the second scroll body 5b from being pressed against the first scroll body 4b. For example, the balance weight 81 is fitted onto the collar of the slider 80 by, for example, shrink fitting.

[0046] The sub-frame 9 is a metal frame. As FIG. 1 illustrates, the sub-frame 9 is provided with the sub-bearing part 90 and an oil pump 91. The sub-bearing part 90 is a ball bearing provided at the center of the sub-frame 9. The oil pump 91 is a pump for pumping up the lubricating oil stored in the oil sump 18 of the shell 1 and is provided below the sub-bearing part 90. The oil pump 91 is disposed such that at least a portion thereof is immersed in the lubricating oil.

[0047] The lubricating oil is stored in the oil sump 18. The lubricating oil is pumped up by the oil pump 91 and passes through the oil passage 72 of the crankshaft 7, thereby reducing wear between, for example, parts of the compression mechanism unit 3 that come into mechanical contact with each other, adjusting the temperature of a sliding part, and improving the sealing performance. For the lubricating oil, there is preferably used an oil that is good in lubricate characteristics, electrical insulation property, stability, refrigerant solubility, and fluidity at low temperature and has a moderate viscosity. For the lubricating oil, there may be used oils such as a naphthene-based oil and oils of polyolester (POE), polyvinyl ether (PVE), and polyalkylene glycol (PAG).

[0048] Next, while referring to FIGS. 1 to 3, the features of the suction port 26 of the main frame 2 will be described with reference to FIGS. 4 to 9. FIG. 4 illustrates the flows of the refrigerant in the scroll compressor 100 according to Embodiment. FIG. 5 schematically illustrates the suction

port 26 of the main frame 2 of the scroll compressor 100 according to Embodiment. FIG. 6 is a transverse sectional view of the compression mechanism unit 3 of the scroll compressor 100 according to Embodiment. FIG. 7 is a vertical sectional view of the inner structure of the scroll compressor 100 according to Embodiment and an enlarged view of a related part in which the suction port 26 is formed. FIG. 8 illustrates the main frame 2 of the scroll compressor 100 according to Embodiment when viewed from below. FIG. 9 illustrates the main frame 2 of the scroll compressor 100 according to Embodiment when viewed from below. Note that, in FIG. 4, the black arrows indicate the directions where the refrigerant flows, and the hollow arrow indicates the rotation direction of the crankshaft 7. In addition, in FIG. 5, only the features of Embodiment are given, and other constituting elements are omitted.

[0049] As the black arrows illustrated in FIG. 4 indicate, the refrigerant flows into the shell 1 through the suction pipe 13 provided in a side portion of the shell 1 and, while swirling around the crankshaft 7 in the lower space below the main frame 2, flows into the compression chamber 30 through the suction port 26 provided in the main frame 2. Note that the refrigerant that has flowed into the shell 1 through the suction pipe 13 is sometimes divided into portions flowing clockwise and flowing counterclockwise around the boss part 51; however, after that, only the flow in a swirling direction, which is the same as the rotation direction of the crankshaft 7 (the hollow arrow in FIG. 4) remains, and the refrigerant swirls in one direction, that is, the rotation direction of the crankshaft 7 (the hollow arrow in FIG. 4). That is, even if the scroll compressor 100 is started over and over, the swirling direction of the refrigerant is determined according to the rotation direction of the crankshaft 7.

[0050] In the case of the scroll compressor 100 in which the suction port 26 formed in the main frame 2 runs in the vertical direction relative to the direction in which the refrigerant swirls around the axis of the crankshaft 7, when the refrigerant swirling in the lower space below the main frame 2 flows into the suction port 26, the refrigerant is likely to receive resistance, and the pressure loss of the refrigerant is thus caused. In addition, if, with the increase in the speed of the rotation of the scroll compressor 100, the circulation amount of the refrigerant is increased, and the flow rate of the refrigerant is increased, the pressure loss is further increased, and performance reduction may thereby be caused.

[0051] Thus, as FIG. 5 illustrates, the suction port 26 of the scroll compressor 100 according to Embodiment is formed so as to be tilted relative to the axial direction of the crankshaft 7 while running in the direction in which the refrigerant flows. That is, the suction port 26 is formed so as to be tilted according to the rotation direction of the crankshaft 7. Thus, the positions of an inlet 26a and an outlet 26b of the suction port 26 are displaced in the circumferential direction of the main frame 2. A greater tilt angle of the suction port 26 is preferable because the suction port 26 can be made more parallel to the direction in which the refrigerant flows; however, the tilt angle is limited due to the structure of the main frame 2, the shape of a hole of the suction port 26, and the size and the installation position of the suction port 26, for example. Thus, the tilt angle of the suction port 26 is set in consideration of the above-described limitations.

[0052] In addition, as FIG. 6 illustrates, two suction ports 26 are provided so as to face each other in the radial direction of the main frame 2. The outlet 26b of one suction port 26 is formed at a position apart from an outer end portion 4c of the first scroll body 4b, with an intersection point O_1 of a line X_1 extended from the outer end portion 4c of the first scroll body 4b (a winding end portion) toward an outer peripheral edge of the main frame 2 and the outer peripheral edge of the main frame 2 as an origin. The outlet 26b of the other suction port 26 is formed at a position apart from an outer end portion 5c of the second scroll body 5b, with an intersection point O_2 of a line X_2 extended from the outer end portion 5c of the second scroll body 5b (a winding end portion) toward the outer peripheral edge of the main frame 2 and the outer peripheral edge of the main frame 2 as an origin.

[0053] The recessed part 27 constituting the suction port 26 is formed, as a twisted groove, in an outer wall surface of the main frame 2. Thus, the action of the centrifugal force causes the refrigerant that has been introduced into the suction port 26 to flow along the inner wall surface of the shell 1. At this point, if the outlet 26b of the suction port 26 is disposed close to the outer end portion 4c of the first scroll body 4b or the outer end portion 5c of the second scroll body 5b, the refrigerant that has flowed out from the suction port 26 flows outside the first scroll body 4b or the second scroll body 5b, along the inner wall surface of the shell 1, and the refrigerant is not thereby successfully introduced into the vortex of the first scroll body 4b or the second scroll body 5b.

[0054] Thus, as described above, the outlet 26b of the suction port 26 is preferably positioned at a certain distance from the outer end portion 4c of the first scroll body 4b or the outer end portion 5c of the second scroll body 5b, by being disposed at the position illustrated in FIG. 6. This arrangement can suppress the refrigerant that has flowed out from the suction port 26 from flowing outside the first scroll body 4b or the second scroll body 5b, and the refrigerant can be introduced efficiently into the vortex of the first scroll body 4b or the second scroll body 5b. However, the outlet 26b of the suction port 26 from which the refrigerant is introduced into the outer end portion 4c of the first scroll body 4b is provided at a position closer to the outer end portion 4c of the first scroll body 4b than to the outer end portion 5c of the second scroll body 5b. Similarly, the outlet 26b of the suction port 26 from which the refrigerant is introduced into the outer end portion 5c of the second scroll body 5b is provided at a position closer to the outer end portion 5c of the second scroll body 5b than to the outer end portion 4c of the first scroll body 4b.

[0055] Note that, the outlet 26b of the suction port 26 is preferably provided at a position where, when the crankshaft 7 makes one rotation to cause the orbiting scroll 5 to orbit, the suction port 26 and the second scroll body 5b do not overlap each other due to the orbital motion. If the outlet 26b of the suction port 26 and the second scroll body 5b overlap each other, at this moment, the pressure loss due to reduction of the opening area of the outlet 26b is caused.

[0056] In addition, as FIG. 7 illustrates, the shell 1 has the second step part 11b protruding from the inner wall surface in the radial direction and supporting the outer peripheral wall of the main frame 2. Thus, when a space surrounded by the recessed part 27 formed in the outer peripheral wall of the main frame 2 and the inner wall surface of the shell 1

serves as the suction port **26**, the opening area of the inlet **26a** through which the refrigerant passes is smaller than the opening area of the outlet **26b** by a dimension of the second step part **11b**. When the opening area of the inlet **26a** through which the refrigerant passes is smaller than the opening area of the outlet **26b**, the speed of the refrigerant at a position close to the outlet **26b** is slightly decreased, and the pressure loss at the inlet **26a** is increased relative to the outlet **26b**. Thus, the inlet **26a** of the suction port **26** is formed larger than the outlet **26b** of the suction port **26** in the radial direction by the dimension of the second step part **11b** protruding in the radial direction. At this point, an inner surface of the recessed part **27** is tilted to the outside diameter side while running from the inlet **26a** toward the outlet **26b**. Thus, the opening area of the inlet **26a** of the suction port **26** and the opening area of the outlet **26b** of the suction port **26** can be made substantially equal, and the pressure loss at the inlet **26a** can thereby be suppressed. Note that the opening area of the inlet **26a** of the suction port **26** and the opening area of the outlet **26b** of the suction port **26** may differ if there is no particular problem of, for example, pressure loss.

[0057] In addition, as FIG. 8 illustrates, the two suction ports **26** may be a main port **260** and a sub-port **261** having an opening area smaller than the main port **260**. The opening areas of the suction ports **26** differ because the amount of the opening area may be limited due to the arrangement relationship of a stiffening rib **28** provided for the main frame **2**, the suction pipe **13** connected to the shell **1**, and other parts. In this case, the sub-port **261** is preferably formed at a position closer to the suction pipe **13** than the main port **260**. Moreover, as FIG. 9 illustrates, the main port **260** is preferably formed at a position where the main port **260** faces the suction pipe **13** with the main bearing part **22** interposed therebetween. The sub-port **261** is most suitably formed circumferentially along the main frame **2**, at a position midway between the main port **260** and the main bearing part **22**. As described above, due to positioning the sub-port **261** close to the suction pipe **13**, the refrigerant easily flows into and through the sub-port **261**, and the refrigerant introduction amounts of the first scroll body **4b** and the second scroll body **5b** can be made similar to each other.

[0058] That is, the hole shapes and the sizes of the inlet **26a** and the outlet **26b** of the suction port **26** may be the same or may differ. In addition, in consideration of the structure of the lower portion of the main frame **2**, the inlet **26a** and the outlet **26b** of the suction port **26** may be displaced in the radial direction of the main frame **2** such that, for example, the inlet **26a** is positioned on the inside diameter side or the outside diameter side of the main frame **2**, and the outlet **26b** is positioned on the outside diameter side or the inside diameter side.

[0059] In addition, the resistance generated when the refrigerant flows into the suction port **26** is reduced by tilting the suction port **26**, and the flow rate of the refrigerant swirling in the lower space below the main frame **2** is thereby increased; thus, the amount of the refrigerating machine oil that is introduced into the compression chamber **30** with the refrigerant may be increased. Thus, as FIG. 5 illustrates, an inner wall surface **26c** of the suction port **26** has a fine uneven shape, and the surface roughness of the inner wall surface **26c** of the suction port **26** is preferably made moderately great. The surface roughness of the inner wall of the suction port **26** is greater than or equal to, for

example, the surface roughness of an unprocessed casting surface in the case of casting or the surface roughness of a surface finished by medium-grade machining in the case of machining. By doing in the above-described ways, the refrigerating machine oil introduced into the compression chamber **30**, with the refrigerant, sticks to the fine uneven surface of the inner wall of the suction port **26**, and the amount of the introduced refrigerating machine oil can be suppressed from increasing.

[0060] When injection refrigerant is injected into the compression chamber **30**, an inflow port for injection is provided, in the first base plate **4a** of the fixed scroll **4**, at a position corresponding to a part A in FIG. 6, and the injection refrigerant, with the refrigerant flowing in from the suction port **26**, can thereby be efficiently introduced into the vortex.

[0061] Note that FIG. 10 illustrates a modification of the scroll compressor **100** according to Embodiment and is a transverse sectional view of the compression mechanism unit **3**. The suction port **26** is not limited to the configurations illustrated in FIGS. 1 to 9. As FIG. 10 illustrates, the suction port **26** may be formed, in an outer edge portion of the flat surface **20** of the main frame **2**, as a through hole passing through in the up-down direction such that the lower space below the main frame **2** and the upper space above the main frame **2** communicate with each other.

[0062] In this case, the outlet **26b** of each of the suction ports **26** is positioned so as to face an introduction position B of the refrigerant that is introduced into the compression chamber **30**. Two positions B where the refrigerant that has flowed into the upper space above the main frame **2** from the outlet **26b** is introduced into the compression chamber **30** are provided at the outer end portion **5c** (the winding end portion) of the second scroll body **5b** of the orbiting scroll **5** and at the outer end portion **4c** (the winding end portion) of the first scroll body **4b** of the fixed scroll **4**. The outlet **26b** of the suction port **26** is provided so as to face the introduction position A of the refrigerant that is introduced into the compression chamber **30**, and the refrigerant that has flowed out from the suction port **26** is thereby introduced into the compression chamber **30** at the shortest distance; thus, the resistance acting on the refrigerant can be suppressed from increasing. Note that the suction port **26** of Embodiment has an elliptical shape in plan view in one example. The major axis direction of the ellipse may be the same as a tangential direction of the outer periphery of the main frame **2**, and the extension line of the major axis may extend through the position A where the refrigerant is introduced into the compression chamber **30**. Moreover, the outlet **26b** of the suction port **26** may be provided at a position where, when one rotation of the crankshaft **7** causes the orbiting scroll **5** to orbit, the suction port **26** and the second scroll body **5b** do not overlap each other due to the orbital motion. This is because, when the outlet **26b** of the suction port **26** and the second scroll body **5b** overlap each other, at this moment, the pressure loss is generated by reducing the opening area.

[0063] In addition, the hole shapes and the sizes of the inlet **26a** and the outlet **26b** of the suction port **26** illustrated in FIG. 10 may be the same or may differ. In addition, in consideration of the structure of the lower portion of the main frame **2**, in the suction port **26**, the inlet **26a** and the outlet **26b** may be displaced in the radial direction of the main frame **2** such that, for example, the inlet **26a** is

positioned on the inside diameter side or the outside diameter side of the main frame 2, and the outlet 26b is positioned on the outside diameter side or the inside diameter side. In addition, as FIG. 5 illustrates, the inner wall surface 26c of the suction port 26 may have a fine uneven shape, and the surface roughness of the inner wall surface 26c of the suction port 26 may be made moderately great.

[0064] As described above, the scroll compressor 100 according to Embodiment includes: the shell 1 forming a sealed space; the main frame 2 fixed to the inner wall surface of the shell 1; the fixed scroll 4 including the first base plate 4a provided with the first scroll body 4b; the orbiting scroll 5 supported by the main frame 2 so as to orbit around the fixed scroll, the orbiting scroll 5 including the second base plate 5a provided with the second scroll body 5b meshing with the first scroll body 4b, the orbiting scroll 5 forming, between the orbiting scroll 5 and the fixed scroll 4, the compression chamber 30 in which refrigerant is compressed; and the crankshaft 7 transmitting rotational driving force to the orbiting scroll 5. The main frame 2 has the suction port 26 for supplying the inside of the compression chamber 30 with the refrigerant swirling around the crankshaft 7 in the lower space below the main frame 2. The suction port 26 is formed so as to be tilted relative to the axial direction of the crankshaft 7 while running in the direction in which refrigerant flows from the lower space below the main frame 2 to the upper space above the main frame 2.

[0065] Because, the suction port 26 in the scroll compressor 100 according to Embodiment is formed so as to be tilted relative to the axial direction of the crankshaft 7 while running in the direction in which the refrigerant flows, that is, the direction in which the refrigerant swirls around the axis of the crankshaft 7, the resistance acting on the refrigerant can be reduced when the refrigerant swirling in the lower space below the main frame 2 flows into the suction port 26. Thus, even if the circulation amount of the refrigerant is increased, and the flow rate of the refrigerant is increased, an increase in the pressure loss of the refrigerant can be reduced, and performance reduction can be suppressed.

[0066] In addition, the outlet 26b of the suction port 26 is formed at one or both of the position apart from the outer end portion 4c of the first scroll body 4b, with the intersection point O₁ of the line X₁ extended from the outer end portion 4c of the first scroll body 4b toward the outer peripheral edge of the main frame 2 and the outer peripheral edge of the main frame 2 as an origin, and the position apart from the outer end portion 5c of the second scroll body 5b, with the intersection point O₂ of the line X₂ extended from the outer end portion 5c of the second scroll body 5b toward the outer peripheral edge of the main frame 2 and the outer peripheral edge of the main frame 2 as an origin. Thus, the outlet 26b of the suction port 26 can be positioned at a certain distance from the outer end portion 4c of the first scroll body 4b or the outer end portion 5c of the second scroll body 5b. Thus, in the scroll compressor 100, the refrigerant that has flowed out from the suction port 26 can be suppressed from flowing outside the first scroll body 4b or the second scroll body 5b and can be introduced efficiently into the vortex of the first scroll body 4b or the second scroll body 5b.

[0067] The suction ports 26 include the main port 260 and the sub-port 261 having an opening area smaller than the main port 260. Thus, it is possible to handle the case where the amount of the opening area of the suction port 26 is

limited due to the arrangement relationship of the stiffening rib 28 provided for the main frame 2, the suction pipe 13 connected to the shell 1, and other parts.

[0068] The scroll compressor 100 according to Embodiment further includes the suction pipe 13 that is connected to the shell 1 and through which refrigerant is sucked inside from outside the shell 1. The sub-port 261 is formed at a position closer to the suction pipe 13 than the main port 260. That is, due to positioning the sub-port 261 close to the suction pipe 13, the refrigerant easily flows into and through the sub-port 261, and the refrigerant introduction amounts at the first scroll body 4b and the second scroll body 5b can be made similar to each other.

[0069] In addition, the main frame 2 includes, in the center portion thereof, the main bearing part 22 supporting the crankshaft 7. The main port 260 is formed at a position where the main port 260 faces the suction pipe 13 with the main bearing part 22 interposed therebetween. The sub-port 261 is formed circumferentially along the main frame 2, at a position midway between the main port 260 and the main bearing part 22. That is, due to positioning the sub-port 261 close to the suction pipe 13, the refrigerant easily flows into and through the sub-port 261, and the refrigerant introduction amounts at the first scroll body 4b and the second scroll body 5b can be made similar to each other.

[0070] The shell 1 has the second step part 11b protruding from the inner wall surface in the radial direction and supporting the main frame 2. The inlet 26a of the suction port 26 is formed larger than the outlet 26b of the suction port 26 in the radial direction by the dimension of the second step part 11b protruding in the radial direction. Although the scroll compressor 100 according to Embodiment includes the second step part 11b, the opening area of the inlet 26a of the suction port 26 and the opening area of the outlet 26b of the suction port 26 can be made substantially equal, and the pressure loss at the inlet 26a can thereby be suppressed from increasing.

[0071] The inner wall surface 26c of the suction port 26 has a fine uneven shape. Thus, the refrigerating machine oil introduced into the compression chamber 30 with the refrigerant sticks to the fine uneven surface of the inner wall of the suction port 26, and the amount of the introduced refrigerating machine oil can be suppressed from increasing.

[0072] Although having so far been described above based on Embodiment, the scroll compressor 100 is not limited to the configurations of Embodiment described above. For example, the illustrated inner configuration of the scroll compressor 100 is not limited to the above-described content and may include another constituting element. In addition, the suction ports 26 are not limited to the illustrated two suction ports, and one suction port 26 or three or more suction ports 26 may be provided. In short, the scroll compressor 100 encompasses a range of design changes and application variations usually made by those who skilled in the art without departing from the technical ideas of the scroll compressor 100.

The invention claimed is:

1. A scroll compressor comprising:
 - a shell forming a sealed space;
 - a suction pipe connected to the shell;
 - a main frame fixed to an inner wall surface of the shell;
 - a fixed scroll including a first base plate provided with a first scroll body;

an orbiting scroll supported by the main frame so as to orbit around the fixed scroll, the orbiting scroll including a second base plate provided with a second scroll body meshing with the first scroll body, the orbiting scroll forming, with the fixed scroll, a compression chamber in which refrigerant is compressed; and a crankshaft transmitting rotational driving force to the orbiting scroll, wherein

the main frame has a suction port for supplying an inside of the compression chamber with refrigerant flowing from the suction pipe into the shell and swirling around the crankshaft in a lower space below the main frame, and

the suction port is formed so as to be tilted relative to an axial direction of the crankshaft while running in a direction in which refrigerant flows from the lower space below the main frame to an upper space above the main frame.

2. The scroll compressor of claim 1, wherein an outer peripheral wall of the main frame has a recessed part allowing the lower space below the main frame and the upper space above the main frame to communicate with each other and formed circumferentially along the main frame, and

the suction port is surrounded by the recessed part and the inner wall surface of the shell.

3. The scroll compressor of claim 1, wherein an inlet and an outlet of the suction port are displaced in a circumferential direction of the main frame.

4. The scroll compressor of claim 1, wherein the suction port is formed so as to be tilted according to a rotation direction of the crankshaft.

5. The scroll compressor of claim 1, wherein an outlet of the suction port is formed at one or both of a position apart from an outer end portion of the first scroll body, with an intersection point of a line extended from the outer end portion of the first scroll body toward an outer peripheral edge of the main frame and the outer peripheral edge of the main frame as an origin, and a position apart from an outer end portion

of the second scroll body, with an intersection point of a line extended from the outer end portion of the second scroll body toward the outer peripheral edge of the main frame and the outer peripheral edge of the main frame as an origin.

6. The scroll compressor of claim 1, wherein the scroll compressor comprises a plurality of the suction ports including a main port and a sub-port having an opening area smaller than the main port.

7. The scroll compressor of claim 6, further comprising: a suction pipe that is connected to the shell and through which refrigerant is sucked inside from outside the shell, wherein

the sub-port is formed at a position closer to the suction pipe than the main port.

8. The scroll compressor of claim 7, wherein the main frame includes, in a center portion, a bearing part supporting the crankshaft,

the main port is formed at a position where the main port faces the suction pipe with the bearing part interposed therebetween, and

the sub-port is formed circumferentially along the main frame, at a position midway between the main port and the bearing part.

9. The scroll compressor of claim 1, wherein the shell has a step part protruding from the inner wall surface in a radial direction and supporting the main frame, and

an inlet of the suction port is formed larger than an outlet of the suction port in the radial direction by a dimension of the step part protruding in the radial direction.

10. The scroll compressor of claim 1, wherein an inner wall surface of the suction port has a fine uneven shape.

11. The scroll compressor of claim 10, wherein the inner wall surface of the suction port has a surface roughness greater than or equal to a casting surface or a surface finished by medium-grade machining.

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