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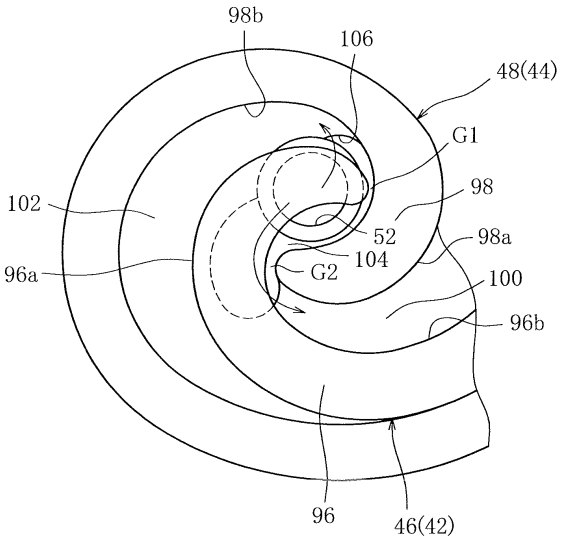
(54) SCROLL FLUID MACHINE

(57) Disclosed is a scroll fluid machine wherein a scroll unit achieves higher performance while maintaining reliability. The disclosed scroll fluid machine is provided with: a first actuation chamber (100) and second actuation chamber (102) partitioned by the central end (98) of a wrap (48, 64) of a fixed scroll (44, 60) and the central end (96) of a wrap (46, 62) of a movable scroll (42, 58); and a connection path (106, 119, 112). When at least part of a connection hole (52, 72) gets blocked by the central end of the wrap of the movable scroll as the movable scroll moves in a circle, the connection path connects the first and second actuation chambers with the connection hole. When the central ends of the wraps of the fixed and movable scrolls abut against each other, the connection path cuts off the connection between the first and second actuation chambers and the connection hole.

FIG. 2



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Description

[Technical Field]

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

[Background Art]

[0002] A kind of scroll fluid machine includes a scroll unit configured to include fixed and movable scrolls in which spiral wraps are each erected to face each other on each base surface of each end plate, wherein the movable scroll revolvably moves around a shaft center of the fixed scroll to form actuation chambers of a refrigerant as a working fluid of a fluid machine between respective wraps of the fixed and movable scrolls. When the fluid machine is used as an expander, a central portion of the end plate of the fixed scroll is provided with a suction hole formed to penetrate therethrough. In this case, the refrigerant from a refrigerant circuit outside the scroll unit is sucked into an expansion chamber as the actuation chamber through the suction hole.

[0003] Meanwhile, Patent Document 1 discloses a technology of forming a recessed portion at a central end of a tooth part (wrap) of an orbiting scroll (movable scroll), connecting a second actuation chamber with an introduction port by the recessed portion when the introduction port (suction hole) is opened in a first actuation chamber, and blocking the first actuation chamber from the second actuation chamber by the recessed portion at the same timing when the first actuation chamber and the introduction port are blocked, so as for the scroll unit to perform an expansion operation with good efficiency by correcting unbalance between the actuation chambers at an expansion starting time of refrigerant.

[Citation List]

[Patent Document]

[0004] Patent Document 1: Japanese Patent Laid-Open Publication No. 2006-242133

[Disclosure]

[Technical Problem]

[0005] However, in the case of the related art, since the central end of the wrap of the movable scroll is provided with the recessed portion, the strength of the wrap is degraded, such that the wrap may be damaged due to the revolving motion of the movable scroll.

[0006] Further, in the case of the related art, since at least a portion of the suction hole is blocked by the central end of the wrap due to the revolving motion of the movable scroll, the refrigerant amount input to the scroll unit may be reduced, the expansion efficiency of refrigerant may be reduced in the scroll unit, and the improvement of the operation efficiency of refrigerant may be still problematic in the scroll unit.

[0007] An object of the present invention is to provide a scroll fluid machine capable of improving performance of a scroll unit while securing reliability of the scroll unit.

[Technical Solution]

[0008] In order to achieve the above object, a scroll fluid machine of claim 1, characterized by including: a scroll unit configured to include fixed and movable scrolls in which spiral wraps are each erected to face each other on each base surface of each end plate and form actuation chambers of a working fluid between respective wraps of the fixed and movable scrolls by revolvably moving the movable scroll around a shaft center of the fixed scroll; a connection hole formed to penetrate through a central portion of the end plate of the fixed scroll and connecting the actuation chambers with an outside of the scroll unit; a first actuation chamber partitioned into an outer wall of a central end of the wrap of the fixed scroll and an inner wall of the central end of the wrap of the movable scroll; a second actuation chamber partitioned into an inner wall of the central end of the wrap of the fixed scroll and an outer wall of the central end of the wrap of the movable scroll; and a connection path connecting the first and second actuation chambers with the connection hole when at least a portion of the connection hole is closed by the central end of the wrap of the movable scroll and a connection path blocking the connection between the first and second actuation chambers and the connection hole when the central ends of the wraps of the fixed and movable scrolls abut against each other, due to the revolving motion of the movable scroll.

[0009] Further, the present invention of claim 2 referring to claim 1 is characterized in that the connection path is the connection groove recessed in the range in which the connection path reaches the connection hole on the base surface of the fixed scroll and the connection groove is formed in the range in which at least a portion of the connection groove is opened in the first and second actuation chambers when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll due to the revolving motion of the movable scroll and all of the connection grooves are concealedly covered by the wrap of the movable scroll when the central ends of the wraps of the fixed and movable scrolls abut against each other, due to the revolving motion of the movable scroll.

[0010] Further, the present invention of claim 3 referring to claim 2 is characterized in that the connection groove connects the first actuation chamber with the second actuation chamber when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll.

[0011] Further, the present invention of claim 4 referring to claim 2 is characterized in that the connection

groove connects the first actuation chamber with the second actuation chamber when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll.

[0012] Further, the present invention of claim 5 referring to claim 2 is characterized in that the connection groove is formed in the range in which the opened areas of the connection grooves for each of the first and second actuation chambers are substantially the same when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll.

[0013] Further, the present invention of claim 6 referring to any one of claims 3 to 5 is characterized in that the scroll unit has the symmetric scroll structure.

Further, the present invention of claim 7 referring to claim 2 is characterized in that the connection groove has the width narrower than the width of the central end of the wrap of the movable scroll.

[0014] Further, the present invention of claim 8 referring to claim 1 is characterized in that the scroll fluid machine is an expander using the actuation chamber as an expansion chamber.

[Advantageous Effects]

[0015] In accordance with the embodiment of the present invention of claim 1, the scroll fluid machine can expand the channel of the working fluid between the first and second actuation chambers and the connection hole by including the connection paths even though at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll due to the revolving motion of the movable scroll, thereby preventing the working fluid amount flowing between the actuation chamber and the outside of the scroll unit from reducing.

[0016] Further, the embodiment of the present invention can block the connection between the first and second actuation chambers and the connection hole even though the central ends of the wraps of the fixed and movable scrolls abut against each other due to the revolving motion of the movable scroll and can form the actuation chamber completely blocked from the first and second actuation chambers at the central portion at which the connection hole is opened. Therefore, the embodiment of the present invention can prevent the working fluid amount flowing between the actuation chambers and the outside of the scroll unit from reducing while preventing the working fluid from the actuation chambers from being leaked, thereby preventing the operation efficiency of the working fluid from reducing in the scroll unit and improving the performance of the scroll unit while securing the reliability of the scroll unit.

[0017] In addition, in accordance with the embodiment of the present invention of claim 2, specifically, the connection path is the connection groove recessed in the range in which the connection path reaches the connection hole on the base surface of the fixed scroll and the connection groove is formed in the range in which at least a portion of the connection groove is opened in the first and second actuation chambers when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll due to the revolving motion of the movable scroll and all of the connection grooves are concealedly covered by the wrap of the movable scroll when the central ends of the wraps of the fixed and movable scrolls abut against each other, due to the revolving motion of the movable scroll. As a result, the embodiment of the present invention can improve the performance of the scroll unit while securing the reliability of the scroll unit by the simple structure in which the grooves are disposed in the fixed scroll, without damaging the durability of the scroll unit by machining the wrap of the movable scroll.

[0018] Moreover, in accordance with the embodiment of the present invention of claim 3, the connection groove connects the first actuation chamber with the second actuation chamber when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll. As a result, when at least a portion of the connection hole is blocked by the central portion of the wrap of the movable scroll, since the pressure of the first actuation chamber and the second actuation chamber can be uniform, the working fluid can more smoothly flow between the actuation chambers and the outside of the scroll unit, thereby more improving the operation efficiency of the working fluid in the scroll unit.

[0019] In addition, in accordance with the embodiment of the present invention of claim 4, the connection groove is configured to include the first connection groove that connects the first actuation channel with the connection hole and the second connection groove that connects the second actuation chamber with the connection hole when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll.

As a result, in order to increase the degree of freedom in the shape of the connection groove, due to the revolving motion of the movable scroll, the central ends of the wraps of the fixed and movable scrolls abut against each other and the first and second connection grooves can each be formed in the range in which the first and second connection grooves are opened in the first and second actuation chambers immediately before the actuation chambers in which the first and second actuation chambers are completely blocked are formed at the central portion at which the connection hole is opened. Therefore, the embodiment of the present invention can more smoothly flow the working fluid between the actuation chambers and the outside of the scroll unit and can more improve the operation efficiency of the working fluid in the scroll unit.

[0020] Further, in accordance with the embodiment of the present invention of claim 5, the connection groove is formed in the range in which the opened areas of the connection grooves for each of the first and second actuation chambers are substantially the same when at least a portion of the connection hole is blocked by the

central end of the wrap of the movable scroll. As a result, when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll, since the substantially same amount of working fluid can flow in the fist actuation chamber and the second actuation chamber, the working fluid can more smoothly flow between the actuation chambers and the outside of the scroll unit, thereby more improving the operation efficiency of the working fluid in the scroll unit.

[0021] Further, in accordance with the embodiment of the present invention of claim 6, since the scroll unit has the symmetric scroll structure to more smoothly moving the working fluid between the actuation chambers and the outside of the scroll unit, the unbalance between the actuation chambers at the operation starting time of the scroll unit can be corrected, thereby certainly preventing the dispersion of the movable scroll for the fixed scroll. Therefore, the embodiment of the present invention can more certainly improve the performance of the scroll unit while securing the reliability of the scroll unit.

[0022] In addition, in accordance with the embodiment of the present invention of claim 7, the connection groove has the groove width narrower than the width of the central end of the wrap of the movable scroll to prevent the central ends of the wraps from being stuck to the connection groove due to the revolving motion, thereby more certainly improving the performance of the scroll unit while securing the reliability of the scroll unit.

[0023] Moreover, in accordance with the embodiment of the present invention of claim 8, specifically, the scroll fluid machine is an expander using the actuation chamber as an expansion chamber, thereby improving the expansion efficiency of the working fluid in the scroll unit.

[Description of Drawings]

[0024]

FIG. 1 is a longitudinal cross-sectional view of a scroll fluid machine in accordance with an embodiment of the present invention.

FIG. 2 is a plan view of a central portion of an expansion-side scroll unit in accordance with a first embodiment of the present invention when viewed from a movable scroll side immediately before forming a central expansion chamber.

FIG. 3(a) is a plan view showing a central portion of only a fixed scroll of the expansion-side scroll unit of FIG. 2 and FIG. 3(b) is a cross-sectional view of a cross section of line A-A of FIG. 3(a) when viewed from an arrow direction.

FIG. 4 is a plan view of the central portion of the expansion-side scroll unit of FIG. 2 when viewed from the movable scroll side at the time of forming a central expansion chamber.

FIG. 5 is a plan view of the central portion of the expansion-side scroll unit of FIG. 4 when viewed from the movable scroll side after forming the central expansion chamber.

FIG. 6 is a plan view of a central portion of an expansion-side scroll unit in accordance with a second embodiment of the present invention when viewed from a movable scroll side immediately before forming a central expansion chamber.

FIG. 7 is a plan view of the central portion of the expansion-side scroll unit of FIG. 6 when viewed from the movable scroll side at the time of forming a central expansion chamber.

FIG. 8 is a plan view of the central portion of the expansion-side scroll unit of FIG. 7 when viewed from the movable scroll side after forming the central expansion chamber.

FIG. 9 is a plan view of the central portion of the expansion-side scroll unit in accordance with a modified example of the second embodiment of the present invention when viewed from the movable scroll side at the time of forming the central expansion chamber.

[Best Mode]

[0025] FIG. 1 shows a longitudinal cross-sectional view of a scroll fluid machine 1. The fluid machine 1 is, for example, an expander integrated with a vertical type compressor and is inserted into a refrigerating cycle (not shown) such as a heat pump, or the like, in which a supercritical carbon dioxide refrigerant is circulated, wherein the refrigerating cycle is assembled in a refrigerating air conditioner (not shown), a heat pump type water heater, or the like. The refrigerating cycle converts expansion energy of refrigerant into power by an expander 4 to be described below to drive the compressor 2.

[0026] The fluid machine 1 includes a housing 6, wherein the housing 6 is extendedly provided with a driving shaft 8 driving the fluid machine 1 while disposing a longitudinal direction of the driving shaft 8 in a vertical direction.

The driving shaft 8 is configured so as to connect an upper shaft part 8a with a lower shaft part 8b, wherein an upper end of the upper shaft part 8a is integrally provided with an upper eccentric shaft part 10a that is eccentric from a shaft center of the driving shaft 8 and the upper eccentric shaft part 10a is connected with a compression-side scroll unit 14 (scroll unit) via a bearing 12.

[0027] Meanwhile, a lower end of the lower shaft part 8b is integrally provided with a lower eccentric shaft part 10b that is eccentric from the shaft center of the driving shaft 4 and the lower eccentric shaft part 10b is connected with an expansion-side scroll unit (scroll unit) 18 via a bearing 16. As such, the housing 6 receives the compressor 2 and the expander 4 in a vertical direction in order from above, with the compressor 2 and the expander 4 being connected with the common driving shaft 8.

[0028] The housing 6 is configured to include a center shell 20 forming a cylindrical body part of the fluid machine 1, a cap type top shell 22 covering the upper portion

of the fluid machine 1, and a cap type bottom shell 24 covering the lower portion of the fluid machine 1. The inside of the center shell 20 is fixed with an upper frame 28 rotatably supporting the upper shaft part 8a via the bearing 26 and a lower frame 32 rotatably supporting the lower shaft portion 8b via a bearing 30. The lower shaft portion 8b is supported and fixed with a balance weight 34, wherein the balance weight 34 is rotated according to a rotation of the driving shaft 8 in a space 36 between the upper frame 28 and the lower frame 32 in the inside of the center shell 20.

[0029] The housing 6 is sealed by the shells 20, 22, and 24 and the inside thereof is applied with a pressure of refrigerant as a working fluid of the fluid machine 1 that is input from an external circuit.

Specifically, the bottom shell 24 is connected with a suction pipe 38 sucking the refrigerant input from the external circuit, the inside of the bottom shell 24 is provided with a suction chamber 40, and the suction pipe 38 is opened in the suction chamber 40.

[0030] The expander 4 is configured to include a movable scroll 42 and a fixed scroll 44. Base surfaces 42b and 44b of end plates 42a and 44a of each of the scrolls 42 and 44 are erected with spiral wraps 46 and 48 facing each other, wherein the spiral wraps have a predetermined involute curved shape.

The movable scroll 42 is revolvably supported on a pedestal part of the lower frame 32, without being rotated, a back 42c of an opposite side to the base surface 42b is projected with a boss part 50, and the boss part 50 is connected with the lower eccentric shaft part 10b.

[0031] The fixed scroll 44 is fixed to the inside of the center shell 20, a central portion of the end plate 44a of the fixed scroll 44 is provided with a suction hole 52 (connection hole) so as to penetrate therethrough, and the suction hole 52 is opened in the suction chamber 40. An outer peripheral inside of the fixed scroll 44 is provided with a discharge chamber 54 of refrigerant and the discharge chamber 54 is connected with a discharge pipe 56 that discharges the refrigerant passing through the expansion-side scroll unit 18 to the outside of the housing 6.

[0032] According to the aforementioned expander 14, as shown by a solid arrow in FIG. 1, the refrigerant sucked from the suction pipe 38 is input to the expansion-side scroll unit 18 through the suction chamber 40 and the suction hole 52 and the movable and fixed scrolls 42 and 44 are cooperated with each other to be expanded in the expansion chamber that is formed between respective wraps 46 and 48 of each scroll 42 and 44. The expansion chamber has the increased volume while moving toward outer peripheral sides of each scroll 42 and 44, such that the movable scroll 42 revolvably moves around the shaft center of the fixed scroll 44.

[0033] The driving shaft 8 is rotatably driven according to the revolving motion of the movable scroll 42 and the refrigerant supplied by the revolving motion of the movable scroll 42 as well as the generation of the driving force of the driving shaft 8 is sent to the external circuit outside the housing 6 via the discharge pipe 56 through the discharge chamber 54.

[0034] Meanwhile, the compressor 2 is configured to include a movable scroll 58 and a fixed scroll 60. Base surfaces 58b and 60b of end plates 58a and 60a of each of the scrolls 58 and 60 are erected with spiral wraps 62 and 64 facing each other, wherein the spiral wraps 62 and 64 have a predetermined involute curved shape.

[0035] The movable scroll 58 is revolvably supported on the pedestal part of the upper frame 32, without being rotated, a back 58c of an opposite side to the base surface 58b is projected with a boss part 66, and the boss part 66 is connected with the upper eccentric shaft part 10a. The top shell 22 is connected with a discharge pipe 68 that discharges the refrigerant passing through the compression-side scroll unit 14 to the outside of the housing 6 and the discharge pipe 68 is opened in a discharge chamber 70 formed in the inside of the top shell 22.

[0036] The fixed scroll 60 is fixed to the inside of the center shell 20, the central portion of the end plate 60a of the fixed scroll 60 is provided with the discharge hole (connection hole) opened in the discharge chamber 70 so as to penetrate therethrough, the outer peripheral inside of the fixed scroll 60 is provided with a suction chamber 74, and the suction chamber 74 is connected with a suction pipe 76.

[0037] According to the aforementioned compressor 2, as shown by a solid arrow in FIG. 1, the refrigerant sucked from the suction pipe 76 is input to the compression-side scroll unit 14 through the suction chamber 74 and the movable and fixed scrolls 58 and 60 are cooperated with each other to be compressed in the compression chamber formed between the wraps 62 and 64 of each scroll 58 and 60. The compression chamber has the reduced volume while moving toward the central portions of each scroll 58 and 60, by revolvably moving the movable scroll 58 around the shaft center of the fixed scroll 60 by rotating the driving shaft 8 into which the boss part 66 is inserted. Further, the refrigerant that is in a high pressure state according to the reduction in volume of the compression chamber is sent to the external circuit outside the housing 6 via the discharge pipe 68 through the discharge hole 72 and the discharge chamber 70.

[0038] As such, in the fluid machine 1, the expansion-side scroll unit 18 at the driving side is driven by the pressure of refrigerant, such that the compression-side scroll unit 14 at the driven side is driven.

Meanwhile, the space 36 is provided with a lubricant chamber 78 in which a lubricant for lubricating the expansion-side and compression-side scroll units 18 and 14 is stored.

[0039] Specifically, in the upper shaft part 8a, an opened oil passage 80 is drilled on the upper end of the upper shaft part 8a along a shaft line direction of the driving shaft 8 and in the lower shaft part 8b, an opened oil passage 82 is drilled on the lower end of the lower shaft part 8b so as to be connected with the oil passage

80 along the shaft line direction of the driving shaft 8. Each oil passage 80 and 82 is connected with the lubricant chamber 78 by an oil supply hole (not shown) bored along a radial direction of the driving shaft 8.

[0040] As shown by a dotted arrow in FIG. 1, the lubricant stored in the lubricant chamber 78 is discharged from the upper end and the lower end of the driving shaft 8 through the oil passages 80 and 82 from the oil supply hole and lubricates the bearings 12 and 16 and then, lubricates the bearings 26 and 30, while sliding parts of each scroll unit 14 and 18 are lubricated in back pressure chambers 84 and 86 of the lubricant formed between the upper frame 28 and the back 58c of the movable scroll 58 and the lower frame 32 and the back 42c of the movable scroll 42, respectively. Further, each movable scroll 42 and 58 is pressed and urged to each of the fixed scrolls 44 and 60 by the pressure of each of the back pressure chambers 84 and 86, such that each of the movable scrolls 42 and 58 can smoothly revolvably move with respect to each of the fixed scrolls 44 and 60.

[0041] Further, in the upper frame 28, an oil passage 88 is drilled from the back pressure chamber 84 to the space 36 and in the lower frame 32, an oil passage 90 is drilled from the space 36 to the back pressure chamber 86. Openings of the space 36 sides of each oil passage 88 and 90 are connected with an oil guide pipe 92, wherein the oil guide pipe 92 is disposed so as to be airtight from the lubricant chamber 78 in the space 36. A back pressure adjustment mechanism 94 of the back pressure chamber 86 is disposed in the halfway of the oil passage 90 and the oil passage 90 can also be used as a pressure opening path releasing the excessive high pressure of the back pressure chamber 86 within the oil guide pipe 92.

[0042] As such, the lubricant for lubricating the expansion-side scroll unit 18 side or forming the back pressure chamber 86 is supplied to the back pressure chamber 84 via the oil guide pipe 92 as shown by the dotted arrow in FIG. 1 to contribute to forming the back pressure chamber 84. The lubricant contributing to forming the back pressure chamber 84 is supplied to the suction chamber 74 through the pressure adjustment mechanism (not shown) connecting the back pressure chamber 84 with the suction chamber 74 and is sent to the external circuit outside the housing 6 via the discharge pipe 68 through the discharge hole 72 and the discharge chamber 70, together with the refrigerant after lubricating the compression-side scroll unit 14.

[0043] FIGS. 2, 4 and 5 are plan views of the central portion of the expansion-side scroll unit 18 in accordance with the first embodiment of the present invention when viewed from the movable scroll 42. Each of the figures shows a first expansion chamber (first actuation chamber) 100 that is partitioned into an outer wall 98a of a central end 98 of the wrap 48 of the fixed scroll 44 and an inner wall 96b of a central end 96 of the wrap 46 of the movable scroll 42 and a second expansion chamber (second actuation chamber) 102 that is partitioned into an inner wall 98b of the central end 98 of the wrap 48 of the fixed scroll 44 and an outer wall 96a of the central end 96 of the wrap 46 of the movable scroll 42.

[0044] FIG. 2 shows a state immediately before a position at which the suction hole 52 is opened is provided with the central expansion chamber (actuation chamber) 104 in which the first and second actuation chambers 100 and 102 are completely blocked, due to the revolving motion of the movable scroll 42.

The base surface 44b of the fixed scroll 44 is recessed with one continuous connection groove (connection path) in the range in which the connection groove 106 reaches the suction hole 52.

[0045] Specifically, referring to a plan view showing only the central portion of the fixing scroll 44 of FIG. 3(a), a portion of an outer edge of the connection groove 106 is along the inner wall 98b and the outer edge of the connection groove 106 crosses over the suction hole 52, such that a plane shape of the whole connection groove 106 when being connected with a virtual line 108 shown by a one-dot chain line in FIG. 3(a) has an S-letter shape including at least a portion of the suction hole 52.

[0046] Further, as also shown in a cross-sectional view when viewing cross section A-A of FIG. 3(a) of FIG. 3(b) from an arrow direction, an opening edge of the suction hole 52 is provided with an annular end 52a, a groove bottom 106a of the connection groove 106 is formed ranging from the base surface 44b to the 52a, and the connection groove 106 is connected with the suction hole 52 via the end 52a.

[0047] Since the connection groove 106 is formed in the aforementioned shape and range, when at least a portion of the suction hole 52 is blocked by the central end 96 of the wrap 46 of the movable scroll 42 immediately before the refrigerant intake formed by the central expansion chamber 104 ends, at least a portion of the connection groove 106 is opened in the first and second expansion chambers 100 and 102 and as shown by a solid line in FIG. 2, the refrigerant path larger than gaps G1 and G2 of the central ends 96 and 98 is formed by the connection groove 106 and the refrigerant flows in the first and second expansion chambers 100 and 102 from the suction hole 52 via the refrigerant path.

[0048] Further, in this case, the first expansion chamber 100 is connected with the second expansion chamber 102 via the connection groove 106 and thus, the refrigerant flows between the first and second expansion chambers 100 and 102.

Further, in this case, the shape and range of the connection groove 106 are previously set so that the opening areas of each of the connection grooves 106 for the first and second expansion chambers 100 and 102 are substantially the same.

[0049] FIG. 4 shows a state in which the revolution of the movable scroll 42 is further progressed from the state of FIG. 2 and the refrigerant intake formed by the central expansion chamber 104 ends. As can be appreciated from the above Figure, the connection groove 106 is

formed over the range in which all the connection grooves 106 is concealedly covered by the wrap 46 of the movable scroll 42 when the central ends 98 and 96 of the wraps 48 and 46 of the fixed and movable scrolls 44 and 42 abut against each other in the case in which the central expansion chamber 104 is formed.

[0050] FIG. 5 shows a state in which the revolution of the movable scroll 42 is further progressed from the state of FIG. 4 and after the central expansion chamber 104 is formed. As can be appreciated from the above Figure, the connection groove 106 is formed over the range in which the revolving motion of the movable scroll 42 or the formation of each expansion chamber including the first and second expansion chambers 100 and 102 are not hindered, before the central expansion chamber 104 is formed, when the central expansion chamber 104 is formed, as well as even after the central expansion chamber 104 is formed. Specifically, the connection groove 106 is formed over the range in which the width of the connection groove 106 is narrower than that of the central end 96 of the wrap 46 of the movable scroll 42.

[0051] As described above, the embodiment of the present invention has the connection groove 106 to expand the refrigerant path between the first and second expansion chambers 100 and 102 and the suction hole 52 immediately before the central expansion chamber 104 in which at least a portion of the suction hole 52 is closed by the central end 96 of the wrap 46 of the movable scroll 42 due to the revolving motion of the movable scroll 42, that is, immediately before the refrigerant intake ends, thereby preventing the refrigerant amount flowing between the expansion chamber and the outside of the expansion-side scroll unit 18, that is, the intake amount of refrigerant into the expansion-side scroll unit 18 from reducing.

[0052] Further, even when the central ends 98 and 96 of the wraps 48 and 46 of the fixed and movable scrolls 44 and 42 abut against each other due to the revolving motion of the movable scroll 42, the connection between the first and second expansion chambers 100 and 102 and the suction hole 52 can be blocked and the central expansion chamber 104 in which the first and second expansion chambers 100 and 102 are completely blocked can be formed at the central portion at which the suction hole 52 is opened. Therefore, since it is possible to prevent the intake amount of refrigerant into the expansion-side scroll unit 18 from reducing while preventing the refrigerant from the central expansion chamber 104 from being leaked, it is possible to prevent the expansion efficiency of refrigerant from reducing in the expansion-side scroll unit 18 and improve the performance of the expansion-side scroll unit 18 while securing the reliability of the expansion-side scroll unit 18.

[0053] Further, since the connection groove 106 is recessed in the range in which the connection groove reaches the suction hole 52 on the base surface 44b of the fixed scroll 44, the embodiment of the present invention can improve the performance of the expansion-side scroll unit while securing the reliability of the expansion-side scroll unit 18 by the simple structure in which the grooves are disposed in the fixed scroll 44, without damaging the durability of the expansion-side scroll unit 18 by machining the wrap 46 of the movable scroll 42.

[0054] Further, the connection groove 106 connects the first expansion chamber 100 with the second expansion chamber 102 immediately before the central expansion chamber 104 is formed, that is, immediately before the refrigerant intake ends to make the pressure of the first expansion chamber 100 and the second expansion chamber 102 uniform, thereby more smoothly performing the refrigerant intake into the expansion-side scroll unit 18 and more improving the expansion efficient of refrigerant in the expansion-side scroll unit 18.

[0055] Further, the connection groove 106 is formed in the range in which the opening areas of the connection grooves 106 for each of the first and second expansion chambers 100 and 102 is substantially the same, immediately before the central expansion chamber 104 is formed, that is, immediately before the refrigerant is input. As a result, the substantially same amount of refrigerant can be input to the first expansion chamber 100 and the second chamber 102 immediately before the central expansion chamber 104 is formed, that is, immediately before the refrigerant is input, thereby more smoothly inputting the refrigerant to the expansion-side scroll unit 18 and more improving the expansion efficiency of refrigerant in the expansion-side scroll unit 18.

[0056] Further, the connection groove 106 has a groove width narrower than a width of the central end 96 of the wrap 46 of movable scroll 42 to prevent the central end 96 of the wrap 46 from being stuck to the connection groove 106 due to the revolving motion of the movable scroll 42, thereby more certainly improving the performance of the expansion-side scroll unit 18 while securing the reliability of the expansion-side scroll unit 18.

[0057] Next, FIGS. 6 to 8 are plan views of the central portion of the expansion-side scroll unit 18 in accordance with a second embodiment of the present invention when viewed from the movable scroll 42. Further, the same components as the first embodiment of the present invention are denoted by the same reference numerals and the description thereof will be described.

[0058] FIG. 6 shows a state immediately before the central expansion chamber 104 is formed, that is, immediately before the refrigerant intake ends due to the revolving motion of the movable scroll 42. As can be appreciated from the above Figure, the connection groove in accordance with the embodiment of the present invention is configured to include a first connection groove (connection path, connection groove) 110 connecting the first expansion chamber 100 with the suction hole 52 and a second connection groove (connection path, connection groove) 112 connecting the second expansion chamber 102 with the suction hole 52.

[0059] Specifically, the first connection groove 110 may extend from the suction hole 52 to the first expansion

chamber 100 side in a long groove shape in the range in which the first connection groove 100 forms a curved line approximately along a revolving trajectory of the movable scroll. Meanwhile, the second connection groove 112 extends from the suction hole 52 to the second expansion chamber 102 in a long groove shape in the range in which the second connection groove 100 forms an approximately straight line in the revolving trajectory of the movable scroll 42.

[0060] The first and second connection grooves 110 and 112 are formed in the shape and range as described above such that the first connection groove 110 is connected with the first expansion chamber 100, the second connection groove 112 is connected with the second expansion chamber 102, and the first expansion chamber 100 and the second expansion chamber 102 are connected with each other, having a slight gap formed therebetween, when at least a portion of the suction hole 52 is closed by the central end 96 of the wrap 46 of the movable scroll 42 immediately before the central expansion chamber 104 is formed, that is, immediately before the refrigerant intake ends.

[0061] Further, in this case, the first and second connection grooves 110 and 112 are opened such that the opening area of the first connection groove 110 for the first expansion chamber 100 are substantially the same as that of the second connection groove 112 for the second expansion chamber 102.

[0062] FIG. 7 shows a state in which the revolution of the movable scroll 42 is further progressed from the state of FIG. 6 and the central expansion chamber 104 is formed, that is, the refrigerant intake is completed. As can be appreciated from the above Figure, the first and second connection grooves 110 and 112 are formed over the range in which both of the first and second connection grooves 110 and 112 are concealedly covered by the wrap 96 of the movable scroll 42 when the central ends 98 and 96 of the wraps 48 and 46 of the fixed and movable scrolls 44 and 42 abut against each other and thus, the central expansion chamber 104 is formed.

[0063] FIG. 8 shows a state in which the revolution of the movable scroll 42 is further progressed from the state of FIG. 7 and after the central expansion chamber 104 is formed. As can be appreciated from the above Figure, the first and second connection grooves 110 and 112 are formed over the range in which the revolving motion of the movable scroll 42 or the formation of the expansion chamber are not hindered, before the central expansion chamber 104 is formed, when the central expansion chamber 104 is formed, as well as even after the central expansion chamber 104 is formed. Specifically, the first and second connection grooves 110 and 112 are formed over the range in which each width of the connection grooves 110 and 112 is narrower than that of the central end 96 of the wrap 46 of the movable scroll 42.

[0064] As described above, similar to the first embodiment of the present invention, the embodiment of the present invention can prevent the refrigerant intake amount to the expansion-side scroll unit 18 from reducing while preventing the refrigerant from the central expansion chamber 104 from being leaked, thereby preventing the expansion efficiency of refrigerant from reducing in the expansion-side scroll unit 18 and improving the performance of the expansion-side scroll unit 18 while securing the reliability thereof.

[0065] In particular, the embodiment of the present invention configures the connection groove from the first and second connection grooves 110 and 112 to increase the degree of freedom of the shape of the connection groove, such that the connection groove can be formed in the range in which the connection groove is opened in each of the first and second actuation chambers until the instant immediately before the central expansion chamber 104 is formed, that is, immediately before the refrigerant intake ends.

[0066] Specifically, FIG. 9 shows a plan view of the central portion of the expansion-side scroll unit 18 in accordance with a modified example of the second embodiment of the present invention when viewed from the movable scroll 42 side at the time of forming the central expansion chamber 104. As can be appreciated from the above Figure, a terminal part 110a of the first expansion chamber 110 side of the first connection groove 110 is fomed to be toward the outer wall 98a of the central end 98 of the fixed scroll 44, while a terminal part 112a of the second expansion chamber 102 side of the second connection groove 112 is formed to be toward the inner wall 98b of the central end 98 of the fixed scroll 44. As a result, as compared with the case of the first embodiment, the second connection groove 112 continues to open the second expansion chamber 102 while continuing to open the first connection groove 110 in the first expansion chamber 100 until the instant immediately before the central expansion chamber 104 is formed. Therefore, the refrigerant intake to the expansion-side scroll unit 18 can be more smoothly performed and the expansion efficiency of refrigerant can be more improved in the expansion-side scroll unit 18.

[0067] Although the embodiments of the present invention are described as above, the present invention is not limited each of the embodiments and therefore, can be variously changed without departing from the scope of the present invention.

For example, each of the embodiments of the present invention forms the connection groove on the base surface 44b of the fixed scroll 44, but is not limited thereto. For example, the connection path is preferably drilled in the end plate 42a. Even in this case, the expansion efficiency of refrigerant can be improved in the expansion-side scroll unit 18 similar to the above description even in this case.

[0068] Further, the shapes of the each connection groove in each of the embodiments are not limited to the aforementioned shapes and therefore, the outer edge of the connection groove may be preferably formed by, for example, a polyline.

[0069] Further, each of the embodiments does not mention the scroll structrue of the expansion-side scroll unit 18 but when the expansion-side scroll unit 18 has a symmetric scroll structure, the refrigerant intake to the expansion-side scroll unit 18 can be more smoothly performed, thereby correcting the unbalance between the expansion chambers at the operation starting time of the expansion-side scroll unit 18 and certainly preventing the dispersion of the movable scroll 42 with respect to the fixed scroll 44. Therefore, the embodiment of the present invention can improve the performance of the expansion-side scroll unit 18 while more certainly securing the reliability of the expansion-side scroll unit 18.

[0070] Further, each of the embodiments forms the connection groove in the base surface 44b of the fixed scroll 44 of the expansion-side scroll unit 18 but is not limited thereto and therefore, can also be formed on the base surface 60b of the fixed scroll 60 of the compression-side scroll unit 14. In this case, each of the embodiments can prevent the refrigerant discharge amount from the compression-side scroll unit from reducing while preventing the refrigerant from the central compression chamber from being leaked, thereby preventing the compression efficiency of refrigerant from reducing in the compression-side scroll unit 14 and improving the performance of the compression-side scroll unit 14 while securing the reliability of the compression-side scroll unit 14.

[0071] Finally, each of the embodiments describes the case in which the present invention is applied to the expander integrated with the compressor but is not limited thereto. Therefore, the present invention can be applied to all of the fluid machines including the scroll unit, such as the expander, the compressor, or the like, having the single scroll unit.

[Detailed Description of Main Elements]

[0072]

1 Scroll fluid machine
4 Expander
14 Compression-side scroll unit (scroll unit)
18 Expansion-side scroll unit (scroll unit)
42 Movable scroll of expansion-side scroll unit (movable scroll)
42a End plate of movable scroll of expansion-side scroll unit (end plate)
42b Base surface of end plate of movable scroll of expansion-side scroll unit (base surface)
44 Fixed scroll of expansion-side scroll unit (fixed scroll)
44a End plate of fixed scroll of expansion-side scroll unit (end plate)
44b Base surface of end plate of fixed scroll of expansion-side scroll unit (base surface)
46 Wrap of movable scroll of expansion-side scroll unit (wrap)
48 Wrap of fixed scroll of expansion-side scroll unit (wrap)
52 Suction hole (connection hole)
58 Movable scroll of compression-side scroll unit (movable scroll)
58a End plate of movable scroll of compression-side scroll unit (end plate)
58b Base surface of end plate of movable scroll of compression-side scroll unit (base surface)
60 Fixed scroll of compression-side scroll unit (fixed scroll)
60a End plate of fixed scroll of compression-side scroll unit (end plate)
60b Base surface of end plate of fixed scroll of compression-side scroll unit (base surface)
62 Wrap of movable scroll of compression-side scroll unit (wrap)
64 Wrap of fixed scroll of compression-side scroll unit (wrap)
72 Discharge hole (connection hole)
96 Central end of wrap of movable scroll of expansion-side scroll unit (central end)
96a Outer wall of central end of wrap of movable scroll of expansion-side scroll unit (outer wall)
96b Inner wall of central end of wrap of movable scroll of expansion-side scroll unit (inner wall)
98 Central end of wrap of fixed scroll of expansion-side scroll unit (central end)
98a Outer wall of central end of wrap of fixed scroll of expansion-side scroll unit (outer wall)
98b Inner wall of central end of wrap of fixed scroll of expansion-side scroll unit (inner wall)
100 First expansion chamber (first actuation chamber)
102 Second expansion chamber (second actuation chamber)
104 Central expansion chamber (actuation chamber)
106 Connection groove (connection path)
110 First connection groove (connection path, connection groove)
112 Second connection groove (connection path, connection groove)

Claims

1. A scroll fluid machine, **characterized by** comprising:

a scroll unit configured to include fixed and movable scrolls in which spiral wraps are each erected to face each other on each base surface of each end plate and form actuation chambers of a working fluid between respective wraps of the fixed and movable scrolls by revolvably moving the movable scroll around a shaft center of the fixed scroll;
a connection hole formed to penetrate through

a central portion of the end plate of the fixed scroll and connecting the actuation chambers with an outside of the scroll unit;
a first actuation chamber partitioned into an outer wall of a central end of the wrap of the fixed scroll and an inner wall of the central end of the wrap of the movable scroll;
a second actuation chamber partitioned into an inner wall of the central end of the wrap of the fixed scroll and an outer wall of the central end of the wrap of the movable scroll; and
a connection path connecting the first and second actuation chambers with the connection hole when at least a portion of the connection hole is closed by the central end of the wrap of the movable scroll and a connection path blocking the connection between the first and second actuation chambers and the connection hole when the central ends of the wraps of the fixed and movable scrolls abut against each other, due to the revolving motion of the movable scroll.

2. The scroll fluid machine of claim 1, **characterized in that** the connection path is the connection groove recessed in a range in which the connection path reaches the connection hole on the base surface of the fixed scroll, and
the connection groove is formed in a range in which at least a portion of the connection groove is opened in the first and second actuation chambers when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll due to the revolving motion of the movable scroll and all of the connection grooves are concealedly covered by the wrap of the movable scroll when the central ends of the wraps of the fixed and movable scrolls abut against each other, due to the revolving motion of the movable scroll.

3. The scroll fluid machine of claim 2, **characterized in that** the connection groove connects the first actuation chamber with the second actuation chamber when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll.

4. The scroll fluid machine of claim 2, **characterized in that** the connection groove connects the first actuation chamber with the second actuation chamber when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll.

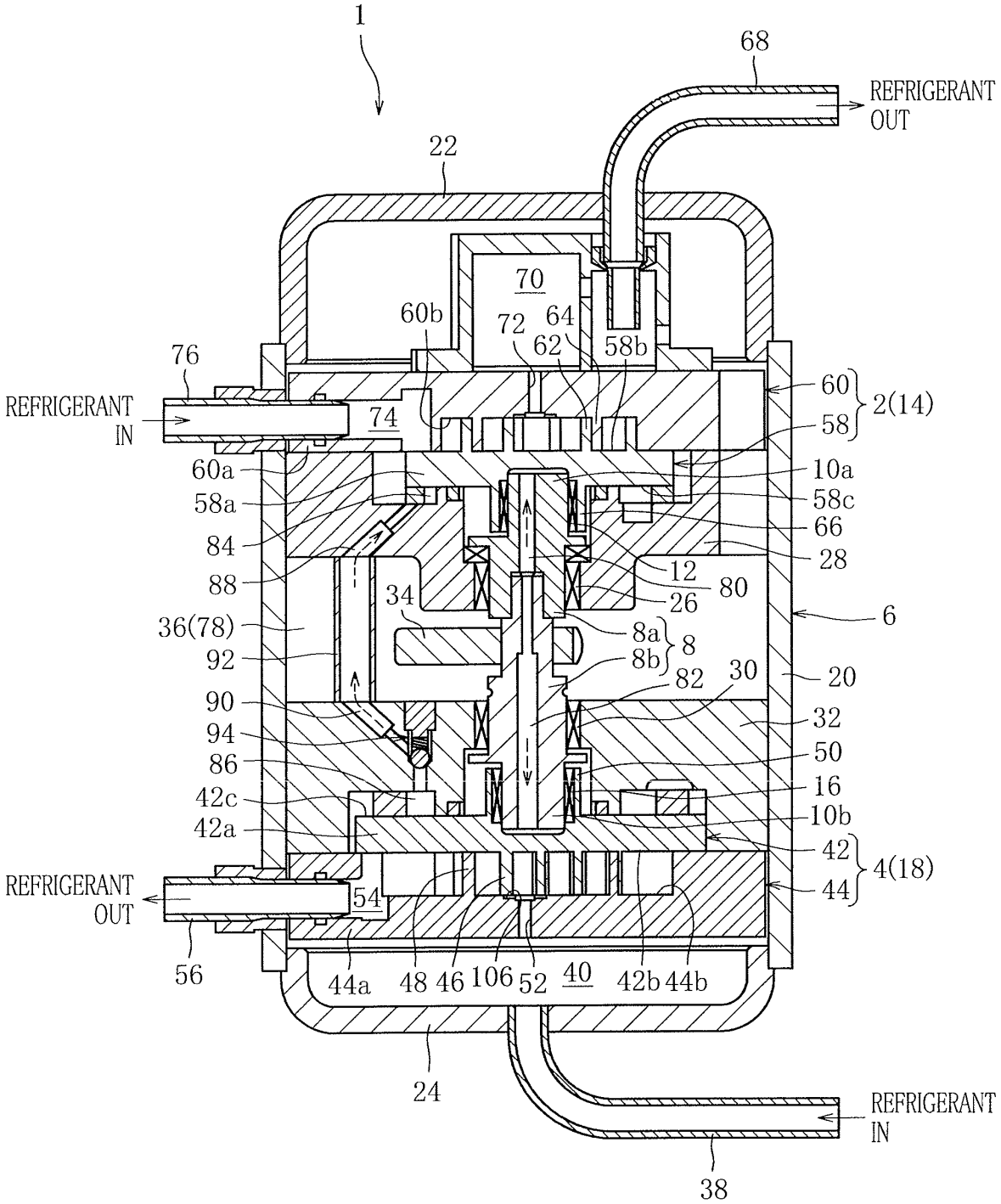
5. The scroll fluid machine of claim 2, **characterized in that** the connection groove is formed in the range in which the opened areas of the connection grooves for each of the first and second actuation chambers are substantially the same when at least a portion of the connection hole is blocked by the central end of the wrap of the movable scroll.

6. The scroll fluid machine of any one of claims 3 to 5, **characterized in that** the scroll unit has the symmetric scroll structure.

7. The scroll fluid machine of claim 2, **characterized in that** the connection groove has the groove width narrower than the width of the central end of the wrap of the movable scroll.

8. The scroll fluid machine of claim 1, **characterized in that** the scroll fluid machine is an expander using the actuation chamber as an expansion chamber.

FIG. 1


1
68
REFRIGERANT OUT
22
70
60b
72
64
62
58b
76
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60
58
2(14)
60a
58a
10a
58c
66
84
28
88
12
80
26
34
6
36(78)
8a
8
92
8b
82
30
20
90
94
32
86
50
42c
16
42a
10b
42
4(18)
REFRIGERANT OUT
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44
56
44a
48
46
106
52
40
42b
44b
24
REFRIGERANT IN
38

FIG. 2

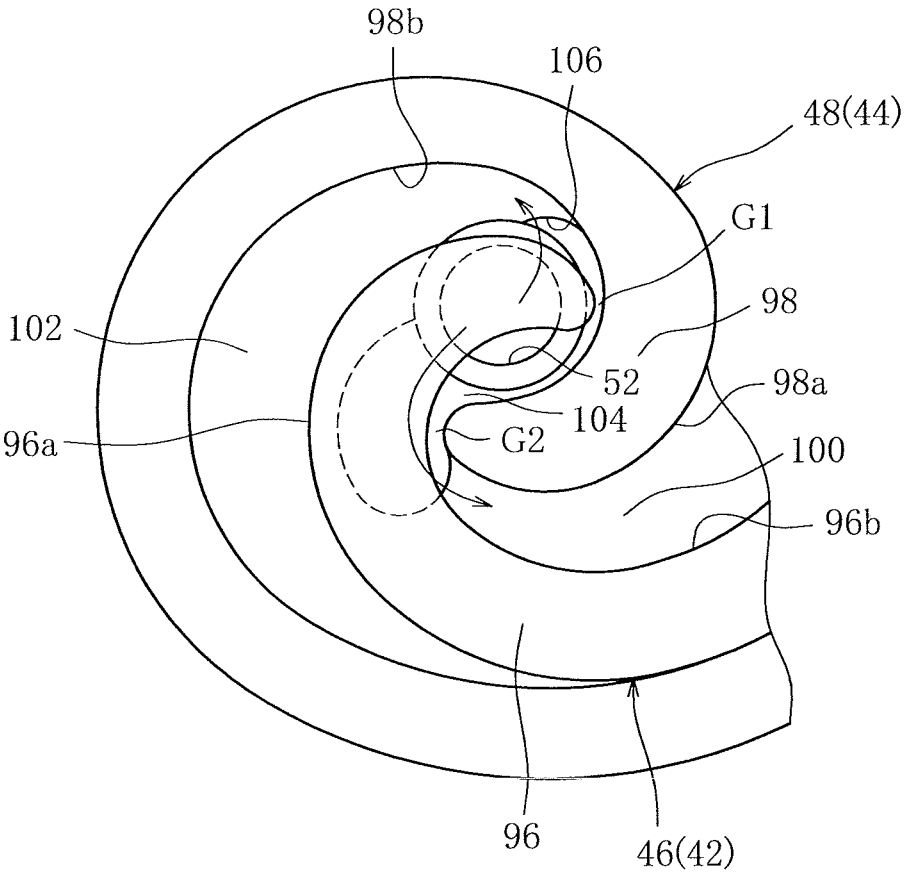
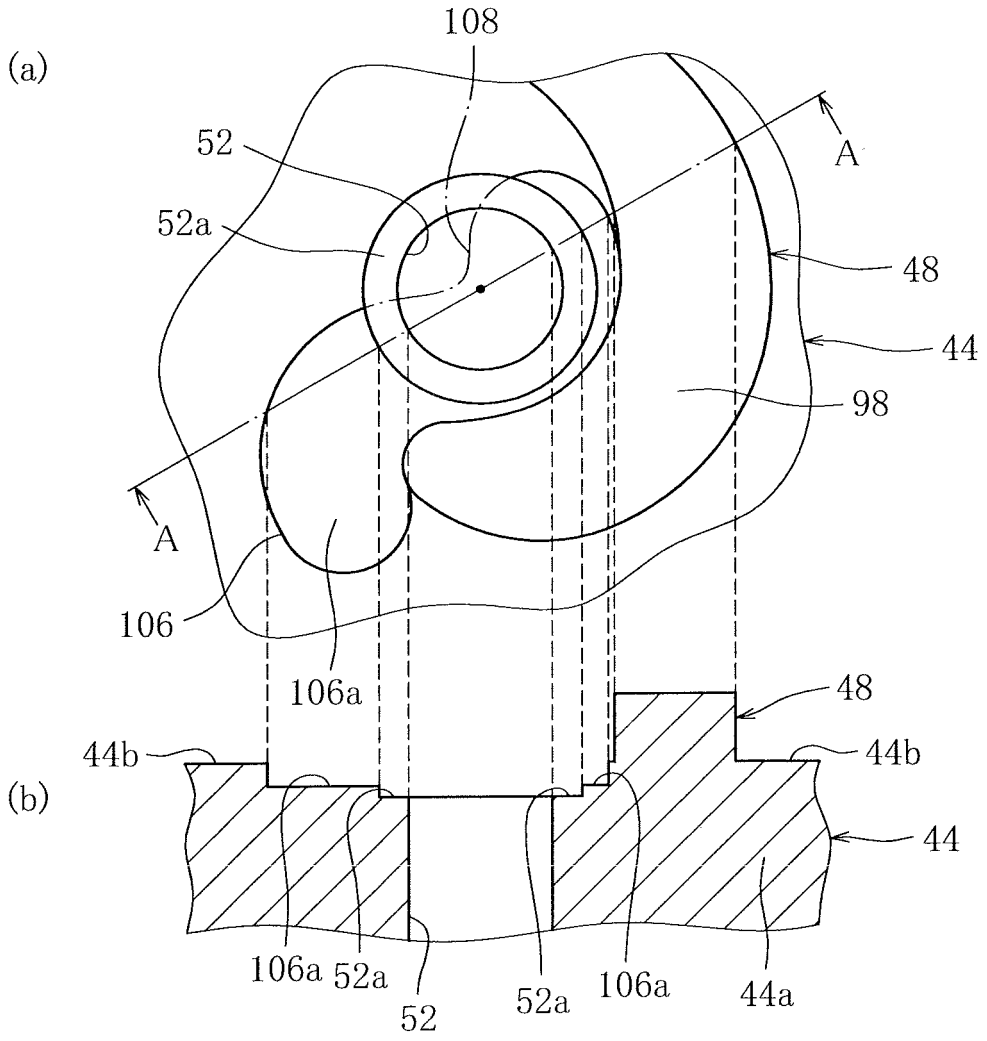


FIG. 3


(a)
108
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52a
A
48
44
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(b)
48
44b
44b
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106a
52a
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52a
106a
44a

FIG. 4

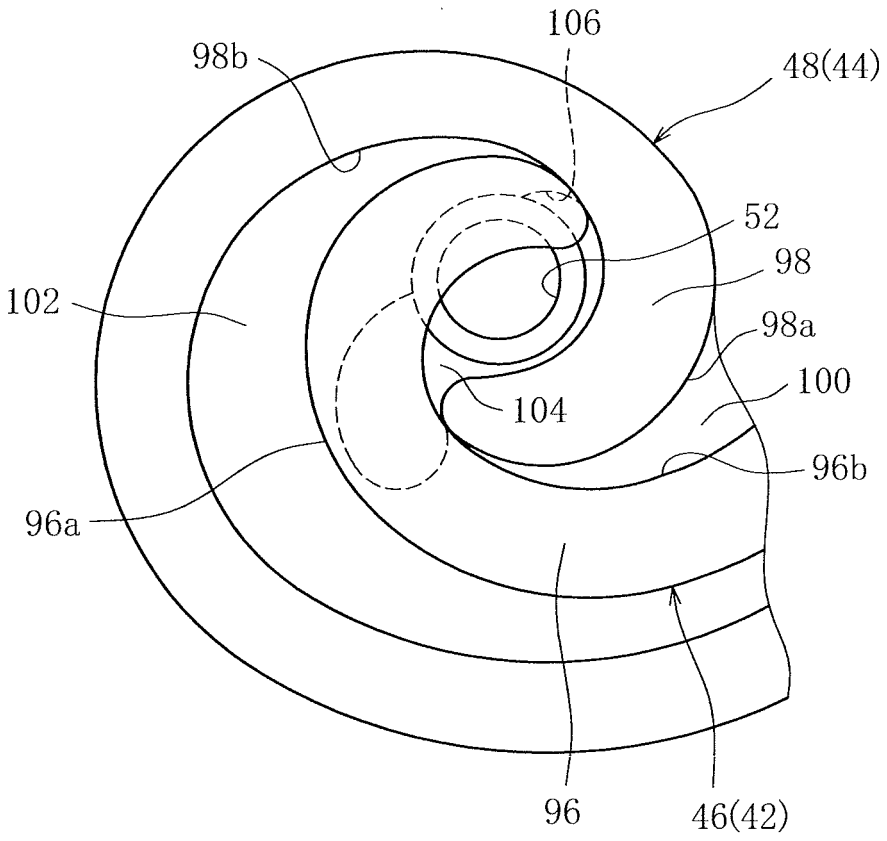


FIG. 5

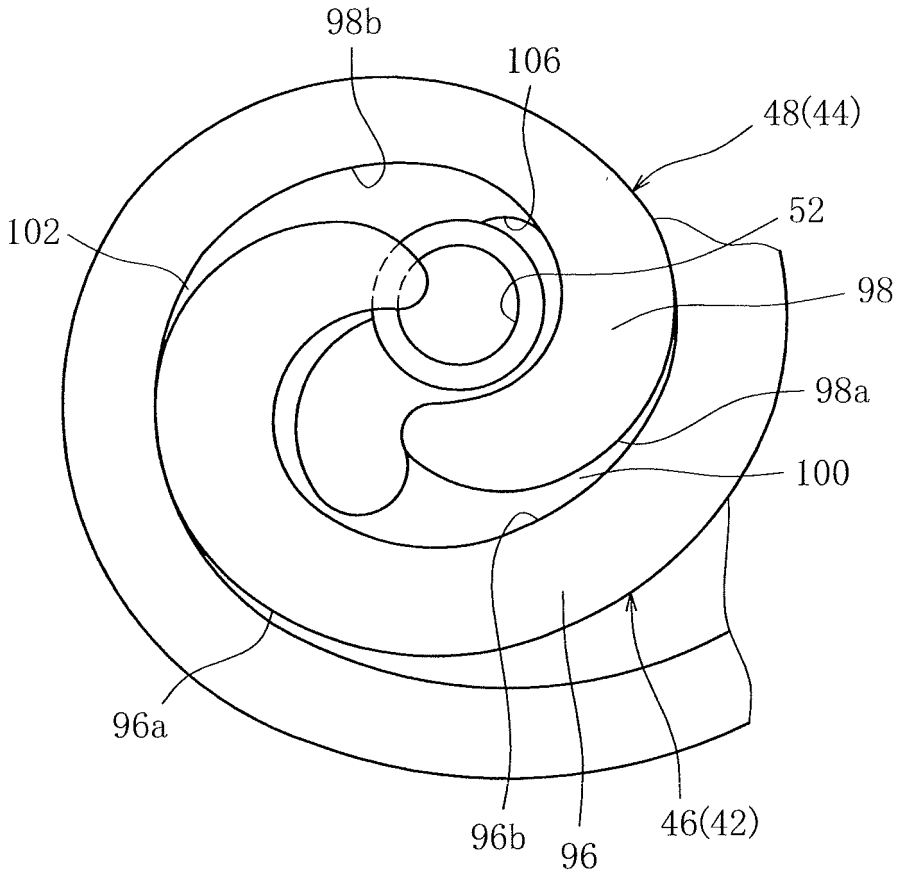


FIG. 6

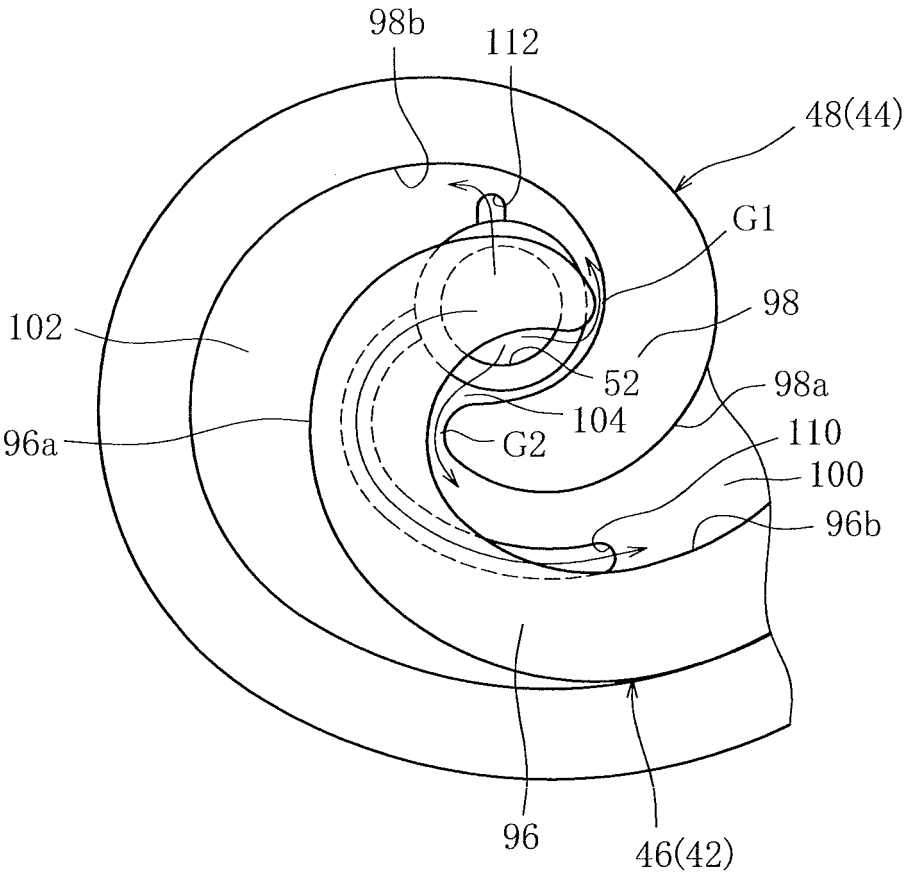


FIG. 7

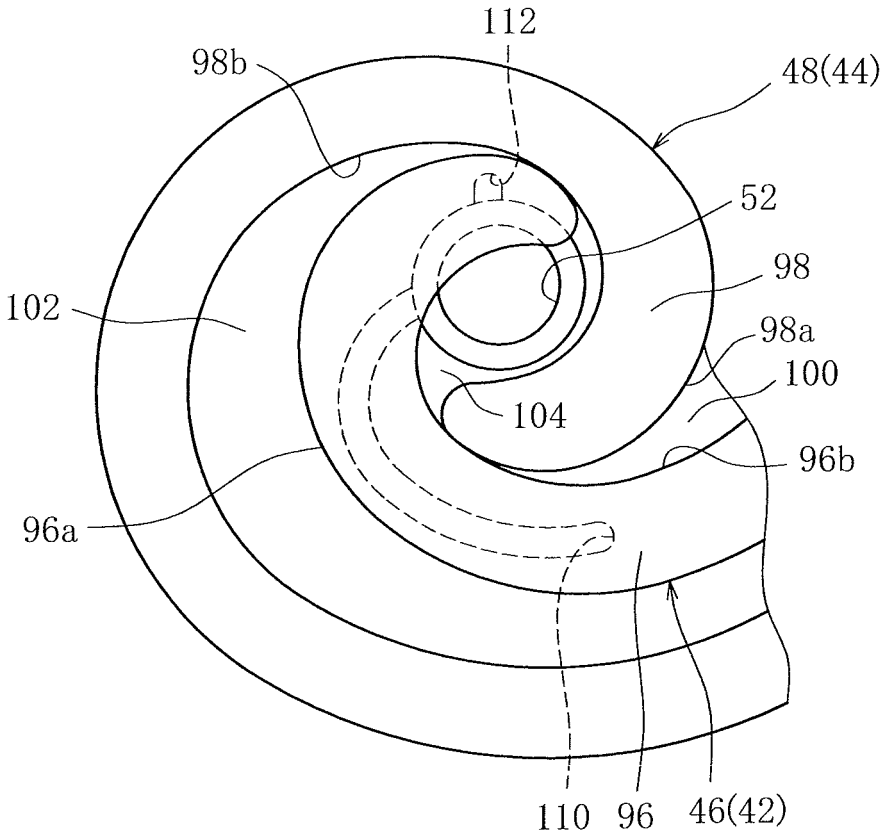


FIG. 8

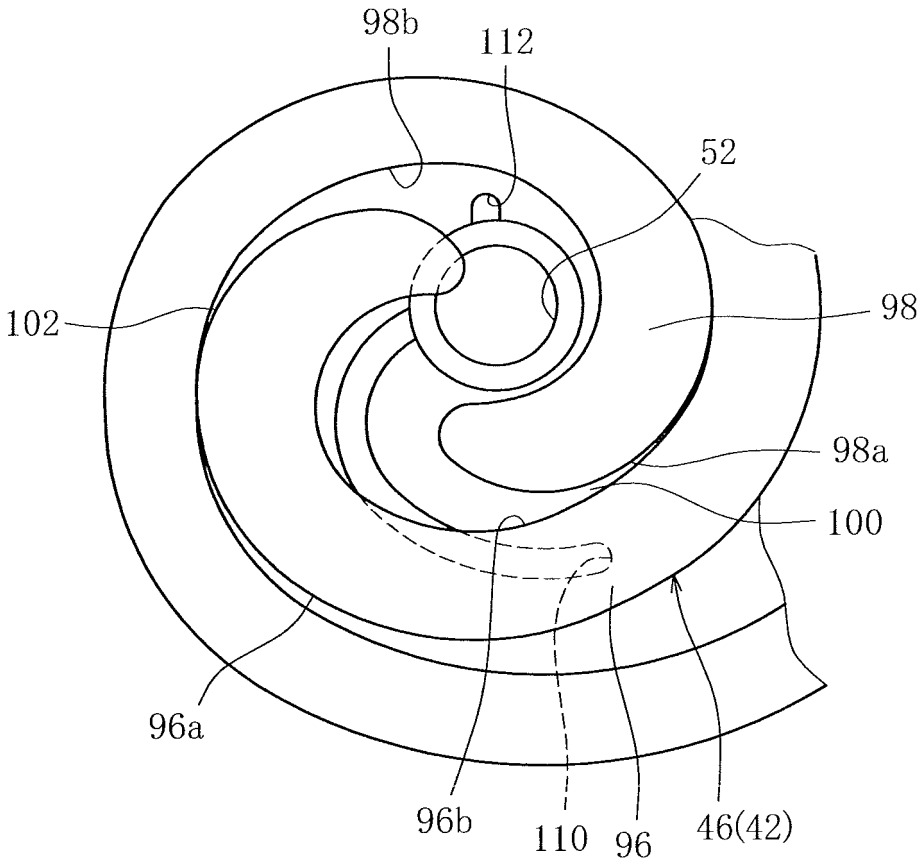
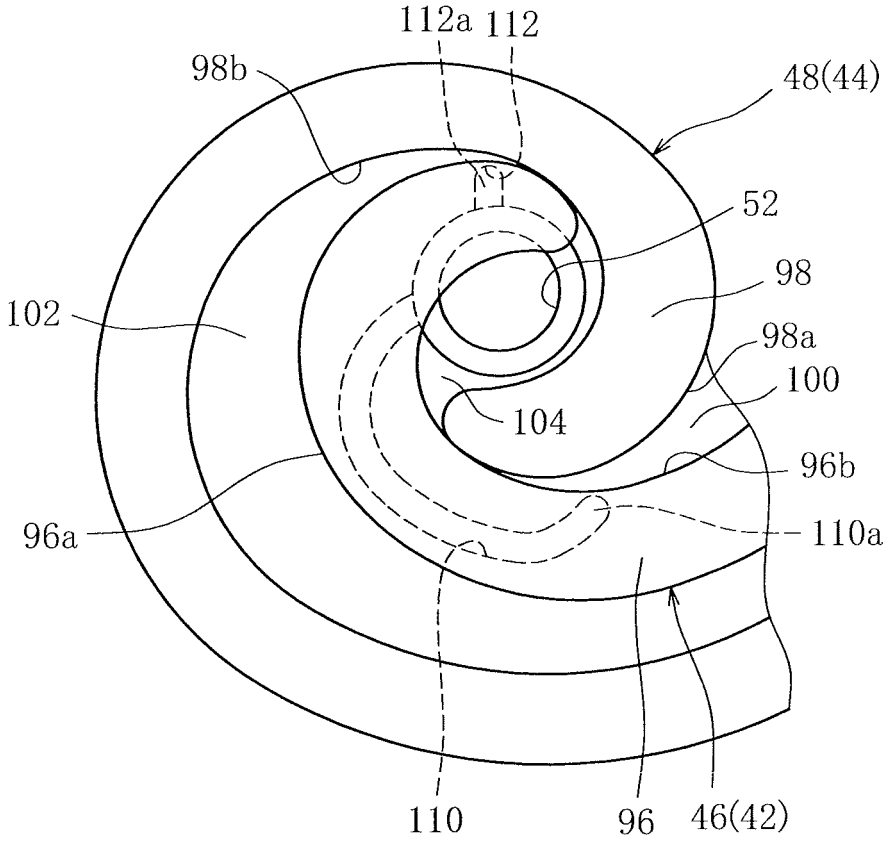


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/063498

A. CLASSIFICATION OF SUBJECT MATTER
F01C1/02(2006.01)i, *F01C21/18*(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)
F01C1/02, F01C21/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010
Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 1-187390 A (Sanyo Electric Co., Ltd.), 26 July 1989 (26.07.1989), page 3, upper left column, line 2 to upper right column, line 4; fig. 2 to 4 (Family: none)	1-7 8
Y A	JP 2006-242133 A (Denso Corp.), 14 September 2006 (14.09.2006), paragraphs [0001], [0095] to [0114]; fig. 7 & US 2006/0198747 A1 & DE 102006009738 A	8 1-7
A	JP 63-215892 A (Sanyo Electric Co., Ltd.), 08 September 1988 (08.09.1988), fig. 2 to 4 & US 4886434 A & EP 279646 A2 & DE 3875982 A & DE 3875982 T & CA 1309070 A	1-8

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

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Date of the actual completion of the international search	Date of mailing of the international search report
14 October, 2010 (14.10.10)	26 October, 2010 (26.10.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/063498

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 58-135393 A (Hitachi, Ltd.), 11 August 1983 (11.08.1983), fig. 4 to 9 (Family: none)	1-8
A	JP 2005-273453 A (Aisin Seiki Co., Ltd.), 06 October 2005 (06.10.2005), fig. 1 to 9 & KR 10-2006-0045341 A & CN 1673542 A	1-8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2006242133 A **[0004]**