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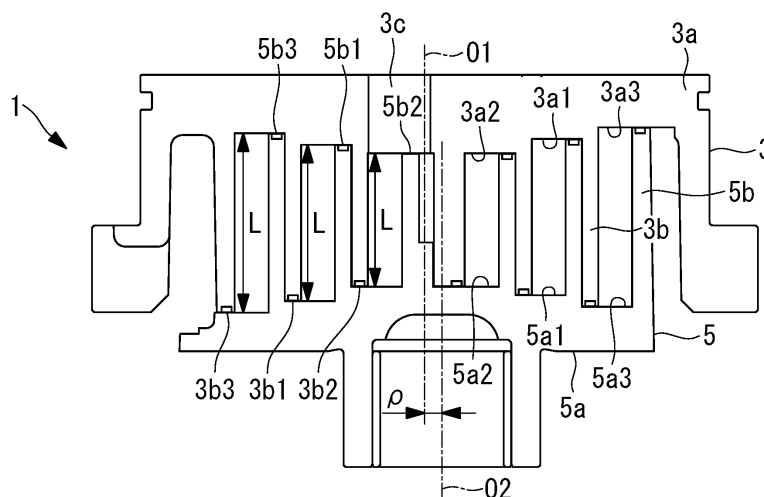
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(54) **SCROLL FLUID MACHINE**

(57) In a scroll compressor (1) including a fixed scroll (3) and an orbiting scroll (5), inclined sections that continuously reduce an inter-facing-surface distance (L) between an end plate (3a) and an end plate (5a) facing each other, from an outer circumferential side toward an inner circumferential side are provided. A groove section formed in a tooth tip of each wall (3b, 5b) is provided with

a tip seal that comes into contact with a facing tooth bottom to seal fluid. Where an orbiting radius of the orbiting scroll 5 is denoted by ρ , and an inclination in a spiral direction of the inclined section is denoted by φ , a tip clearance change amount (ΔT) is obtained by $\Delta T = 2\rho \times \tan \varphi$, and the tip clearance change amount (ΔT) is 50% or less of a height dimension of the tip seal.

FIG. 1A



Description

[Technical Field]

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

[Background Art]

[0002] Generally, there is known a scroll fluid machine in which a fixed scroll member and an orbiting scroll member provided with respective spiral walls on respective end plates are engaged and revolved to compress or expand fluid.

[0003] As such a scroll fluid machine, a so-called stepped scroll compressor disclosed in PTL 1 is known. In this stepped scroll compressor, respective step sections are provided at positions along the spiral directions of tooth tip surfaces and tooth bottom surfaces of spiral walls of a fixed scroll and an orbiting scroll, and the height of the outer circumferential side of the wall is made higher than the height of the inner circumferential side of the wall with each step section as a boundary. The stepped scroll compressor performs compression not only in the circumferential direction of the walls, but also in the height direction (three-dimensional compression), and therefore it is possible to increase displacement and increase compressor capacity compared to a general scroll compressor with no step section (two-dimensional compression).

[Citation List]

[Patent Literature]

[0004] [PTL 1] Japanese Unexamined Patent Application, Publication No. 2015-55173

[Summary of Invention]

[Technical Problem]

[0005] However, the stepped scroll compressor has a problem that fluid leakage at the step sections is large. Further, there is a problem that stress is concentrated on root portions of the step sections, and strength is reduced.

[0006] To cope with the above, the inventors are considering providing continuous inclined sections in place of the step sections provided on the walls and the end plates.

[0007] However, even when the inclined sections are provided, it is not yet established what is a proper degree of inclination for each inclined section.

[0008] The present invention has been made in view of such a circumstance, and an object of the present invention is to provide a scroll fluid machine having inclined sections in a wall and an end plate capable of effectively

exhibiting performance.

[Solution to Problem]

[0009] In order to solve the aforementioned problems, a scroll fluid machine of the present invention employs the following solutions.

[0010] That is, a scroll fluid machine according to an aspect of the present invention is a scroll fluid machine including: a first scroll member provided with a spiral first wall on a first end plate; and a second scroll member that is provided with a spiral second wall on a second end plate disposed so as to face the first end plate, and that relatively revolves by engagement between the second wall and the first wall, wherein an inclined section that continuously reduces an inter-facing-surface distance between the first end plate and the second end plate facing each other, from an outer circumferential side toward an inner circumferential side of each of the first wall and the second wall is provided, each of the inclined sections is provided over a range of 180° or more around a spiral center, a groove section formed in a tooth tip of each of the first wall and the second wall corresponding to the inclined sections is provided with a tip seal that comes into contact with a facing tooth bottom to seal fluid, where an orbiting radius of the scroll member that orbits is denoted by ρ , and an inclination in a spiral direction of the inclined section is denoted by φ , a tip clearance change amount ΔT is defined by an expression as follows:

$$\Delta T = 2\rho \times \tan \varphi,$$

and

the tip clearance change amount ΔT is 50% or less of a height dimension of the tip seal in a height direction of the wall.

[0011] The inclined section that continuously reduces the inter-facing-surface distance between the first end plate and the second end plate from the outer circumferential side toward the inner circumferential side of each wall is provided, and therefore fluid sucked from the outer circumferential side is not only compressed by reduction of compression chambers in accordance with the spiral shape of the wall, but also further compressed by reduction of the inter-facing-surface distance between the end plates, toward the inner circumferential side.

[0012] The inclined sections are provided, and therefore the tip clearance between the tooth tip and the tooth bottom changes in accordance with orbiting movement. Where the orbiting radius of the scroll member that orbits is denoted by ρ , and the inclination in the spiral direction of the inclined section is denoted by φ , the tip clearance change amount ΔT in accordance with this orbiting movement is obtained by the expression as follows:

$$\Delta T = 2\rho \times \tan \varphi.$$

[0013] The tip seal advances and retreats in the height direction from the groove section by an amount in accordance with this tip clearance change amount ΔT . Therefore, when the tip clearance change amount ΔT is large, the tip seal may be detached from the groove section.

[0014] To cope with the above, the tip clearance change amount ΔT is made to be 50% or less of the height dimension of the tip seal, so that drop of the tip seal is prevented.

[0015] More preferably, the tip clearance change amount ΔT is made to be 20% or less of the height dimension of the tip seal.

[0016] A scroll fluid machine according to an aspect of the present invention is a scroll fluid machine including: a first scroll member provided with a spiral first wall on a first end plate; and a second scroll member that is provided with a spiral second wall on a second end plate disposed so as to face the first end plate, and that relatively revolves by engagement between the second wall and the first wall, wherein an inclined section that continuously reduces an inter-facing-surface distance between the first end plate and the second end plate facing each other, from an outer circumferential side toward an inner circumferential side of each of the first wall and the second wall is provided, each of the inclined sections is provided over a range of 180° or more around a spiral center, where an orbiting radius of the scroll member that orbits is denoted by ρ , and an inclination in a spiral direction of the inclined section is denoted by φ , a tip clearance change amount ΔT is defined by an expression as follows:

$$\Delta T = 2\rho \times \tan \varphi,$$

and

a value obtained by dividing the tip clearance change amount ΔT by a height of an outermost circumference of the wall is 0.01 or less.

[0017] The inclined section that continuously reduces the inter-facing-surface distance between the first end plate and the second end plate from the outer circumferential side toward the inner circumferential side of each wall is provided, and therefore fluid sucked from the outer circumferential side is not only compressed by reduction of compression chambers in accordance with the spiral shape of the wall, but also further compressed by reduction of the inter-facing-surface distance between the end plates, toward the inner circumferential side.

[0018] The inclined sections are provided, and therefore the tip clearance between the tooth tip and the tooth bottom changes in accordance with orbiting movement. Where the orbiting radius of the scroll member that orbits

is denoted by ρ , and the inclination in the spiral direction of the inclined section is denoted by φ , the tip clearance change amount ΔT in accordance with this orbiting movement is obtained by the expression as follows:

$$\Delta T = 2\rho \times \tan \varphi.$$

[0019] An oil film seal by lubricating oil is formed between the tooth tip and the tooth bottom. However, when the tip clearance change amount ΔT is increased, the oil film seal between the tooth tip and the tooth bottom may be broken, seal performance of a compression chamber may be deteriorated, and efficiency may be reduced.

[0020] As a result of keen examination by the present inventors, it is found that when the value obtained by dividing the tip clearance change amount ΔT by the height of the outermost circumference of the wall is 0.01 or less, the oil film seal is maintained, significant performance deterioration does not appear, and expected efficiency can be maintained.

[0021] A scroll fluid machine according to an aspect of the present invention is a scroll fluid machine including: a first scroll member provided with a spiral first wall on a first end plate; and a second scroll member that is provided with a spiral second wall on a second end plate disposed so as to face the first end plate, and that relatively revolves by engagement between the second wall and the first wall, wherein an inclined section that continuously reduces an inter-facing-surface distance between the first end plate and the second end plate facing each other, from an outer circumferential side toward an inner circumferential side of each of the first wall and the second wall is provided, each of the inclined sections is provided over a range of 180° or more around a spiral center, and a tip clearance between a tooth tip of the wall and a tooth bottom of the end plate is set larger than a tip clearance reduction amount based on a torsion angle around a center of the scroll member due to an assembly error.

[0022] The inclined section that continuously reduces the inter-facing-surface distance between the first end plate and the second end plate from the outer circumferential side toward the inner circumferential side of each wall is provided, and therefore fluid sucked from the outer circumferential side is not only compressed by reduction of compression chambers in accordance with the spiral shape of the wall, but also further compressed by reduction of the inter-facing-surface distance between the end plates, toward the inner circumferential side.

[0023] In the scroll fluid machine, when the first scroll member and the second scroll member are assembled, an assembly error inevitably occurs due to dimensional accuracy of an Oldham ring, or location accuracy of a centering pin or the like. When the assembly error occurs, the scroll member is twisted around the center, and the tip clearance between the tooth tip and the tooth bottom

of the inclined sections is reduced on the basis of the torsion angle.

[0024] To cope with the above, the tip clearance between the tooth tip and the tooth bottom is set larger than the tip clearance reduction amount based on the torsion angle around the center of the scroll member due to the assembly error, and interference between the tooth tip and the tooth bottom is avoided.

[Advantageous Effects of Invention]

[0025] The tip clearance change amount ΔT ($= 2\rho \times \tan \phi$) is made to be 50% or less of the height dimension of the tip seal, so that it is possible to prevent drop of the tip seal. Consequently, even when the wall and the end plate have the inclined sections, it is possible to exhibit performance.

[0026] The value obtained by dividing the tip clearance change amount ΔT ($= 2\rho \times \tan \phi$) by the height of the outermost circumference of the wall is 0.01 or less, so that the oil film seal is maintained, significant performance deterioration does not appear, and expected efficiency can be maintained.

[0027] The tip clearance between the tooth tip and the tooth bottom is set larger than the tip clearance reduction amount based on the torsion angle around the center of the scroll member due to an assembly error, so that it is possible to avoid interference between the tooth tip and the tooth bottom.

[Brief Description of Drawings]

[0028]

[Fig. 1A] Fig. 1A is a longitudinal sectional view illustrating a fixed scroll and an orbiting scroll of a scroll compressor according to one embodiment of the present invention.

[Fig. 1B] Fig. 1B is a plan view of the fixed scroll of Fig. 1A viewed from a wall side.

[Fig. 2] Fig. 2 is a perspective view illustrating the orbiting scroll of Fig. 1.

[Fig. 3] Fig. 3 is a plan view illustrating end plate flat sections provided in the fixed scroll.

[Fig. 4] Fig. 4 is a plan view illustrating a wall flat section provided in the fixed scroll.

[Fig. 5] Fig. 5 is a schematic diagram illustrating a wall represented so as to extend in the spiral direction.

[Fig. 6] Fig. 6 is a partially enlarged view illustrating an enlarged region of reference symbol Z in Fig. 1B.

[Fig. 7A] Fig. 7A is a side view illustrating a tip seal clearance of a portion illustrated in Fig. 6, and illustrating a state in which the tip seal clearance is relatively small.

[Fig. 7B] Fig. 7B is a side view illustrating the tip seal clearance of the portion illustrated in Fig. 6, and illustrating a state in which the tip seal clearance is

relatively large.

[Fig. 8] Fig. 8 is a graph illustrating an efficiency change rate to a tip clearance change amount, according to a second embodiment of the present invention.

[Fig. 9A] Fig. 9A is a partially enlarged sectional view illustrating a portion between a tooth tip and a tooth bottom, and illustrating a state in which an oil film seal is formed.

[Fig. 9B] Fig. 9B is a partially enlarged sectional view illustrating a portion between the tooth tip and the tooth bottom, and illustrating a state in which the oil film seal is destroyed.

[Fig. 10] Fig. 10 is a plan view illustrating a fixed scroll and an orbiting scroll according to a third embodiment of the present invention, viewed from a wall side of a fixed scroll.

[Fig. 11A] Fig. 11A is a longitudinal sectional view illustrating a modified example, and illustrating combination of scrolls having no step section.

[Fig. 11B] Fig. 11B is a longitudinal sectional view illustrating a modified example, and illustrating combination of stepped scrolls.

[Description of Embodiments]

[First Embodiment]

[0029] Hereinafter, a first embodiment according to the present invention will be described with reference to the drawings.

[0030] Fig. 1 illustrates a fixed scroll (first scroll member) 3 and an orbiting scroll (second scroll member) 5 of a scroll compressor (scroll fluid machine) 1. The scroll compressor 1 is used as a compressor that compresses a gas refrigerant (fluid) for performing refrigerating cycle of an air conditioner or the like, for example.

[0031] The fixed scroll 3 and the orbiting scroll 5 are a compression mechanism made of metal such as aluminum alloy and iron, and are housed in a housing (not illustrated). The fixed scroll 3 and the orbiting scroll 5 suck, from the outer circumferential side, fluid guided into the housing, and discharge the compressed fluid from a discharge port 3c at the center of the fixed scroll 3 to the outside.

[0032] The fixed scroll 3 is fixed to the housing, and includes a substantially disk-shaped end plate (first end plate) 3a, and a spiral wall (first wall) 3b erected on a side surface of the end plate 3a, as illustrated in Fig. 1A. The orbiting scroll 5 includes a substantially disk-shaped end plate (second end plate) 5a, and a spiral wall (second wall) 5b erected on a side surface of the end plate 5a. The respective spiral shapes of the walls 3b, 5b are each defined by using, for example, an involute curve or an Archimedes curve.

[0033] The center of the fixed scroll 3 and the center of the orbiting scroll 5 are separated by an orbiting radius p , are engaged such that the phases of the walls 3b, 5b

are shifted by 180°, and are assembled so as to have slight clearances (tip clearances) in the height direction between tooth tips and tooth bottoms of the walls 3b, 5b of both the scrolls at normal temperature. Consequently, a plurality of pairs of compression chambers formed so as to be surrounded by the end plates 3a, 5a and the walls 3b, 5b are formed between the scrolls 3, 5 so as to be symmetrical with respect to the scroll centers. The orbiting scroll 5 revolves around the fixed scroll 3 by a rotation prevention mechanism such as an Oldham ring (not illustrated).

[0034] As illustrated in Fig. 1A, inclined sections that continuously reduce an inter-facing-surface distance L between the facing end plates 3a, 5a from the outer circumferential sides toward the inner circumferential sides of the spiral walls 3b, 5b are provided.

[0035] As illustrated in Fig. 2, a wall inclined section 5b1 having a height that continuously reduces from the outer circumferential side toward inner circumferential side is provided in the wall 5b of the orbiting scroll 5. An end plate inclined section 3a1 (see Fig. 1A) that inclines in accordance with inclination of the wall inclined section 5b1 is provided in a tooth bottom surface of the fixed scroll 3 facing a tooth tip of this wall inclined section 5b1. The continuous inclined section is formed by these wall inclined section 5b1 and end plate inclined section 3a1. Similarly, a wall inclined section 3b1 having a height that continuously inclines from the outer circumferential side toward inner circumferential side is provided in the wall 3b of the fixed scroll 3, and an end plate inclined section 5a1 facing a tooth tip of this wall inclined section 3b1 is provided in the end plate 5a of the orbiting scroll 5.

[0036] The meaning of "continuously" in the inclined section mentioned in this embodiment is not limited to smoothly connected inclination, but includes inclination that is formed by stepwisely connecting small steps inevitably generated in machining, and that is an inclined section continuously inclined as a whole. However, the above meaning does not include a large step such as a so-called stepped scroll.

[0037] The wall inclined sections 3b1, 5b1 and/or the end plate inclined sections 3a1, 5a1 are coated. Examples of the coating include manganese phosphate treatment, and nickel-phosphorus plating.

[0038] As illustrated in Fig. 2, wall flat sections 5b2, 5b3 each having a constant height are provided on the innermost circumferential side and the outermost circumferential side of the wall 5b of the orbiting scroll 5, respectively. These wall flat sections 5b2, 5b3 are each provided over a region of 180° around the center O2 (see Fig. 1A) of the orbiting scroll 5. Wall inclined connecting sections 5b4, 5b5 serving as bent sections are provided at respective positions where the wall flat sections 5b2, 5b3 and the wall inclined section 5b1 are connected.

[0039] Similarly, end plate flat sections 5a2, 5a3 each having a constant height are provided on a tooth bottom of the end plate 5a of the orbiting scroll 5. These end plate flat sections 5a2, 5a3 are also each provided over

a region of 180° around the center of the orbiting scroll 5. End plate inclined connecting sections 5a4, 5a5 serving as bent sections are provided at respective positions where the end plate flat sections 5a2, 5a3 and the end plate inclined section 5a1 are connected.

[0040] As illustrated by hatching in Fig. 3 and Fig. 4, end plate flat sections 3a2, 3a3, wall flat sections 3b2, 3b3, end plate inclined connecting sections 3a4, 3a5, and wall inclined connecting sections 3b4, 3b5 are provided in the fixed scroll 3, like the orbiting scroll 5.

[0041] Fig. 5 illustrates the walls 3b, 5b represented so as to extend in the spiral direction. As illustrated in Fig. 5, the wall flat sections 3b2, 5b2 on the innermost circumferential sides are each provided so as to extend over a distance D2, and the wall flat sections 3b3, 5b3 on the outermost circumferential sides are each provided so as to extend over a distance D3. The distance D2 and the distance D3 are equivalent to the lengths of the regions of 180° (180° or more and 360° or less, preferably 210° or less) around the centers O1, O2 of the scrolls 3, 5. The wall inclined sections 3b1, 5b1 are provided between the wall flat sections 3b2, 5b2 on the innermost circumferential sides and the wall flat sections 3b3, 5b3 on the outermost circumferential sides so as to extend over a distance D1. Where each of height differences between the wall flat sections 3b2, 5b2 on the innermost circumferential sides and the wall flat sections 3b3, 5b3 on the outermost circumferential sides is denoted by h, the inclination ϕ of each of the wall inclined sections 3b1, 5b1 is expressed by the following expression.

$$\Phi = \tan^{-1} (h/D1) \quad \dots (1)$$

[0042] Thus, the inclination ϕ in the inclined section is constant with respect to the circumferential direction in which each of the spiral walls 3b, 5b extends. The distance D1 is longer than the distance D2, and is longer than the distance D3.

[0043] For example, in this embodiment, the specifications of the scrolls 3, 5 are as follows.

- (1) Orbiting radius ρ [mm]: 2 or more and 15 or less, preferably 3 or more and 10 or less
- (2) The number of turns of each of the walls 3b, 5b: 1.5 or more and 4.5 or less, preferably 2.0 or more and 3.5 or less
- (3) Height difference h [mm]: 2 or more and 20 or less, preferably 5 or more and 15 or less
- (4) h/Lout (wall height on outermost circumferential side): 0.05 or more and 0.35 or less, preferably 0.1 or more and 0.25 or less
- (5) Angular range of inclined section (angular range equivalent to distance D1) [°]: 180 or more and 1080 or less, preferably 360 or more and 720 or less
- (6) Angle Φ [°] of inclined section: 0.2 or more and 4 or less, preferably 0.5 or more and 2.5 or less

[0044] In Fig. 6, an enlarged view of a region indicated by reference symbol Z in Fig. 1B is illustrated. As illustrated in Fig. 6, a tip seal 7 is provided on the tooth tip of the wall 3b of the fixed scroll 3. The tip seal 7 is made of resin, and comes into contact with the tooth bottom of the end plate 5a of the facing orbiting scroll 5 to seal fluid. The tip seal 7 is housed in a tip seal groove 3d formed in the circumferential direction of the tooth tip of the wall 3b. Compressed fluid enters this tip seal groove 3d, and the tip seal 7 is pressed from a back surface, and pressed out to the tooth bottom side to be brought into contact with the facing tooth bottom. Similarly, a tip seal is provided on the tooth tip of the wall 5b of the orbiting scroll 5.

[0045] When both the scrolls 3, 5 relatively revolve, the respective positions of the tooth tip and the tooth bottom relatively shift by an orbiting diameter (orbiting radius $\rho \times 2$). In the inclined section, a tip clearance between the tooth tip and the tooth bottom changes due to this position shift between the tooth tip and the tooth bottom. A tip clearance change amount Δh [mm] is, for example, 0.05 or more and 1.0 or less, preferably 0.1 or more and 0.6 or less. For example, the tip clearance T is small in Fig. 7A, and the tip clearance T is large in Fig. 7B. Even when this tip clearance T changes due to the orbiting movement, the tip seal 7 is pressed to the tooth bottom side of the end plate 5a from the back surface by compressed fluid, and therefore can seal following this pressing.

[0046] As illustrated in Fig. 7, a tip clearance change amount ΔT in which the tip clearance T changes during a single orbit can be expressed by the following expression.

$$\Delta T = 2\rho \times \tan \varphi \quad \dots (2)$$

[0047] Herein, ρ denotes an orbiting radius.

[0048] The tip clearance change amount ΔT is 50% or less of the height dimension Hc of the tip seal in the height direction of each of the walls 3b, 5b.

[0049] The aforementioned scroll compressor 1 is operated as follows.

[0050] The orbiting scroll 5 revolves around the fixed scroll 3 by a driving source such as an electric motor (not illustrated). Consequently, fluid is sucked from the outer circumferential sides of the scrolls 3, 5, and is taken in the compression chambers surrounded by the walls 3b, 5b and the end plates 3a, 5a. The fluid in the compression chambers is sequentially compressed in accordance with movement from the outer circumferential side to the inner circumferential side, and the compressed fluid is finally discharged from the discharge port 3c formed in the fixed scroll 3. When the fluid is compressed, the fluid is compressed also in the height direction of the walls 3b, 5b in the inclined sections formed by the end plate inclined sections 3a1, 5a1 and the wall inclined sections 3b1, 5b1, and is three-dimensionally compressed.

[0051] According to this embodiment, the following

working effects are exhibited.

[0052] To cope with the above, the tip clearance change amount ΔT is made to be 50% or less of the height dimension Hc of the tip seal 7. Consequently, even when the tip seal 7 advances and retreats in the height direction from the tip seal groove 3d by an amount in accordance with the tip clearance change amount ΔT , it is possible to avoid detachment of the tip seal 7 from the tip seal groove 3d, and prevent drop of the tip seal 7.

[0053] The tip clearance change amount ΔT may be 20% or less of the height dimension Hc of the tip seal 7.

[Second Embodiment]

[0054] Now, a second embodiment of the present invention will be described.

[0055] This embodiment is different in a way of thinking about setting an upper limit of a tip clearance change amount ΔT , and other configurations are similar. Therefore, in the following description, only differences from the first embodiment will be described. Other configurations are similar, and therefore description thereof will be omitted.

[0056] In this embodiment, $\Delta T/L_{out}$ which is a value obtained by dividing a tip clearance change amount ΔT by the height of an outermost circumference of each of walls 3b, 5b (see reference symbol L_{out} of Fig. 2) is 0.01 or less. The reason will be described with reference to Fig. 8 and Fig. 9.

[0057] In Fig. 8, a horizontal axis indicates $\Delta T/L_{out}$, and a vertical axis indicates an efficiency change rate. The efficiency change rate indicates a rate of efficiency at predetermined $\Delta T/L_{out}$ in a case where the tip clearance change amount ΔT is zero, that is, in a case where efficiency in a case of no inclination in a wall height, a so-called two-dimensional scroll is 1. As illustrated in Fig. 8, when $\Delta T/L_{out}$ is 0.01, reduction of the efficiency change rate is less than 1%. Therefore, when $\Delta T/L_{out}$ is 0.01 or less, the reduction of the efficiency change rate can be limited to be less than 1%.

[0058] As illustrated in Fig. 9A, it is considered that in a range where $\Delta T/L_{out}$ is 0.01 or less, each tip clearance T is made to be a predetermined value or less, so that oil film seals OS by lubricating oil are formed between tooth tips of the walls 3b, 5b and tooth bottoms of facing end plates 5a, 3a. Thus, since the oil film seal OS in each tip clearance T is secured, fluid leakage in compression chambers is reduced, and reduction of the efficiency change rate becomes small.

[0059] On the other hand, when $\Delta T/L_{out}$ becomes larger than 0.01, the tip clearance T increased, and as illustrated in Fig. 9B, an oil film in each tip clearance T is separated, and the oil film seal OS (see Fig. 9A) disappears, and fluid leakage in the compression chambers occurs. Consequently, the efficiency change rate is significantly reduced.

[0060] As described above, according to this embodiment, $\Delta T/L_{out}$ is made to be 0.01 or less, so that the oil

film seal OS in each tip clearance T is maintained. Consequently, it is possible to maintain expected efficiency.

[Third Embodiment]

[0061] Now, a third embodiment of the present invention will be described.

[0062] In this embodiment, setting of a lower limit of a tip clearance T will be described. Other configurations are similar to those of each of the aforementioned embodiments. Therefore, in the following description, only differences from each of the aforementioned embodiments will be described. Other configurations are similar, and therefore description thereof will be omitted. This embodiment can be used by combination with the first embodiment or the second embodiment.

[0063] In this embodiment, as to setting of tip clearances T between tooth tips of walls 3b, 5b and tooth bottoms of end plates 5a, 3a, a torsion angle $\delta\theta$ around the center of each of scrolls 3, 5 due to an assembly error is considered. As illustrated in Fig. 10, when the scrolls 3, 5 are assembled to be operated, an assembly error inevitably occurs due to dimensional accuracy of an Oldham ring, or location accuracy of a centering pin or the like, and the torsion angle $\delta\theta$ is generated due to backlash generated around the centers of the scrolls 3, 5. Fig. 10 is a diagram similar to Fig. 1B. Gas pressure inside compression chambers is added during operation, and therefore the tooth tips of the inclined sections of the walls 3b, 5b, and the tooth bottoms of the end plates 5a, 3a approach each other due to the backlash around the centers of the scrolls 3, 5, so that the tip clearances T reduce. Each of these tip clearance reduction amounts δT is expressed by the following expression.

$$\delta T = r \times \delta\theta \times \tan \varphi \quad \dots (3)$$

[0064] Herein, r denotes a radius on an outer circumferential side where an inclined section starts, that is, a radius at each of wall inclined connecting sections 3b5, 5b5 (see Figs. 2 and 5) on the outer circumferential sides of the walls 3b, 5b. φ denotes an inclination of the inclined section (see Fig. 5). The torsion angle $\delta\theta$ can be obtained by measurement of an actual object. The dimensions of portions that cause torsion of the scrolls such as the dimensional accuracy of the Oldham ring and the location accuracy of the centering pin are individually measured, and the torsion angle $\delta\theta$ can be also obtained by calculation from these dimension.

[0065] In this embodiment, when the scrolls 3, 5 are assembled, each tip clearance T is made larger than the tip clearance reduction amount δT obtained from the aforementioned expression (3) obtained by considering the radius on the outer circumferential side where the inclined section starts, the tip clearance reduction amount, and the inclination φ of the inclined section. Con-

sequently, it is possible to avoid interference between the tooth tips and the tooth bottoms.

[0066] The end plate inclined sections 3a1, 5a1 and the wall inclined sections 3b1, 5b1 are provided in both the scrolls 3, 5 in each of the aforementioned embodiments, but may be provided in either one.

[0067] Specifically, as illustrated in Fig. 11A, in a case where a wall inclined section 5b1 is provided in a first wall (for example, an orbiting scroll 5), and an end plate inclined section 3a1 is provided in a second end plate 3a, a second wall and a first end plate 5a may be flat.

[0068] As illustrated in Fig. 11B, a shape formed by combination with a conventional stepped shape, that is, a shape, in which while an end plate inclined section 3a1 is provided in an end plate 3a of a fixed scroll 3, a step section is provided in an end plate 5a of an orbiting scroll 5, may be combined.

[0069] In each of the aforementioned embodiment, the wall flat sections 3b2, 3b3, 5b2, 5b3 and the end plate flat sections 3a2, 3a3, 5a2, 5a3 are provided. However, the flat sections on the inner circumferential sides and/or the outer circumferential sides may be omitted, and the inclined sections may be provided so as to extend over the entire walls 3b, 5b.

[0070] The present invention is applied to a scroll compressor in each of the aforementioned embodiments, but can be also applied to a scroll expander used as an expander.

[Reference Signs List]

[0071]

- 1 scroll compressor (scroll fluid machine)
- 3 fixed scroll (first scroll member)
- 3a end plate (first end plate)
- 3a1 end plate inclined section
- 3a2 end plate flat section (inner circumferential side)
- 3a3 end plate flat section (outer circumferential side)
- 3a4 end plate inclined connecting section (inner circumferential side)
- 3a5 end plate inclined connecting section (outer circumferential side)
- 3b wall (first wall)
- 3b1 wall inclined section
- 3b2 wall flat section (inner circumferential side)
- 3b3 wall flat section (outer circumferential side)
- 3b4 wall inclined connecting section (inner circumferential side)
- 3b5 wall inclined connecting section (outer circumferential side)
- 3c discharge port
- 3d tip seal groove
- 5 orbiting scroll (second scroll member)
- 5a end plate (second end plate)
- 5a1 end plate inclined section
- 5a2 end plate flat section (inner circumferential side)
- 5a3 end plate flat section (outer circumferential side)

5a4 end plate inclined connecting section (inner circumferential side)
 5a5 end plate inclined connecting section (outer circumferential side)
 5b wall (second wall)
 5b1 wall inclined section
 5b2 wall flat section (inner circumferential side)
 5b3 wall flat section (outer circumferential side)
 5b4 wall inclined connecting section (inner circumferential side)
 5b5 wall inclined connecting section (outer circumferential side)
 7 tip seal
 Hc height dimension of tip seal
 L inter-facing-surface distance
 OS oil film seal
 T tip clearance
 ΔT tip clearance change amount
 δT tip clearance reduction amount
 φ inclination
 θ torsion angle

Claims

1. A scroll fluid machine comprising:

a first scroll member provided with a spiral first wall on a first end plate; and
 a second scroll member that is provided with a spiral second wall on a second end plate disposed so as to face the first end plate, and that relatively revolves by engagement between the second wall and the first wall, wherein
 an inclined section that continuously reduces an inter-facing-surface distance between the first end plate and the second end plate facing each other, from an outer circumferential side toward an inner circumferential side of each of the first wall and the second wall is provided,
 each of the inclined sections is provided over a range of 180° or more around a spiral center,
 a groove section formed in a tooth tip of each of the first wall and the second wall corresponding to the inclined sections is provided with a tip seal that comes into contact with a facing tooth bottom to seal fluid,
 where an orbiting radius of the scroll member that orbits is denoted by ρ , and an inclination in a spiral direction of the inclined section is denoted by φ , a tip clearance change amount ΔT is defined by an expression as follows:

$$\Delta T = 2\rho \times \tan \varphi,$$

and

the tip clearance change amount ΔT is 50% or less of a height dimension of the tip seal in a height direction of the wall.

2. A scroll fluid machine comprising:

a first scroll member provided with a spiral first wall on a first end plate; and
 a second scroll member that is provided with a spiral second wall on a second end plate disposed so as to face the first end plate, and that relatively revolves by engagement between the second wall and the first wall, wherein
 an inclined section that continuously reduces an inter-facing-surface distance between the first end plate and the second end plate facing each other, from an outer circumferential side toward an inner circumferential side of each of the first wall and the second wall is provided,
 each of the inclined sections is provided over a range of 180° or more around a spiral center, where an orbiting radius of the scroll member that orbits is denoted by ρ , and an inclination in a spiral direction of the inclined section is denoted by φ , a tip clearance change amount ΔT is defined by an expression as follows:

$$\Delta T = 2\rho \times \tan \varphi,$$

and

a value obtained by dividing the tip clearance change amount ΔT by a height of an outermost circumference of the wall is 0.01 or less.

3. A scroll fluid machine comprising:

a first scroll member provided with a spiral first wall on a first end plate; and
 a second scroll member that is provided with a spiral second wall on a second end plate disposed so as to face the first end plate, and that relatively revolves by engagement between the second wall and the first wall, wherein
 an inclined section that continuously reduces an inter-facing-surface distance between the first end plate and the second end plate facing each other, from an outer circumferential side toward an inner circumferential side of each of the first wall and the second wall is provided,
 each of the inclined sections is provided over a range of 180° or more around a spiral center, and
 a tip clearance between a tooth tip of the wall and a tooth bottom of the end plate is set larger than a tip clearance reduction amount based on a torsion angle around a center of the scroll

member due to an assembly error.

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FIG. 1A

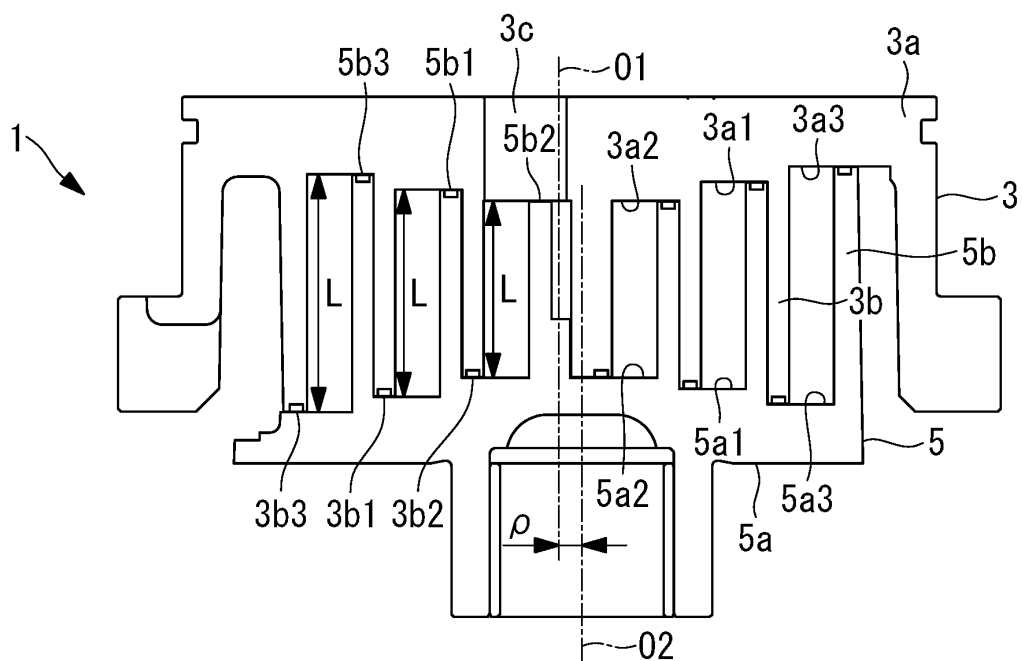


FIG. 1B

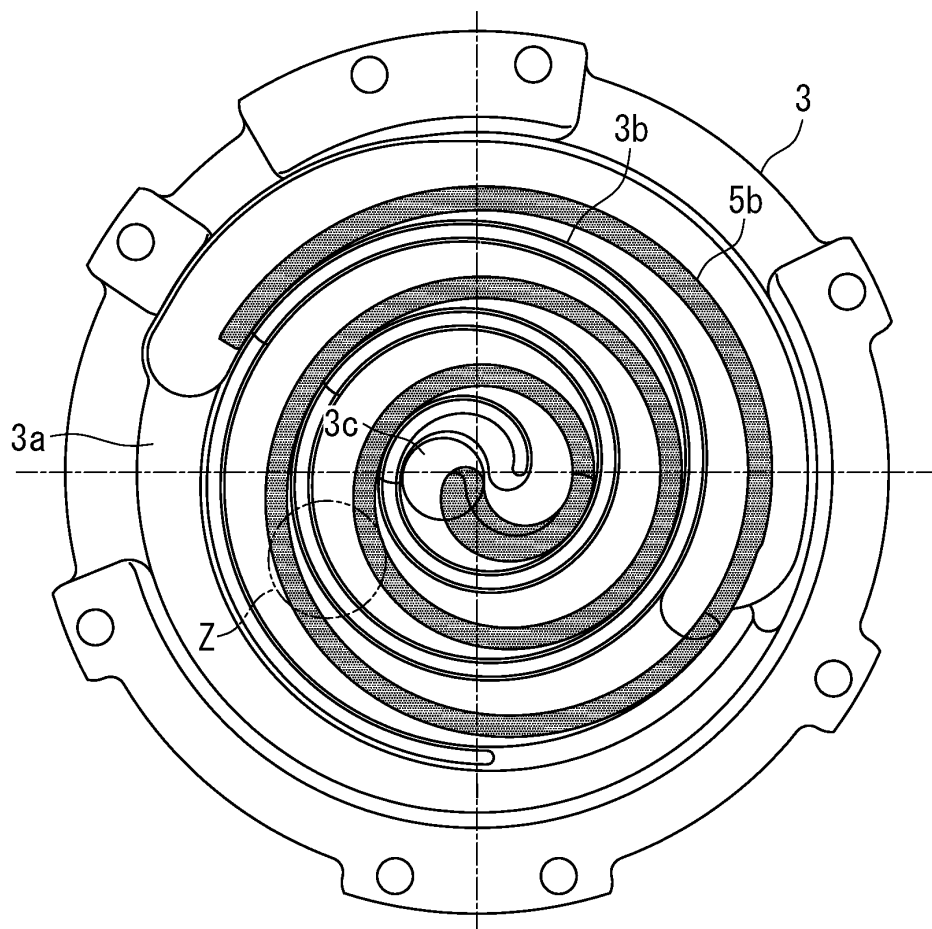


FIG. 2

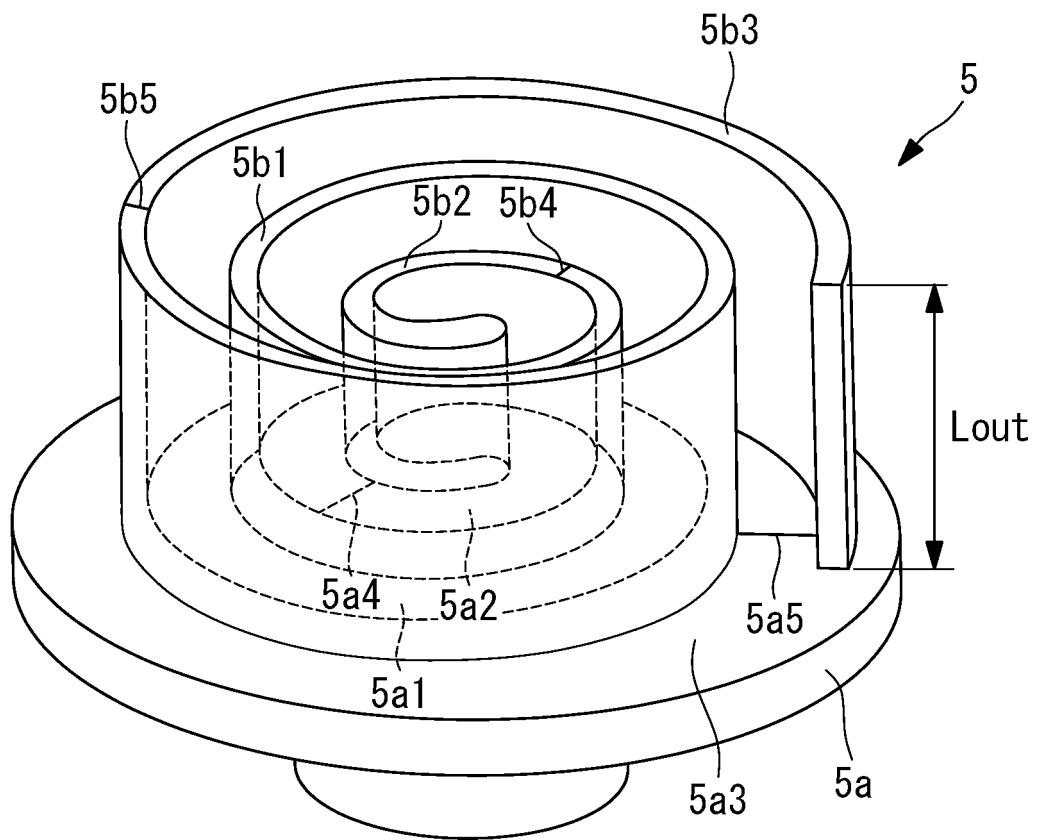


FIG. 3

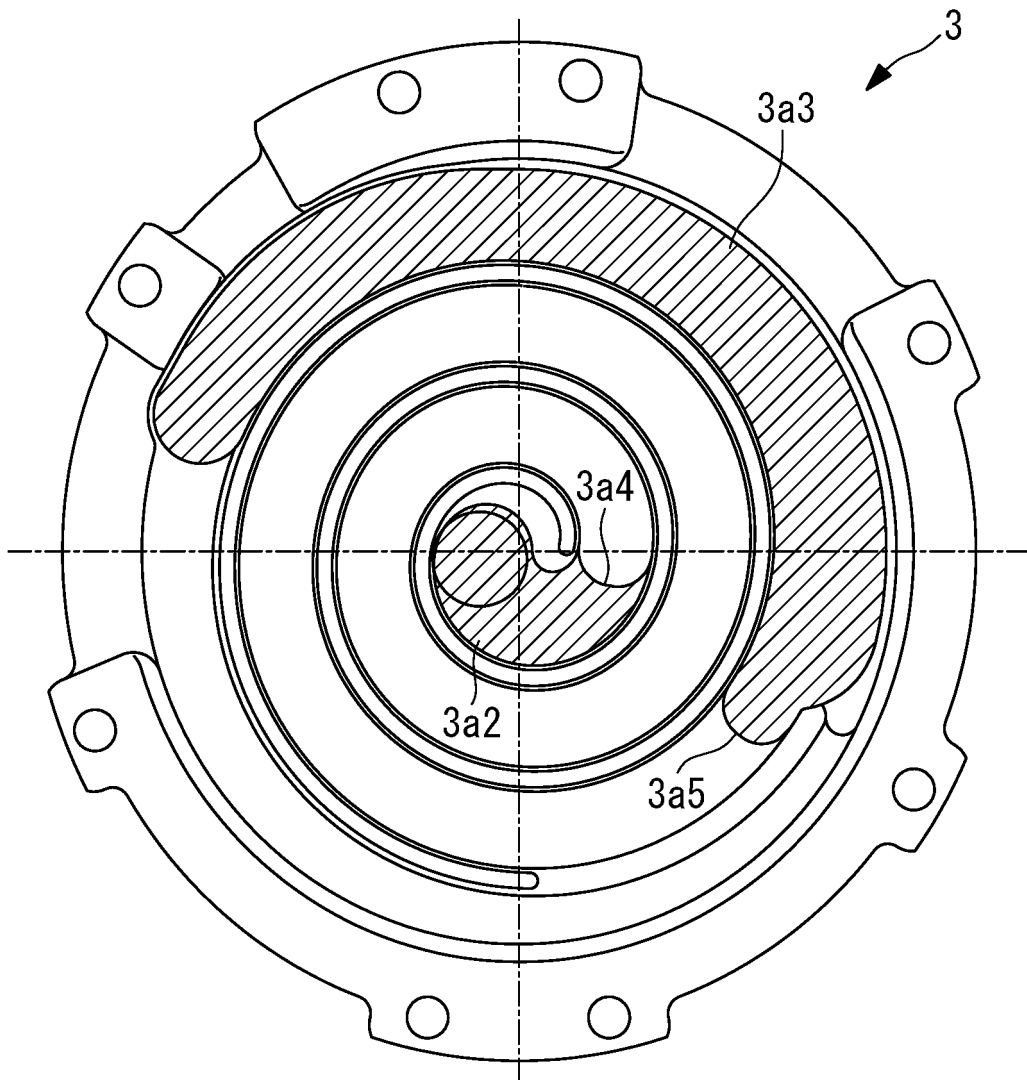


FIG. 4

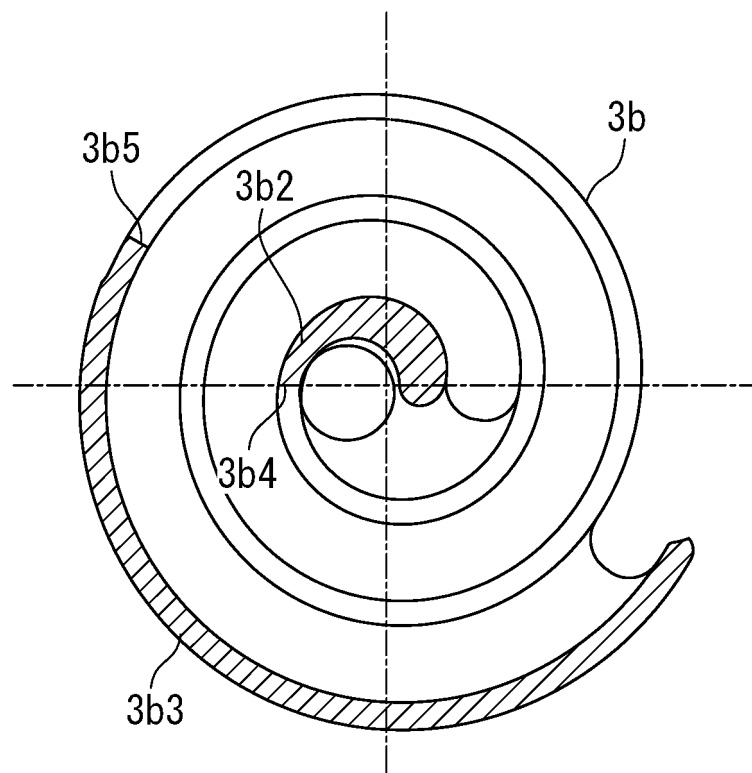


FIG. 5

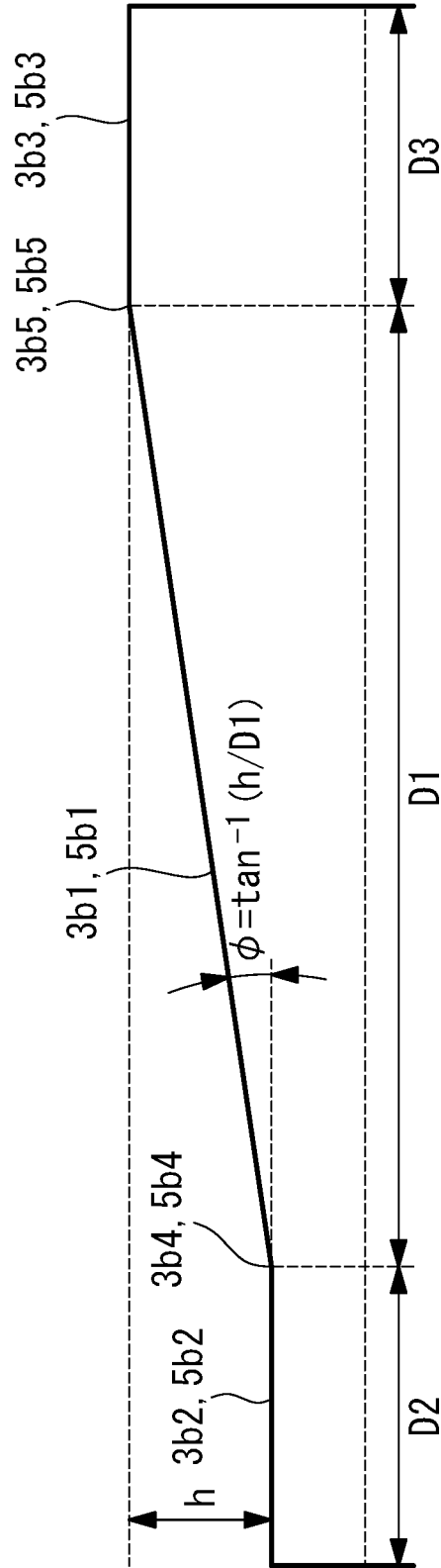


FIG. 6

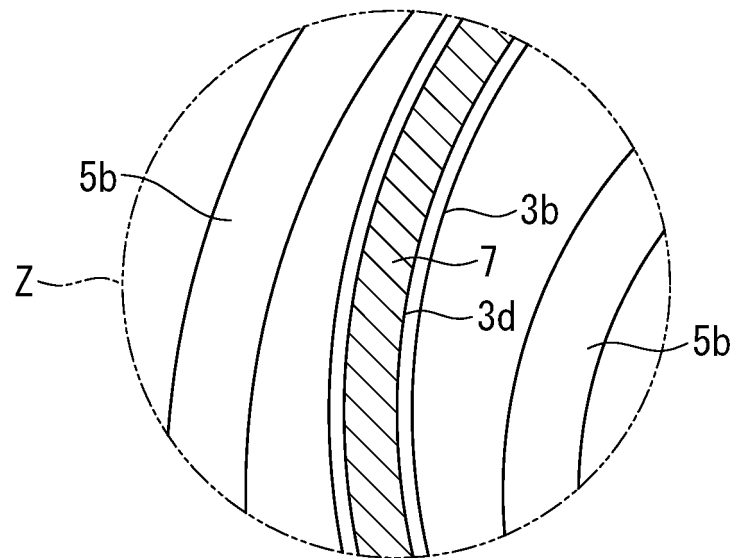


FIG. 7A

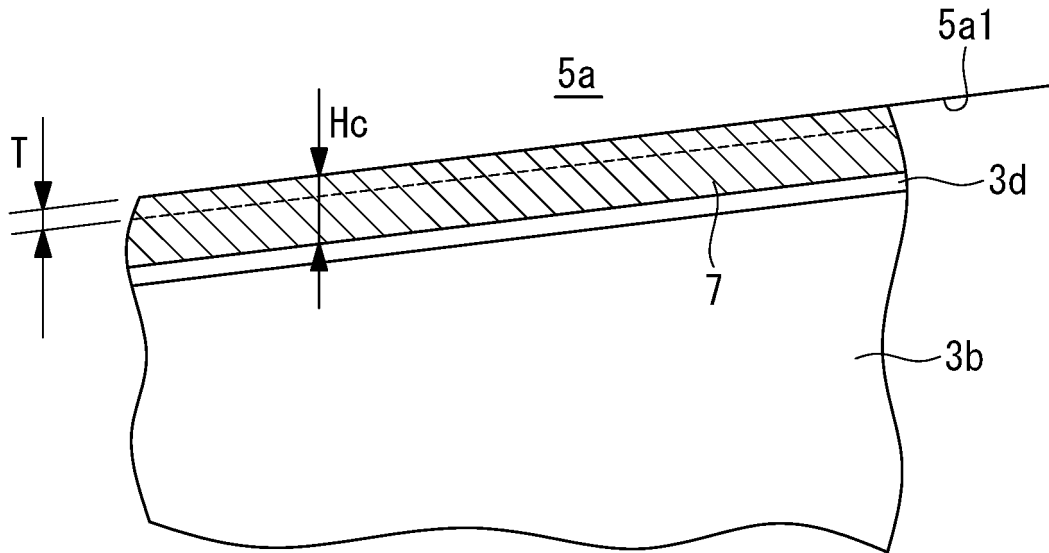


FIG. 7B

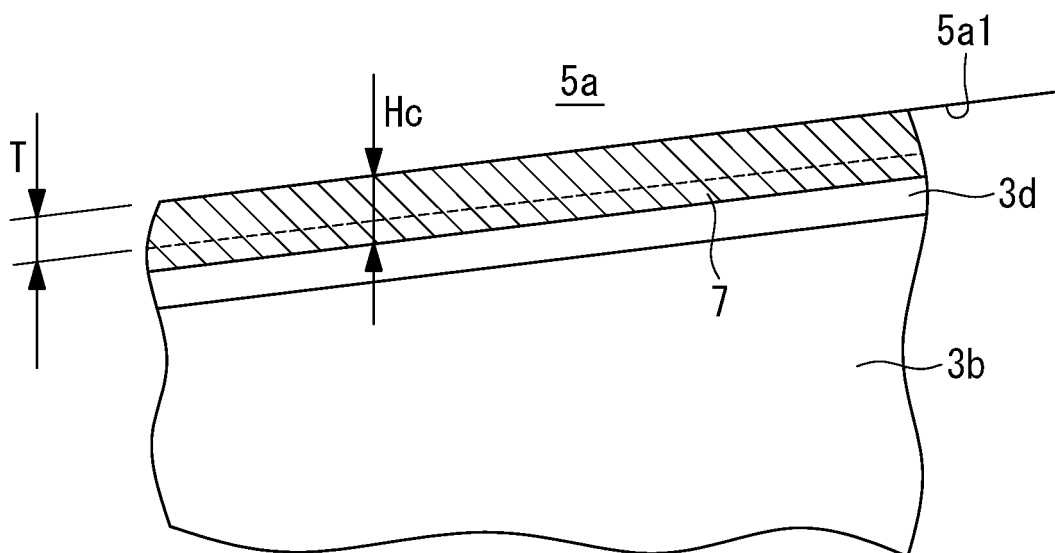


FIG. 8

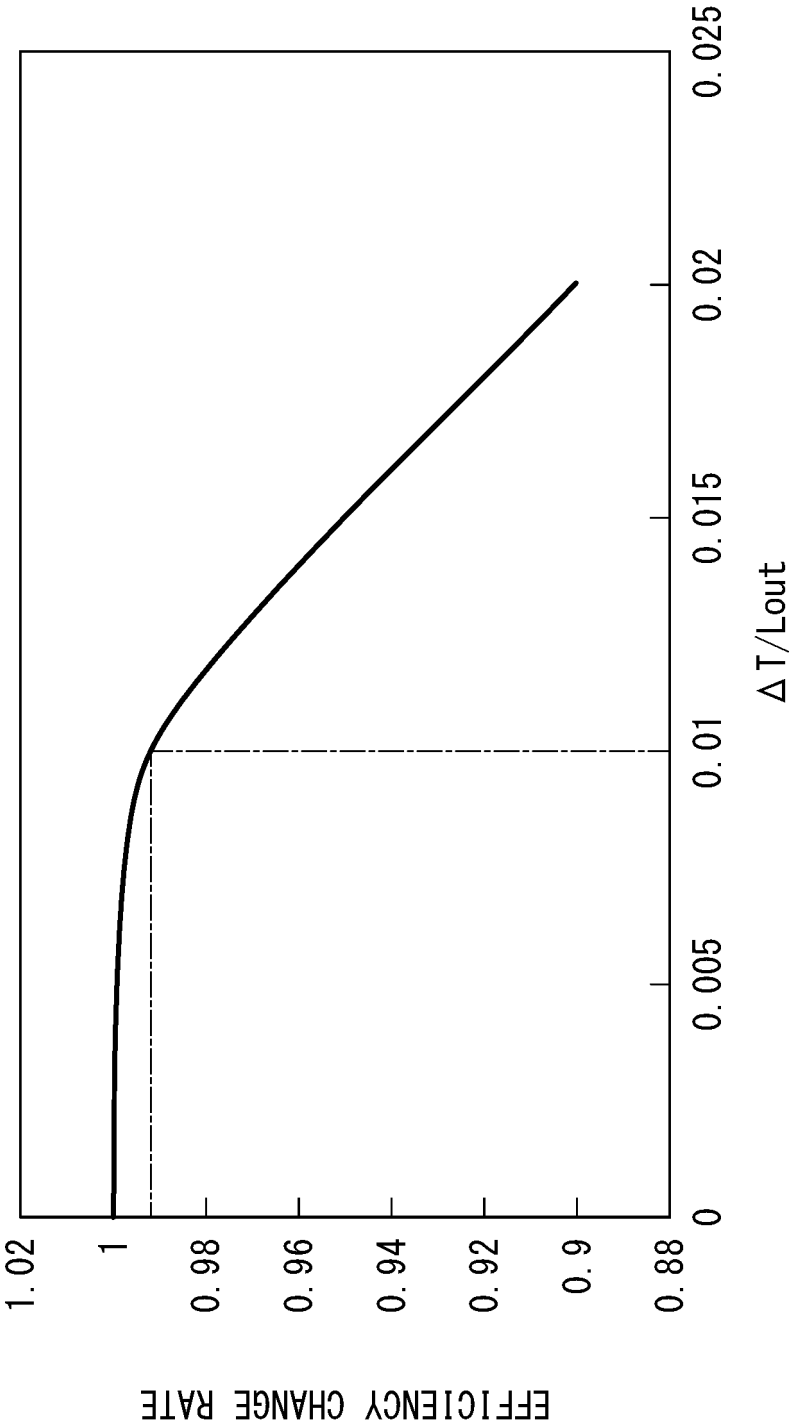


FIG. 9A

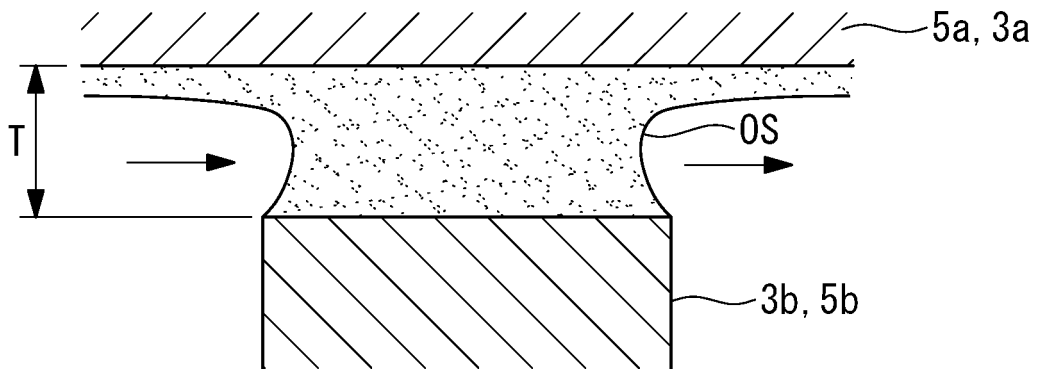


FIG. 9B

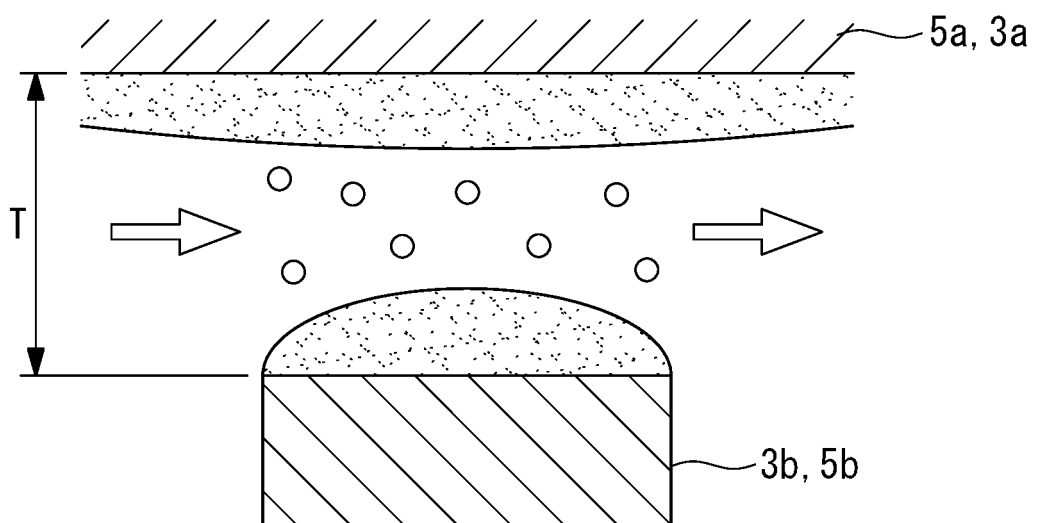


FIG. 10

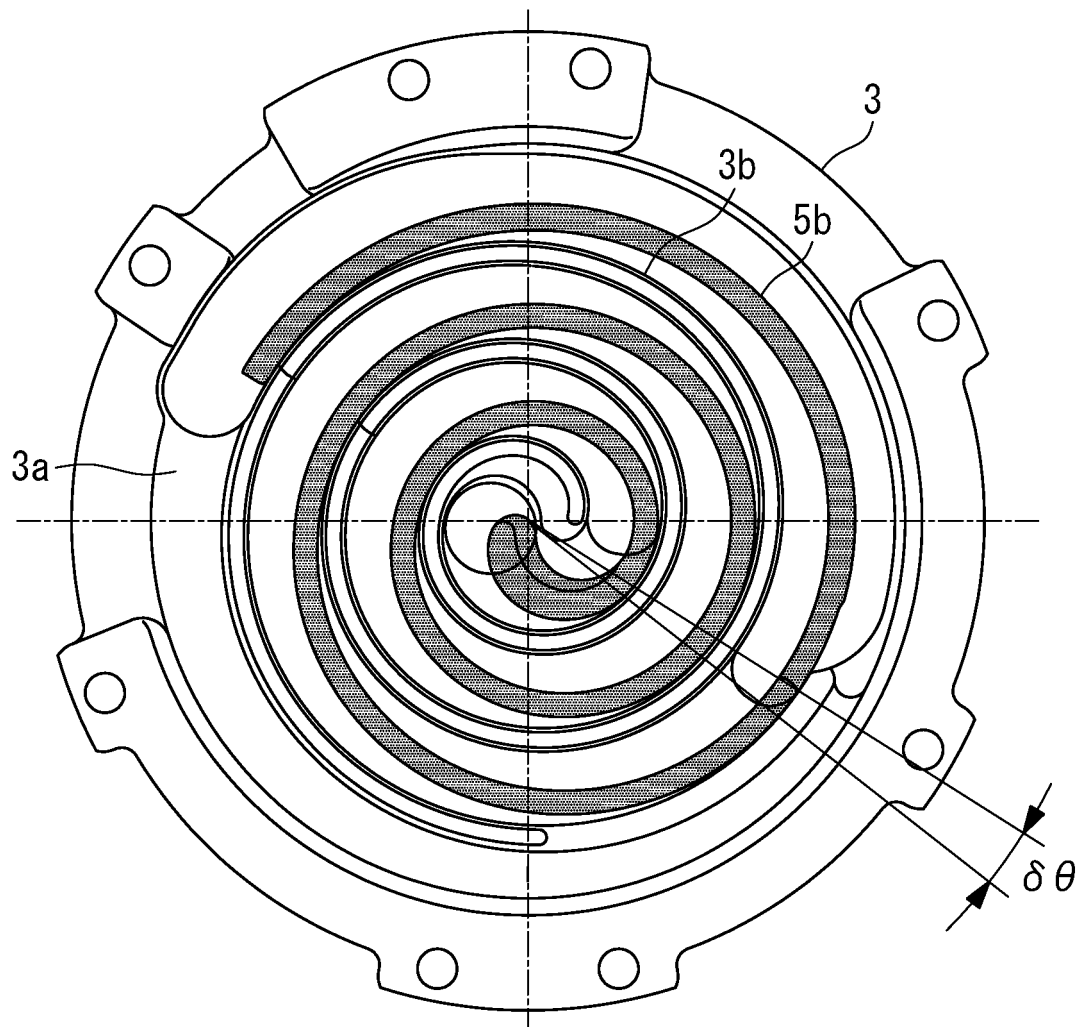


FIG. 11A

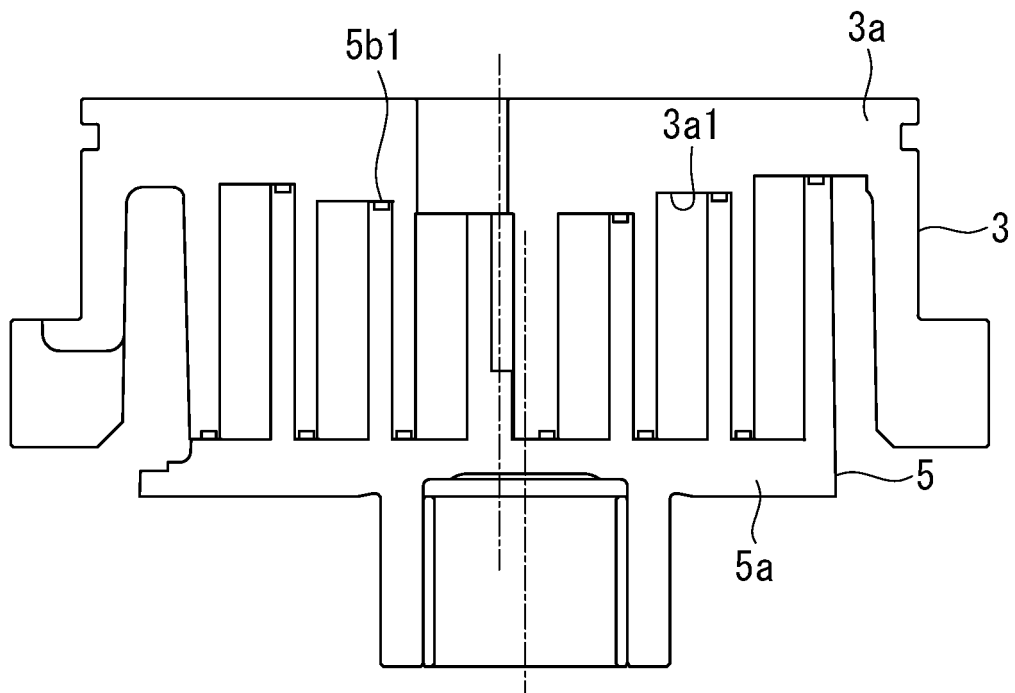
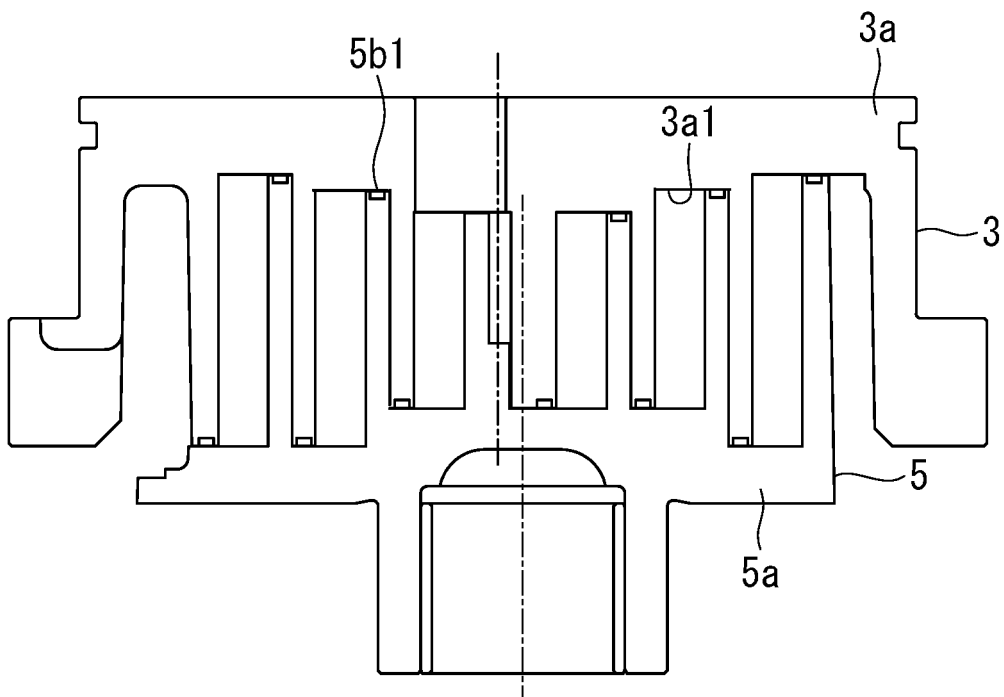


FIG. 11B



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/000738

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F04C18/02(2006.01)i, F01C1/02(2006.01)i, F01C19/08(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, F01C1/02, F01C19/08

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.
X	CN 204003446 U (HENGSHENG PRECISE SCIENCE CO., LTD.) 10 December 2014, paragraph [0039], fig. 7-9 (Family: none)	1-3
P, X	JP 2018-028303 A (MITSUBISHI HEAVY INDUSTRIES THERMAL SYSTEMS LTD.) 22 February 2018, paragraphs [0023], [0026], [0031], [0032], [0036], [0041], fig. 1-11 & WO 2018/034255 A1	1-3

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

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"&" document member of the same patent family

Date of the actual completion of the international search
01.03.2019Date of mailing of the international search report
19.03.2019Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/000738

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 2010-196663 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 09 September 2010, paragraphs [0032], [0038] (Family: none)	1-3
A	JP 2009-228476 A (DAIKIN INDUSTRIES, LTD.) 08 October 2009, paragraph [0064] (Family: none)	1-3

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2015055173 A [0004]