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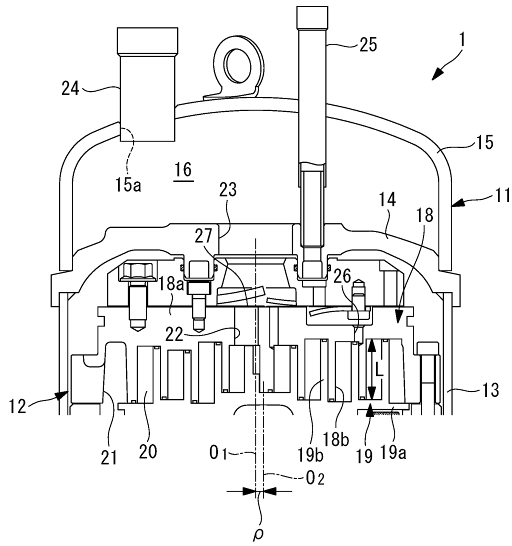
(54) **SCROLL FLUID MACHINE**

(57) The present invention is to provide a scroll fluid machine capable of reliably introducing an intermediate-pressure refrigerant during a compression process and improving the efficiency of a compressor. A scroll compressor (1) includes a fixed scroll (18) and an orbiting scroll (19); after sealing of a compression chamber (20) is started, a first region is set in which a volume change of the compression chamber (20) is gradual or substantially constant; a wall body (18b) and a wall body (19b) include a first wall-body inclined part in which heights of the wall bodies (18b) and (19b) continuously increase from an outer peripheral side to an inner peripheral side in a spiral direction; an end plate (18a) and an end plate (19a) include a first end-plate inclined part in which a tooth bottom opposite to a tooth tip of the first wall-body inclined part is inclined according to an inclination of the first wall-body inclined part; and at least a part of the first region is set by positions and shapes of the first wall-body inclined part and the first end-plate inclined part.

FIG. 2



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Description

[Technical Field]

[0001] The present invention relates to a scroll fluid machine.

[Background Art]

[0002] In general, a scroll fluid machine is known, in which a fixed scroll member and an orbiting scroll member each having a spiral wall body provided on an end plate are meshed with each other and an orbiting and revolving motion is performed to compress or expand a fluid. A scroll compressor in the scroll fluid machine is an apparatus that compresses a refrigerant circulating in a refrigeration cycle applied to an air conditioner, for example.

[0003] As a refrigeration cycle, a two-stage compression refrigeration cycle may be used in which a refrigerant is compressed in two stages to improve performance of a heat pump and improve the coefficient of performance (COP). In the two-stage compression refrigeration cycle, an economizer (gas-liquid separator) is provided between two expansion valves to introduce a refrigerant that has an intermediate-pressure from the economizer in the middle of a compression process. Such a refrigeration cycle is also referred to as a gas injection cycle or an economizer cycle.

[Citation List]

[Patent Literature]

[0004] [PTL 1] Japanese Unexamined Patent Application, Publication No. 2006-312898

[Summary of Invention]

[Technical Problem]

[0005] In order to realize the above-described two-stage compression refrigeration cycle, one of the following three types is required as a structure of the compressor. (1) In a two-stage compressor in which a high-stage compression portion and a low-stage compression portion are housed in a single compressor, an intermediate-pressure refrigerant is introduced between a discharge side of the low-stage compression portion and a suction side of the high-stage compression portion. (2) Two single-stage compressors with only one compression portion are connected in series, and an intermediate-pressure refrigerant is introduced between a discharge side of the low-stage compressor and a suction side of the high-stage compressor. (3) In a single-stage compressor with only one compression portion, an intermediate-pressure refrigerant is introduced in the middle of a compression process of the compression portion.

[0006] In the case of (1) described above, since the two-stage compressor, which houses the high-stage compression portion and the low-stage compression portion therein, is required, the structure of the single compressor becomes complicated. In the case of (2) described above, since two compressors are required, a system constituting the refrigeration cycle becomes complicated and the size of the system becomes large. In the case of (3) described above, the volume of the compression chamber decreases and the compression of the refrigerant proceeds even when the intermediate-pressure refrigerant is being introduced in the compression portion. Therefore, the pressure of the refrigerant in the compression chamber increases, and the difference from the pressure of the refrigerant before introduction decreases, so that a sufficient amount of refrigerant may not be introduced. In this case, it is not possible to sufficiently improve performance of the heat pump and improve the COP.

[0007] In PTL 1 described above, a wall-body stepped part is formed at an upper edge of a wall body of a scroll compressor, and, on the wall body, a higher part is formed to have a higher height from the wall-body stepped part toward a center in a spiral direction and a lower part is formed to have a lower height toward an outer peripheral end. An end-plate stepped part is formed on one side surface of an end plate on which the wall body is erected, and, on the one side surface, a low surface part is formed to have a lower surface from the end-plate stepped part toward a center in the spiral direction and a high surface part is formed to have a high surface toward the outer peripheral end. The end-plate stepped part is formed at a position opposite to the wall-body stepped part. A fluid supply portion (injection port) is provided in a region of the low surface part in the vicinity of the end-plate stepped part to supply a fluid having a pressure higher than a fluid pressure in a compression chamber into the compression chamber.

[0008] In the configuration of PTL 1, when the compression chamber moving toward the center in the spiral direction passes through the wall-body stepped part and the end-plate stepped part, a volume of the compression chamber is gradually reduced, or the volume is increased. The fluid supply portion is provided in a region of the low surface part in the vicinity of the end-plate stepped part.

[0009] In PTL 1, an interval from a time when the sealing of the compression chamber is started by the orbit of an orbiting scroll member (when the suction is closed) to a section set as a section where the volume of the compression chamber is gradually reduced or the volume is increased is short. For this reason, when the refrigerant is introduced into the compression chamber, the pressure in the compression chamber quickly increases to an intermediate pressure (injection pressure), so that a compression period with the pressure after introduction becomes long and useless compression power is generated.

[0010] With the wall-body stepped part and the end-plate stepped part as boundaries, the lower part and the higher part are switched or the high surface part and the low surface part are switched from the outer peripheral end side in the spiral direction toward the center, so that the change in volume is adjusted only by the height and position of the step. Therefore, it is difficult to provide a section where the volume is substantially constant, and the degree of freedom is low during setting of an orbiting angle range of the section where the volume is substantially constant.

[0011] The present invention has been made in view of such circumstances, and an object thereof is to provide a scroll fluid machine capable of reliably introducing an intermediate-pressure refrigerant during a compression process or an expansion process.

[Solution to Problem]

[0012] In order to solve the above-described problems, a scroll fluid machine of the present invention employs the following solutions.

[0013] A scroll compressor according to an aspect of the present invention includes: a first scroll member in which a first wall body having a spiral shape is provided on a first end plate; and a second scroll member in which a second wall body having a spiral shape is provided on a second end plate disposed so as to face the first end plate, the second scroll member being configured to perform a relative orbiting and revolving motion such that the second wall body is meshed with the first wall body to form a sealed space, wherein after sealing of the sealed space is started, a first region is set in which a volume change of the sealed space is gradual or substantially constant, at least one of the first end plate and the second end plate includes a first wall-body inclined part in which a height of the wall body continuously increases from an outer peripheral side to an inner peripheral side in a spiral direction, at least one of the first wall body and the second wall body includes a first end-plate inclined part in which a tooth bottom opposite to a tooth tip of the first wall-body inclined part is inclined according to an inclination of the first wall-body inclined part, and at least a part of the first region is set by positions and shapes of the first wall-body inclined part and the first end-plate inclined part.

[0014] With such a configuration, the first scroll member and the second scroll member relatively perform an orbiting and revolving motion, and the second wall body is meshed with the first wall body to form the sealed space. Then, after the sealing of the sealed space is started by the orbiting and revolving motion, the first region is set in which the volume change of the sealed space is gradual or substantially constant.

[0015] The height of the wall body in the first wall-body inclined part continuously increases from the outer peripheral side to the inner peripheral side in the spiral direction, and the tooth bottom of the first end-plate inclined part opposite to the tooth tip of the first wall-body inclined part is inclined according to the inclination of the first wall-body inclined part. Thus, the width of the sealed space decreases according to the spiral shape of the wall body during the orbiting and revolving motion, and the height of the sealed space, that is, the distance between the opposing surfaces of the end plates increases. Accordingly, at least a part of the first region where the volume change of the sealed space is gradual or substantially constant is set by the positions and the shapes of the first wall-body inclined part and the first end-plate inclined part. As the fluid sucked from the outer peripheral side is directed toward the inner peripheral side, the pressure in the sealed space is kept substantially constant in the first region.

[0016] Further, the height of the wall body continuously increases, so that fluid leakage can be reduced compared with the conventional stepped scroll fluid machine in which a stepped part is provided on the wall body and the tooth bottom.

[0017] The inclinations of the first wall-body inclined part and the first end-plate inclined part are not limited to a smoothly connected inclination, but may include a form that is visually recognized as being continuously inclined as viewed in the entire first wall-body inclined part in which small steps are connected in the form of steps. The first wall-body inclined part and the first end-plate inclined part may be provided on both the first scroll member and the second scroll member, or may be provided on any one of both scroll members. When one wall body is provided with the first wall-body inclined part and when the other end plate is provided with the first end-plate inclined part, the other wall body and one end plate may be flat, or may have a shape combined with the stepped shape of the related art.

[0018] In the aspect of the invention, a fluid supply portion may be provided on the first end plate or the second end plate to supply a fluid having a pressure higher than a fluid pressure in the sealed space into the sealed space, and the fluid supply portion may be provided in the first region.

[0019] With such a configuration, the fluid supply portion is provided on the first end plate or the second end plate, and the fluid supply portion supplies the fluid having the pressure higher than the fluid pressure in the sealed space into the compressor chamber. Then, since the fluid supply portion is provided in the first region where the volume change of the sealed space is gradual or substantially constant, the fluid can be supplied to the sealed space while the pressure difference from the fluid to be supplied is maintained at a predetermined value or more in the process where the increase in pressure in the sealed space is gradual or substantially constant.

[0020] In the aspect of the invention, a second region, in which a volume of the sealed space decreases, may be set before the first region, and a third region, in which the volume of the sealed space decreases, may be set behind the first region.

[0021] With such a configuration, when the scroll fluid machine is applied as a scroll compressor, the second region, in which the volume of the sealed space decreases, is set before the first region, so that the pressure in the sealed space increases as the fluid moves toward the inner peripheral side in the second region before the first region. The pressure-increased fluid moves toward the inner peripheral side in the first region, the pressure in the sealed space is kept substantially constant. Then, since the third region, in which the volume of the sealed space decreases, is set behind the first region, the pressure in the sealed space increases again as the fluid moves toward the inner peripheral side in the third region behind the first region.

[0022] In the aspect of the invention, at least one of the first wall body and the second wall body may include a second wall-body inclined part in which a height of the wall body continuously decreases from the outer peripheral side to the inner peripheral side in the spiral direction, at least one of the first wall body and the second wall body may include a second end-plate inclined part in which the tooth bottom opposite to the tooth tip of the first wall-body inclined part is inclined according to an inclination of the second wall-body inclined part, and at least a part of each of the second region and the third region may be set by positions and shapes of the second wall-body inclined part and the second end-plate inclined part.

[0023] With such a configuration, the height of the wall body in the second wall-body inclined part decreases from the outer peripheral side to the inner peripheral side, and the tooth bottom of the second end-plate inclined part opposite to the tooth tip of the second wall-body inclined part is inclined according to the inclination of the second wall-body inclined part. Accordingly, at least a part of the each of the second region and the third region where the volume of the sealed space decreases is set by the positions and the shapes of the second wall-body inclined part and the second end-plate inclined part. Thereby, as being directed toward the inner peripheral side, the fluid sucked from the outer peripheral side is not only compressed by the reduction of the width of the sealed space corresponding to the spiral shape of the wall body, but also further compressed by the reduction of the height of the sealed space, that is, the distance between the opposing surfaces of the end plates. As a result, three-dimensional compression can be made, and a small size can be realized.

[0024] In the aspect of the invention, a height of a tooth tip at an outer peripheral side end of the second wall-body inclined part disposed closer to the outer peripheral side compared with the first wall-body inclined part may be equal to a height of a tooth tip at an inner peripheral side end of the first wall-body inclined part.

[0025] With such a configuration, the ends on both sides with the first wall-body inclined part and the second wall-body inclined part sandwiched therebetween are measured, and thus it is possible to suitably measure the dimension of the first scroll member or the second scroll member.

[0026] In the aspect of the invention, a height of a tooth bottom at an outer peripheral side end of the second end-plate inclined part disposed closer to the outer peripheral side compared with the first end-plate inclined part may be equal to a height of a tooth bottom at an inner peripheral side end of the first end-plate inclined part.

[0027] With such a configuration, the ends on both sides with the first end-plate inclined part and the second end-plate inclined part sandwiched therebetween are measured, and thus it is possible to suitably measure the dimension of the first scroll member or the second scroll member.

[0028] In the aspect of the invention, tip seals may be provided at the tooth tips of the first wall body and the second wall body, respectively, to seal the fluid by contacting with the tooth bottoms opposite to the tooth tips.

[0029] With such a configuration, when both the scroll members perform the relative orbiting and revolving motion, the positions of the tooth tips of the first/second wall-body inclined parts and the positions of the tooth bottoms of the first/second end-plate inclined parts are relatively shifted by an orbiting diameter (the orbiting radius$\times$2). A gap (tip clearance) between the tooth tip and the tooth bottom varies due to the positional displacement of the tooth tip and the tooth bottom. In order to prevent the fluid leakage due to the influence of the change in the tip clearance, the tip seals are provided on the tooth tips of the first wall body and the second wall body.

[0030] In the aspect of the invention, a coating may be provided on at least one of the tooth tips of the first wall body and the second wall body and the tooth bottoms opposite to the tooth tips.

[0031] With such a configuration, the coating is provided on at least one of the tooth tips of the first wall body and the second wall body and the tooth bottoms opposite to the tooth tips, and thus it is possible to compensate the machining variation of the inclined part, which is difficult to obtain the machining accuracy, by the film thickness of the coating. Thereby, it is possible to further prevent the fluid leakage.

[0032] In the aspect of the invention, wall-body flat parts, which do not change in height, may be provided on outermost peripheral parts and/or innermost peripheral parts of the first wall body and the second wall body, and end-plate flat parts corresponding to the wall-body flat parts may be provided on the first end plate and the second end plate.

[0033] With such a configuration, when the tooth tip of the wall body is inclined, it is difficult to set measurement points and to improve measurement accuracy. Therefore, the flat parts are provided on the outermost peripheral parts and/or the innermost peripheral parts of the wall body and the end plate, so that the shape measurement is performed with high accuracy. Thereby, it becomes easy to manage the size and tip clearance of the scroll shape.

[0034] In the aspect of the invention, the wall-body flat parts and the end-plate flat parts may be provided over a region of 180° around a center of the first scroll member or the second scroll member.

[0035] With such a configuration, since the wall-body flat part and the end-plate flat part are provided over the region of 180°, the flat parts on both sides from the center of the first scroll member or the second scroll member can be measured. Thus, it is possible to suitably measure the dimensions of the scroll members.

[0036] When the range of the flat part greatly exceeds 180°, the region where the first/second wall-body inclined part or the first/second end-plate inclined part are provided decreases and the slope angle of the inclined part becomes large. When the slope angle becomes large, the amount of change in the tip clearance due to the orbiting diameter at the time of orbiting and revolving motion becomes large, and the fluid leakage may become large. Accordingly, the wall-body flat part and the end-plate flat part are preferably within the region of 180°. However, the region of 180° is not strict, and an angle slightly exceeding 180° is allowed within a range where the fluid leakage does not increase.

[Advantageous Effects of Invention]

[0037] According to the present invention, since the region is set where the volume change of the sealed space is gradual or substantially constant, the intermediate-pressure refrigerant can be reliably introduced during the compression process, and the pressure increase in the sealed space can be prevented. When the scroll fluid machine is applied as a scroll compressor, the efficiency of the compressor can be improved. Since the height of the wall body continuously increases, fluid leakage can be reduced compared with the conventional stepped scroll fluid machine in which a stepped part is provided on the wall body and the tooth bottom.

[Brief Description of Drawings]

[0038]

[Fig. 1] Fig. 1 is a configuration diagram illustrating a refrigeration cycle according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is a partially longitudinal sectional view illustrating a principal part of a scroll compressor according to the embodiment of the present invention.

[Fig. 3] Fig. 3 is a longitudinal sectional view illustrating a fixed scroll of the scroll compressor according to the embodiment of the present invention, and is a sectional view taken along a line III-III of Fig. 4.

[Fig. 4] Fig. 4 is a plan view illustrating the fixed scroll according to the embodiment of the present invention.

[Fig. 5] Fig. 5 is a plan view illustrating tooth tips of wall bodies and end plates of the fixed scroll according to the embodiment of the present invention.

[Fig. 6] Fig. 6 is a side view illustrating a state in which the wall bodies and the end plates of the fixed scroll according to the embodiment of the present invention are expanded in a spiral direction.

[Fig. 7] Fig. 7 is a longitudinal sectional view illustrating an orbiting scroll of the scroll compressor according to the embodiment of the present invention, and is a sectional view taken along a line VII-VII of Fig. 8.

[Fig. 8] Fig. 8 is a plan view illustrating the orbiting scroll according to the embodiment of the present invention.

[Fig. 9] Fig. 9 is a plan view illustrating tooth tips of wall bodies and end plates of the orbiting scroll according to the embodiment of the present invention.

[Fig. 10] Fig. 10 is a side view illustrating a state in which the wall bodies and the end plates of the orbiting scroll according to the embodiment of the present invention are expanded in a spiral direction.

[Fig. 11A] Fig. 11A illustrates a tip seal gap of the scroll compressor according to the embodiment of the present invention, and is a side view illustrating a state where the tip seal gap is relatively small.

[Fig. 11B] Fig. 11B illustrates the tip seal gap of the scroll compressor according to the embodiment of the present invention, and is a side view illustrating a state where the tip seal is relatively large.

[Fig. 12] Fig. 12 is a graph illustrating a relation between a volume of a compression chamber and an orbiting angle, and a graph illustrating a relation between a pressure of the compression chamber and the orbiting angle.

[Description of Embodiment]

[0039] Hereinafter, an embodiment according to the present invention will be described with reference to the drawings.

[0040] As illustrated in Fig. 1, a refrigeration cycle 10 includes a scroll compressor 1 that compresses a refrigerant (fluid), a condenser 2 that radiates heat of the compressed refrigerant to the outside, a first expansion valve 3 that is provided on a high pressure side to decompress the refrigerant flowing out from the condenser 2, an economizer (gas-liquid separator) 4 that separates the decompressed refrigerant into a liquid refrigerant and a gas refrigerant, a second expansion valve 5 that is provided on a low pressure side to further decompress a liquid refrigerant, an evaporator 6 that causes the decompressed refrigerant to absorb heat, and an injection flow passage 7 that guides the gas refrigerant from the economizer 4 to the scroll compressor 1.

[0041] The scroll compressor 1 is a hermetic type compressor, and includes a housing 11 having a hermetically sealed space therein, a scroll compression mechanism 12 that is disposed in the housing 11 and compresses a refrigerant taken in the hermetically sealed space, a rotating shaft that transmits a rotational force to the scroll compression mechanism 12, and an electric motor that revolves an orbiting scroll 19 of the scroll compression mechanism 12 through the rotating shaft, as main components, as illustrated in Fig. 2.

[0042] The housing 11 has a bottom sealed by a lower cover, and includes a vertically elongated cylindrical intermediate cover 13 at an upper part of the lower cover. A discharge cover 14 and an upper cover 15 are provided at an upper part of the intermediate cover 13 to hermetically seal the housing 11, and a discharge chamber 16, from which compressed high-pressure gas is discharged, is formed between the discharge cover 14 and the upper cover 15.

[0043] The scroll compression mechanism 12 is incorporated in the housing 11, and the electric motor including a stator and a rotor is installed below the scroll compression mechanism. The stator is fixedly installed in the housing 11, so that the electric motor is incorporated, and the rotating shaft is fixed to the rotor.

[0044] The scroll compression mechanism 12 includes a fixed scroll 18 fixedly installed in the housing 11 and the orbiting scroll 19 that is slidably supported and is meshed with the fixed scroll 18 to form a compression chamber 20.

[0045] A suction port (not illustrated), which sucks a refrigerant, is formed in a side surface of the housing 11 to communicate with the sealed space, and a discharge port 15a is formed on a top side of the upper cover 15 to communicate with the discharge chamber 16 and discharge compressed refrigerant gas.

[0046] The scroll compression mechanism 12 sucks refrigerant gas, which is sucked into the housing 11 through a suction pipe and the suction port, from a suction port 21 on an outer peripheral side opened to the inside of the housing 11 into the compression chamber 20, and compresses the sucked refrigerant gas. The compressed refrigerant gas is discharged into the discharge chamber 16 through a discharge port 22 provided at a central part of the fixed scroll 18 and a discharge port 23 provided in the discharge cover 14, and is further sent out to the outside of the compressor through a discharge pipe 24 provided in the upper cover 15 and communicating with the discharge chamber 16.

[0047] The discharge cover 14 is provided with an injection pipe 25 that penetrates the upper cover 15, and an intermediate-pressure refrigerant is introduced from the outside into the compression chamber 20 of the scroll compression mechanism 12 through the injection pipe 25. The refrigerant is supplied to the compression chamber 20 through the injection pipe 25 and an injection port (a fluid supply portion) 26.

[0048] A reed valve 27, which is a thin plate member, is provided in an outlet of the discharge port 22, and opens and closes the discharge port 22. The reed valve 27 regulates a flow of the refrigerant in only one direction. The reed valve 27 is provided, so that the refrigerant flows from the compression chamber 20 toward the discharge chamber 16.

[0049] As illustrated in Fig. 2, the fixed scroll 18 includes a substantially disk-shaped end plate (a first end plate) 18a and a spiral wall body (a first wall body) 18b erected on one side surface of the end plate 18a. As illustrated in Fig. 2, the orbiting scroll 19 includes a substantially disk-shaped end plate (a second end plate) 19a and a spiral wall body (a second wall body) 19b erected on one side surface of the end plate 19a. The respective spiral shapes of the wall bodies 18b and 19b are defined using, for example, an involute curve or an Archimedean spiral curve.

[0050] The fixed scroll 18 and the orbiting scroll 19 are meshed with each other in a state where centers O1 and O2 thereof are separated by an orbiting radius ρ and phases of the wall bodies 18b and 19b are shifted by 180°, and are assembled such that slight clearances (tip clearances) in a height direction are present between tooth tips and tooth bottoms of the wall bodies 18b and 19b of the both scrolls 18 and 19 at room temperature. Consequently, between the both of the scrolls 18 and 19, a plurality of pairs of the compression chambers 20 surrounded by the end plates 18a and 19a and the wall bodies 18b and 19b are symmetrically formed with respect to the centers of the scrolls. The orbiting scroll 19 revolves around the fixed scroll 18 by a rotation preventing mechanism such as an oldham ring (not illustrated).

[0051] As illustrated in Fig. 2, the inclination of the tooth tip in the wall bodies 18b and 19b and the inclination of the tooth bottom in the end plates 18a and 19a are set such that a distance L between opposing surfaces of both the end plates 18a and 19a facing each other continuously decreases or increases from the outer peripheral sides to the inner peripheral sides of the spiral wall bodies 18b and 19b.

[0052] As illustrated in Figs. 3, 5, and 6, on the wall body 18b of the fixed scroll 18, a wall-body flat part 18b1, a second wall-body inclined part 18b2, a wall-body flat part 18b3, a first wall-body inclined part 18b4, a wall-body flat part 18b5, a second wall-body inclined part 18b6, and a wall-body flat part 18b7 are provided in this order from the outer peripheral side to the inner peripheral side. As illustrated in Figs. 3, 4, and 6, on the tooth bottom of the fixed scroll 18, an end-plate flat part 18a1, a second end-plate inclined part 18a2, an end-plate flat part 18a3, a first end-plate inclined part 18a4, an end-plate flat part 18a5, a second end-plate inclined part 18a6, and an end-plate flat part 18a7 are provided in this order from the outer peripheral side to the inner peripheral side.

[0053] As illustrated in Figs. 7, 9, and 10, on the wall body 19b of the orbiting scroll 19, a wall-body flat part 19b1, a second wall-body inclined part 19b2, a wall-body flat part 19b3, a first wall-body inclined part 19b4, a wall-body flat part 19b5, a second wall-body inclined part 19b6, and a wall-body flat part 19b7 are provided in this order from the outer peripheral side to the inner peripheral side. As illustrated in Figs. 7, 8, and 10, on the tooth bottom of the orbiting scroll 19, an end-plate flat part

19a1, a second end-plate inclined part 19a2, an end-plate flat part 19a3, a first end-plate inclined part 19a4, an end-plate flat part 19a5, a second end-plate inclined part 19a6, and an end-plate flat part 19a7 are provided in this order from the outer peripheral side to the inner peripheral side.

[0054] Each of the wall-body flat parts 19b1, 19b3, 19b5, and 19b7 provided on the wall body 19b of the orbiting scroll 19 has a constant height from the outer peripheral side to the inner peripheral side. In other words, a dimension in an axial direction passing through the center 02 (see Fig. 2) of the orbiting scroll 19 is constant. Hereinafter, heights of the wall body and the tooth bottom mean the dimensions in the axial direction passing through the centers O1 and O2, respectively.

[0055] As illustrated in Fig. 10, the wall-body flat parts 19b1 and 19b7 having the constant height are provided on the outermost peripheral side and the innermost peripheral side of wall body 19b of the orbiting scroll 19, respectively. These wall-body flat parts 19b1 and 19b7 are provided over a region of 180° (for example, 180° or more and 360° or less, and preferably 210° or less) around the center 02 (see Fig. 2) of the orbiting scroll 19, as illustrated in Fig. 8.

[0056] Similarly, the end-plate flat parts 19a1 and 19a7 having a constant height are provided on the tooth bottom of the end plate 19a of the orbiting scroll 19. These end-plate flat parts 19a1 and 19a7 are also provided over a region of 180° (for example, 180° or more and 360° or less, and preferably 210° or less) around the center 02 of the orbiting scroll 19.

[0057] Similarly to the orbiting scroll 19, as illustrated in Fig. 4, the fixed scroll 18 is also provided with the wall-body flat parts 18b1 and 18b7 and the end-plate flat parts 18a1 and 18a7. The wall-body flat parts 18b1 and 18b7 and the end-plate flat parts 18a1 and 18a7 are also provided over a region of 180° (for example, 180° or more and 360° or less, and preferably 210° or less) around the center O1 of the fixed scroll 18.

[0058] As illustrated in Fig. 10, the height of the first wall-body inclined part 19b4 provided on the wall body 19b of the orbiting scroll 19 continuously increases from the outer peripheral side to the inner peripheral side. As illustrated in Fig. 6, on the tooth bottom on the end plate 18a of the fixed scroll 18 facing the tooth tip of the first wall-body inclined part 19b4, the first end-plate inclined part 18a4 is provided to be inclined according to the inclination of the first wall-body inclined part 19b4. Similarly, as illustrated in Fig. 6, the first wall-body inclined part 18b4 provided on the wall body 18b of the fixed scroll 18 also continuously increases from the outer peripheral side to the inner peripheral side, and as illustrated in Fig. 10, on the tooth bottom on the end plate 19a of the orbiting scroll 19 facing the tooth tip of the first wall-body inclined part 18b4, the first end-plate inclined part 19a4 is provided to be inclined according to the inclination of the first wall-body inclined part 18b4. The length in the spiral direction of the first wall-body inclined parts 18b4 and the 19b4 and the length in the spiral direction of the first end-plate inclined parts 18a4 and 19a4 are 20° or more, and preferably 180° or more around the centers O1 and O2, respectively.

[0059] Thus, the width of the compression chamber 20 decreases according to the spiral shapes of the wall bodies 18b and 19b during an orbiting and revolving motion of the orbiting scroll 19, and the height of the compression chamber 20, that is, the distance between the opposing surfaces of the end plates 18a and 19a increases. Accordingly, at least a part of the first region where the volume change of the compression chamber 20 is gradual or substantially constant is set by the positions and the shapes in the spiral direction (for example, the inclination angle and the length in the spiral direction) of the first wall-body inclined parts 18b4 and 19b4 and the first end-plate inclined parts 18a4 and 19a4. As the fluid sucked from the suction port 21 on the outer peripheral side is directed toward the inner peripheral side, the pressure in the compression chamber 20 is kept substantially constant in the first region.

[0060] Only one first wall-body inclined part 18b4 or 19b4 or one first end-plate inclined part 18a4 or 19a4 is provided in the spiral direction, so that the first region may be set, or a plurality of first wall-body inclined parts 18b4 and 19b4 or a plurality of first end-plate inclined parts 18a4 and 19a4 are provided in series, so that the first region may be set. When the plurality of first wall-body inclined parts 18b4 and 19b4 or the plurality of first end-plate inclined parts 18a4 and 19a4 are provided in series, the first region is set with different inclination angles of the respective inclined parts and with the wall-body flat part or the end-plate flat part interposed therebetween.

[0061] The end plate 18a of the fixed scroll 18 is provided with the injection port 26 that supplies a refrigerant having a pressure higher than the pressure of the fluid in the compression chamber 20 into the compression chamber 20. When the orbiting scroll 19 makes an orbiting and revolving motion and the tooth tip of the wall body 19b of the orbiting scroll 19 moves over and overlaps the injection port 26, the communication between the compression chamber 20 and the injection port 26 is closed. On the contrary, when the tooth tip of the wall body 19b of the orbiting scroll 19 moves from the injection port 26 to open the injection port 26, the compression chamber 20 and the injection port 26 communicate with each other. The injection port 26 is provided in the first region where the volume change of the compression chamber 20 described above is gradual or substantially constant. Thus, it is possible to supply the refrigerant into the compression chamber 20 while maintaining the pressure difference with the refrigerant supplied from the injection port 26 at a predetermined value or more in the process where the pressure change in the compression chamber 20 is gradual or substantially constant. In the first region, an injection process of the intermediate-pressure refrigerant is performed.

[0062] The heights of the second wall-body inclined parts 19b2 and 19b6 provided on the wall body 19b of the orbiting scroll 19 continuously decrease from the outer peripheral side to the inner peripheral side. On the tooth bottom on the end plate 18a of the fixed scroll 18 facing the tooth tips of the second wall-body inclined parts 19b2 and 19b6, the second end-plate inclined parts 18a2 and 18a6 are provided to be inclined according to the inclinations of the second wall-body inclined parts 19b2 and 19b6. Similarly, the second wall-body inclined parts 18b2 and 18b6 provided on the wall body 18b of the fixed scroll 18 also continuously decrease from the outer peripheral side to the inner peripheral side, and on the tooth bottom on the end plate 19a of the orbiting scroll 19 facing the tooth tips of the second wall-body inclined parts 18b2 and 18b6, the second end-plate inclined parts 19a2 and 19a6 are provided to be inclined according to the inclinations of the second wall-body inclined parts 18b2 and 18b6.

[0063] Thus, the width of the compression chamber 20 decreases according to the spiral shapes of the wall bodies 18b and 19b during the orbiting and revolving motion of the orbiting scroll 19, and the height of the compression chamber 20, that is, the distance between the opposing surfaces of the end plates 18a and 19a decreases. Accordingly, at least a part of each of a second region and a third region where the volume of the compression chamber 20 decreases is set by the positions and the shapes in the spiral direction (for example, the inclination angles and the lengths in the spiral direction) of the second wall-body inclined parts 18b2, 18b6, 19b2, and 19b6 and the second end-plate inclined parts 18a2, 18a6, 19a2, and 19a6. As being directed toward the inner peripheral side, the refrigerant sucked from the suction port 21 on the outer peripheral side is not only compressed by the reduction of the width of the compression chamber 20 corresponding to the spiral shapes of the wall bodies 18b and 19b, but also further compressed by the reduction of the height of the compression chamber 20, that is, the distance between the opposing surfaces of the end plates 18a and 19a. As a result, three-dimensional compression can be made, and a small size can be realized.

[0064] The second region, in which the volume of the compression chamber 20 decreases, is set before the first region in the moving direction of the compression chamber 20 accompanying the orbiting and revolving motion of the orbiting scroll 19, and the third region is set behind the first region in the moving direction of the compression chamber 20. The second region is a region from when the wall bodies 18b and 19b are meshed with each other on the outer peripheral side to form the compression chamber 20 and are closed until the first region starts to be set. The third region is a region from when the first region is completed until the discharge of the compressed refrigerant is finished from the discharge port 22.

[0065] Since the second region, in which the volume of the compression chamber 20 decreases, is set before the first region, the pressure in the compression chamber 20 increases as the refrigerant moves toward the inner peripheral side in the second region before the first region. The pressure-increased refrigerant moves toward the inner peripheral side in the first region, the pressure in the compression chamber 20 is kept substantially constant. Then, since the third region, in which the volume of the compression chamber 20 decreases, is set behind the first region, the pressure in the compression chamber 20 increases again as the refrigerant moves toward the inner peripheral side in the third region behind the first region. A low-stage compression process is performed in the second region, and a high-stage compression process is performed in the third region. The gradual volume change or the substantially constant volume change of the compression chamber 20 in the first region means that the volume change is gradual or substantially constant compared with the volume change of the compression chamber 20 in the second region or the third region.

[0066] As described above, a two-stage compression refrigeration cycle is realized in which the refrigerant is introduced from the economizer 4 through the injection flow passage 7 and the injection port 26 during the compression process of the scroll compression mechanism 12. Between the second region and the third region where the volume of the compression chamber 20 decreases, the first region, in which the volume change of the compression chamber 20 is gradual or substantially constant, is provided, and the intermediate-pressure refrigerant can be introduced from the economizer 4 during the compression process of the scroll compression mechanism 12 in the single-stage scroll compressor 1 including only one scroll compression mechanism 12.

[0067] In the present embodiment, the meaning of "continuous" in the first wall-body inclined parts 18b4 and 19b4, the first end-plate inclined parts 18a4 and 19a4, the second wall-body inclined parts 18b2, 18b6, 19b2, and 19b6, and the second end-plate inclined parts 18a2, 18a6, 19a2, and 19a6 is not limited to a smoothly connected inclination, but may include a form that is visually recognized as being continuously inclined as viewed in the entire inclined part in which small steps inevitably generated during manufacturing such as machining or additive manufacturing (AM) are connected in the form of steps. Note that a large step such as a so-called stepped scroll is not included.

[0068] A coating is provided on the first wall-body inclined parts 18b4 and 19b4, the first end-plate inclined parts 18a4 and 19a4, the second wall-body inclined parts 18b2, 18b6, 19b2, and 19b6, and the second end-plate inclined parts 18a2, 18a6, 19a2, and 19a6. Examples of the coating include manganese phosphate treatment and nickel phosphor plating.

[0069] As illustrated in Figs. 6 and 10, the height of the tooth tip at the outer peripheral side ends 18b8 and 19b8 of the second wall-body inclined parts 18b2 and 19b2 disposed closer to the outer peripheral side compared with the first wall-body inclined parts 18b4 and 19b4 may be equal to the height of the tooth tip at the inner peripheral side ends 18b9 and 19b9 of the first wall-body inclined parts 18b4 and 19b4. Thereby, it is possible to measure one ends 18b8 and 19b8 and the other ends 18b9 and 19b9 with the first wall-body inclined parts 18b4 and 19b4 and the second wall-body inclined parts 18b2 and 19b2 sandwiched therebetween, and it is possible to suitably measure the dimension of the fixed scroll 18 or the orbiting scroll 19.

[0070] As for the end plates 18a and 19a, as illustrated in Figs. 6 and 10, the tooth bottom height at the outer peripheral side ends 18a8 and 19a8 of the second end-plate inclined parts 18a2 and 19a2 disposed closer to the outer peripheral side compared with the first end-plate inclined parts 18a4 and 19a4 may be equal to the tooth bottom height at the inner peripheral side ends 18a9 and 19a9 of the first end-plate inclined parts 18a4 and 19a4. Thereby, it is possible to measure one ends 18a8 and 19a8 and the other ends 18a9 and 19a9 with the first end-plate inclined parts 18a4 and 19a4 and the second end-plate inclined parts 18a2 and 19a2 sandwiched therebetween, and it is possible to suitably measure the dimension of the fixed scroll 18 or the orbiting scroll 19.

[0071] A tip seal is provided in the tooth tip of the wall body 18b of the fixed scroll 18. The tip seal is made of resin, and contacts with the tooth bottom of the end plate 19a of the opposite orbiting scroll 19 to seal the fluid. The tip seal is housed in a tip seal groove 18d formed in the tooth tip of the wall body 18b in a circumferential direction. Similarly, a tip seal groove 19d is also formed in the tooth tip of the wall body 19b of the orbiting scroll 19, and a tip seal is provided in the tip seal groove 19d.

[0072] When the scrolls 18 and 19 perform a relative orbiting and revolving motion, the positions of the tooth tip and the tooth bottom are relatively shifted by an orbiting diameter (the orbiting radius $\rho\times2$). In the inclined part, the tip clearance between the tooth tip and the tooth bottom varies in response to the positional displacement of the tooth tip and the tooth bottom. For example, Fig. 11A illustrates a small tip clearance T, and Fig. 11B illustrates a large tip clearance T. Even when the tip clearance T changes due to the orbiting motion, the tip seal 28 is pressed from the back surface toward the tooth bottom of the end plate 19a by the compressed fluid, and thus can follow up and perform sealing.

[0073] The scroll compressor 1 described above operates as follows.

[0074] The orbiting scroll 19 revolves around the fixed scroll 18 by a driving source such as an electric motor (not illustrated). Thus, the fluid is sucked from the outer peripheral side of each of the scrolls 18 and 19, and the refrigerant is taken into the compression chamber 20 surrounded by the wall bodies 18b and 19b and the end plates 18a and 19a.

[0075] First, after the wall bodies 18b and 19b are meshed with each other on the outer peripheral side to form the compression chamber 20 and are closed, the refrigerant in the compression chamber 20 is compressed in the second region as moving from the outer peripheral side to the inner peripheral side, and the pressure in the compression chamber 20 increases as illustrated in Fig. 12. The compressed refrigerant moves to the first region, and the refrigerant moves toward the inner peripheral side in the first region. Then, the intermediate-pressure refrigerant is supplied to the compression chamber 20 from the economizer 4 through the injection pipe 25 and the injection port (fluid supply portion) 26. In the first region, as illustrated in Fig. 12, the pressure change in the compression chamber 20 is gradual or substantially constant, and the fluid can be supplied to the compression chamber 20 while the pressure difference from the refrigerant supplied from the economizer 4 is maintained at a predetermined value or more.

[0076] Thereafter, the refrigerant moves to the third region, the refrigerant is compressed as moving toward the inner peripheral side in the third region, and the pressure in the compression chamber 20 increases again as illustrated in Fig. 12. The compressed refrigerant is finally discharged from the discharge port 22 formed in the fixed scroll 18.

[0077] As described above, according to the scroll compressor 1 of the present embodiment, the following operational effects are obtained.

[0078] Since inclination is provided in which the distance between opposing surfaces of the end plates 18a and 19a continuously decreases from the outer peripheral side to the inner peripheral side of the wall bodies 18b and 19b, three-dimensional compression can be made, and a small size can be realized.

[0079] Since inclination is provided in which the distance between opposing surfaces of the end plates 18a and 19a continuously increases from the outer peripheral side to the inner peripheral side of the wall bodies 18b and 19b, after the sealing of the compression chamber 20 is started, the first region is set in which the volume change of the compression chamber 20 is gradual or substantially constant. Since the injection port 26 is provided in the first region, it is possible to reliably supply the refrigerant into the compression chamber 20 while maintaining the pressure difference with the supplied refrigerant at a predetermined value or more in the process where the pressure change in the compression chamber 20 is gradual or substantially constant.

[0080] Since inclination is provided in which the distance between opposing surfaces of the end plates 18a and 19a continuously decreases from the outer peripheral side to the inner peripheral side of the wall bodies 18b and 19b, three-dimensional compression can be made, and a small size can be realized.

[0081] Further, the inclined part continuously increases or decreases, so that fluid leakage can be reduced compared with the conventional stepped scroll fluid machine in which a stepped part is provided on the wall body and the tooth bottom.

[0082] Since the tip seal 28 is provided at the tooth tip of each of the wall bodies 18b and 19b, even when the tip clearance T (see Figs. 11A and 11B) between the tooth tip and the tooth bottom in the inclined part changes according to the orbiting motion, the tip seal can be made to follow up, and fluid leakage can be prevented.

[0083] The coating is provided on the wall bodies 18b and 19b and/or the end plates 18a and 19a. Thus, it is possible to compensate the machining variation of the inclined part, which is difficult to obtain the machining accuracy, by the film thickness of the coating, and it is possible to further prevent the fluid leakage.

[0084] The wall-body flat parts 18b1, 18b7, 19b1, and 19b7 and the end-plate flat parts 18a1, 18a7, 19a1, and 19a7 are provided on the outermost peripheral parts and the innermost peripheral parts of the wall bodies 18b and 19b and the end plates 18a and 19a. Thus, it is possible to avoid the difficulty of setting measurement points and increasing measurement accuracy when the tooth tip of the wall body is inclined, and to perform shape measurement with high accuracy. Then, it becomes easy to manage the size and tip clearance of the scroll shape.

[0085] Since the wall-body flat parts 18b1, 18b7, 19b1, and 19b7 and the end-plate flat parts 18a1, 18a7, 19a1, and 19a7 are provided over the region of 180°, the flat parts on both sides from the centers 01 and 02 of the scrolls 18 and 19 can be measured. Thus, the shape dimension of the fixed scroll 18 or the orbiting scroll 19 can be favorably measured.

[0086] When the range of the flat part greatly exceeds 180°, the region of the inclined part decreases and the slope angle φ of the inclined part becomes large. When the slope angle φ becomes large, the amount of change in the tip clearance T due to the orbiting diameter at the time of orbiting and revolving motion becomes large, and the fluid leakage may become large. Accordingly, the wall-body flat parts 18b1, 18b7, 19b1, and 19b7 and the end-plate flat parts 18a1, 18a7, 19a1, and 19a7 are within the region of 180°. However, the region of 180° is not strict, and an angle slightly (for example, about 30°) exceeding 180° is allowed within a range where the fluid leakage does not increase.

[0087] The slope angle φ of the inclined part is set to be constant in the circumferential direction in which the spiral wall bodies 18b and 19b extend. Thus, the tip clearance T due to the orbiting diameter at the time of orbiting and revolving motion can be made equal at each position of the inclined part, and the fluid leakage can be prevented.

[0088] In the present embodiment, the first wall-body inclined parts 18b4 and 19b4, the first end-plate inclined parts 18a4 and 19a4, the second wall-body inclined parts 18b2, 18b6, 19b2, and 19b6, and the second end-plate inclined parts 18a2, 18a6, 19a2, and 19a6 are provided on both the scrolls 18 and 19, but may be provided on any one of both the scrolls.

[0089] Specifically, when one wall body (for example, the wall body 19b of the orbiting scroll 19) is provided with the first wall-body inclined parts 19b4 and the second wall-body inclined parts 19b2 and 19b6 and when the other end plate (for example, the end plate 18a of the fixed scroll 18) is provided with the first end-plate inclined part 19a4 and the second end-plate inclined parts 19a2 and 19a6, the other wall body 18b and one end plate 19a are flat.

[0090] It is possible to adopt a shape combined with the stepped shape of the related art, that is, a shape combined with a shape in which the first end-plate inclined part 18a4 and the second end-plate inclined parts 18a2 and 18a6 are provided in the end plate 18a of the fixed scroll 18 and a step is provided in the end plate 19a of the orbiting scroll 19.

[0091] In the present embodiment, although the wall-body flat parts 18b1, 18b7, 19b1, and 19b7 and the end-plate flat parts 18a1, 18a7, 19a1, and 19a7 are provided, the flat part on the inner peripheral side and/or the outer peripheral side may not be provided, and the second wall-body inclined parts 18b2 and 19b2 may be provided to extend over the entire wall bodies 18b and 19b.

[0092] Although the scroll compressor is described in the present embodiment, the present invention is applicable to a scroll expander used as an expander.

[Reference Signs List]

[0093]

1	scroll compressor
2	condenser
3	first expansion valve
4	economizer
5	second expansion valve
6	evaporator
7	injection flow passage
10	refrigeration cycle
11	housing
12	scroll compression mechanism
13	intermediate cover
14	discharge cover
15	upper cover
15a	discharge port
16	discharge chamber
18	fixed scroll
18a	end plate
18a1	end-plate flat part
18a2	second end-plate inclined part
18a3	end-plate flat part
18a4	first end-plate inclined part
18a5	end-plate flat part
18a6	second end-plate inclined part
18a7	end-plate flat part
18a8	outer peripheral side end
18a9	inner peripheral side end
18b	wall body
18b1	wall-body flat part
18b2	second wall-body inclined part
18b3	wall-body flat part
18b4	first wall-body inclined part

18b5 wall-body flat part
18b6 second wall-body inclined part
18b7 wall-body flat part
18b8 outer peripheral side end
18b9 inner peripheral side end
18d tip seal groove
19 orbiting scroll
19a end plate
19a1 end-plate flat part
19a2 second end-plate inclined part
19a3 end-plate flat part
19a4 first end-plate inclined part
19a5 end-plate flat part
19a6 second end-plate inclined part
19a7 end-plate flat part
19a8 outer peripheral side end
19a9 inner peripheral side end
19b wall body
19b1 wall-body flat part
19b2 second wall-body inclined part
19b3 wall-body flat part
19b4 first wall-body inclined part
19b5 wall-body flat part
19b6 second wall-body inclined part
19b7 wall-body flat part
19b8 outer peripheral side end
19b9 inner peripheral side end
20 compression chamber
21 suction port
22 discharge port
23 discharge port
24 discharge pipe
25 injection pipe
26 injection port
27 reed valve
28 tip seal

Claims

1. A scroll fluid machine comprising:

   a first scroll member in which a first wall body having a spiral shape is provided on a first end plate; and
   a second scroll member in which a second wall body having a spiral shape is provided on a second end plate disposed so as to face the first end plate, the second scroll member being configured to perform a relative orbiting and revolving motion such that the second wall body is meshed with the first wall body to form a sealed space, wherein
   after sealing of the sealed space is started, a first region is set in which a volume change of the sealed space is gradual or substantially constant,
   at least one of the first wall body and the second wall body includes a first wall-body inclined part in which a height of the wall body continuously increases from an outer peripheral side to an inner peripheral side in a spiral direction,
   at least one of the first end plate and the second end plate includes a first end-plate inclined part in which a tooth bottom opposite to a tooth tip of the first wall-body inclined part is inclined according to an inclination of the first wall-body inclined part, and
   at least a part of the first region is set by positions and shapes of the first wall-body inclined part and the first end-plate inclined part.

2. The scroll fluid machine according to claim 1, wherein
   a fluid supply portion is provided on the first end plate or the second end plate to supply a fluid having a pressure higher than a fluid pressure in the sealed space into the sealed space, and
   the fluid supply portion is provided in the first region.

3. The scroll fluid machine according to claim 1 or 2, wherein
   a second region, in which a volume of the sealed space decreases, is set before the first region, and a third region, in which the volume of the sealed space decreases, is set behind the first region.

4. The scroll fluid machine according to claim 3, wherein
   at least one of the first wall body and the second wall body includes a second wall-body inclined part in which a height of the wall body continuously decreases from the outer peripheral side to the inner peripheral side in the spiral direction,
   at least one of the first wall body and the second wall body includes a second end-plate inclined part in which the tooth bottom opposite to the tooth tip of the first wall-body inclined part is inclined according to an inclination of the second wall-body inclined part, and
   at least a part of each of the second region and the third region is set by positions and shapes of the second wall-body inclined part and the second end-plate inclined part.

5. The scroll fluid machine according to claim 4, wherein
   a height of a tooth tip at an outer peripheral side end of the second wall-body inclined part disposed closer to the outer peripheral side compared with the first wall-body inclined part is equal to a height of a tooth tip at an inner peripheral side end of the first wall-body inclined part.

6. The scroll fluid machine according to claim 4 or 5, wherein

a height of a tooth bottom at an outer peripheral side end of the second end-plate inclined part disposed closer to the outer peripheral side compared with the first end-plate inclined part is equal to a height of a tooth bottom at an inner peripheral side end of the first end-plate inclined part.

7. The scroll fluid machine according to any one of claims 1 to 6, wherein
tip seals are provided at the tooth tips of the first wall body and the second wall body, respectively, to seal the fluid by contacting with the tooth bottoms opposite to the tooth tips.

8. The scroll fluid machine according to any one of claims 1 to 7, wherein
a coating is provided on at least one of the tooth tips of the first wall body and the second wall body and the tooth bottoms opposite to the tooth tips.

9. The scroll fluid machine according to any one of claims 1 to 8, wherein
wall-body flat parts, which do not change in height, are provided on outermost peripheral parts and/or innermost peripheral parts of the first wall body and the second wall body, and
end-plate flat parts corresponding to the wall-body flat parts are provided on the first end plate and the second end plate.

10. The scroll fluid machine according to claim 9, wherein
the wall-body flat parts and the end-plate flat parts are provided over a region of 180° around a center of the first scroll member or the second scroll member.

FIG. 1

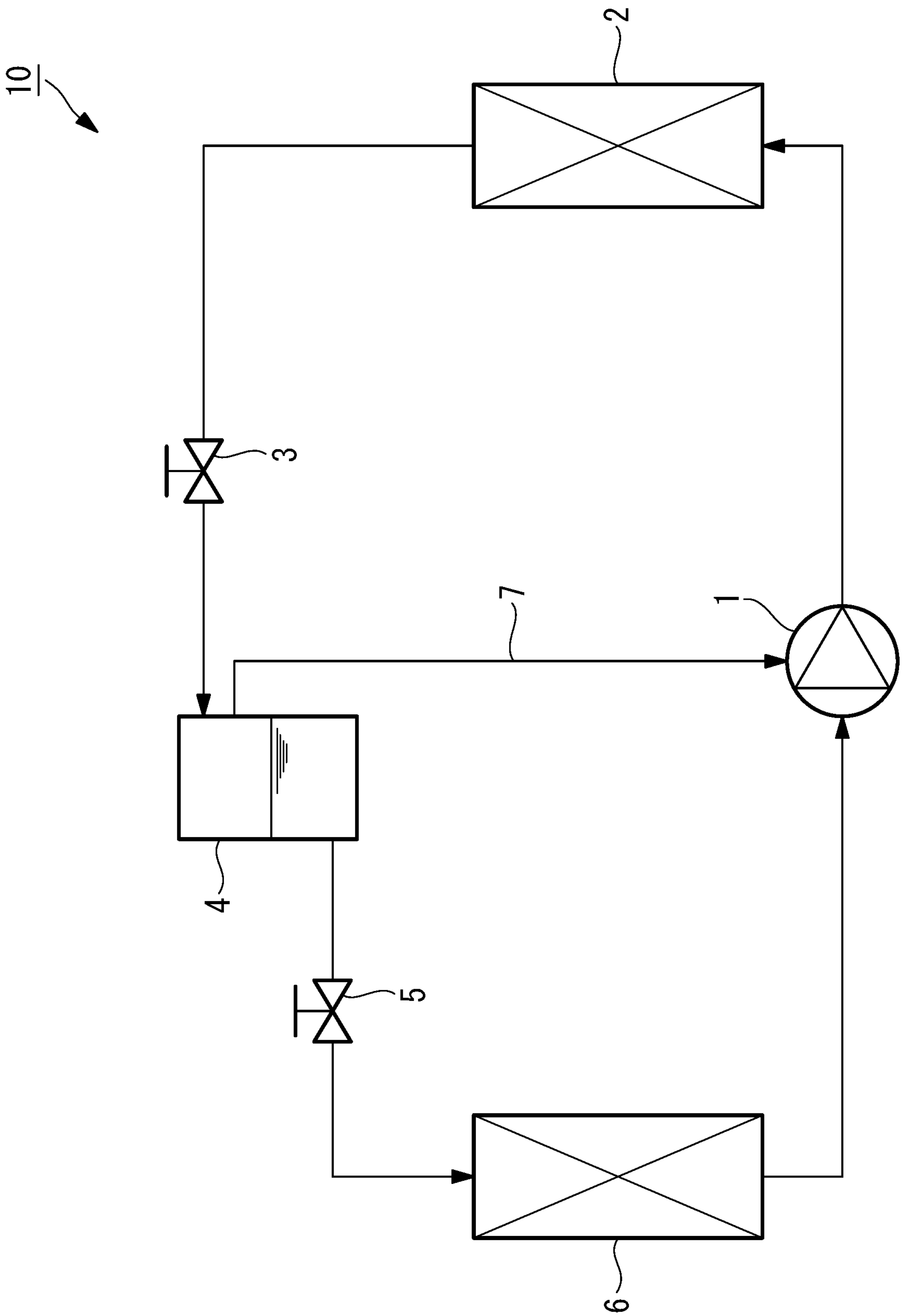


FIG. 2

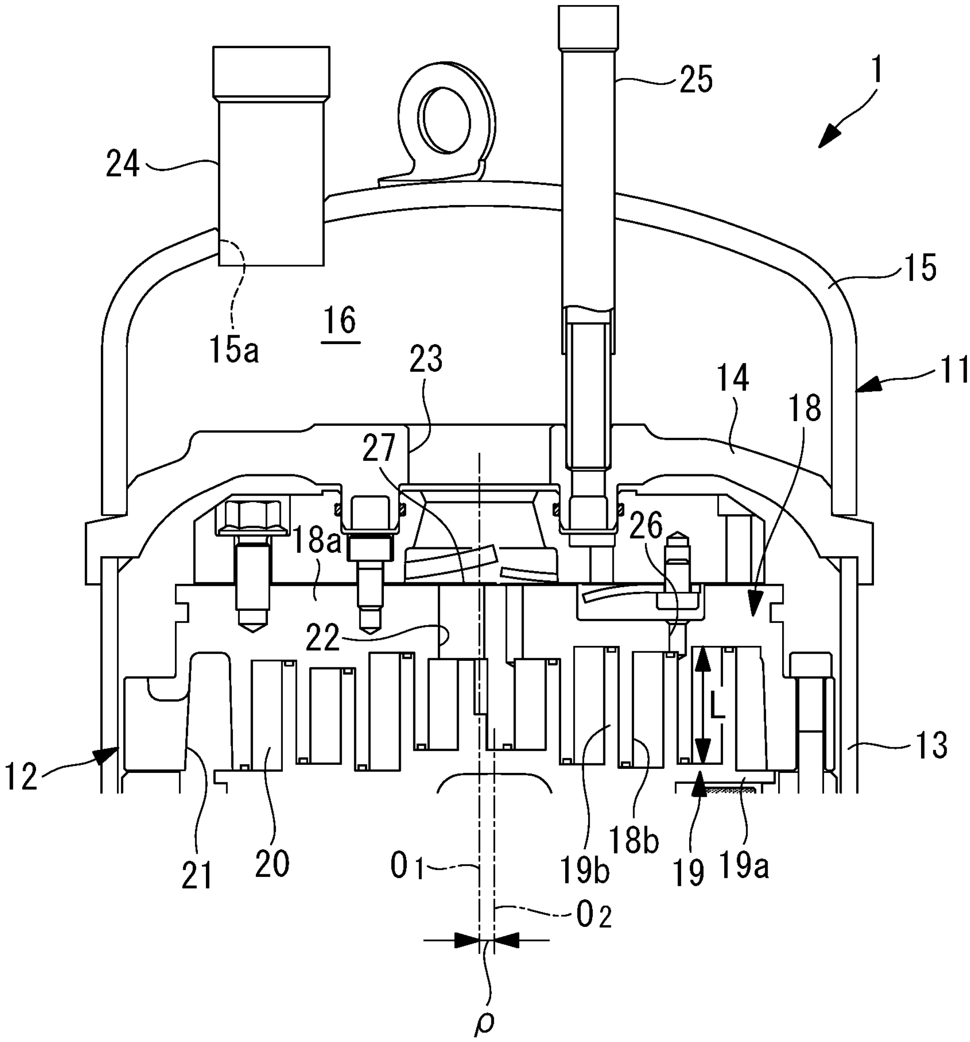
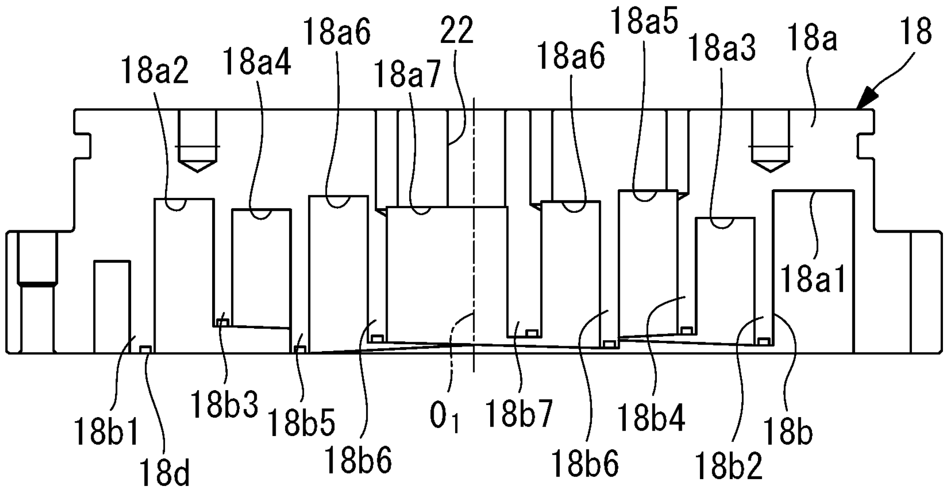

1
24
25
15
15a
16
23
14
18
11
27
18a
26
22
L
12
13
21
20
0₁
19b
18b
19
19a
0₂
ρ

FIG. 3


18a2
18a4
18a6
18a7
22
18a6
18a5
18a3
18a
18
18a1
18b1
18d
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18b5
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18b4
18b2
18b

FIG. 4

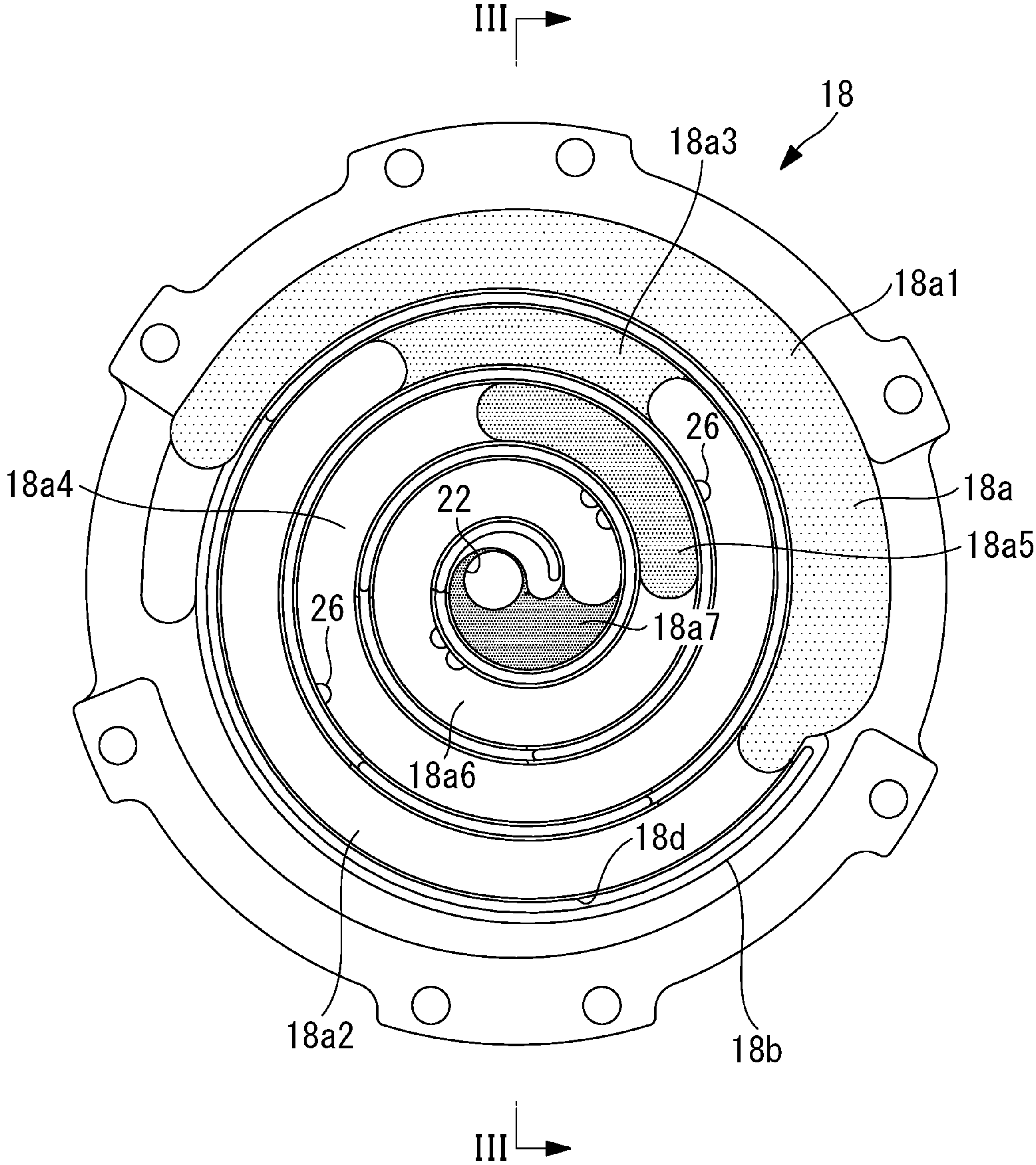

III
III
18
18a3
18a1
26
18a4
18a
22
18a5
26
18a7
18a6
18d
18a2
18b

FIG. 5

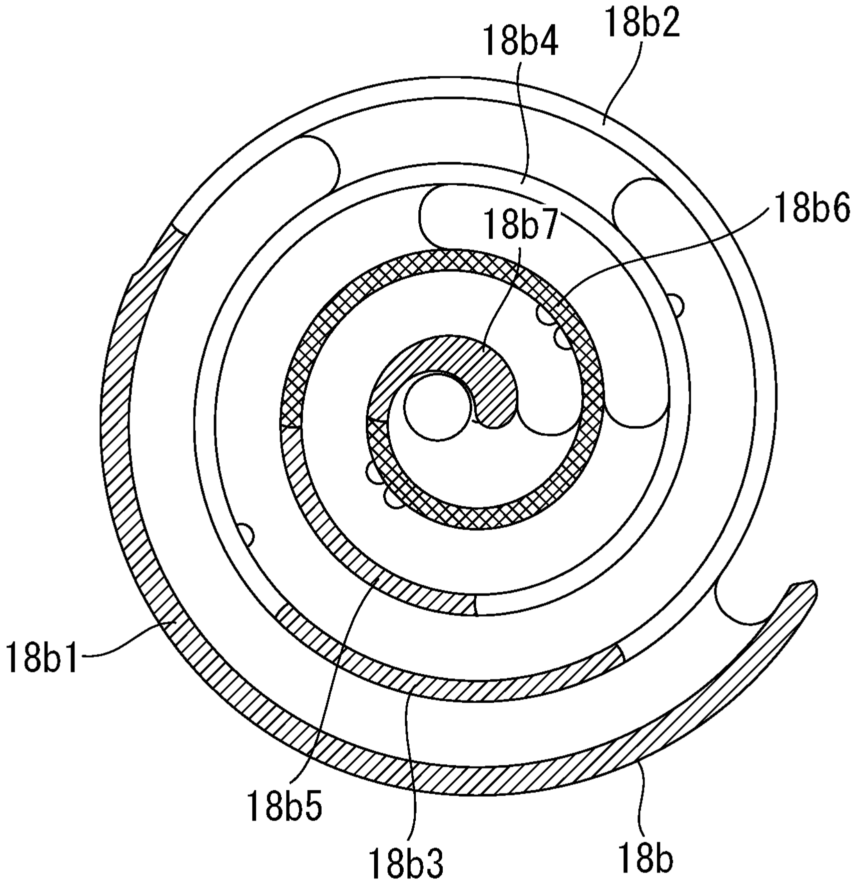


FIG. 6

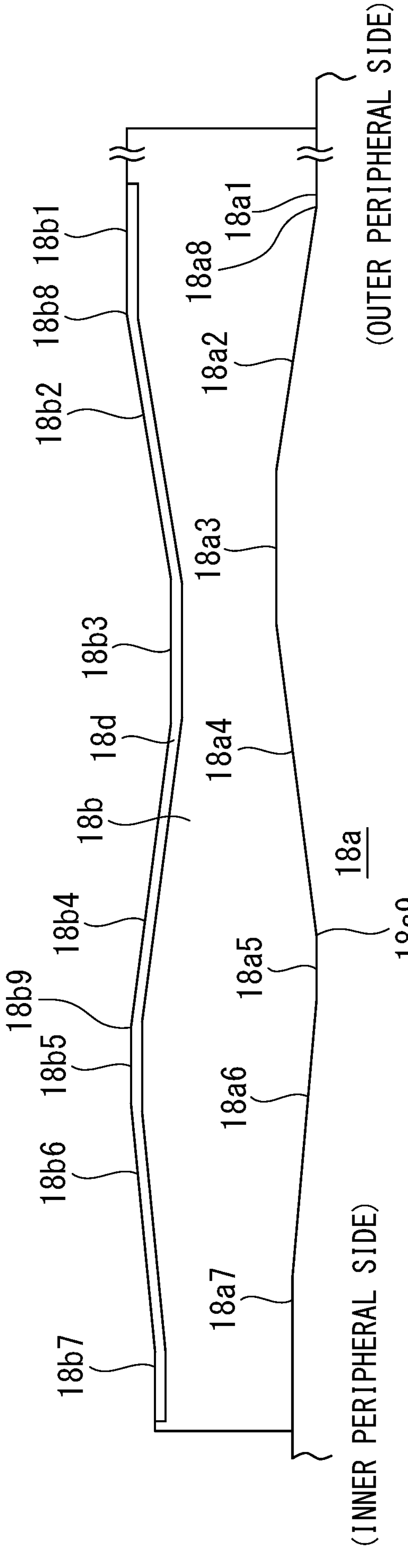

(OUTER PERIPHERAL SIDE)
18a1
18a8
18a2
18a3
18a4
18a
18a9
18a5
18a6
18a7
18b1
18b8
18b2
18b3
18d
18b
18b4
18b9
18b5
18b6
18b7
(INNER PERIPHERAL SIDE)

FIG. 7

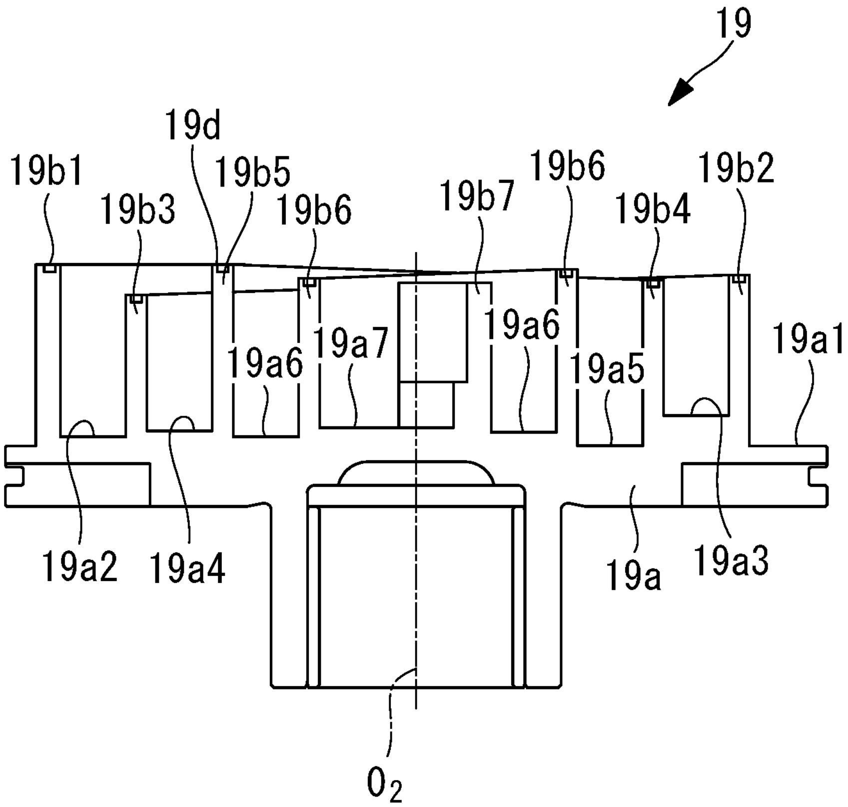

19
19d
19b1
19b5
19b3
19b6
19b7
19b6
19b4
19b2
19a6
19a7
19a6
19a5
19a1
19a2
19a4
19a
19a3
0$_2$

FIG. 8

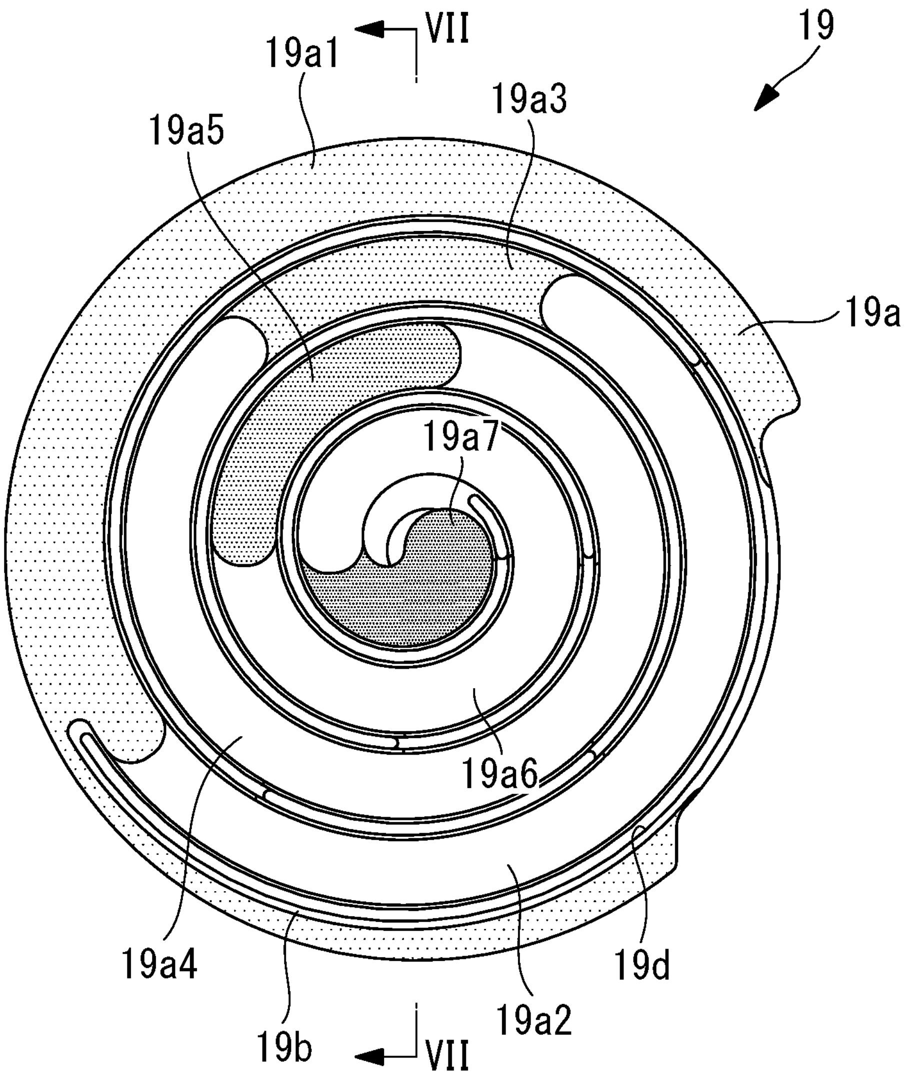


FIG. 9

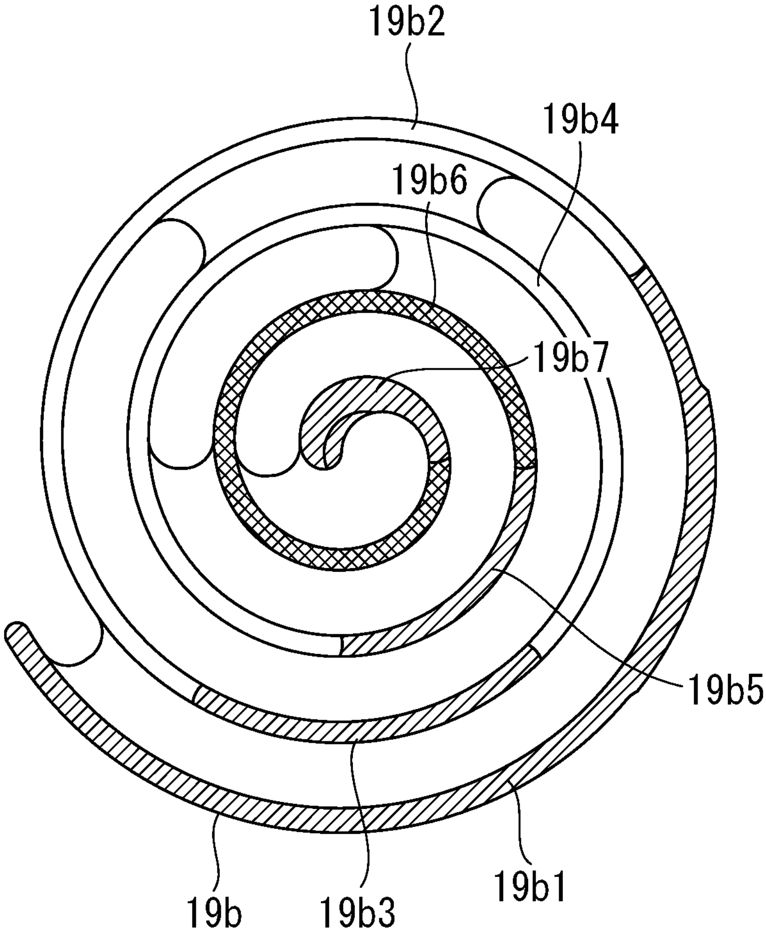
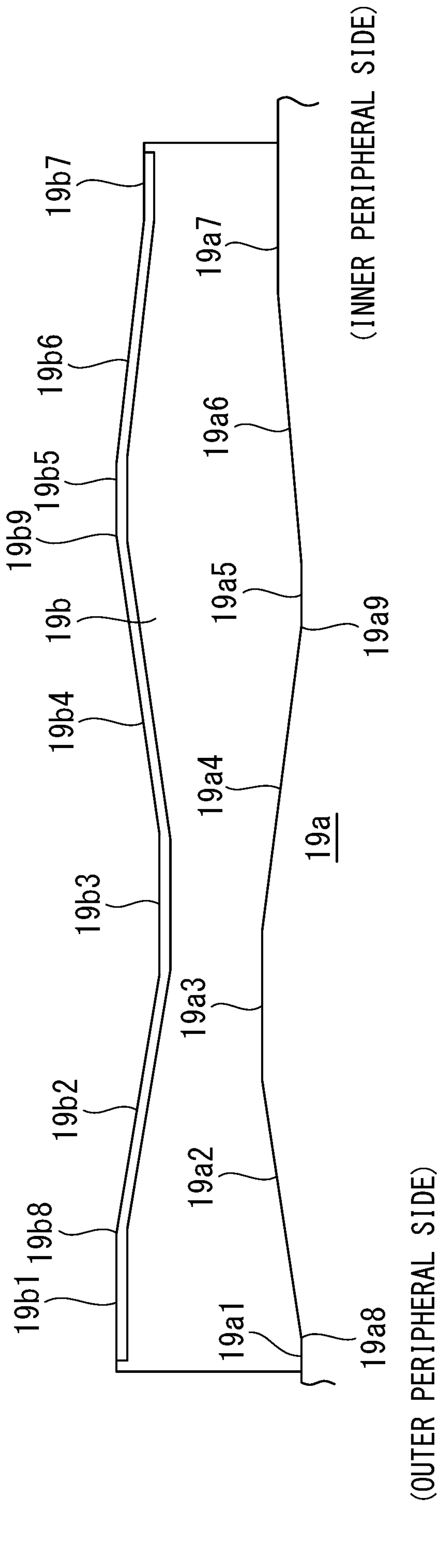


FIG. 10


(INNER PERIPHERAL SIDE)
19b7
19b6
19b5
19b9
19b
19b4
19b3
19b2
19b8
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19a7
19a6
19a5
19a9
19a4
19a
19a3
19a2
19a1
19a8
(OUTER PERIPHERAL SIDE)

FIG. 11A

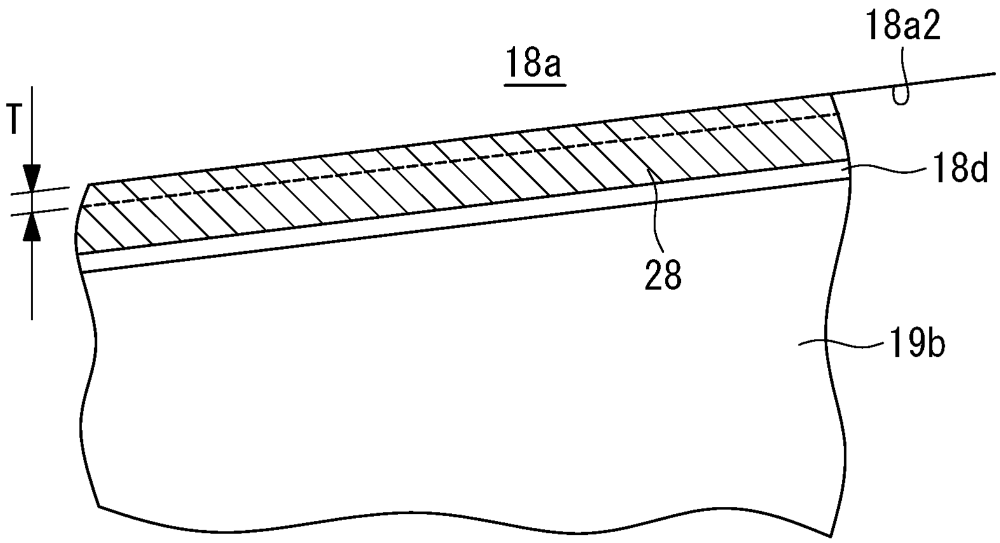


FIG. 11B

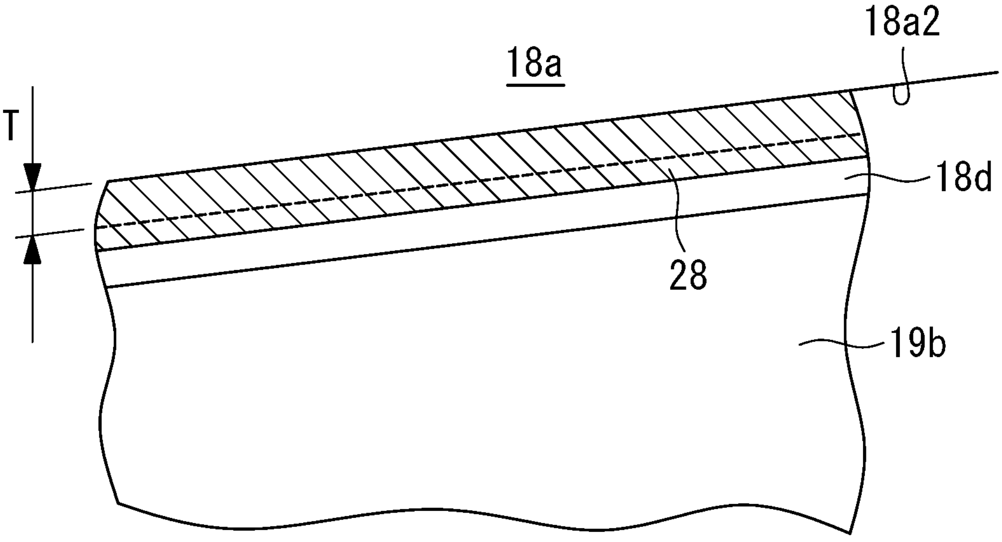
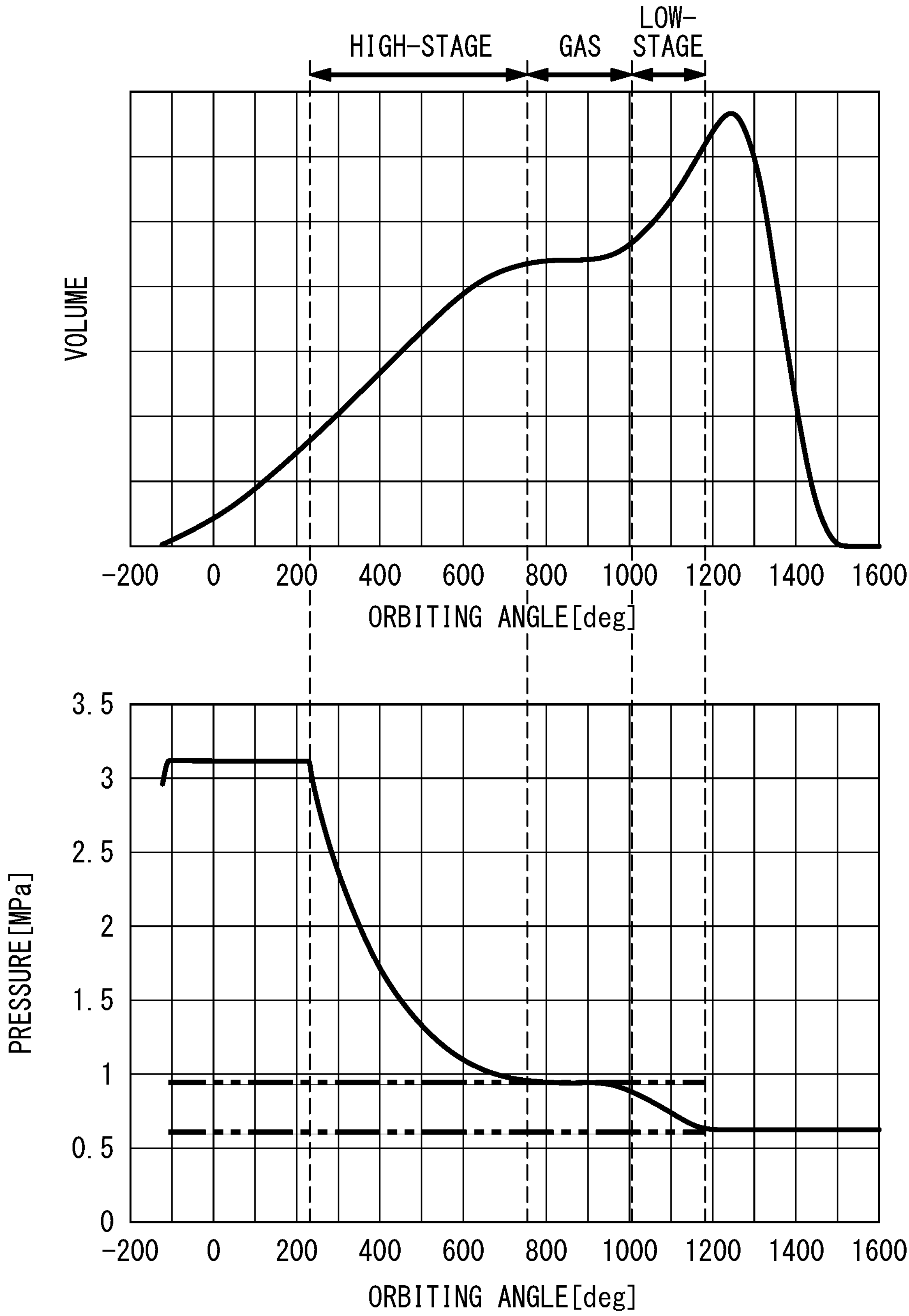


FIG. 12


HIGH-STAGE
GAS
LOW-
STAGE
VOLUME
-200
0
200
400
600
800
1000
1200
1400
1600
ORBITING ANGLE[deg]
PRESSURE[MPa]
3.5
3
2.5
2
1.5
1
0.5
0
-200
0
200
400
600
800
1000
1200
1400
1600
ORBITING ANGLE[deg]

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2019/004254

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F04C18/02(2006.01)i, F04C29/04(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)
Int.Cl. F04C18/02, F04C29/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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.
Y A	JP 2012-533028 A (EDWARDS LIMITED) 20 December 2012, paragraphs [0014]-[0016], [0023]-[0025], fig. 1-2 & US 2012/0100026 A1, paragraphs [0023]-[0025], [0032]-[0035], fig. 1-2	1-3, 7-10, 4-6
Y A	JP 2002-303281 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 18 October 2002, paragraph [0102], fig. 1-2 & US 2002/0054821 A1, paragraph [0153], fig. 1-2	1-3, 7-10, 4-6
Y A	JP 2007-064005 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 15 March 2007, paragraphs [0008]-[0013], fig. 13, 16 (Family: none)	2-3, 7-10 1, 4-6
A	JP 2006-312898 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 16 November 2006, paragraph [0009], fig. 2-4 (Family: none)	1-10

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

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- "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
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- "&" document member of the same patent family

Date of the actual completion of the international search 23 April 2019 (23.04.2019)	Date of mailing of the international search report 14 May 2019 (14.05.2019)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

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Patent documents cited in the description

- JP 2006312898 A **[0004]**