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(54) **SCROLL COMPRESSOR**

(57) To stably hold a tip seal without requiring a difficult processing when providing the tip seal also on a step part of a wrap of a 3D-type scroll compressor. In a scroll compressor 1, a tip seal 40, which is interposed between a wrap 21 and an end plate 300 of the mating scroll, is configured of an outer peripheral tip seal 41 provided on the outer peripheral side of a step part 21C, a step tip seal 42 provided on the step part 21C, and an inner peripheral tip seal 43 provided on the inner peripheral side of the step part 21C. The step tip seal 42 is provided continuously on a leading end part T of an outer peripheral-side wrap 21B, a side surface part S of the step part 21C opposite to a stepped wall 30C, and a leading end part T of an inner peripheral-side wrap 21A. A border Bd between the step tip seal 42 and the inner peripheral tip seal 43 always lies on the outside of a circular path R which the step part 21C traces as the scroll orbits.

FIG. 4A

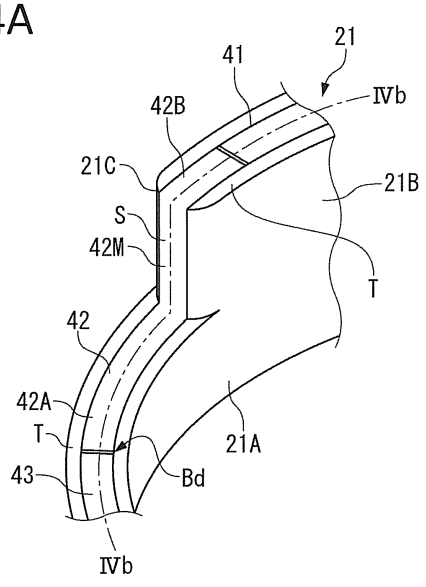

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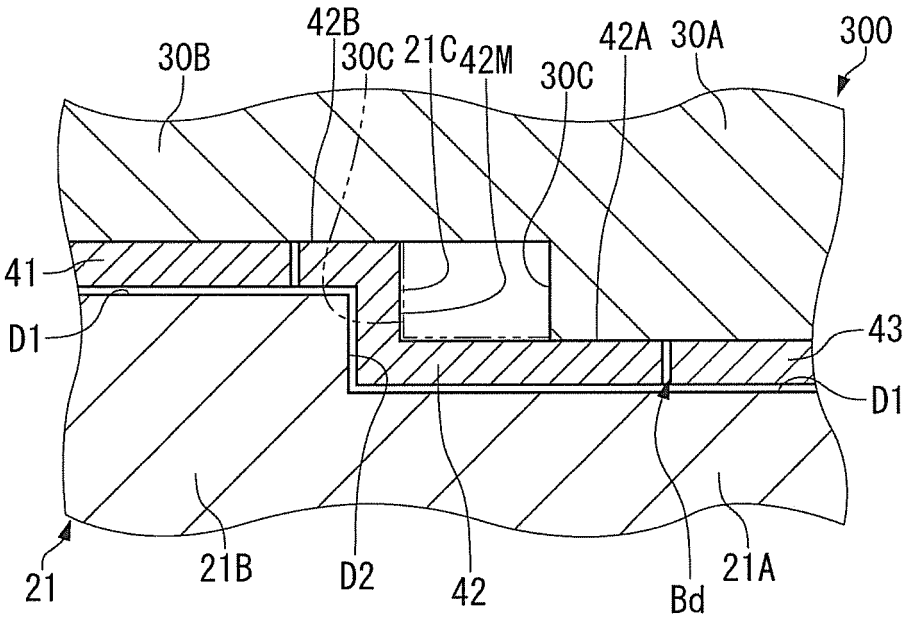
FIG. 4B



Description

Technical Field

[0001] The present invention relates to a scroll compressor.

Background Art

[0002] A scroll compressor includes a fixed scroll and an orbiting scroll. The fixed scroll and the orbiting scroll are both a spiral wrap provided upright on one surface side of a disc-shaped end plate. Such fixed scroll and orbiting scroll are opposed to each other with their wraps meshed, and the orbiting scroll is put in orbital motion relative to the fixed scroll. Then, the volume of a compression chamber formed between these scrolls is reduced as the orbiting scroll orbits to thereby compress a working fluid (refrigerant).

[0003] There is a type of such scroll compressors in which, in order to obtain a high compression ratio by compressing not only in the circumferential direction but also in the height direction, the lap height is lowered on the inner peripheral side compared with on the outer peripheral side and a portion on the inner peripheral side of the end plate of the mating scroll is correspondingly formed so as to protrude further toward the inner surface side than the outer peripheral side.

[0004] In this type of scroll compressor called 3D scroll (R), a step part is formed in each of the wrap and the end plate. When the orbiting scroll is orbited, the step part of the wrap traces a circular path, cyclically coming into and out of contact with a stepped wall of the end plate which is formed in an arc-like shape.

[0005] In general, both the fixed scroll and the orbiting scroll are provided with a tip seal (seal member) on the leading end part of the spiral shape of the wrap. The tip seal is inserted into a seal grove formed in the wrap, and under a back pressure due to a high-pressure refrigerant introduced into the seal groove, the tip seal lifts and comes into close contact with the opposite end plate. The clearance between the wrap and the end plate is sealed by this tip seal.

[0006] In a 3D-type scroll compressor, it is desirable to provide a tip seal also on the step parts of the wrap and the end plate to thereby prevent refrigerant leak from the step parts.

[0007] In Patent Literature 1, therefore, a step tip seal is provided on the step of the wrap in addition to an outer peripheral tip seal provided on an outer peripheral-side wrap and an inner peripheral tip seal provided on an inner peripheral-side wrap. The step tip seal is formed in an L-shape so as to be bent from the step part-side end part of the outer peripheral-side wrap toward the leading end surface of the inner peripheral-side wrap, and the inner peripheral tip seal is provided down to the root of the wrap step part so as to butt against this step tip seal.

[0008] Here, since the step tip seal may fall out of the seal groove while the step part of the wrap is out of contact with the stepped wall of the end plate, the end part of the step tip seal is loosely fitted in a recessed part formed in the root of the wrap step part. In addition, Patent Literature 1 also shows that a joint part having a shape which can mutually retain the step tip seal and the outer peripheral tip seal is formed in these tip seals in order to prevent the step tip seal from falling out of the seal groove.

[0009] Patent Literature 1 also shows that combining the end part of the step tip seal and the end part of the inner peripheral tip seal into a hook shape can not only hold the step tip seal but also prevent lifting of the inner peripheral tip seal.

Citation List

Patent Literature

[0010] Patent Literature 1: Japanese Patent Laid-Open No. 2002-303281

Summary of Invention

Technical Problem

[0011] The following problems attributable to the step part exist in providing a tip seal on the wrap of a 3D-type scroll compressor.

[0012] If, as in Patent Literature 1, a recessed part, into which the end part of the step tip seal is loosely fitted, is formed in the root of the step part so as to continue to the seal groove, or if a joint part is formed in the step tip seal and the outer peripheral tip seal, as the means for holding the step tip seal inside the seal groove, the tip seal and the scroll becomes difficult to process due to the complicated shapes of the seal groove and the tip seal.

[0013] Moreover, since these holding means are provided close to the step part of the wrap which repeatedly comes into and out of contact with the stepped wall of the end plate, the holding is likely to become unstable due to the repetitive load. Long-term use may result in degradation of airtightness between the fixed scroll and the orbiting scroll.

[0014] Furthermore, although the step part side of the inner peripheral tip seal is pressed by the end plate while the step part of the wrap is in contact with the stepped wall of the end plate, the step part side lifts when the pressing by the end plate is lost as the step part of the wrap comes out of contact with the end plate inner wall. As a result, the inner peripheral tip seal may be damaged by being caught between the end plate and the wrap when the wrap returns toward the stepped wall of the end plate. In order to prevent this, the root of the wrap step part is usually avoided when providing the inner peripheral tip seal. While Patent Literature 1 also shows that the step tip seal and the inner peripheral tip seal are combined into a hook shape to thereby hold the inner periph-

eral tip seal so as not to lift, as described above, the holding is likely to become unstable if the tip seal holding means is provided close to the step part of the wrap, which may result in damage or degradation of airtightness.

[0015] The object of the present invention is to stably hold a tip seal without requiring a difficult processing when providing the tip seal also on a step part of a wrap of a 3D-type scroll compressor.

Solution to Problem

[0016] A scroll compressor of the present invention includes a pair of scrolls, of which one is put in orbital motion relative to the other, the pair of scrolls each having: a spiral wrap which is provided upright toward the mating scroll and decreases in height from the outer peripheral side toward the inner peripheral side through a step part; and an end plate in which a stepped wall rising to follow the shape of the step part of the wrap of the mating scroll is formed.

[0017] A tip seal, which seals the clearance between the wrap and the end plate of the mating scroll, is inserted into a seal groove formed in the wrap.

[0018] The tip seal is configured of an outer peripheral tip seal provided on the outer peripheral side of the step part; a step tip seal provided on the step part; and an inner peripheral tip seal provided on the inner peripheral side of the step part.

[0019] In the present invention, the step tip seal is provided continuously on a leading end part of the outer peripheral-side wrap, a side surface part of the step part opposite to the stepped wall, and a leading end part of the inner peripheral-side wrap, and the border between the step tip seal and the inner peripheral tip seal always lies on the outside of a circular path which the step part traces as the scroll orbits.

[0020] According to the present invention, the step tip seal is provided continuously from the outer peripheral-side wrap to the inner peripheral-side wrap, and the entire step tip seal is surrounded between the wrap and the end plate of the mating scroll. Moreover, since the border between the step tip seal and the inner peripheral tip seal always lies on the outside of the circular path which the step part traces as the scroll orbits, the state in which the end parts of the step tip seal are both pressed by the end plate can be maintained throughout the course of the step part coming into and out of contact with the stepped wall.

[0021] Thus, it is possible to stably hold the step tip seal by reliably preventing it from disengaging or falling, as well as to prevent damage due to lifting of the tip seal. That is, even when the step part comes out of contact with the stepped wall, the inner peripheral tip seal does not enter the inside of the stepped wall and the step tip seal is always kept pressed by the end plate, so that it is possible to suppress further lifting of the inner peripheral-side end part of the step tip seal which has already lifted to the end plate surface due to the back pressure. Thus, damage of the tip seal caused by interference with the edge of the stepped wall can be avoided.

[0022] Moreover, it is possible to easily manufacture the long outer peripheral tip seal and inner peripheral tip seal without forming a bent part in them by, as in the present invention, providing the step tip seal around the step part which is separate from the tip seals preceding and succeeding it. Since the step tip seal is a shorter member than the outer peripheral tip seal and the inner peripheral tip seal, it is easy to manufacture even if it has a bent shape.

[0023] In the present invention, the configuration in which the end parts of the step tip seal extend for a predetermined length along the leading end part of each of the outer peripheral-side wrap and the inner peripheral-side wrap is adopted as means for holding the step tip seal. According to this configuration, since it is not necessary to perform a difficult processing on the tip seal or the seal groove for holding the tip seal, and since the step tip seal is stably held by the end plate at both ends, the holding does not become unstable even under a repeated load applied to the step tip seal but the tip seal can be held stably for a long period.

[0024] In the scroll compressor of the present invention, it is preferable that lapped parts, which are reduced in thickness and lapped over each other in the thickness direction, are formed in both adjacent end parts of the outer peripheral tip seal, the step tip seal, and the inner peripheral tip seal, and that one of the lapped parts, which lies on the inner peripheral side, lies between the other one which lies on the outer peripheral side and the bottom part of the seal groove.

[0025] Thus, when the pressure of the refrigerant inside the seal groove acts on the tip seal lying on the inner peripheral side, the tip seal lying on the outer peripheral side is pushed up by the lapped part of the tip seal. Since a pressure transmission path is thereby secured on the back surface side of the tip seal, the high pressure of the compressed refrigerant on the inner peripheral side is smoothly introduced to the back surface of each tip seal from the inner peripheral side toward the outer peripheral side. As this allows the tip seals to reliably lift, high airtightness can be obtained.

[0026] In the scroll compressor of the present invention, it is preferable that at least one of the corner part of the wrap opposite to the inside of the corner part of the step tip seal and the corner part of the end plate opposite to the inside of the other corner part of the step tip seal is chamfered, and the inside of the corner part of the step tip seal is increased in thickness along the chamfered portion.

[0027] Thus, it is possible to enhance the strength of the corner part of the step tip seal at which stress is likely to concentrate.

[0028] In the scroll compressor of the present invention, it is preferable that the step tip seal and the area of the seal groove where the step tip seal is inserted are

formed linearly from one end side to the other end side substantially along an involute curve traced by the spiral wrap.

[0029] Thus, other than the difference in height between one end and the other end in the length direction, only the width, the length perpendicular to the width, and the thickness of the step tip seal need to be controlled for dimensional control during molding of the step tip seal. Therefore, the step tip seal can be more easily molded than in the case where the step tip seal has an involute curve shape. For the same reason, the die for molding the step tip seal is easy to produce as it has no curved part.

[0030] The present invention is also applicable to a configuration in which the height of the wrap is sequentially reduced through two or more step parts from the outer peripheral side toward the inner peripheral side, and two or more stepped walls are formed in the end plate.

[0031] In this case, the step tip seal may be provided continuously on these step parts or may be provided in each of the two or more step parts.

Advantageous Effects of Invention

[0032] According to the scroll compressor of the present invention, it is possible to stably hold the tip seal without requiring a difficult processing for providing the tip seal also on the step part of the wrap. This makes it possible to deal with mass production and improve the efficiency and reliability of the scroll compressor.

Brief Description of Drawings

[0033]

[FIG. 1] FIG. 1 is a longitudinal cross-sectional view of a scroll compressor according to a first embodiment.

[FIG. 2] FIG. 2 is a plan view in which a wrap of an orbiting scroll is cut away to show a fixed scroll and the orbiting scroll.

[FIG. 3] FIG. 3 is a perspective view of the fixed scroll and the orbiting scroll.

[FIG. 4] FIG. 4A is a perspective view showing a step part of the wrap, and FIG. 4B is a cross-sectional view along the line IVb-IVb of FIG. 4A.

[FIG. 5] FIG. 5 is a view showing how the step part of the wrap comes into and out of contact with a stepped wall of an end plate as the orbiting scroll orbits.

[FIG. 6] FIG. 6 is a view showing a preferred embodiment of a step tip seal, in which FIG. 6B is a cross-sectional view along the line VIb-VIb of FIG. 6A, FIG. 6C is a cross-sectional view along the line VIc-VIc of FIG. 6A, and FIG. 6D is a modified example of FIG. 6C.

[FIG. 7] FIG. 7 is a cross-sectional view showing step parts of a wrap and an end plate in a scroll compressor according to a second embodiment.

[FIG. 8] FIG. 8 is a cross-sectional view showing step parts of a wrap and an end plate in a scroll compressor according to a third embodiment.

[FIG. 9] FIG. 9 is a view showing a step tip seal used for a scroll compressor according to a fourth embodiment, in which FIG. 9A is a perspective view of the step tip seal, and FIG. 9B is a plan view showing that the step tip seal is formed linearly.

[FIG. 10] FIG. 10 is a cross-sectional view showing a modified example of the present invention.

Description of Embodiments

[0034] In the following, the present invention will be described in detail on the basis of embodiments shown in the accompanying drawings.

(First Embodiment)

[0035] As shown in FIG. 1, a scroll compressor 1 includes, inside a housing 10, a motor 12 and a compression mechanism 2 driven by the motor 12. This scroll compressor 1 configures, for example, an air conditioner, a refrigerator, etc.

[0036] The housing 10 includes a cylindrical closed-end housing main body 101 having an open upper end, and a housing top 102 covering the upper end of the housing main body 101.

[0037] On the side surface of the housing main body 101, a suction pipe 13 is provided which introduces a refrigerant flowing through a refrigerant circuit through an accumulator (not shown) into the housing main body 101.

[0038] On the housing top 102, a discharge pipe 14 is provided which discharges the refrigerant compressed by the compression mechanism 2. The inside of the housing 10 is partitioned by a discharge cover 25 into a low-pressure chamber 10A and a high-pressure chamber 10B.

[0039] The motor 12 includes a stator 15 and a rotor 16.

[0040] A coil provided in the stator 15 is energized by a power supply unit (not shown) provided on the upper surface of the housing top 102. A rotary shaft 17 is integrally coupled with the rotor 16.

[0041] A lower bearing 19 and an upper bearing 18 rotatably supporting the rotary shaft 17 are provided on the end sides of the rotary shaft 17 across the motor 12.

[0042] An eccentric pin 17A provided at the upper end of the rotary shaft 17 protrudes into an internal space 190 formed in the upper bearing 18.

[0043] The compression mechanism 2 includes a fixed scroll 20 and an orbiting scroll 30 which makes an orbital motion relative to the fixed scroll 20.

[0044] The fixed scroll 20 includes a disc-shaped fixed end plate 200 and a spiral wrap 21 provided upright on the inner surface side of the fixed end plate 200.

[0045] The orbiting scroll 30 also includes a disc-shaped orbiting end plate 300 and a spiral wrap 31 provided upright on the inner surface side of the orbiting end plate 300.

[0046] A boss 34 is provided on the back surface of the orbiting end plate 300 of the orbiting scroll 30, and a drive bush 36 is mounted on the boss 34 through the bearing. The eccentric pin 17A is fitted inside the drive bush 36. Thus, since the orbiting scroll 30 is eccentrically coupled with the axis of the rotary shaft 17, when the rotary shaft 17 rotates, the orbiting scroll 30 orbits (revolves) with the eccentric distance from the axis of the rotary shaft 17 being an orbiting radius Tr.

[0047] An Oldham ring (not shown) which restricts rotation is provided between the orbiting scroll 30 and the rotary shaft 17 to prevent rotation while allowing revolution of the orbiting scroll 30.

[0048] The wraps 21, 31, which are eccentric to each other by a predetermined amount and are meshed together 180 degrees out of phase, come into contact with each other at a plurality of positions according to the orbiting angle of the orbiting scroll 30 as shown in FIG. 2. Thus, a compression chamber 2P is formed in point symmetry relative to the central part (most inner peripheral part) of the spirals of the wraps 21, 31, and the compression chamber 2P is moved gradually toward the inner peripheral side while decreasing in volume as the orbiting scroll 30 orbits. Then, the refrigerant is compressed most in the central part of the spirals.

[0049] In this compression mechanism 2, the volume of the compression chamber 2P formed between the scrolls 20, 30 is reduced also in the height direction of the wraps 21, 31 in the course of the spirals. For this purpose, as shown in FIG. 3, in both the fixed scroll 20 and the orbiting scroll 30, the height of the wraps 21, 31 is lowered on the inner peripheral side compared with on the outer peripheral side, and the end plates 200, 300 of the mating scrolls opposite to these step-shaped wraps 21, 31 are formed so as to protrude further toward the inner surface side of the end plates 200, 300 on the inner peripheral side than on the outer peripheral side.

[0050] The wrap 21 of the fixed scroll 20 includes an inner peripheral-side wrap 21A and an outer peripheral-side wrap 21B. A step part 21C is formed between the inner peripheral-side wrap 21A and the outer peripheral-side wrap 21B. The step part 21C rises from the inner peripheral side toward the outer peripheral side. When the wrap 21 and the wrap 31 are meshed with each other, the outer peripheral-side wrap 21B is opposed to an outer peripheral bottom part 30B and the inner peripheral-side wrap 21A is opposed to an inner peripheral bottom part 30A as shown in FIG. 4B.

[0051] The upper-lower direction here refers to a relative direction with reference to either one of the fixed scroll 20 and the orbiting scroll 30.

[0052] The stepped wall 30C, which is formed between the outer peripheral bottom part 30B of the orbiting end plate 300 and the inner peripheral bottom part 30A protruding further toward the inner surface side than the outer peripheral bottom part 30B, rises from the outer peripheral side toward the inner peripheral side and is formed in an arc-like shape in planar view as shown in FIG. 2. A side surface part S of the step part 21C, which comes into and out of contact with this stepped wall 30C according to the orbiting angle of the orbiting scroll 30, is formed in an arc-like shape in planar view to follow the shape of the stepped wall 30C (FIG. 2 and FIG. 4A).

[0053] Similarly to the wrap 21 of the fixed scroll 20, the wrap 31 of the orbiting scroll 30 also includes an inner peripheral-side wrap 31A and an outer peripheral-side wrap 31B, and a step part 31C is formed between these wrap 31A and 31B (FIG. 2 and FIG. 3). The step part 31C of the outer peripheral-side wrap 31B is opposed to the end part of the outer peripheral bottom part 20B of the fixed end plate 200.

[0054] A stepped wall 20C, which is formed between the inner peripheral bottom part 20A and the outer peripheral bottom part 20B of the fixed end plate 200, is also formed similarly to the stepped wall 30C.

[0055] In the following, a tip seal provided on the wrap 21 of the fixed scroll 20 and on the wrap 31 of the orbiting scroll 30 will be described.

[0056] As shown in FIG. 3, a tip seal 40 is provided on the wrap 21 of the fixed scroll 20 throughout its winding from the starting point (on the inner peripheral side) nearly to the ending point.

[0057] On the other hand, the wrap 31 of the orbiting scroll 30 is also provided with a tip seal 50 over an area similar to that of the tip seal 40.

[0058] Resin materials such as polytetrafluoroethylene (PTFE), modified polyphenylene ether (PPS), polyetheretherketone (PEEK), or metal materials such as iron and aluminum can be used as the material of the tip seals 40, 50.

[0059] As shown in FIG. 2 and FIG. 3, in view of the ease of processing, the tip seal 40 provided on the wrap 21 is configured of an outer peripheral tip seal 41 provided on the outer peripheral side of the step part 21C, a step tip seal 42 provided on the step part 21C, and the inner peripheral tip seal 43 provided on the inner peripheral side of the step part 21C.

[0060] The outer peripheral tip seal 41 and the inner peripheral tip seal 43 are both a long spiral member.

[0061] As shown in FIG. 4A, the step tip seal 42 is provided continuously on a leading end part T of the outer peripheral-side wrap 21B, the side surface part S of the step part 21C, and a leading end part T of the inner peripheral-side wrap 21A.

[0062] This step tip seal 42 is formed in a crank shape by an outer peripheral end part 42B extending along the leading end part T of the outer peripheral-side wrap 21B, an inner peripheral end part 42A extending along the leading end part T of the inner peripheral-side wrap 21A, and a middle part 42M perpendicular to both ends 42A, 42B.

[0063] As shown in FIG. 4B, when the wrap 21 and the

wrap 31 are meshed with each other, the outer peripheral end part 42B of the step tip seal 42 is sandwiched between the outer peripheral-side wrap 21B and the outer peripheral bottom part 30B, while the inner peripheral end part 42A is sandwiched between the inner peripheral-side wrap 21A and the inner peripheral bottom part 30A. The entire step tip seal 42 is thereby surrounded by the wrap 21 and the orbiting end plate 300. Thus, as will be described later, the step tip seal 42 is held stably without disengaging from or falling out of seal grooves D1, D2.

[0064] The length of the inner peripheral end part 42A of the step tip seal 42 is defined such that, even when the stepped wall 30C moves farthest away (the state shown in FIG. 4B) relative to the middle part 42M of the step tip seal 42 as the orbiting scroll 30 orbits, the inner peripheral end part 42A reaches the back surface side of the stepped wall 30C without interruption on the inside of the stepped wall 30C. Thus, a border Bd between the step tip seal 42 and the inner peripheral tip seal 43 does not enter the inside of the stepped wall 30C but always lies on the outside of a circular path R traced by the step part 21C (FIG. 5B).

[0065] The length of the inner peripheral end part 42A of the step tip seal 42 is more than twice the orbiting radius Tr. On the other hand, the length of the outer peripheral end part 42B of the step tip seal 42 may be shorter than the length of the inner peripheral end part 42A. The length of the outer peripheral end part 42B is determined so as to be long enough to stably hold the step tip seal 42. If the length of the outer peripheral end part 42B is shorter than the length of the inner peripheral end part 42A, it is easy to see the direction of mounting the step tip seal 42 on the wrap 21, which improves the work efficiency.

[0066] As shown in FIG. 4B, each of the outer peripheral tip seal 41 and the inner peripheral tip seal 43 is inserted into the seal groove D1 formed in the leading end part T of the wrap 21.

[0067] Each of the inner peripheral end part 42A and the outer peripheral end part 42B of the step tip seal 42 is inserted into the seal groove D1. The middle part 42M of the step tip seal 42 is inserted into the seal groove D2 formed in the side surface part S of the step part 21C.

[0068] The outer peripheral end part 42B and the inner peripheral end part 42A are rectangular in cross-section as shown in FIG. 6B which shows the cross-section vertical to the length direction, and a surface U1 of these end parts is formed smoothly in parallel to the leading end part T of the wrap 21.

[0069] On the other hand, a surface U2 of the middle part 42M is formed in an arc-like shape along the arc-like shape of the side surface part S of the step part 21C as shown in FIG. 6C which shows the cross-section vertical to the length direction. It is preferable that the radius of curvature of the surface U2 is almost equal to the orbiting radius Tr. A back surface U3 of the middle part 42M is also formed in an arc-like shape. The bottom part of the seal groove D2 which accommodates the middle part 42M of the step tip seal 42 is also formed in an arc-like shape corresponding to the back surface U3. If the bottom part of the seal groove D2 has an arc-like shape, it is easy to process the seal groove D2 with an end mill, a drill, etc. The radius of curvature of the bottom part of the seal groove D2 is determined according to the tool used.

[0070] The middle part 42M may be formed to be thinner as shown in FIG. 6D. Thus, the depth of the seal groove D2 becomes shallow, so that it is easy to secure the strength of the wrap of the step part 21C.

[0071] When the compressed refrigerant is introduced into the seal groove D1 from the clearance between the end parts of the outer peripheral/inner peripheral tip seals 41, 43 and the seal groove D1 etc., as the pressure on the front surface side of the tip seal becomes negative relative to the pressure on the back surface side, the outer peripheral tip seal 41 lifts from the bottom part of the seal groove D1 and comes into close contact with the outer peripheral bottom part 30B, and the inner peripheral tip seal 43 also lifts and comes into close contact with the inner peripheral bottom part 30A as shown in FIG. 4B. Then, under the pressure of the refrigerant inside the seal groove D1 and the seal groove D2 communicating with the seal groove D1, the step tip seal 42 also lifts from the bottom parts of the seal grooves D1, D2 and comes into close contact with the stepped wall 30C over the area of a predetermined orbiting angle. Since the surface U2 of the middle part 42M of the step tip seal 42 has an arc-like shape of the orbiting radius Tr, the degree of close contact with the stepped wall 30C, which has similarly an arc-like shape of the orbiting radius Tr, is increased.

[0072] The clearance between the wrap 21 of the fixed scroll 20 and the orbiting end plate 300 is sealed by these tip seals 41 to 43 to keep the airtightness of the compression chamber 2P.

[0073] As shown in FIG. 2, similarly to the above-described tip seal 40, the tip seal 50 provided in the wrap 31 of the orbiting scroll 30 is also configured of an outer peripheral tip seal 51 provided on the outer peripheral side of the step part 31C, a step tip seal 52 provided on the step part 31C, and an inner peripheral tip seal 53 provided on the inner peripheral side of the step part 31C. The tip seals 51 to 53 are formed similarly to the above-described tip seals 41 to 43. In addition, the seal grooves D1, D2, into which these tip seals 51 to 53 are inserted, are also formed similarly to those of the wrap 31 as described above.

[0074] To start the scroll compressor 1, the motor 12 should be excited and a refrigerant should be introduced through the suction pipe 13 into the low-pressure chamber 10A inside the housing 10.

[0075] When the motor 12 is excited, the rotary shaft 17 rotates and accordingly the orbiting scroll 30 makes an orbital motion relative to the fixed scroll 20. Then, the refrigerant is compressed in the compression chamber

2P between the orbiting scroll 30 and the fixed scroll 20, and the refrigerant inside the low-pressure chamber 10A is suctioned into the space between the orbiting scroll 30 and the fixed scroll 20. Then, the compressed refrigerant is discharged into the high-pressure chamber 10B through a discharge hole 201 in the central part of the fixed end plate 200 and a discharge port 251 of the discharge cover 25, and is further discharged through the discharge pipe 14 to the refrigerant circuit. In this way, a refrigerant is suctioned, compressed, and discharged continuously.

[0076] As the orbiting scroll 30 orbits, the step part 21C of the wrap 21 shifts and cyclically comes into and out of contact with the stepped wall 30C of the orbiting end plate 300 as shown in FIGS. 5A and 5B. Similarly, the step part 31C of the wrap 31 also cyclically comes into and out of contact with the stepped wall 20C of the fixed end plate 200.

[0077] In the following, the advantages of this embodiment will be described taking the relation between the tip seal 40 provided on the step part 21C of the wrap 21 and the orbiting end plate 300 as an example.

[0078] The step part 21C of the wrap 21 shifts on the circular path R (shown in FIG. 5B) having the orbiting radius Tr. Since this circular path R extends along the inner circumferential surface of the stepped wall 30C, the middle part 42M of the step tip seal 42, which forms the outline of the side surface part of the step part 21C, comes into contact with the stepped wall 30C (FIG. 5A) in one orbiting angle range (e.g., 180°), while in the rest of the orbiting angle range (e.g., 180°), the stepped wall 30C moves away from the step part 21C, so that the step part 21C comes out of contact with the stepped wall 30C (FIG. 5B). As the step part 21C thus shifts, the inner peripheral end part 42A of the step tip seal 42 cyclically appears on the inside of the stepped wall 30C.

[0079] Due to orbiting of the orbiting scroll 30, the tip seal 40 comes into sliding contact with the opposite surface of the orbiting end plate 300. In addition, in the step part 21C, the tip seal 40 repeatedly comes into sliding contact with the stepped wall 30C. Under this repetitive stress, the tip seal provided on the step part 21C is likely to fall out of the seal groove. If the tip seal provided on the step part 21C is formed as a small piece (step tip seal 42) which is separate from the longer portions (outer peripheral tip seal 41 and inner peripheral tip seal 43) for the ease of processing, the tip seal is likely to be displaced from the seal groove due to the stress.

[0080] In this embodiment, therefore, the step tip seal 42 is configured as described above in order to stably hold the step tip seal 42 inside the seal groove as will be described below.

[0081] When the step part 21C (the middle part 42M of the step tip seal 42) is in contact with the stepped wall 30C as shown in FIG. 5A, the step tip seal 42 is held with its middle part 42M butted against the stepped wall 30C. As the inner peripheral end part 42A of the step tip seal 42 is pressed by the inner peripheral bottom part 30A of the orbiting end plate 300, the inner peripheral end part 42A is also held, as shown in FIG. 4B in which the orbiting end plate 300 with the step part 21C in contact with the stepped wall 30C is indicated by the two-dot chain line. Moreover, the outer peripheral end part 42B of the step tip seal 42 is also held by being pressed by the outer peripheral bottom part 30B of the orbiting end plate 300.

[0082] When the step part 21C comes out of contact with the stepped wall 30C from this state as shown in FIG. 5B, the middle part 42M of the step tip seal 42 is released from the holding. However, since the length of the inner peripheral end part 42A is defined such that, even when the stepped wall 30C moves farthest away from the middle part 42M, the inner peripheral end part 42A reaches the back surface side of the stepped wall 30C without interruption on the inside of the stepped wall 30C, the border Bd between the step tip seal 42 and the inner peripheral tip seal 43 does not enter the inside of the stepped wall 30C but the state in which the inner peripheral end part 42A is pressed by the inner peripheral bottom part 30A is maintained. The outer peripheral end part 42B also remains in the same state in which it is held by being pressed by the outer peripheral bottom part 30B.

[0083] The step tip seal 42 of this embodiment is provided integrally from the outer peripheral-side wrap 21B to the inner peripheral-side wrap 21A, and the entire step tip seal 42 is surrounded between the wrap 21 and the orbiting end plate 300. Moreover, since the border Bd between the step tip seal 42 and the inner peripheral tip seal 43 always lies on the outside of the circular path R which the step part 21C traces as the scroll orbits, the state in which the end parts 42A, 42B of the step tip seal 42 are both pressed by the orbiting end plate 300 can be always maintained throughout the course of the step part 21C coming into and out of contact with the stepped wall 30C.

[0084] Thus, it is possible to more stably hold the step tip seal 42 by reliably preventing it from disengaging or falling, as well as to prevent damage attributable to lifting of the inner peripheral end part 42A of the step tip seal 42. That is, even when the step part 21C comes out of contact with the stepped wall 30C, the inner peripheral tip seal 43 does not enter the inside of the stepped wall 30C but the step tip seal 42 is always kept pressed by the orbiting end plate 300, so that it is possible to prevent further lifting of the inner peripheral end part 42A which has already lifted to the surface of the inner peripheral bottom part 30A under a back pressure. Thus, it is possible to avoid the tip seal getting caught at the edge of the stepped wall 30C or getting drawn between the inner peripheral bottom part 30A and the wrap and broken.

[0085] In this embodiment, the tip seal 40 is divided into three portions of the portion on the outer peripheral side of the step part 21C, the portion of the step part 21C, and the portion on the inner peripheral side of the step part 21C, and the tip seal 40 is a member having a crank shape following the shape of the step part 21C. Thus, it is possible to easily manufacture the long outer periph-

eral tip seal 41 and inner peripheral tip seal 43 without forming a bent part in them by providing the step tip seal 42 around the step part 21C which is separate from the tip seals preceding and succeeding it. Since the step tip seal 42 is a shorter member than the outer peripheral tip seal 41 and the inner peripheral tip seal 43, it is easy to manufacture even if it has a bent shape.

[0086] As the means for holding the step tip seal 42, this embodiment adopts the configuration in which the end parts 42A, 42B of the step tip seal 42 extend along the respective leading end parts T of the outer peripheral-side wrap 21B and the inner peripheral-side wrap 21A. According to this configuration, it is not necessary to perform a difficult processing for holding the tip seal, and since the step tip seal 42 is stably held at the extending portions, the holding does not become unstable even under the repetitive load applied to the step tip seal 42, and the step tip seal 42 can be stably held for a long period.

[0087] The above description of the advantages also apply to the relation between the tip seal 50 provided in the step part 31C of the wrap 31 and the fixed end plate 200.

[0088] According to this embodiment, it is possible to deal with mass production owing to the improved ease of processing of the tip seals 40, 50.

[0089] In addition, it is possible to increase the airtightness of the compression chamber 2P by providing the tip seals 40, 50 on the entire wrap 21 including the step part 21C and the entire wrap 31 including the step part 31C, as well as to stably keep the airtightness by stably holding the step tip seal 42 which tends to disengage or fall. Thus, the efficiency and reliability of the scroll compressor 1 can be improved.

(Second Embodiment)

[0090] Next, a second embodiment of the present invention will be described with reference to FIG. 7.

[0091] The following embodiments will be described mainly in terms of differences from the first embodiment. The same configurations as those described in the first embodiment are denoted by the same reference signs.

[0092] In the second embodiment, the shapes of the end parts of the tip seal 40 and the tip seal 50 are different from those of the first embodiment. In the following description, while the tip seal 40 will be taken as an example, the tip seal 50 is configured in the same manner.

[0093] Lapped parts Lp1, Lp2, which are reduced in thickness and lapped over each other in the thickness direction, are formed in both adjacent end parts of the outer peripheral tip seal 41, the step tip seal 42, and the inner peripheral tip seal 43 configuring the tip seal 40.

[0094] These lapped parts Lp1, Lp2 are roughly half as thick as the tip seal, and are combined into a hook shape through a crank-shaped border (clearance) with the adjacent lapped part.

[0095] Here, one (Lp1) of the lapped parts Lp1, Lp2 lapping over each other, which lies on the inner peripheral side, lies on the back surface side of the other (Lp2) which lies on the outer peripheral side, namely, between the outer peripheral-side lapped part Lp2 and the bottom part of the seal groove D1. Therefore, when the pressure of the refrigerant inside the seal groove D1 acts on the tip seal lying on the inner peripheral side, the lapped part Lp1 of the tip seal pushes up the lapped part Lp2 of the tip seal lying on the outer peripheral side. Since a pressure transmission path is thereby secured on the back surface side of the tip seal, the high pressure of the compressed refrigerant on the inner peripheral side can be smoothly introduced to the back surface of the tip seals 41 to 43 from the inner peripheral side toward the outer peripheral side. As this allows the tip seals 41 to 43 to reliably lift, high airtightness can be obtained.

(Third Embodiment)

[0096] Next, a third embodiment of the present invention will be described with reference to FIG. 8.

[0097] In the third embodiment, the shapes of the corner parts of the tip seal 40 and the tip seal 50 are different from those of the first embodiment.

[0098] In the following description, while the tip seal 40 will be taken as an example, the tip seal 50 is configured in the same manner.

[0099] As shown in FIG. 8A, the inside of a corner part 42L1 at which the outer peripheral end part 42B and the middle part 42M of the step tip seal 42 intersect is increased in thickness to form a thicker part F.

[0100] A bottom corner part DL of the seal groove opposite to the inside of the corner part 42L1 is chamfered correspondingly. The thicker part F is formed along a chamfered portion of the bottom corner part DL which is chamfered linearly.

[0101] Such a thicker part F can enhance the strength of the corner part 42L1 at which stress is likely to concentrate.

[0102] As shown in FIG. 8B, it is also possible to enhance the strength of a corner part 42L2 by forming the thicker part F also on the inside of the corner part 42L2 at which the middle part 42M and the inner peripheral end part 42A of the step tip seal 42 intersect. In this case, a corner part 30L of the inner peripheral bottom part 30A opposite to the inside of the corner part 42L2 should be chamfered.

(Fourth Embodiment)

[0103] Next, a fourth embodiment of the present invention will be described with reference to FIG. 9.

[0104] In the fourth embodiment, a step tip seal 44 shown in FIG. 9A is used. As shown in FIG. 9B, the step tip seal 44 is formed linearly substantially along the involute curve traced by the spiral outer peripheral tip seal 41 and inner peripheral tip seal 43. The step tip seal 44 is constant in width and thickness from the inner peripheral end part 42A to the outer peripheral end part 42B,

and is rectangular in planar view.

[0105] The area of the seal groove D1 where the step tip seal 44 is inserted is also formed linearly following the shape of the step tip seal 44.

[0106] In this embodiment, the end parts adjacent to the step tip seal 44 of the outer peripheral tip seal 41 and the inner peripheral tip seal 43 are also formed linearly, and the area of the seal groove D in which these end parts are inserted is also formed linearly. FIG. 9B shows a linear section SL which stretches across the outer peripheral tip seal 41, the step tip seal 44, and the inner peripheral tip seal 43.

[0107] According to this embodiment, since the step tip seal 44 has a linear shape, other than the middle part 42M, only the width, the length perpendicular to the width, and the thickness need to be controlled for dimensional control during molding. Therefore, the step tip seal can be more easily molded than in the case where it has an involute curve shape. The die for molding the step tip seal 44 is also easy to produce.

[0108] Moreover, if the end parts of the outer peripheral tip seal 41 and the inner peripheral tip seal 43 adjacent to the step tip seal 44 are also linear, even when the dimensions of these tip seals vary, it is unlikely that the adjacent end parts of the outer peripheral tip seal 41, the inner peripheral tip seal 43, and the step tip seal 44 interfere with each other and get damaged or an uneven clearance is left between the adjacent end parts. Thus, it is possible, without particularly increasing the dimensional accuracy, to accurately butt the end parts of the tip seals against each other and to stably seal them.

[0109] In the above description, the configuration has been described in which one step part (21C, 31C) is formed in each wrap of the fixed scroll 20 and the orbiting scroll 30. However, as shown in FIG. 10, the present invention is also applicable to a configuration in which a plurality of (two or more) step parts are formed in the wrap and the same number of stepped walls are formed in the end plate of the mating scroll. In such a configuration in which the wrap height is sequentially lowered from the outer peripheral side toward the inner peripheral side, the stress applied to the step part can be relieved compared with the configuration in which the level difference is the same between the outer peripheral-side wrap 21B and the inner peripheral-side wrap 21A and only one step part is formed.

[0110] FIG. 10A shows step parts 21C, 21D, 21E of the wrap 21 and stepped wall 30C, 30D, 30E of the orbiting end plate 300 opposite to these step parts. One step tip seal 52 is provided continuously on these three step parts 21C, 21D, 21E. The border Bd between the step tip seal 52 and the inner peripheral tip seal 43, similarly to that described above, always lies on the outside of the circular path R.

[0111] Due to the provision of the plurality of these step parts 21C, 21D, 21E, the shape of the tip seal, if it is to be provided on these step parts 21C, 21D, 21E, becomes complicated. However, since only that portion is taken out and formed as the step tip seal 52 which is separate from the outer peripheral tip seal 41 and the inner peripheral tip seal 43, all the tip seals 41, 52, 43 are easy to process.

[0112] As shown in FIG. 10B, a step tip seal 42C may be provided on the step part 21C, a step tip seal 42D may be provided on the step part 21D, and a step tip seal 42E may be provided on the step part 21E. This configuration is suitable in the case where the intervals of the step parts 21C, 21D, 21E are relatively large. The border Bd between the step tip seal 42C and the step tip seal 42D on the inner peripheral side thereof always lies on the outside of the circular path R. The same applies to the border Bd between the step tip seal 42D and the step tip seal 42E on the inner peripheral side thereof, and to the border Bd between the step tip seal 42E and the inner peripheral tip seal 43.

[0113] In both configurations shown in FIG. 10A and FIG. 10B, as in the first embodiment, the state in which the step tip seal is pressed on the inner peripheral side and the outer peripheral side by the bottom part of the end plate of the mating scroll can be always maintained. Therefore, it is possible to more stably hold the step tip seals 42C to 42E and the step tip seal 52 by more reliably preventing them from disengaging or falling, as well as to prevent damage attributable to lifting of these step tip seals.

[0114] It is possible to make a selection of the configurations presented above or to appropriately change one configuration into another within the scope of the present invention.

Reference Signs List

[0115]

1	Scroll compressor
2	Compression mechanism
10	Housing
12	Motor
13	Suction pipe
14	Discharge pipe
15	Stator
16	Rotor
17	Rotary shaft
17A	Eccentric pin
18	Upper bearing
19	Lower bearing
20	Fixed scroll
20A	Inner peripheral bottom part
20B	Outer peripheral bottom part
20C	Stepped wall
21A	inner peripheral-side wrap
21B	Outer peripheral-side wrap
21C, 21D, 21E	Step part
25	Discharge cover
30	Orbiting scroll
30A	Inner peripheral bottom part

30B	Outer peripheral bottom part
30C, 30D, 30E	Stepped wall
30L	Corner part
31A	Inner peripheral-side wrap
31B	Outer peripheral-side wrap
31C	Step part
40, 50	Tip seal
41	Outer peripheral tip seal
42, 44	Step tip seal
42A	Inner peripheral end part
42B	Outer peripheral end part
42M	Middle part
42C, 42D, 42E	Step tip seal
42L1, 42L2	Corner part
43	Inner peripheral tip seal
51	Outer peripheral tip seal
52	Step tip seal
53	Inner peripheral tip seal
101	Housing main body
102	Housing top
200	Fixed end plate
201	Discharge hole
251	Discharge port
300	Orbiting end plate
Bd	Border
D1, D2	Seal groove
DL	Corner part
F	Thicker part
Lp1, Lp2	Lapped part
S	Side surface part
T	Leading end part
R	Circular path

Claims

1. A scroll compressor comprising a pair of scrolls, of which one is put in orbital motion relative to the other, the pair of scrolls each having: a spiral wrap which is provided upright toward the mating scroll and decreases in height from the outer peripheral side toward the inner peripheral side through a step part; and an end plate in which a stepped wall rising to follow the shape of the step part of the wrap of the mating scroll is formed, wherein
a tip seal, which seals the clearance between the wrap and the end plate of the mating scroll, is inserted into a seal groove formed in the wrap,
the tip seal comprises an outer peripheral tip seal provided on the outer peripheral side of the step part, a step tip seal provided on the step part, and an inner peripheral tip seal provided on the inner peripheral side of the step part,
the step tip seal is provided continuously on a leading end part of the wrap on the outer peripheral side, a side surface part of the step part opposite to the stepped wall, and a leading end part of the wrap on the inner peripheral side, and
the border between the step tip seal and the inner peripheral tip seal always lies on the outside of a circular path which the step part traces as the scroll orbits.

2. The scroll compressor according to claim 1, wherein lapped parts, which are reduced in thickness and lapped over each other in the thickness direction, are formed in both adjacent end parts of the outer peripheral tip seal, the step tip seal, and the inner peripheral tip seal, and
one of the lapped parts, which lies on the inner peripheral side, lies between the other one which lies on the outer peripheral side and the bottom part of the seal groove.

3. The scroll compressor according to claim 1 or 2, wherein
at least one of the corner part of the wrap opposite to the inside of the corner part of the step tip seal and the corner part of the end plate opposite to the inside of the other corner part of the step tip seal is chamfered, and
the inside of the corner part of the step tip seal is increased in thickness along the chamfered portion.

4. The scroll compressor according to any one of claims 1 to 3, wherein the step tip seal and an area of the seal groove where the step tip seal is inserted are formed linearly almost along the involute curve traced by the wrap.

5. The scroll compressor according to any one of claims 1 to 4, wherein
the height of the wrap is sequentially reduced from the outer peripheral side toward the inner peripheral side through two or more step parts,
two or more stepped walls are formed in the end plate, and
the step tip seal is provided continuously on the two or more step parts.

6. The scroll compressor according to any one of claims 1 to 4, wherein
the height of the wrap is sequentially reduced from the outer peripheral side toward the inner peripheral side through two or more step parts,
two or more stepped walls are formed in the end plate, and
the step tip seal is provided on each of the two or more step parts.

FIG. 1

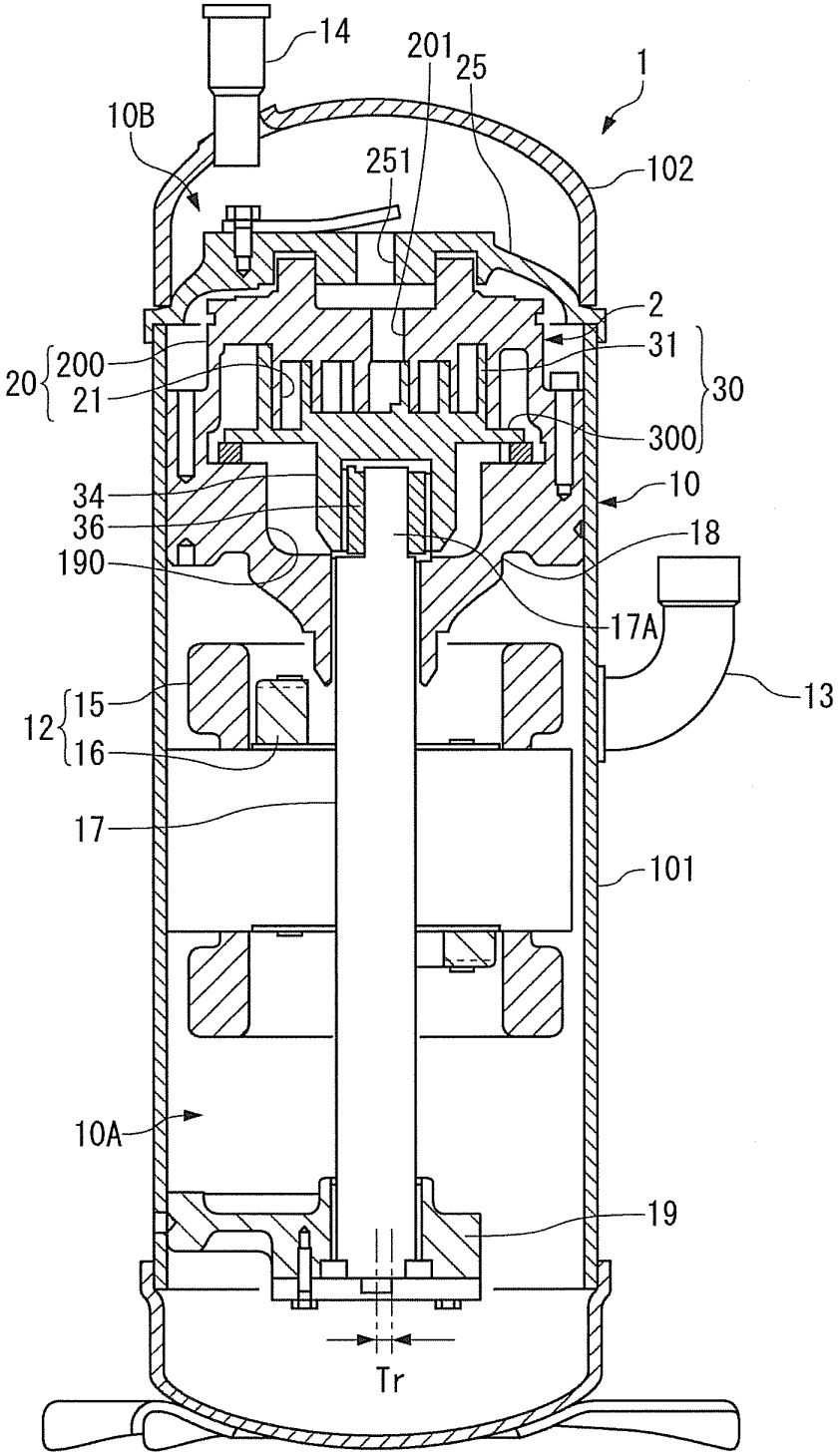

14
201
25
1
10B
251
102
2
31
30
20
200
21
300
34
10
36
18
190
17A
13
12
15
16
17
101
10A
19
Tr

FIG. 2

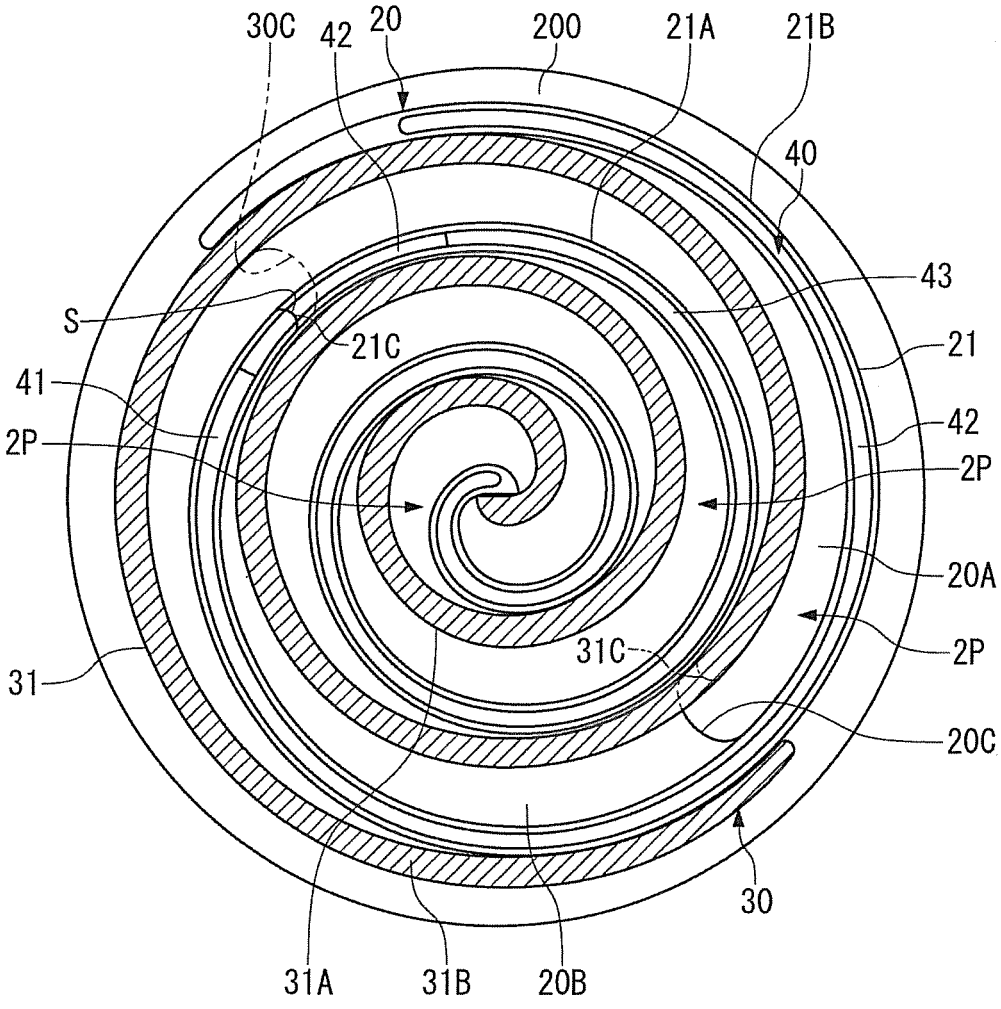
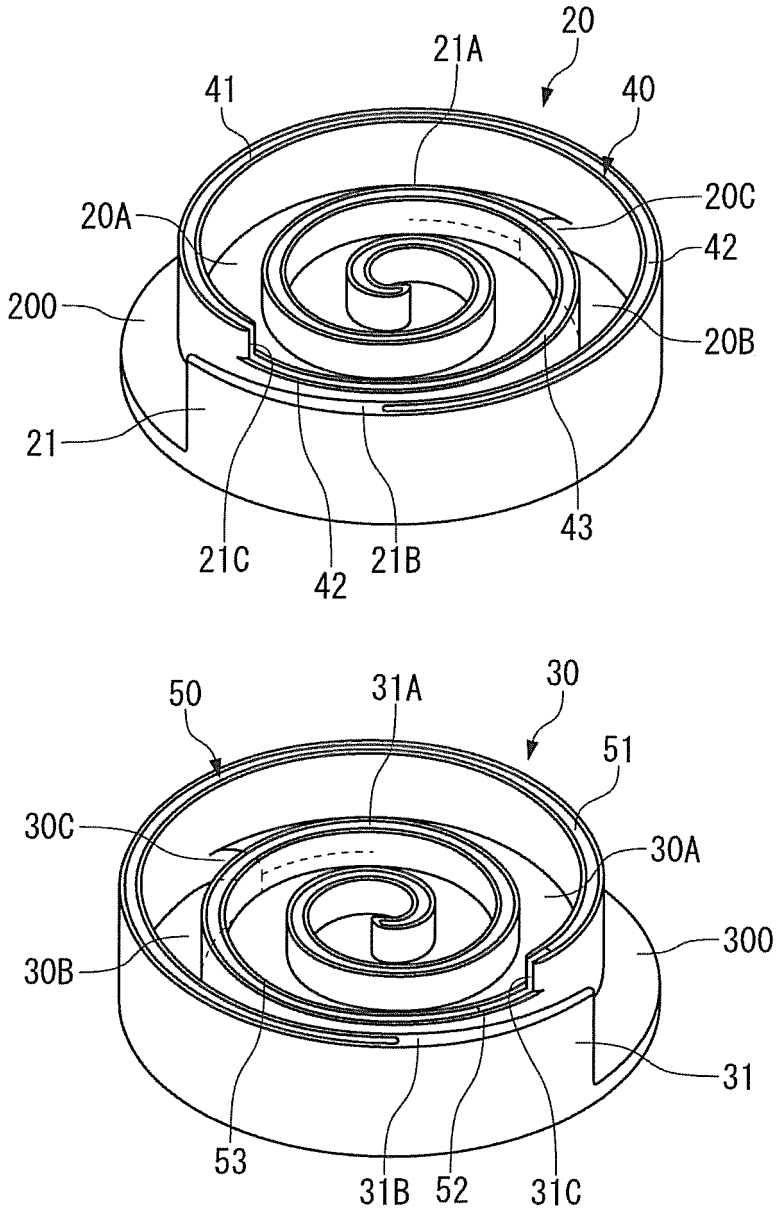

30C
42
20
200
21A
21B
40
43
S
21C
21
41
42
2P
2P
20A
2P
31C
31
20C
30
31A
31B
20B

FIG. 3


20
21A
41
40
20C
20A
42
200
20B
21
43
21C
42
21B
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31A
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30C
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300
30B
31
53
31B
52
31C

FIG. 4A

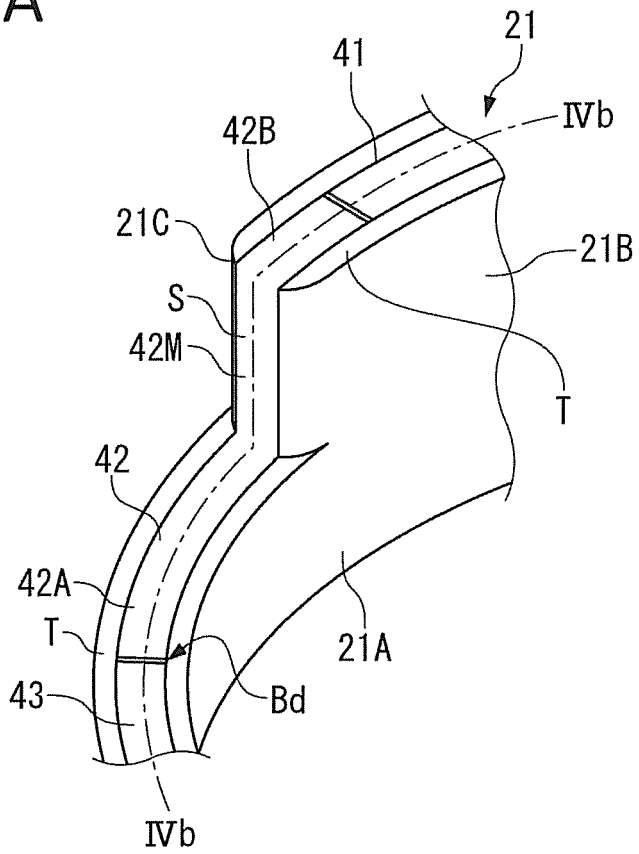

21
41
IVb
42B
21C
21B
S
42M
T
42
42A
T
21A
43
Bd
IVb

FIG. 4B

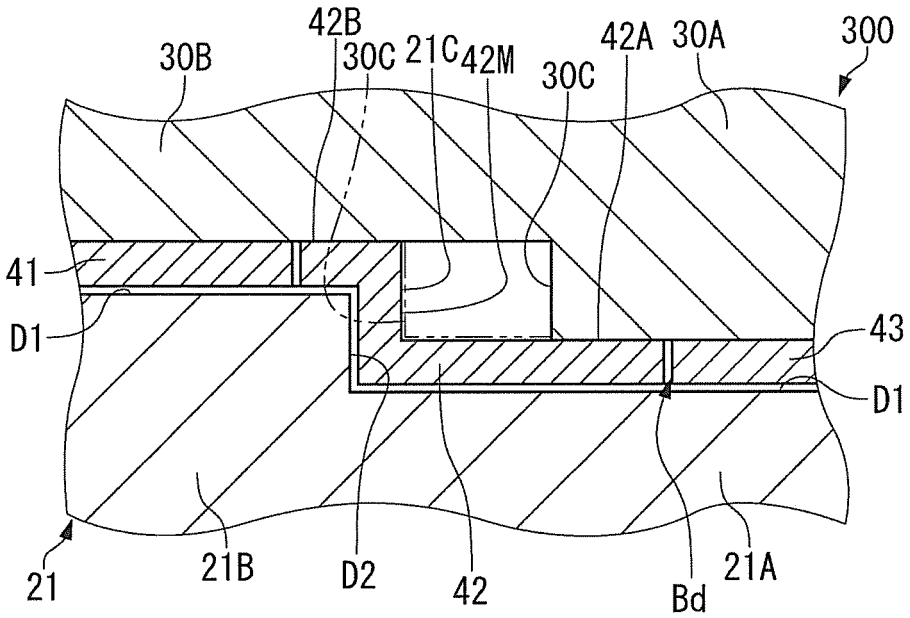
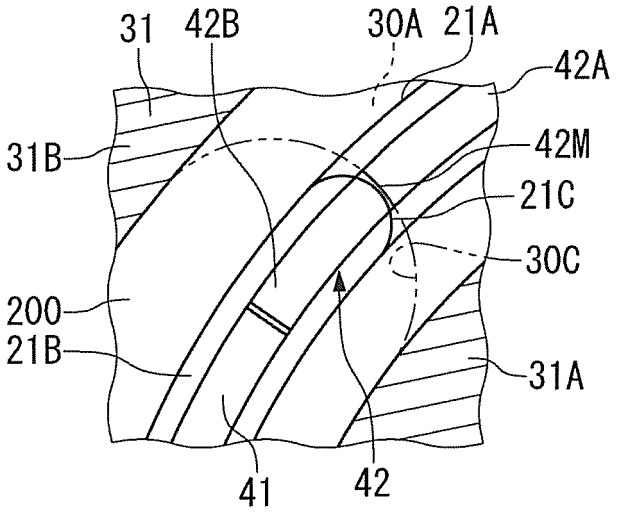

42B
30B
30C
21C
42M
30C
42A
30A
300
41
D1
43
D1
21
21B
D2
42
Bd
21A

FIG. 5A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21A
42A
31B
42M
21C
30C
200
21B
31A
41
42

FIG. 5B

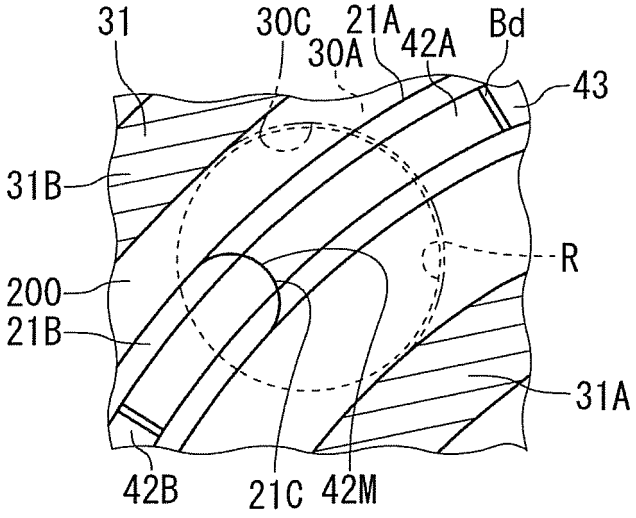

31
30C
21A
30A
42A
Bd
43
31B
R
200
21B
31A
42B
21C
42M

FIG. 6A

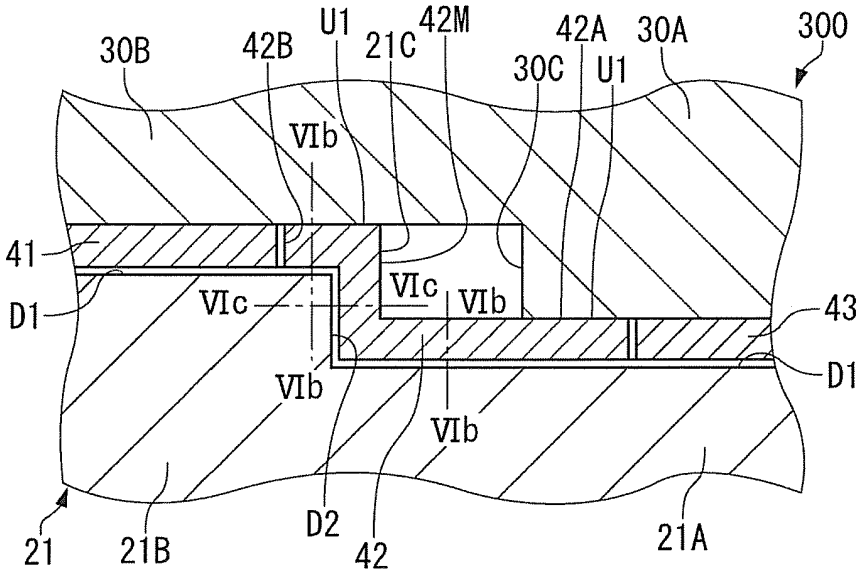


FIG. 6B

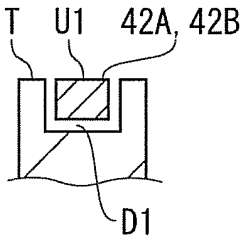


FIG. 6C

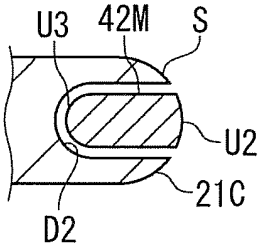


FIG. 6D

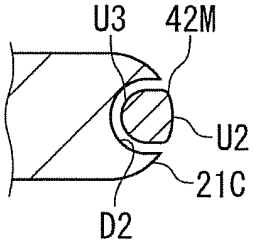


FIG. 7

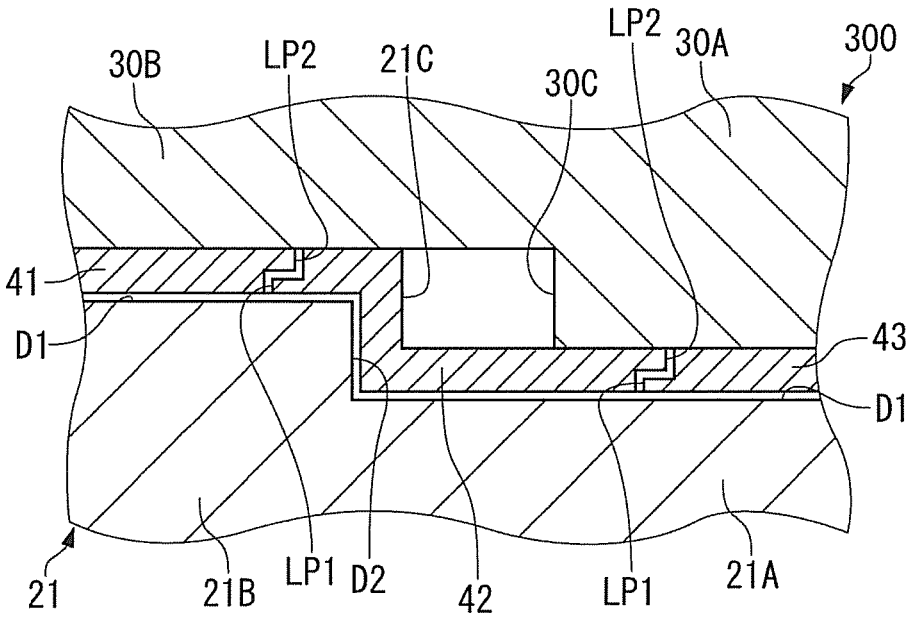


FIG. 8A

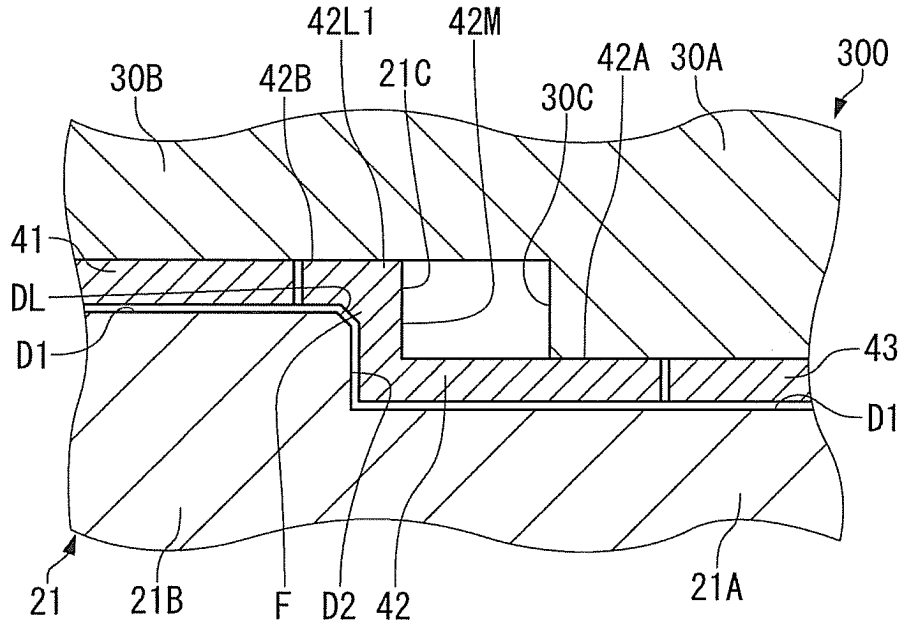

42L1
42M
30B
42B
21C
42A
30A
300
30C
41
DL
D1
43
D1
21
21B
F
D2
42
21A

FIG. 8B

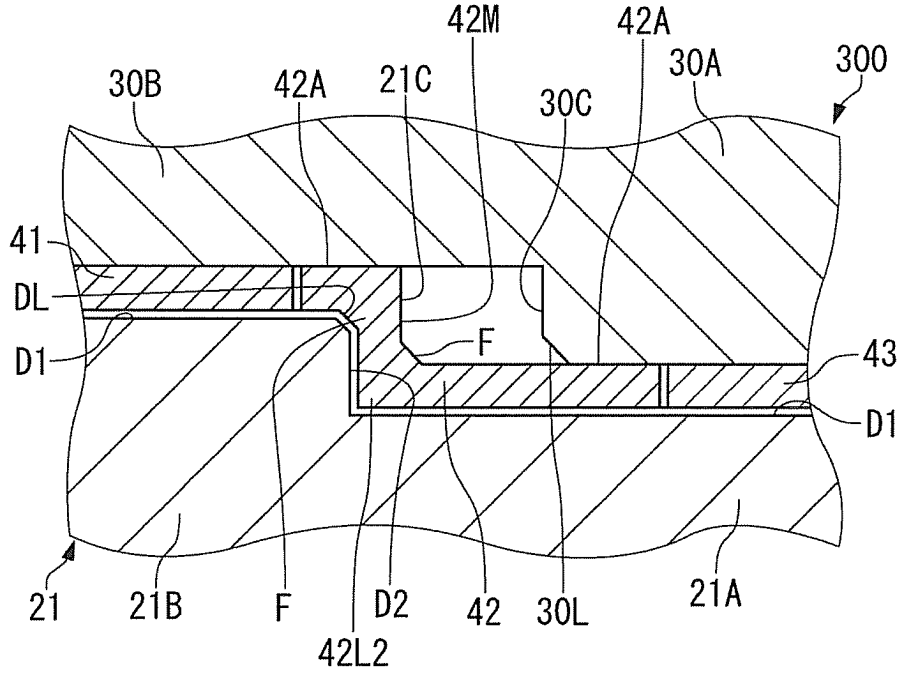

42M
42A
30A
300
30B
42A
21C
30C
41
DL
F
D1
43
D1
21
21B
F
D2
42
30L
21A
42L2

FIG. 9A

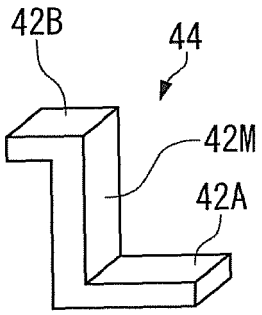


FIG. 9B

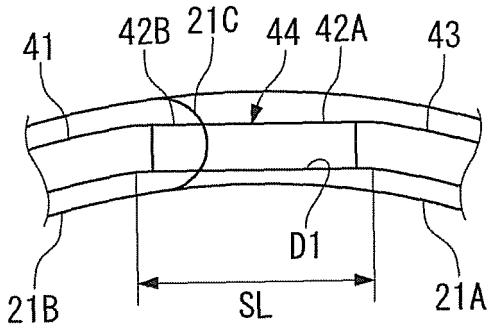


FIG. 10A

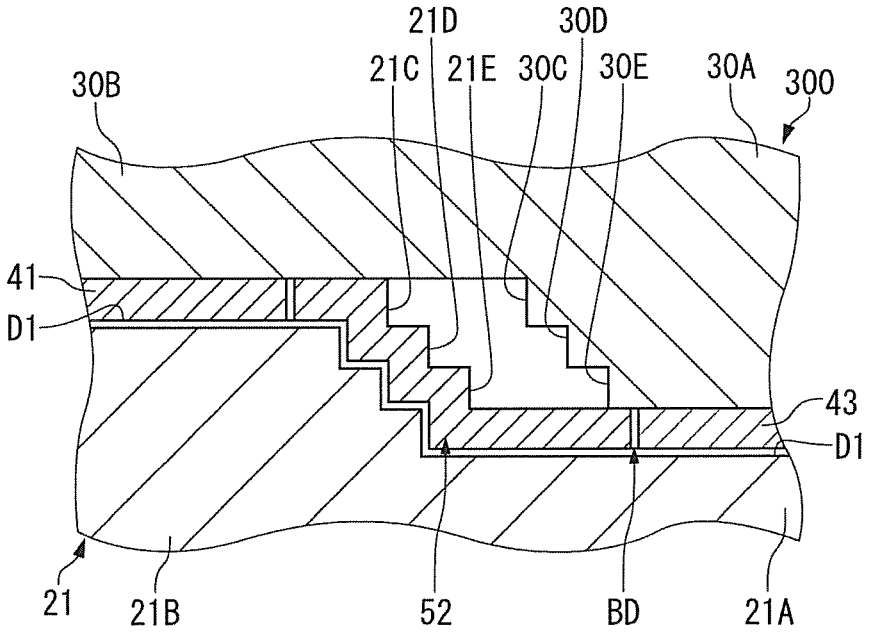
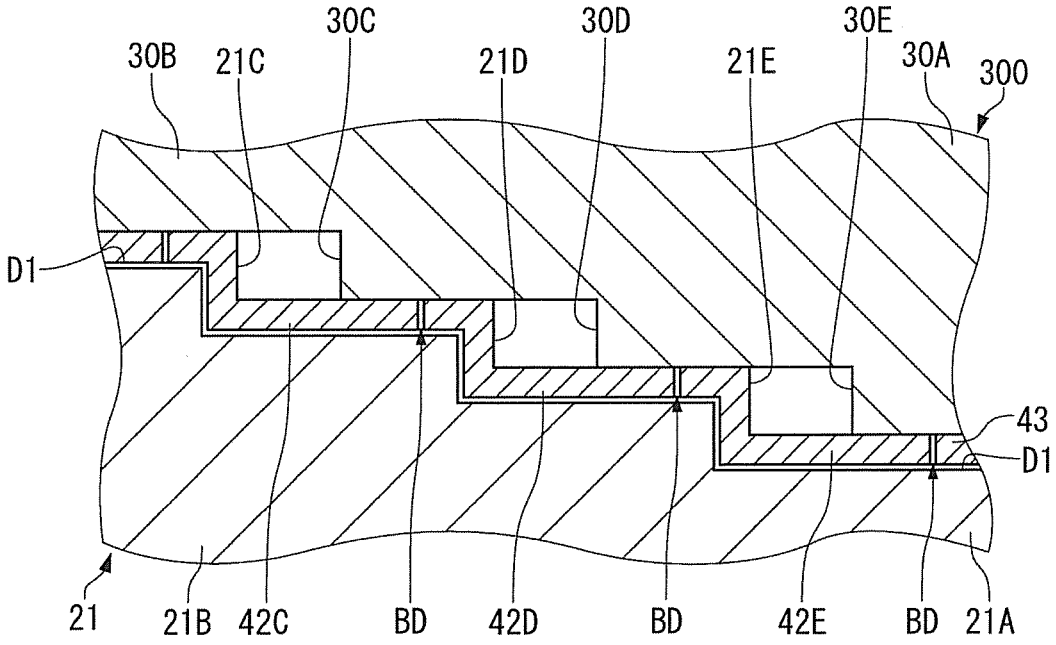


FIG. 10B



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/005068

A. CLASSIFICATION OF SUBJECT MATTER
F04C18/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04C18/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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.
A	JP 2002-303281 A (Mitsubishi Heavy Industries, Ltd.), 18 October 2002 (18.10.2002), paragraphs [0081] to [0084]; fig. 13 & US 2002/0054821 A1 & US 2003/0194341 A1 & EP 1205665 A2 & KR 10-2002-0035450 A & CN 1353247 A & CN 1673543 A	1-6
A	JP 8-28461 A (Toshiba Corp., Toshiba AVE Co., Ltd.), 30 January 1996 (30.01.1996), paragraph [0021]; fig. 13 (Family: none)	1-6

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

* Special categories of cited documents:
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
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06 November, 2013 (06.11.13)	19 November, 2013 (19.11.13)
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International application No.
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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 2008-163895 A (Mitsubishi Heavy Industries, Ltd.), 17 July 2008 (17.07.2008), paragraphs [0068] to [0070]; fig. 9, 10 & US 2010/0092318 A1 & EP 2055955 A1 & WO 2008/081906 A1 & CN 101449061 A	1-6
A	JP 2006-342776 A (Mitsubishi Heavy Industries, Ltd.), 21 December 2006 (21.12.2006), entire text; all drawings (Family: none)	1-6

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2002303281 A **[0010]**