



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
13.02.2019 Bulletin 2019/07

(51) Int Cl.:
F04C 18/02 ^(2006.01)

(21) Application number: **17827398.3**

(86) International application number:
PCT/JP2017/023425

(22) Date of filing: **26.06.2017**

(87) International publication number:
WO 2018/012268 (18.01.2018 Gazette 2018/03)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **15.07.2016 JP 2016140551**

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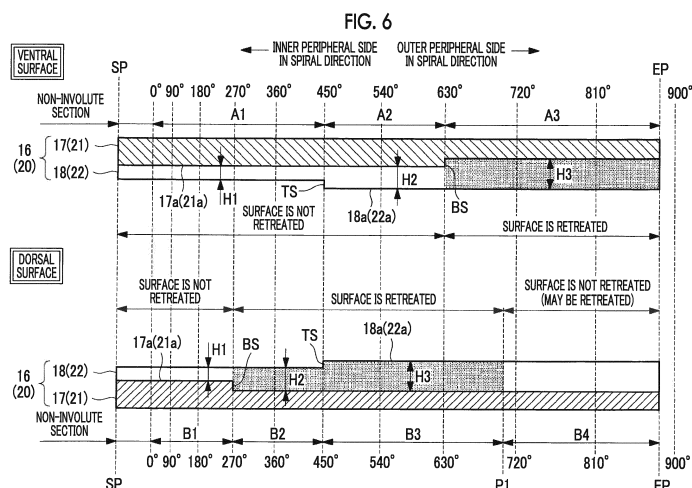
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(54) **STEPPED SCROLL COMPRESSOR AND DESIGN METHOD THEREFOR**

(57) In order to prevent damage to lap walls in a stepped scroll compressor, and to increase durability and reliability, a tooth-base step part (BS), the height of which increases from the outer circumferential side toward the inner circumferential side in the spiral direction of a spiral lap wall (18, 22), is provided on one side surface of an end plate (17, 21) of a fixed scroll (16) and/or a rotating scroll (20). A tooth-tip step part (TS), which becomes lower from the outer circumferential side to the inner circumferential side in the spiral direction, is provided in the

spiral lap wall (18, 22) of the corresponding other scroll (16, 20). Among these spiral lap walls (18, 22), only the ventral surface of the spiral lap wall (18, 22) that is adjacent to the tooth-base surface (17a, 21a) closer to the outer circumferential side in the spiral direction than the tooth-base step part (BS) and is in a range overlapping at least the corresponding spiral lap wall (18, 22) is recessed more toward the inside than the original side-surface profile thereof.



Description

Technical Field

[0001] The present invention relates to a stepped scroll compressor which prevents a damage of a spiral lap wall body and a design method thereof.

Background Art

[0002] In a scroll compressor which compresses a refrigerant, air, or the like, as described in PTL 1 or the like, a stepped scroll compressor is known in which respective step portions are provided at predetermined positions along a spiral direction of a tooth-tip surface and a tooth-base surface of a spiral lap wall body erected on end plates of a fixed scroll and an orbiting scroll, and an outer peripheral-side lap height of each step portion is higher than an inner peripheral-side lap height.

[0003] Compared to a non-stepped scroll compressor, in the stepped scroll compressor, in order to three-dimensionally compress a compression target fluid in both a circumferential direction and a height direction of the spiral lap wall body, it is possible to increase a compression ratio without increasing the number of turns of the spiral lap wall body.

[0004] Accordingly, it is possible to increase a designed volume ratio without increasing an outer diameter of the scroll compressor, and it is possible to decrease a size and weight of the scroll compressor.

[0005] PTL 1 discloses that, in the stepped scroll compressor, a thin wall portion is formed on a side surface of the spiral lap wall body in the vicinities of the step portions formed on bottom surfaces of the end plates of the fixed scroll and the orbiting scroll. The thin wall portion is formed, and thus, it is possible to eliminate a noise generated by the spiral lap wall body of the corresponding scroll interfering with burr which easily occurs when the stepped portion on the bottom surface of the end plate is processed.

Citation List

Patent Literature

[0006] [PTL 1] Japanese Unexamined Patent Application Publication No. 2007-224775

Summary of Invention

Technical Problem

[0007] Another problem in the above-described stepped scroll compressor is a damage on the spiral lap wall body in an outer peripheral-side section of the spiral lap wall body, that is, a section in which the lap height is high.

[0008] In the stepped scroll compressor, the lap height

of the spiral lap wall body decreases from an outer peripheral side toward an inner peripheral side stepwise. Meanwhile, it is possible to increase the compression ratio by increasing a difference in elevation between the outermost peripheral-side section and the inner peripheral-side section.

[0009] Accordingly, in the outermost peripheral-side section, the lap height of the spiral lap wall body tends to be designed to be higher than the lap height of the spiral lap wall body in the non-stepped scroll compressor.

[0010] If the lap height of the spiral lap wall body increases, when the spiral lap wall body comes into contact with the corresponding spiral lap wall body, bending stress applied to a root of a lap increases, and thus, the spiral lap wall body is likely to be damaged.

[0011] In the stepped scroll compressor disclosed in PTL 1, in order to prevent the noise, the thin wall portion is formed on the side surface of the spiral lap wall body in the vicinity of the step portion formed on the bottom surface of the scroll end plate. However, if the spiral lap wall bodies come into contact with each other on an outer peripheral side of a region in which the thin wall portion is formed, there is a risk that the spiral lap wall body is damaged.

[0012] The present invention is made to solve the above-described problems, and an object thereof is to provide a stepped scroll compressor capable of preventing the damage of the spiral lap wall body in the stepped scroll compressor, increasing durability and reliability, and minimizing a compression leakage to prevent a decrease in compression performance, and a design method thereof.

Solution to Problem

[0013] According to a first aspect of the present invention, there is provided a stepped scroll compressor, in which a fixed scroll and an orbiting scroll which respectively have spiral lap wall bodies erected on one surface of each end plate form a pair of compression chambers which compresses a compression target fluid by causing the spiral lap wall bodies to mesh with each other, a tooth-base step portion, in which a height of a tooth-base surface increases from an outer peripheral side toward an inner peripheral side in a spiral direction of the spiral lap wall body, is provided on the one surface of the end plate of at least one of the fixed scroll and the orbiting scroll, a tooth-tip step portion, in which a height of a tooth-tip surface decreases from the outer peripheral side toward the inner peripheral side in the spiral direction, is provided in the spiral lap wall body of the other scroll corresponding to the tooth-base step portion, and in at least one of the fixed scroll and the orbiting scroll, only a ventral surface of the spiral lap wall body which is adjacent to the tooth-base surface on the outer peripheral side in the spiral direction from the tooth-base step portion and is within a range of overlapping at least the corresponding spiral lap wall body is retreated inward from an original side surface

profile.

[0014] According to a second aspect of the present invention, there is provided a design method of a stepped scroll compressor, in which a fixed scroll and an orbiting scroll which respectively have spiral lap wall bodies erected on one surface of each end plate form a pair of compression chambers which compresses a compression target fluid by causing the spiral lap wall bodies to mesh with each other, a tooth-base step portion, in which a height of a tooth-base surface increases from an outer peripheral side toward an inner peripheral side in a spiral direction of the spiral lap wall body, is provided on the one surface of the end plate of at least one of the fixed scroll and the orbiting scroll, a tooth-tip step portion, in which a height of a tooth-tip surface decreases from the outer peripheral side toward the inner peripheral side in the spiral direction, is provided in the spiral lap wall body of the other scroll corresponding to the tooth-base step portion, and in at least one of the fixed scroll and the orbiting scroll, only a ventral surface and a dorsal surface of the spiral lap wall body which are adjacent to the tooth-base surface on the outer peripheral side in the spiral direction from the tooth-base step portion are retreated inward from original side surface profiles thereof.

[0015] According to the stepped scroll compressor and the design method, only a section in which a lap height of the spiral lap wall body is highest, that is, only the ventral surface of the spiral lap wall body adjacent to the tooth-base surface on the outer peripheral side in the spiral direction from the tooth-base step portion is retreated inward from the original side surface profile.

[0016] Accordingly, in the section on the outmost peripheral side in the spiral direction in which the lap height is highest and a risk of damage is large, the spiral lap wall bodies of the fixed scroll and the orbiting scroll do not come into contact with each other, and it is possible to prevent a damage caused by a contact between the spiral lap wall bodies in advance.

[0017] An amount by which the ventral surface of the spiral lap wall body is retracted inward is set to the extent that it does not adversely affect the compression of the compression target fluid, for example, approximately 100 μm or less. Accordingly, a compression leakage of the stepped scroll compressor is minimized, a decrease in compression performance is prevented, a damage of the spiral lap wall body is prevented, and it is possible to increase durability and reliability of the stepped scroll compressor.

[0018] In the stepped scroll compressor according to the first aspect of the present invention and the design method of a stepped scroll compressor according to the second aspect of the present invention, in the spiral lap wall body, a spiral length of a section on the inner peripheral side in the spiral direction from the tooth-tip step portion except for a non-involute section may be less than 360° .

[0019] In other words, in a case where the spiral length of the section on the inner peripheral side in the spiral

direction from the tooth-tip step portion is less than 360° , it is preferable to apply the stepped scroll compressor according to the first aspect of the present invention and the design method of a stepped scroll compressor according to the second aspect of the present invention.

[0020] According to this configuration, in the section on the inner peripheral side in the spiral direction from the tooth-base step portion, the ventral surface and the dorsal surface of the spiral lap wall body are not retreated inward and the original side surface profiles are maintained.

[0021] Here, even when the spiral length of the section on the inner peripheral side in the spiral direction from the tooth-tip step portion is less than 360° , if the section between the tooth-tip step portion and the tooth-base step portion is combined, the spiral length exceeds 360° .

[0022] Accordingly, when the stepped scroll compressor is operated, in any one of the section on the inner peripheral side in the spiral direction and the section continuous to the outer peripheral side in the spiral direction, the spiral lap wall bodies come into two-contact with each other, and thus, an orbiting trajectory of the orbiting scroll with respect to the fixed scroll is determined.

[0023] Accordingly, in the section on the outer peripheral side in the spiral direction from the tooth-base step portion, that is, in the section in which the lap height of the spiral lap wall body is highest, even when both the inner side surface and the outer side surface of the spiral lap wall body are retreated inward, the orbiting scroll is not moved in the plane direction of the end plate by the retreated amount, and it is possible to prevent the damage caused by the contact between the spiral lap wall bodies.

[0024] According to a third aspect of the present invention, there is provided a stepped scroll compressor, in which a fixed scroll and an orbiting scroll which respectively have spiral lap wall bodies erected on one surface of each end plate form a pair of compression chambers which compresses a compression target fluid by causing the spiral lap wall bodies to mesh with each other, a tooth-base step portion, in which a height of a tooth-base surface increases from an outer peripheral side toward an inner peripheral side in a spiral direction of the spiral lap wall body, is provided on the one surface of the end plate of at least one of the fixed scroll and the orbiting scroll, a tooth-tip step portion, in which a height of a tooth-tip surface decreases from the outer peripheral side toward the inner peripheral side in the spiral direction, is provided in the spiral lap wall body of the other scroll corresponding to the tooth-base step portion, and in at least one of the fixed scroll and the orbiting scroll, only a ventral surface and a dorsal surface of the spiral lap wall body which are adjacent to the tooth-base surface on the outer peripheral side in the spiral direction from the tooth-base step portion are retreated inward from original side surface profiles thereof.

[0025] According to a fourth aspect of the present invention, there is provided a design method of a stepped

scroll compressor, in which a fixed scroll and an orbiting scroll which respectively have spiral lap wall bodies erected on one surface of each end plate form a pair of compression chambers which compresses a compression target fluid by causing the spiral lap wall bodies to mesh with each other, a tooth-base step portion, in which a height of a tooth-base surface increases from an outer peripheral side toward an inner peripheral side in a spiral direction of the spiral lap wall body, is provided on the one surface of the end plate of at least one of the fixed scroll and the orbiting scroll, a tooth-tip step portion, in which a height of a tooth-tip surface decreases from the outer peripheral side toward the inner peripheral side in the spiral direction, is provided in the spiral lap wall body of the other scroll corresponding to the tooth-base step portion, and in at least one of the fixed scroll and the orbiting scroll, a ventral surface and a dorsal surface of the spiral lap wall body which are adjacent to the tooth-base surface on the outer peripheral side in the spiral direction from the tooth-base step portion are retreated inward from original side surface profiles thereof.

[0026] According to the stepped scroll compressor and the design method, in the section in which the lap height of the spiral lap wall body is high, that is, in the range which is adjacent to the tooth-base surface on the outer peripheral side in the spiral direction from the tooth-base step portion and overlaps at least the corresponding spiral lap wall body, the ventral surface and the dorsal surface of the spiral lap wall body are retreated inward from the original side surface profiles.

[0027] Accordingly, in the section on the outer peripheral side in the spiral direction in which the lap height is high, the spiral lap wall bodies of the fixed scroll and the orbiting scroll do not come into contact with each other, and it is possible to prevent a damage caused by a contact between the spiral lap wall bodies in advance.

[0028] An amount by which each of the ventral surface and the dorsal surface of the spiral lap wall body is retracted inward is set to the extent that it does not adversely affect the compression of the compression target fluid, for example, approximately 100 μm or less. Accordingly, the compression leakage of the stepped scroll compressor is minimized, the decrease in the compression performance is prevented, the damage of the spiral lap wall body is prevented, and it is possible to increase durability and reliability of the stepped scroll compressor.

[0029] In the stepped scroll compressor according to the third aspect of the present invention and the design method of a stepped scroll compressor according to the fourth aspect of the present invention, in the spiral lap wall body, a spiral length of a section on the inner peripheral side in the spiral direction from the tooth-tip step portion except for a non-involute section may be 360° or more.

[0030] In other words, in a case where the spiral length of the section on the inner peripheral side in the spiral direction from the tooth-tip step portion is 360° or more, it is preferable to apply the stepped scroll compressor

according to the third aspect of the present invention and the design method of a stepped scroll compressor according to the fourth aspect of the present invention.

[0031] According to this configuration, the spiral length of the section on the inner peripheral side in the spiral direction from the tooth-tip step portion except for the non-involute section is 360° or more, and in this section, the ventral surface and the dorsal surface of the spiral lap wall body are not retreated inward and the original side surface profiles are maintained.

[0032] Accordingly, when the stepped scroll compressor is operated, the spiral lap wall bodies come into two-point contact with each other in only the section on the inner peripheral side in the spiral direction, and thus, the orbiting trajectory of the orbiting scroll with respect to the fixed scroll is determined.

[0033] Therefore, in the section on the outer peripheral side in the spiral direction from the tooth-base step portion, even when the ventral surface and the dorsal surface of the spiral lap wall body are retreated inward, the orbiting scroll does not move in a plane direction of the end plate by the retreated amount, and thus, it is possible to prevent the damage caused by the contact between the spiral lap wall bodies.

[0034] An amount by which each of the ventral surface and the dorsal surface of the spiral lap wall body is retracted inward is set to the extent that it does not adversely affect the compression of the compression target fluid, for example, approximately 100 μm or less. Accordingly, the compression leakage of the stepped scroll compressor is minimized, the decrease in the compression performance is prevented, the damage of the spiral lap wall body is prevented, and it is possible to increase durability and reliability of the stepped scroll compressor.

[0035] In the configuration, preferably, in a case where a maximum amount of a retreat amount of each of the ventral surface and the dorsal surface of the spiral lap wall body is defined as δ and an orbiting radius of the orbiting scroll is defined as ρ , the maximum amount δ of the retreat amount is set such that a range of $\delta/\rho \leq 0.01$ is satisfied.

[0036] In this way, if the maximum amount of the retreat amount is determined, in the stepped scroll compressor having various sizes, it is possible to achieve both prevention of the damage of the spiral lap wall body and prevention of the decrease in performance caused by the compression leakage.

[0037] In the configuration, at a position of the tooth-base step portion, a retreat amount of each of the ventral surface and the dorsal surface of the spiral lap wall body may gradually decrease from the outer peripheral side toward the inner peripheral side in the spiral direction. Accordingly, it is possible to prevent occurrence of noise caused by an interference of the spiral lap wall body of the corresponding scroll with a burr which is likely to occur when the tooth-base step portion in the end plate is processed.

[0038] In the configuration, a retreat amount of each

of the ventral surface and the dorsal surface of the spiral lap wall body may increase from a root side of the spiral lap wall body toward a tip side thereof. Accordingly, it is possible to prevent the contact between the spiral lap wall bodies on the tip side and the damage of the spiral lap wall body without decreasing a thickness dimension on the root side of the spiral lap wall body and reducing strength thereof.

Advantageous Effects of Invention

[0039] As described above, according to the stepped scroll compressor and the design method of the present invention, the damage of the spiral lap wall body in the section in which the lap height is high is prevented, the durability and reliability increase, the compression leakage is minimized, and it is possible to prevent the decrease in the compression performance.

Brief Description of Drawings

[0040]

Fig. 1 is a longitudinal sectional view of a stepped scroll compressor according to an embodiment of the present invention.

Fig. 2 is a longitudinal sectional view of a fixed scroll according to a first embodiment of the present invention.

Fig. 3 is a bottom view of the fixed scroll when viewed from an arrow III-III of Fig. 2.

Fig. 4 is a conceptual perspective view of the fixed scroll.

Fig. 5 is a conceptual perspective view of an orbiting scroll.

Fig. 6 is a developed view of a spiral lap wall body in the fixed scroll and the orbiting scroll showing the first embodiment of the present invention.

Fig. 7 is a longitudinal sectional view showing an aspect in which a side of the spiral lap wall body is retreated.

Fig. 8 is a longitudinal sectional view showing an aspect in which the side of the spiral lap wall body is retreated.

Fig. 9 is a longitudinal sectional view of a fixed scroll according to a second embodiment of the present invention.

Fig. 10 is a bottom view of the fixed scroll when viewed from an arrow X-X of Fig. 9.

Fig. 11 is a view when the fixed scroll and an orbiting scroll in the second embodiment are combined with each other.

Fig. 12 is a developed view of a spiral lap wall body in the fixed scroll and the orbiting scroll showing the second embodiment of the present invention.

Fig. 13 is a partial plan view around a tooth-base step portion.

Description of Embodiments

[0041] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

[0042] Fig. 1 is a longitudinal sectional view of a stepped scroll compressor according to an embodiment of the present invention. For example, the stepped scroll compressor 1 is a hermetic electric scroll compressor for a hydrofluorocarbon (HFC) refrigerant. However, the present invention is not limited to this type of scroll compressor.

[0043] The stepped scroll compressor 1 includes a tubular bottomed steel hermetic housing 2 which is long in an up-down direction. A scroll compression mechanism 3 is installed in an upper portion inside the hermetic housing 2, and an electric motor 4 is installed in a lower portion thereof.

[0044] In the hermetic housing 2, a portion above a partition member 30 provided above the scroll compression mechanism 3 becomes a discharge chamber 5 to which a high-pressure gas compressed by the scroll compression mechanism 3 is discharged, and a discharge pipe 6 is connected to the discharge chamber 5. In addition, a portion below the partition member 30 and the scroll compression mechanism 3 becomes a suction chamber 7 into which a low-pressure suction gas is sucked, and a suction pipe 8 is connected to the suction chamber 7. The electric motor 4 including a stator 9 and a rotor 10 is installed on the suction chamber 7 side in the hermetic housing 2 by press-fitting or the like, and a crank shaft 11 connected to the rotor 10 of the electric motor 4 extends in the up-down direction.

[0045] A lower end portion of the crank shaft 11 is supported by a lower bearing 12 provided in the hermetic housing 2, and an upper portion of the crank shaft 11 is rotatably supported by a journal bearing portion 15B of an upper bearing member 15. In addition, the scroll compression mechanism 3 is fixed in the hermetic housing 2 via the upper bearing member 15. The scroll compression mechanism 3 is configured to include a fixed scroll 16 which is fixed to the upper bearing member 15 and an orbiting scroll 20 which is supported on the upper bearing member 15 so as to be orbited revolvingly with respect to the fixed scroll.

[0046] As shown in Figs. 2 to 4, the fixed scroll 16 includes a fixed end plate 17 (end plate) which is fixed to the hermetic housing 2 and a spiral fixed lap wall body 18 (spiral lap wall body) which is erected on one surface of the fixed end plate 17, and a discharge port 19 is provided at a center portion of the fixed end plate 17. In addition, as shown in Figs. 1 and 5, the orbiting scroll 20 includes an orbiting end plate 21 (end plate) and a spiral orbiting lap wall body 22 (spiral lap wall body) which is erected on one surface of the orbiting end plate 21, and an orbiting boss portion 23 is integrally formed on a rear surface side of the orbiting end plate 21.

[0047] In the orbiting scroll 20, the rear surface of the orbiting end plate 21 is supported on a thrust bearing

portion 15A of the upper bearing member 15, a crank pin 11A installed on an upper end of the crank shaft 11 so as to have an eccentricity ρ is connected to the orbiting boss portion 23 via a drive bush 25 and an orbiting bearing 26 constituting a known driven crank mechanism, and thus, the orbiting scroll 20 is configured to be capable of revolving and orbiting around the fixed scroll 16. The eccentricity ρ of the crank pin 11A is an orbiting radius of the orbiting scroll 20 with respect to the fixed scroll 16.

[0048] In the fixed end plate 17 of the fixed scroll 16 and the orbiting end plate 21 of the orbiting scroll 20, tooth-base step portions BS are provided, in which heights of respective tooth-base surfaces 17a and 21a increase one step from an outer peripheral side toward an inner peripheral side in a spiral direction of each of the lap wall bodies 18 and 22. Corresponding to the tooth-base step portions BS, tooth-tip step portions TS in which heights of tooth-tip surfaces 18a and 22a decrease from the outer peripheral side toward the inner peripheral side in the spiral direction are formed on the lap wall bodies 18 and 22 of other scrolls 16 and 20.

[0049] In the fixed scroll 16 and the orbiting scroll 20, the fixed lap wall body 18 and the orbiting lap wall body 22 are shifted in phase by 180° and mesh with each other in a known manner, and thus, a pair of compression chambers 24 is formed between both the lap wall bodies 18 and 22. The pair of compression chambers 24 is configured so as to perform a compressing action by moving the orbiting scroll 20 while a volume is decreased from an outer peripheral position to a central portion as the orbiting scroll 20 is revolved and orbited.

[0050] An axial height of the crank shaft 11 on an outer peripheral side of each of the lap wall bodies 18 and 22 is higher than that on an inner peripheral side, and thus, the compression chambers 24 configure a three-dimensionally compressible scroll compression mechanism 3 in which a gas can be compressed in both a circumferential direction and a height direction of each of the lap wall bodies 18 and 22. Tip seals 18b and 22b (refer to Fig. 5) for sealing a portion between the tooth-tip surfaces 18a and 22a of the respective lap wall bodies 18 and 22 and the tooth-base surfaces 17a and 21a of the other scrolls are fitted to grooves provided on the tooth-tip surfaces 18a and 18b.

[0051] Rotation prevention means 27 including Oldham ring or the like for preventing a rotation of the orbiting scroll 20 is incorporated into a portion between the rear surface of the orbiting end plate 21 of the orbiting scroll 20 and the thrust bearing portion 15A of the upper bearing member 15. In the fixed end plate 17 of the fixed scroll 16, a discharge cover 28 is provided on the rear surface side of the fixed end plate 17, and a reed valve type discharge valve 29 for opening and closing the discharge port 19 is provided.

[0052] In the stepped scroll compressor 1 having the above-described configuration, if the electric motor 4 is driven, a low-pressure refrigerant gas (HFC refrigerant) is sucked into the hermetic housing 2 via the suction pipe

8, and the refrigerant gas is sucked into the compression chamber 24 of the scroll compression mechanism 3 via a refrigerant flow path provided in the upper bearing member 15 or the like. The refrigerant gas sucked into the compression chamber 24 is compressed to a high-temperature and high-pressure gas while the orbiting scroll 20 is revolved and orbited around the fixed scroll 16 and the compression chamber 24 is moved while decreasing a volume from an outer peripheral position to a center side. The compressed refrigerant gas flows into the discharge chamber 5 by opening a discharge valve 29 and is supplied from the discharge pipe 6 to a heat exchanger such as a condenser or the like via an external pipe.

[First Embodiment]

[0053] Next, a first embodiment of the present invention will be described.

[0054] Fig. 6 is a developed view of the spiral lap wall bodies 18 and 22 in the fixed scroll 16 and the orbiting scroll 20 showing the first embodiment of the present invention. Angular numerical values shown in Fig. 6 correspond to the positions of the same numerical values in the fixed lap wall body 18 and the orbiting lap wall body 22 shown in Fig. 3, respectively.

[0055] In each of the lap wall bodies 18 and 22, a surface on a radially inner side thereof is referred to a "ventral surface", and a surface on a radially outer side thereof is referred to as a "dorsal surface".

[0056] The ventral surface of each of the lap wall bodies 18 and 22 can be divided into three sections such as a non-involute section from a starting point SP to 0° , a section A1 from 0° to 450° , a section A2 from 450° to 630° , and a section A3 from 630° to an end point EP before 900° along a circumferential direction thereof. In the three sections A1, A2, and A3, lap heights of tooth-base surfaces 17a and 21a to tooth-tip surfaces 18a and 22a are respectively defined as H1, H2, and H3, and a magnitude relationship thereof is $H1 < H2 < H3$.

[0057] The dorsal surface of each of the lap wall bodies 18 and 22 can be divided into four sections such as a non-involute section from a starting point SP to 0° , a section B1 from 0° to 270° , a section B2 from 270° to 450° , and a section B3 from 450° to a point P1 before 720° , and a section B4 from the point P1 to an end point EP before 900° along a circumferential direction thereof. The ventral surfaces of the corresponding lap wall bodies do not overlap each other in the section B4. In the four sections B1, B2, B3, and B4, lap heights of the tooth-base surfaces 17a and 21a to the tooth-tip surfaces 18a and 22a are respectively defined as H1, H2, and H3, and a magnitude relationship thereof is $H1 < H2 < H3$.

[0058] In the fixed lap wall body 18 and the orbiting lap wall body 22, an effective spiral length of a section on an inner peripheral side in the spiral direction from the tooth-tip step portion TS, that is, a spiral length of the section A1 on the ventral surface except for the non-involute sec-

tion from the starting point SP to 0° or a spiral length of the section B1 + B2 on the dorsal surface except for the non-involute section is 360° or more. That is, when the fixed lap wall body 18 and the orbiting lap wall body 22 are combined with each other, the section A1 on the ventral surface and the section B1 + B2 on the dorsal surface of both the lap wall bodies 18 and 22 overlap each other by one or more laps in the spiral direction.

[0059] In each of the lap wall bodies 18 and 22, respective surfaces of the ventral surface-side sections A3 and the dorsal surface-side sections B2 and B3 adjacent to outer peripheral-side tooth-base surfaces 17a and 21a in the spiral direction from the tooth-base step portion BS are slightly inward retreated from surface profiles of an original ventral surface and dorsal surface to an extent that it does not adversely affect compression of a refrigerant which is a compression target fluid. In other words, a thickness of each of the lap wall bodies 18 and 22 becomes thinner than that of the related art. In Fig. 3, a range in which the surface is retracted is indicated by a symbol xxx, and in Fig. 6, a range in which the surface is retracted is shaded.

[0060] In addition, the dorsal surface-side section B4 is retreated inward. However, the corresponding spiral lap wall bodies 18 and 22 do not overlap this surface (there is no concern of contact), and thus, the surface may be not retreated.

[0061] In a case where a maximum amount of a retreat amount is defined as δ and an orbiting radius of the orbiting scroll 20 is p , the retreat amount is set such that a range of $\delta/p \leq 0.01$ is satisfied. As a specific value, for example, the retreat amount is 100 μm or less, and preferably, approximately 10 to 20 μm . As a method of retracting the surface, it is conceivable to manufacture the lap wall bodies 18 and 22 with a retracted shape from the beginning, or to post-process the lap wall bodies 18 and 22 which are not retracted. As a method of post-processing, a mechanical method such as polishing and cutting, or a chemical method such as etching can be considered.

[0062] The fixed scroll 16 and the orbiting scroll 20 are configured as described above. Accordingly, in the sections in which the lap heights of the lap wall bodies 18 and 22 increase, that is, in the section A3 (ventral surface side) and the sections B2 and B3 (dorsal surface side) on the outer peripheral side in the spiral direction from the tooth-base step portion BS, both surface of the lap wall bodies 18 and 22 are retreated inward from the surface profile of the original ventral surface, and thus, in the sections on the outer peripheral side in the spiral direction in which the lap heights H2 and H3 increases, the fixed lap wall body 18 and the orbiting lap wall body 22 do not contact with each other. Accordingly, a damage caused by contact between the lap wall bodies 18 and 22 can be prevented in advance.

[0063] In the above-described configuration, the spiral length in the section A1 (ventral surface side) and the sections B1 and B2 (dorsal surface side) on the inner

peripheral side in the spiral direction from the tooth-tip step portion TS is 360° or more, and in the sections, both surface of the ventral surface and the dorsal surface of each of the lap wall bodies 18 and 22 are not retreated inward and the original side surface profiles are maintained.

[0064] Accordingly, when the stepped scroll compressor 1 is operated, the lap wall bodies 18 and 22 come into two-point contact with each other in only the sections A1, B1, and B2 on the inner peripheral side in the spiral direction, and thus, an orbiting trajectory of the orbiting scroll 20 with respect to the fixed scroll 16 is determined.

[0065] Therefore, in the sections A3, B2, and B3 on the outer peripheral side in the spiral direction from the tooth-base step portion BS, even when the ventral surface and the dorsal surface of each of the lap wall bodies 18 and 22 are retreated inward, the orbiting scroll 20 does not move in a plane direction of the end plate 21 by the retreated amount, and thus, it is possible to prevent the damage caused by the contact between the lap wall bodies 18 and 22.

[0066] The amount by which the ventral surface and the dorsal surface of each of the lap wall bodies 18 and 22 are retracted inward is set to the extent that it does not adversely affect the compression of the refrigerant, for example, approximately 100 μm or less, and thus, a compression leakage of the stepped scroll compressor 1 is minimized, a decrease in compression performance is prevented, damages of the lap wall bodies 18 and 22 are prevented, and it is possible to increase durability and reliability of the stepped scroll compressor 1. In the sections A1 and B1 on the inner peripheral side in the spiral direction in which the compression pressure is the highest, the ventral surface and the dorsal surface of each of the lap wall bodies 18 and 22 are not retreated, a gap is generated between both lap wall bodies 18 and 22, and thus, it is possible to the compression leakage of the refrigerant.

[0067] In the retreat amount of the ventral surface and the dorsal surface of each of the lap wall bodies 18 and 22, in the case where the maximum amount of the retreat amount is defined as δ and the orbiting radius of the orbiting scroll 20 is defined as p , the maximum amount δ is set such that the range of $\delta/p \leq 0.01$ is satisfied. Accordingly, in the stepped scroll compressor having various sizes, it is possible to achieve both prevention of damages of the lap wall bodies 18 and 22, and prevention of the decrease in performance caused by the compression leakage.

[0068] The retreat of each of the ventral surfaces and the dorsal surfaces of the lap wall bodies 18 and 22 does not necessarily have to be performed uniformly over the entire height direction of each of the ventral surface and the dorsal surface. That is, any retreat may be performed as long as the retreat amount increases from a root side of each of the lap wall bodies 18 and 22 toward a tip side thereof. For example, as shown in Fig. 7, a longitudinal sectional shape of each of the lap wall bodies 18 and 22

may be tapered from a root side toward a tip side, or as shown in Fig. 8, a longitudinal sectional shape of each of the lap wall bodies 18 and 22 may be tapered from a root side toward a tip side stepwise.

[0069] Accordingly, it is possible to prevent the contact between the lap wall bodies 18 and 22 on the tip side and the damages of the lap wall bodies 18 and 22 without decreasing a thickness dimension on the root side of each of the lap wall bodies 18 and 22 and reducing strength thereof. If the corresponding fixed lap wall body 18 and the orbiting lap wall body 22 both have the same tapered sectional shape or the same stepped cross sectional shape, the sectional shapes of both lap wall bodies 18 and 22 are equal and opposite to each other, and thus, it is possible to prevent the leakage of the refrigerant by minimizing an intermeshing interval between the wall bodies 18 and 22.

[Second Embodiment]

[0070] Next, a second embodiment of the present invention will be described.

[0071] Fig. 9 is an enlarged longitudinal sectional view of the fixed scroll 16 according to the second embodiment of the present invention, and Fig. 10 is a bottom view of the fixed scroll 16. In addition, Fig. 11 is a view when the fixed scroll and an orbiting scroll are combined with each other. In addition, Fig. 12 is a developed view of spiral lap wall bodies 18 and 22 in the fixed scroll and the orbiting scroll showing the second embodiment of the present invention. In the fixed scroll 16 and the orbiting scroll 20 shown here, only the number of turns (angular numerical value) of each of the lap wall bodies 18 and 22 is different from that of the first embodiment, and the height of each of the lap wall bodies 18 and 22 or the basic structure of each portion is similar to that of the first embodiment. Accordingly, the same reference numerals are assigned to the respective portions having the same configurations, and descriptions thereof are omitted.

[0072] The ventral surface of each of the lap wall bodies 18 and 22 can be divided into three sections such as the non-involute section from the starting point SP to 0°, the section A1 from 0° to the tooth-tip step portion TS (point P1), the section A2 from the tooth-tip step portion TS (P1) to the tooth-base step portion BS (point P2), and the section A3 from the tooth-base step portion BS (P2) to the end point EP along the circumferential direction thereof. In the three sections A1, A2, and A3, the lap heights of the tooth-base surfaces 17a and 21a to the tooth-tip surfaces 18a and 22a are respectively defined as H1, H2, and H3, and the magnitude relationship thereof is $H1 < H2 < H3$.

[0073] The dorsal surface of each of the lap wall bodies 18 and 22 can be divided into three sections such as the non-involute section from the starting point SP to 0°, the section B1 from 0° to the tooth-base step portion BS, the section B2 from the tooth-base step portion BS to the tooth-tip step portion TS (point P1), and the section B3

from the tooth-tip step portion TS (P1) to the end point EP along the circumferential direction thereof. In the three sections B1, B2, and B3, the lap heights of the tooth-base surfaces 17a and 21a to the tooth-tip surfaces 18a and 22a are respectively defined as H1, H2, and H3, and the magnitude relationship thereof is $H1 < H2 < H3$.

[0074] In the fixed lap wall body 18 and the orbiting lap wall body 22, the effective spiral length of the section on the inner peripheral side in the spiral direction from the tooth-tip step portion TS, that is, the spiral length of the section B1 from 0° to the tooth-tip step portion TS except for the non-involute section from the starting point SP to 0° is less than 360°. That is, when the fixed lap wall body 18 and the orbiting lap wall body 22 are combined with each other, a circumferential length in which the sections A1 and B1 + B2 on the inner peripheral side of the lap wall bodies 18 and 22 overlap each other is less than one lap, the total number of turns also decreases, and the orbiting radius ρ of the orbiting scroll is set to be larger by the decrease in the total number of turns.

[0075] In this way, in a case where the spiral length of each of the sections A1 and B1+B2 on the inner peripheral side in the spiral direction from the tooth-tip step portion TS is less than 360°, only the ventral surface of each of the spiral lap wall bodies 18 and 22 adjacent to the tooth-base surfaces 17a and 21a on the outer peripheral side in the spiral direction from the tooth-base step portion BS is retreated slightly inward from the original side surface profile to the extent that it does not adversely affect the compression of the refrigerant. That is, the surface is retreated with respect to the section A3 on the ventral surface side of each of the lap wall bodies 18 and 22. In Fig. 10, a range in which the surface is retracted is indicated by a symbol xxx, and in Fig. 12, a range in which the surface is retracted is shaded. The setting conditions of the retreat amount are similar to those of the first embodiment.

[0076] In this way, in the section in which the lap height of each of the lap wall bodies 18 and 22 is highest, in the section A3 on the outer peripheral side in the spiral direction from the tooth-base step portion BS, the ventral surface of each of the lap wall bodies 18 and 22 is retreated inward from the original side surface profile. Accordingly, in the sections A3 and B3 on the outmost peripheral side in the spiral direction in which the lap height H3 is highest and the risk of the damage is large, the lap wall bodies 18 and 22 do not come into contact with each other, and it is possible to prevent the damage caused by the contact between the lap wall bodies 18 and 22 in advance.

[0077] In the above-described configuration, in the sections A1 + A2 on the inner peripheral side in the spiral direction from the tooth-base step portion BS on the ventral surface side and all sections B1+B2+B3 on the dorsal surface side, the side surface on the spiral lap wall body (18, 22) is not retreated inward and the original side surface profile is maintained.

[0078] In the present embodiment, in the section on

the inner peripheral side in the spiral direction from the tooth-tip step portion TS, that is, the section A1 on the ventral surface side, and the sections B1+B2 on the dorsal surface side, the spiral length is less than 360°. However, on the ventral surface side, if the section A2 between the tooth-tip step portion TS and the tooth-base step portion BS (point P2) is combined, the spiral length exceeds 360°. On the dorsal surface side, if the section from the point P1 to the point P2 in the section B3 is combined, the spiral length exceeds 360° (also refer to Fig. 11).

[0079] Accordingly, as shown in Fig. 11, when the stepped scroll compressor 1 is operated, the sections (shaded range) from 0° to the point P2 in the respective lap wall bodies 18 and 22 exceed 360°, the lap wall bodies 18 and 22 come into contact with each other at two points of T1 and T2 at the position of any one of both sections, and thus, the orbiting trajectory of the orbiting scroll 20 with respect to the fixed scroll 16 is defined.

[0080] Accordingly, in the section A3 on the outer peripheral side in the spiral direction from the tooth-base step portion BS, that is, in the section in which the lap height H3 of each of the lap wall bodies 18 and 22 is highest, even when the ventral surface of each of the lap wall bodies 18 and 22 is retreated inward, the orbiting scroll 20 is not moved in the plane direction of the end plate 21 by the retreated amount, and it is possible to prevent the damage caused by the contact between the lap wall bodies 18 and 22.

[0081] According to the present configuration and the design method, in the entire circumference of each of the lap wall bodies 18 and 22, only the ventral surface side in the section A3 on the outermost peripheral side having the highest lap height is retreated, and in other sections A1 and A2 and the sections B1, B2, and B3 on the dorsal side, both the ventral surface side and the dorsal surface side are not retreated. Accordingly, compared to the configuration of the first embodiment, the compression leakage of the refrigerant can be suppressed, and particularly, it is possible to prevent a decrease in compression efficiency in the stepped scroll compressor having the small number of turns of each of the lap wall bodies 18 and 22.

[0082] Meanwhile, as shown in Fig. 13, at the position of the tooth-base step portion BS, the retreat amount of the ventral surface of each of the lap wall bodies 18 and 22 may gradually decrease from the outer peripheral side toward the inner peripheral side in the spiral direction. Accordingly, it is possible to prevent occurrence of noise caused by an interference of the lap wall bodies 18 and 22 of the corresponding scrolls 16 and 20 with the burr which is likely to occur when the tooth-base step portion BS in each of the end plates 17 and 21 is processed.

[0083] As described above, according to the stepped scroll compressor and the design method thereof according to the present invention, the damage of the spiral lap wall body in the section in which the lap height is high is prevented, durability and reliability increase, the com-

pression leakage is minimized, and it is possible to prevent the decrease in the compression performance.

[0084] In addition, the present invention is not limited to only the above-described embodiments, appropriate modifications or improvements can be added, and embodiments to which the modifications or the improvements are added are included in the scope of the present invention.

[0085] For example, an internal configuration of the stepped scroll compressor 1, an attitude arrangement such as a vertical type compressor and a horizontal type compressor, a usage thereof, a type of the compression target fluid, detailed shapes of the fixed scroll 16 and the orbiting scroll 20, or the like do not necessarily have to conform to the above-described embodiments.

[0086] In addition, in the present embodiment, the compressor is described in which the tooth-base step portions BS are provided on the tooth-base surfaces 17a and 21a of both the fixed scroll 16 and the orbiting scroll 20 and the tooth-tip step portions TS are provided on the tooth-tip surfaces 18a and 22a of both the fixed scroll 16 and the orbiting scroll 20. However, the present invention can be applied to a compressor in which only the tooth-base step portion BS is provided on one scroll and only the tooth-tip step portion TS is provided on the other scroll.

[0087] In addition, in the present embodiment, the ventral surface or the dorsal surface of each of both the fixed lap wall body 18 of the fixed scroll 16 and the orbiting lap wall body 22 of the orbiting scroll 20 is retreated. However, it is considered that only the lap wall body of either one of the scrolls is retreated. In this case, in either the ventral surface or the dorsal surface of the lap wall body, a contact with the corresponding lap is prevented.

Reference Signs List

[0088]

1:	scroll compressor
16:	fixed scroll
17:	fixed end plate (end plate)
17a, 21a:	tooth-base surface
18:	fixed lap wall body (spiral lap wall body)
18a, 22a:	tooth-tip surface
20:	orbiting scroll
21:	orbiting end plate (end plate)
22:	orbiting lap wall body (spiral lap wall body)
24:	compression chamber
BS:	tooth-base step portion
TS:	tooth-tip step portion
ρ:	orbiting radius of orbiting scroll

Claims

1. A stepped scroll compressor, wherein a fixed scroll and an orbiting scroll which

respectively have spiral lap wall bodies erected on one surface of each end plate form a pair of compression chambers which compresses a compression target fluid by causing the spiral lap wall bodies to mesh with each other,

wherein a tooth-base step portion, in which a height of a tooth-base surface increases from an outer peripheral side toward an inner peripheral side in a spiral direction of the spiral lap wall body, is provided on the one surface of the end plate of at least one of the fixed scroll and the orbiting scroll,

wherein a tooth-tip step portion, in which a height of a tooth-tip surface decreases from the outer peripheral side toward the inner peripheral side in the spiral direction, is provided in the spiral lap wall body of the other scroll corresponding to the tooth-base step portion, and

wherein in at least one of the fixed scroll and the orbiting scroll, only a ventral surface of the spiral lap wall body which is adjacent to the tooth-base surface on the outer peripheral side in the spiral direction from the tooth-base step portion and is within a range of overlapping at least the corresponding spiral lap wall body is retreated inward from an original side surface profile.

2. A stepped scroll compressor,

wherein a fixed scroll and an orbiting scroll which respectively have spiral lap wall bodies erected on one surface of each end plate form a pair of compression chambers which compresses a compression target fluid by causing the spiral lap wall bodies to mesh with each other,

wherein a tooth-base step portion, in which a height of a tooth-base surface increases from an outer peripheral side toward an inner peripheral side in a spiral direction of the spiral lap wall body, is provided on the one surface of the end plate of at least one of the fixed scroll and the orbiting scroll,

wherein a tooth-tip step portion, in which a height of a tooth-tip surface decreases from the outer peripheral side toward the inner peripheral side in the spiral direction, is provided in the spiral lap wall body of the other scroll corresponding to the tooth-base step portion, and

wherein in at least one of the fixed scroll and the orbiting scroll, a ventral surface and a dorsal surface of the spiral lap wall body which are adjacent to the tooth-base surface on the outer peripheral side in the spiral direction from the tooth-base step portion are retreated inward from original side surface profiles thereof.

3. The stepped scroll compressor according to claim 1, wherein in the spiral lap wall body, a spiral length of a section on the inner peripheral side in the spiral direction from the tooth-tip step portion except for a non-involute section is less than 360°.

4. The stepped scroll compressor according to claim 2, wherein in the spiral lap wall body, a spiral length of a section on the inner peripheral side in the spiral direction from the tooth-tip step portion except for a non-involute section is 360° or more.

5. The stepped scroll compressor according to any one of claims 1 to 4, wherein in a case where a maximum amount of a retreat amount of each of the ventral surface and the dorsal surface of the spiral lap wall body is defined as δ and an orbiting radius of the orbiting scroll is defined as ρ , the maximum amount δ of the retreat amount is set such that a range of $\delta/\rho \leq 0.01$ is satisfied.

6. The stepped scroll compressor according to any one of claims 2 to 4, wherein at a position of the tooth-base step portion, a retreat amount of each of the ventral surface and the dorsal surface of the spiral lap wall body gradually decreases from the outer peripheral side toward the inner peripheral side in the spiral direction.

7. The stepped scroll compressor according to any one of claims 1 to 4, wherein a retreat amount of each of the ventral surface and the dorsal surface of the spiral lap wall body increases from a root side of the spiral lap wall body toward a tip side thereof.

8. A design method of a stepped scroll compressor, wherein a fixed scroll and an orbiting scroll which respectively have spiral lap wall bodies erected on one surface of each end plate form a pair of compression chambers which compresses a compression target fluid by causing the spiral lap wall bodies to mesh with each other,

wherein a tooth-base step portion, in which a height of a tooth-base surface increases from an outer peripheral side toward an inner peripheral side in a spiral direction of the spiral lap wall body, is provided on the one surface of the end plate of at least one of the fixed scroll and the orbiting scroll,

wherein a tooth-tip step portion, in which a height of a tooth-tip surface decreases from the outer peripheral side toward the inner peripheral side in the spiral direction, is provided in the spiral lap wall body of the other scroll corresponding to the tooth-base step portion, and

wherein in at least one of the fixed scroll and the orbiting scroll, only a ventral surface of the spiral lap wall body which is adjacent to the tooth-base surface on the outer peripheral side in the spiral direction from the tooth-base step portion and is within a range of overlapping at least the corresponding spiral lap wall body is retreated inward from an original side surface profile.

9. A design method of a stepped scroll compressor, wherein a fixed scroll and an orbiting scroll which respectively have spiral lap wall bodies erected on one surface of each end plate form a pair of compression chambers which compresses a compression target fluid by causing the spiral lap wall bodies to mesh with each other, wherein a tooth-base step portion, in which a height of a tooth-base surface increases from an outer peripheral side toward an inner peripheral side in a spiral direction of the spiral lap wall body, is provided on the one surface of the end plate of at least one of the fixed scroll and the orbiting scroll, wherein a tooth-tip step portion, in which a height of a tooth-tip surface decreases from the outer peripheral side toward the inner peripheral side in the spiral direction, is provided in the spiral lap wall body of the other scroll corresponding to the tooth-base step portion, and wherein in at least one of the fixed scroll and the orbiting scroll, a ventral surface and a dorsal surface of the spiral lap wall body which are adjacent to the tooth-base surface on the outer peripheral side in the spiral direction from the tooth-base step portion are retreated inward from original side surface profiles thereof.
10. The design method of a stepped scroll compressor according to claim 8, wherein in the spiral lap wall body, a spiral length of a section on the inner peripheral side in the spiral direction from the tooth-tip step portion except for a non-involute section is less than 360° .
11. The design method of a stepped scroll compressor according to claim 9, wherein in the spiral lap wall body, a spiral length of a section on the inner peripheral side in the spiral direction from the tooth-tip step portion except for a non-involute section is 360° or more.

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FIG. 1

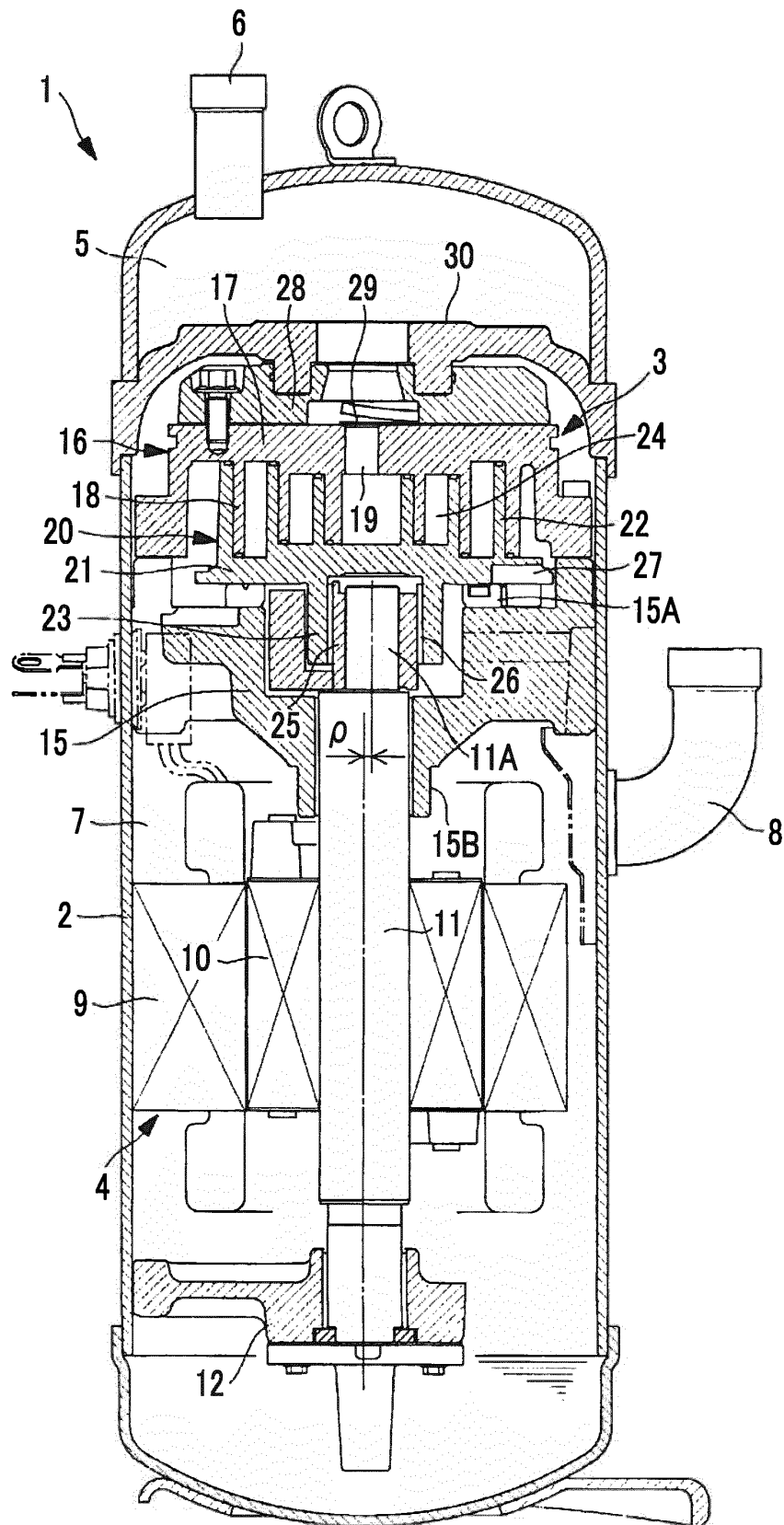


FIG. 2

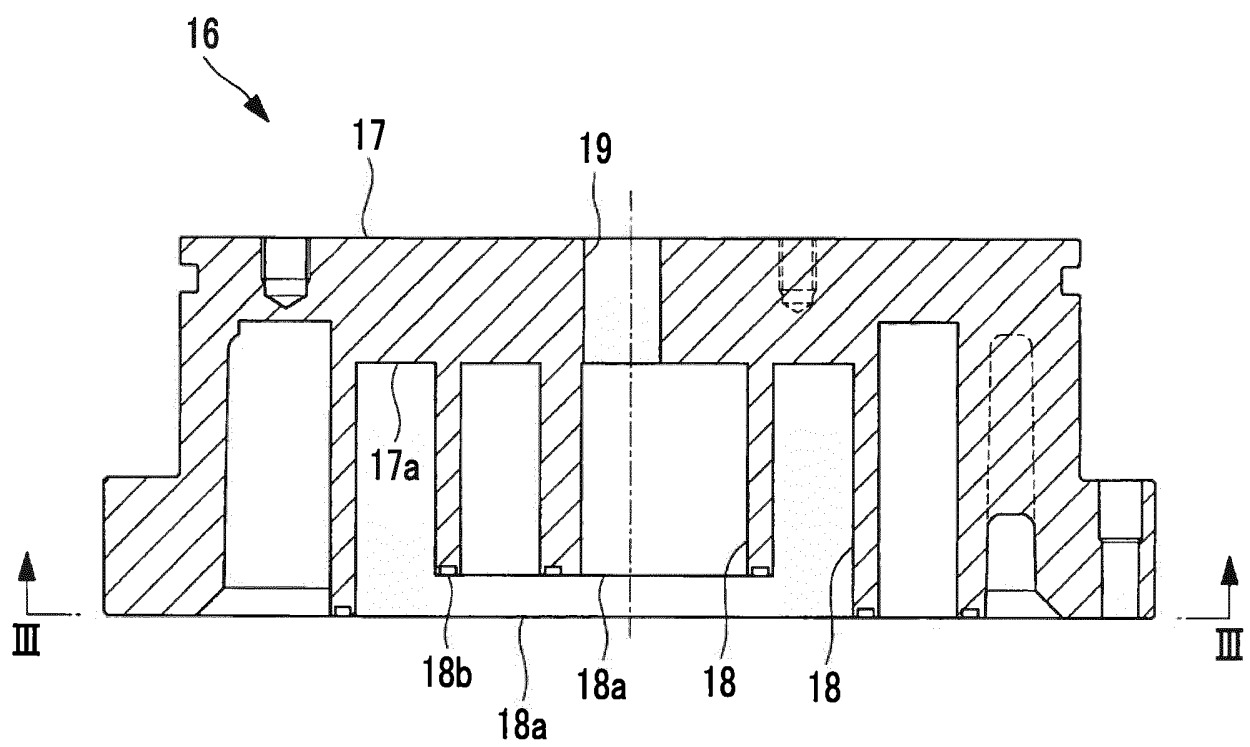


FIG. 3

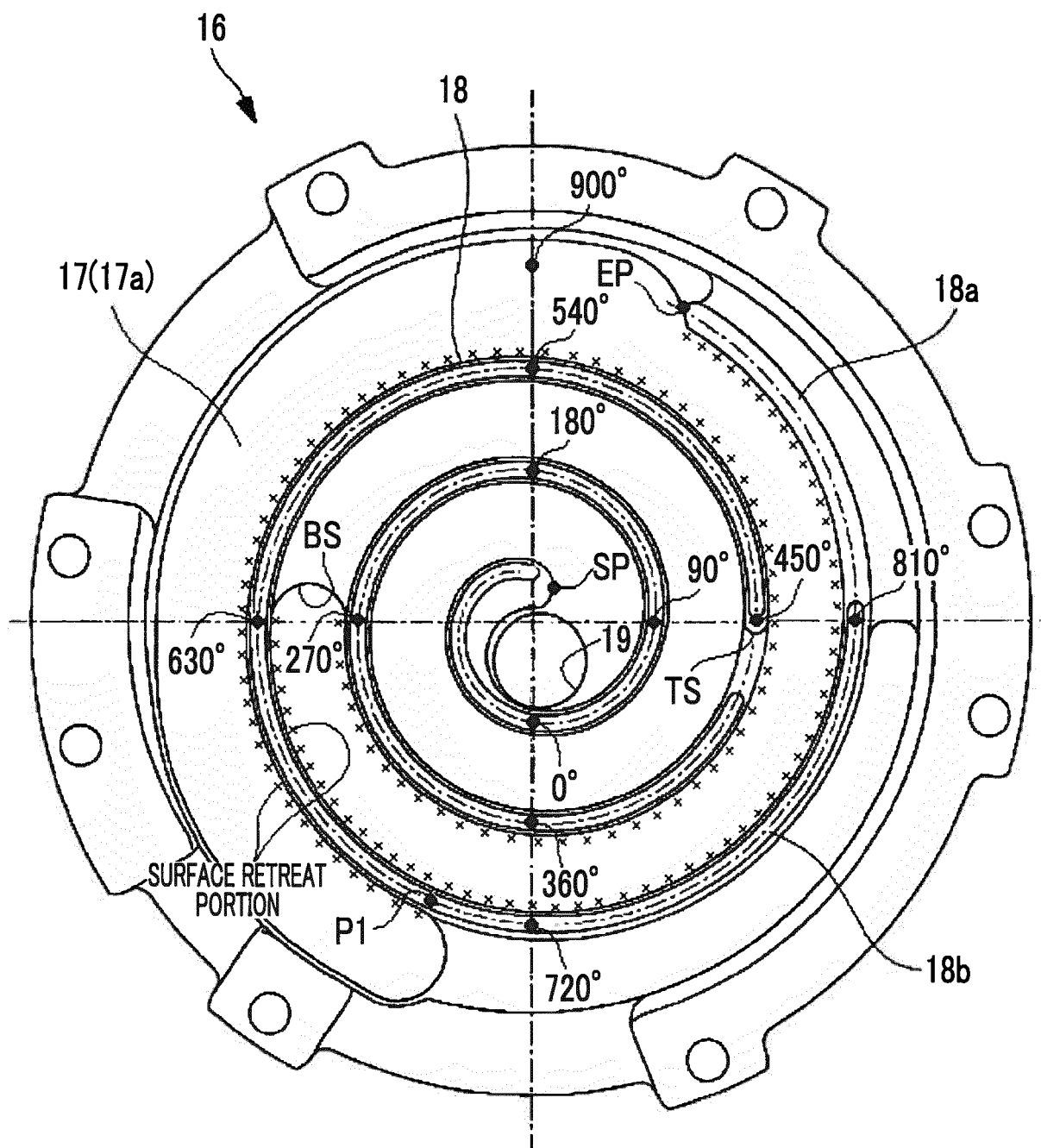


FIG. 4

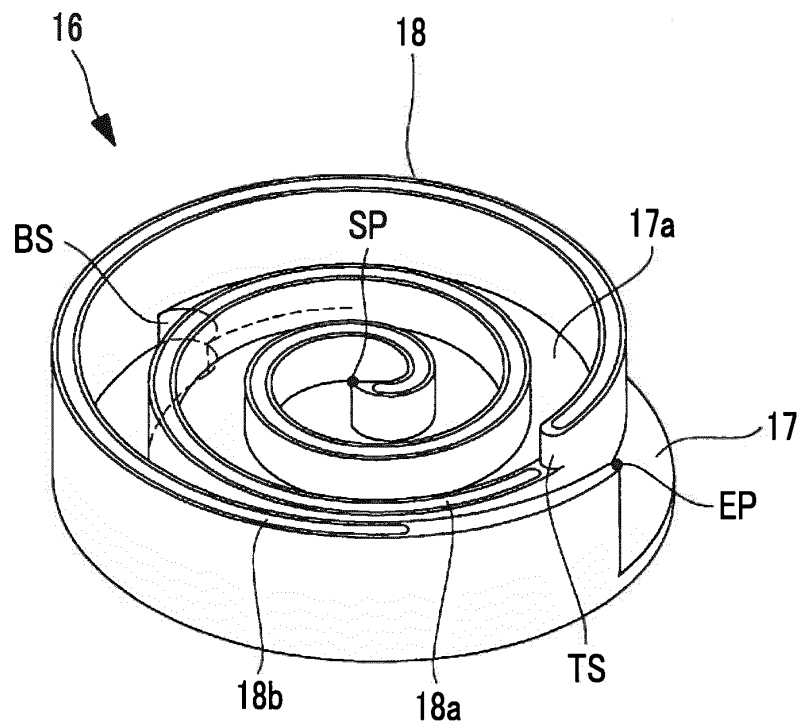


FIG. 5

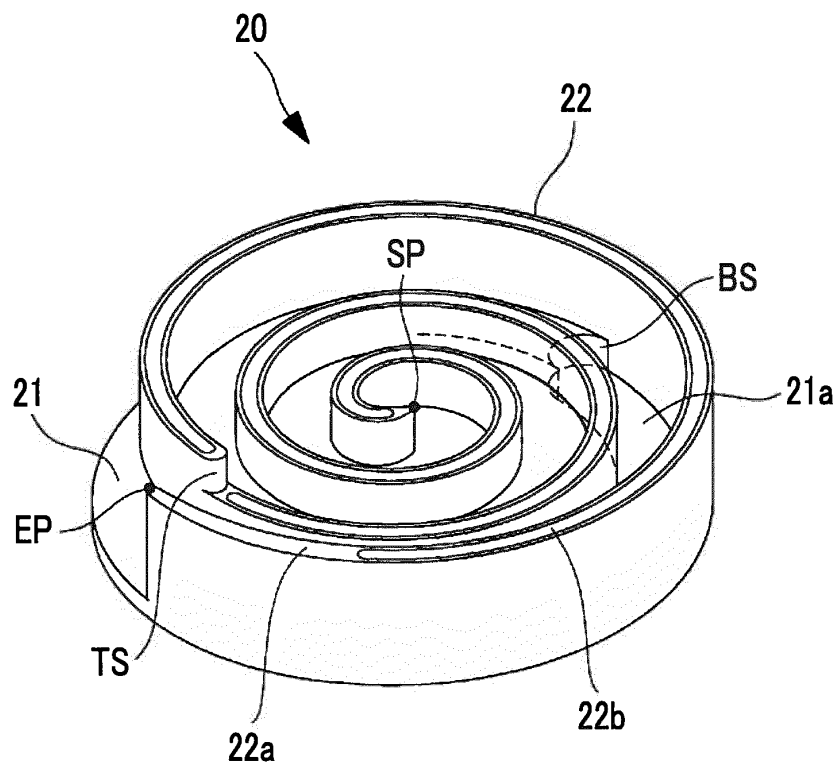


FIG. 6

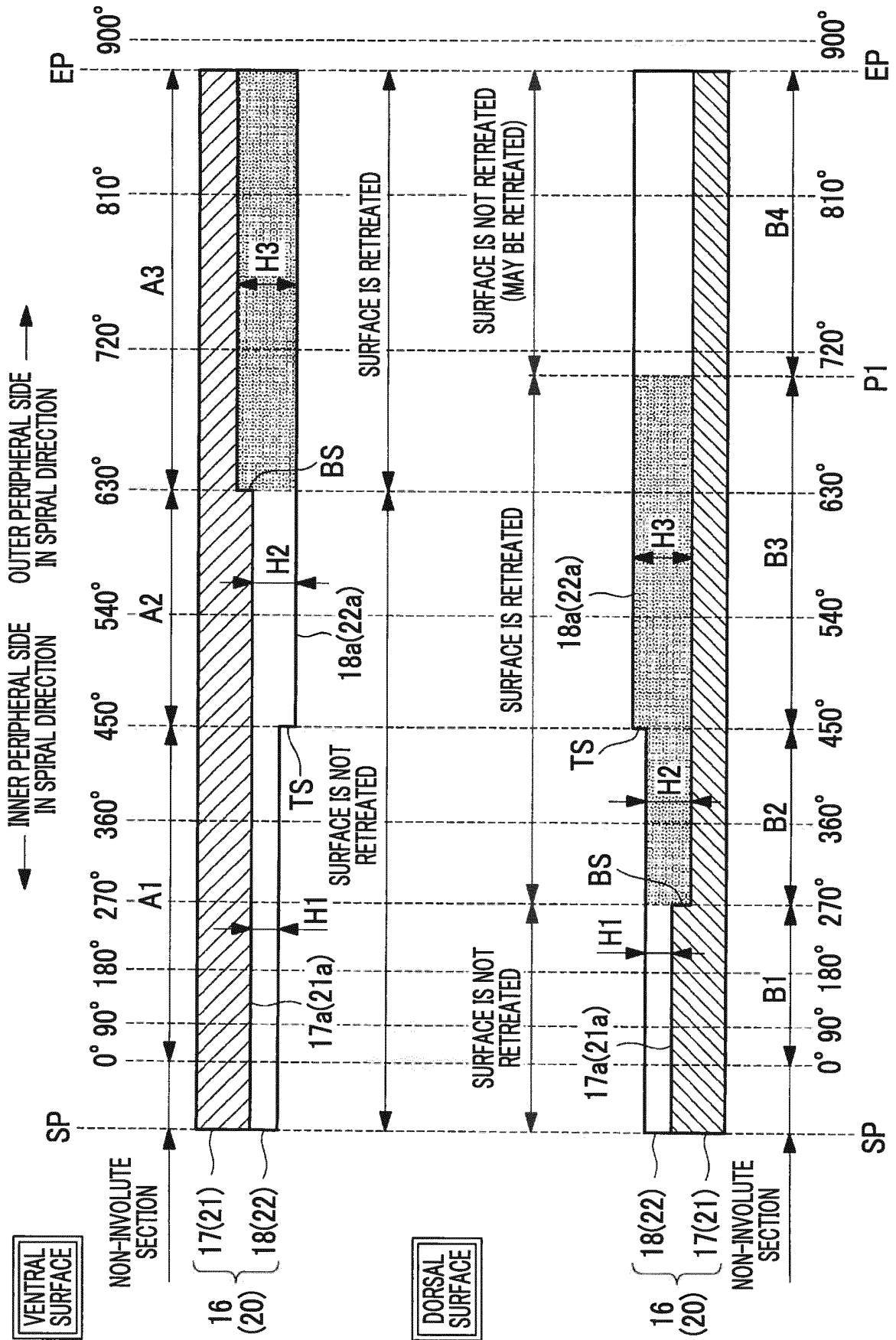


FIG. 7

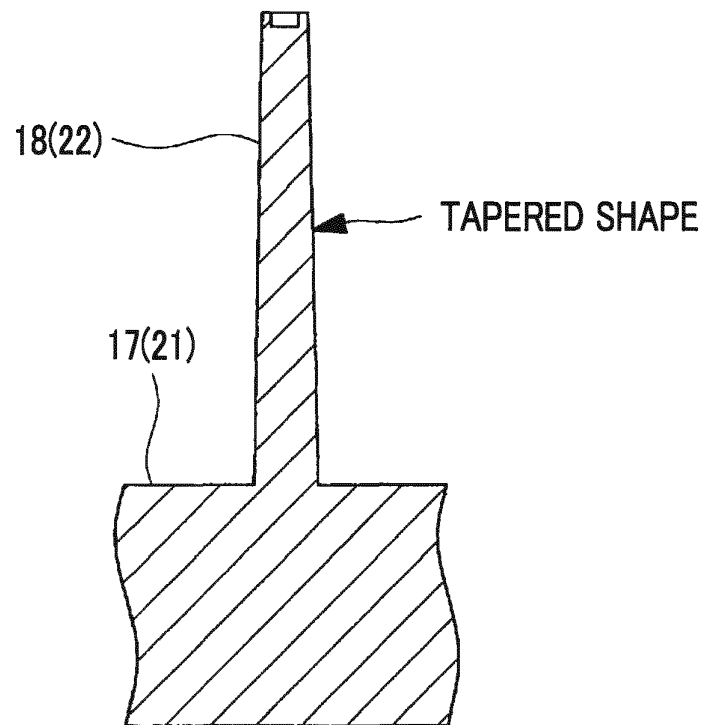


FIG. 8

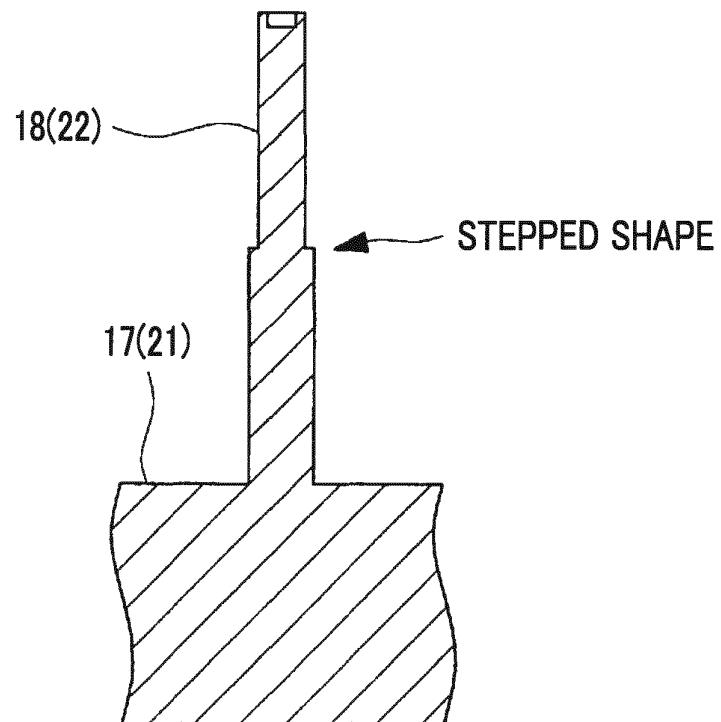


FIG. 9

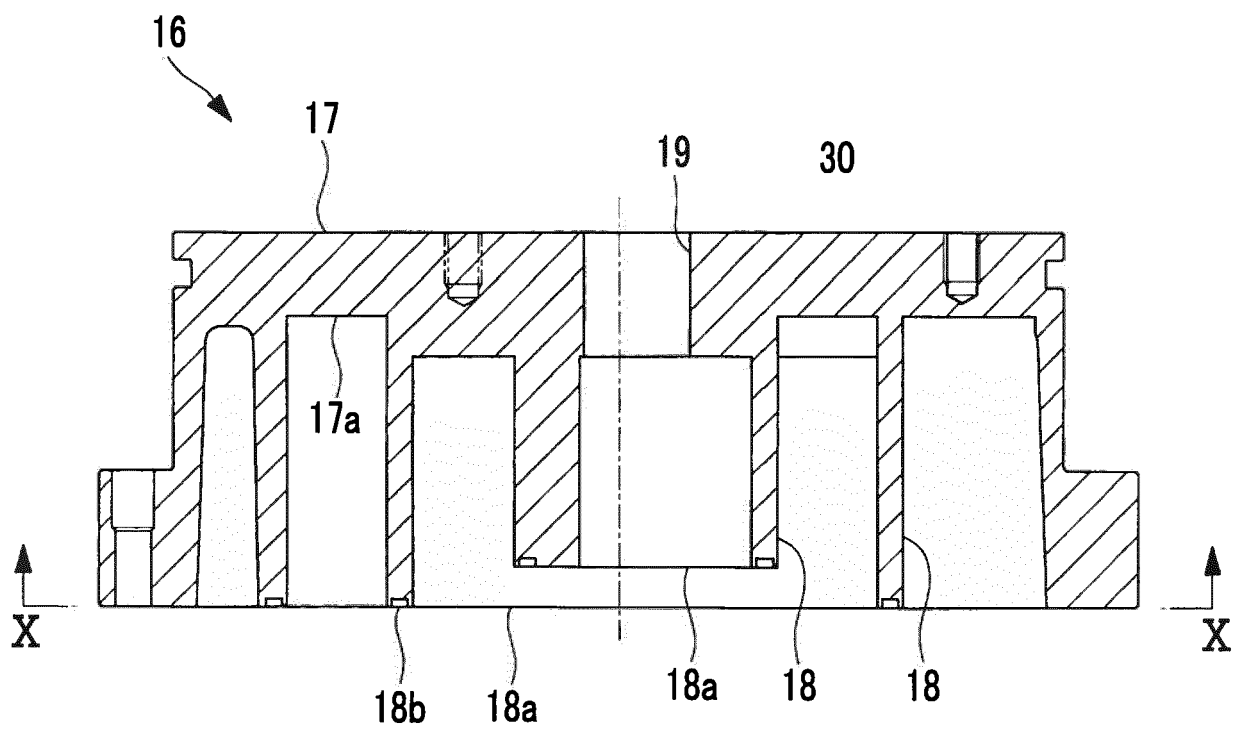


FIG. 10

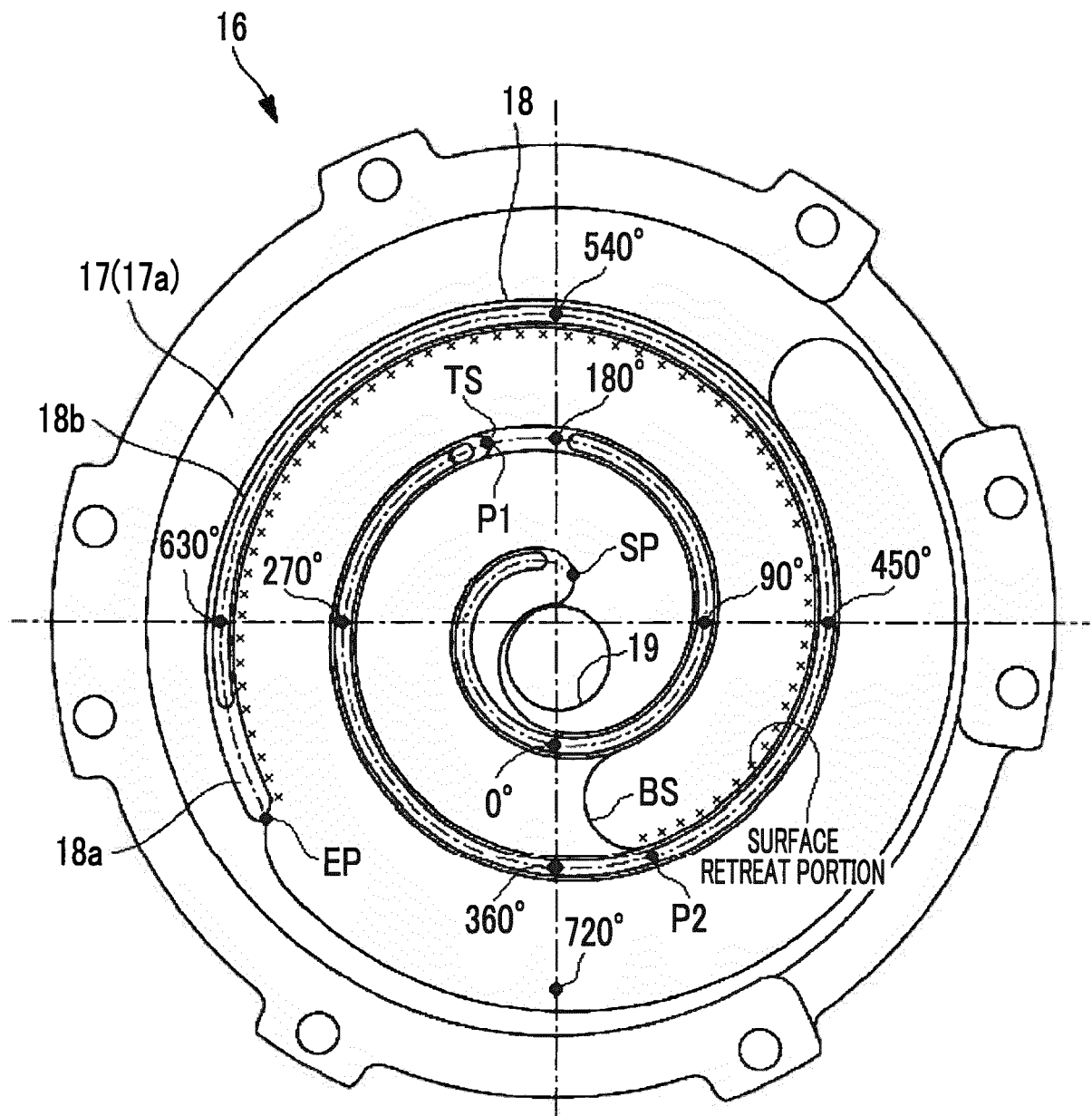


FIG. 11

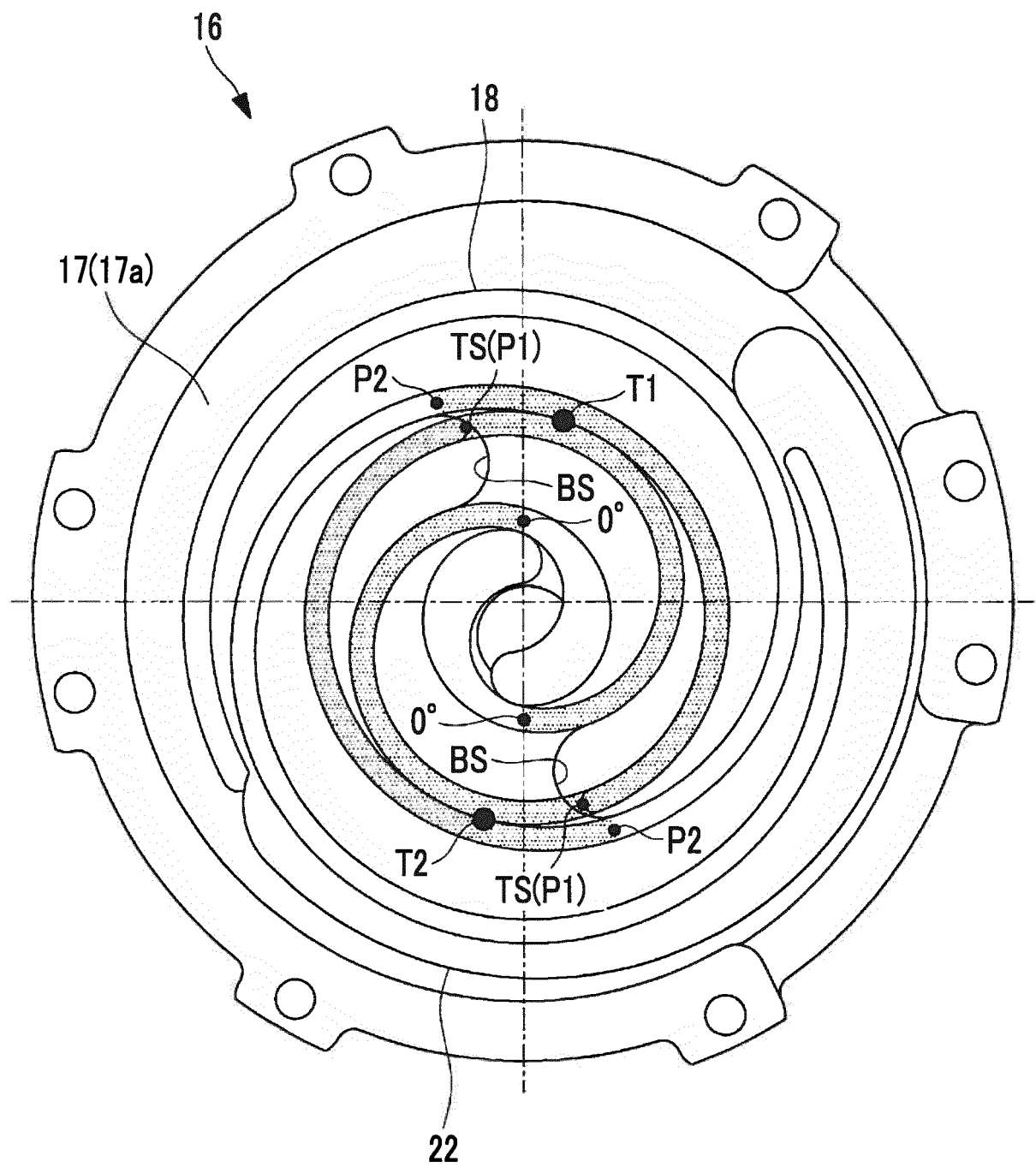


FIG. 12

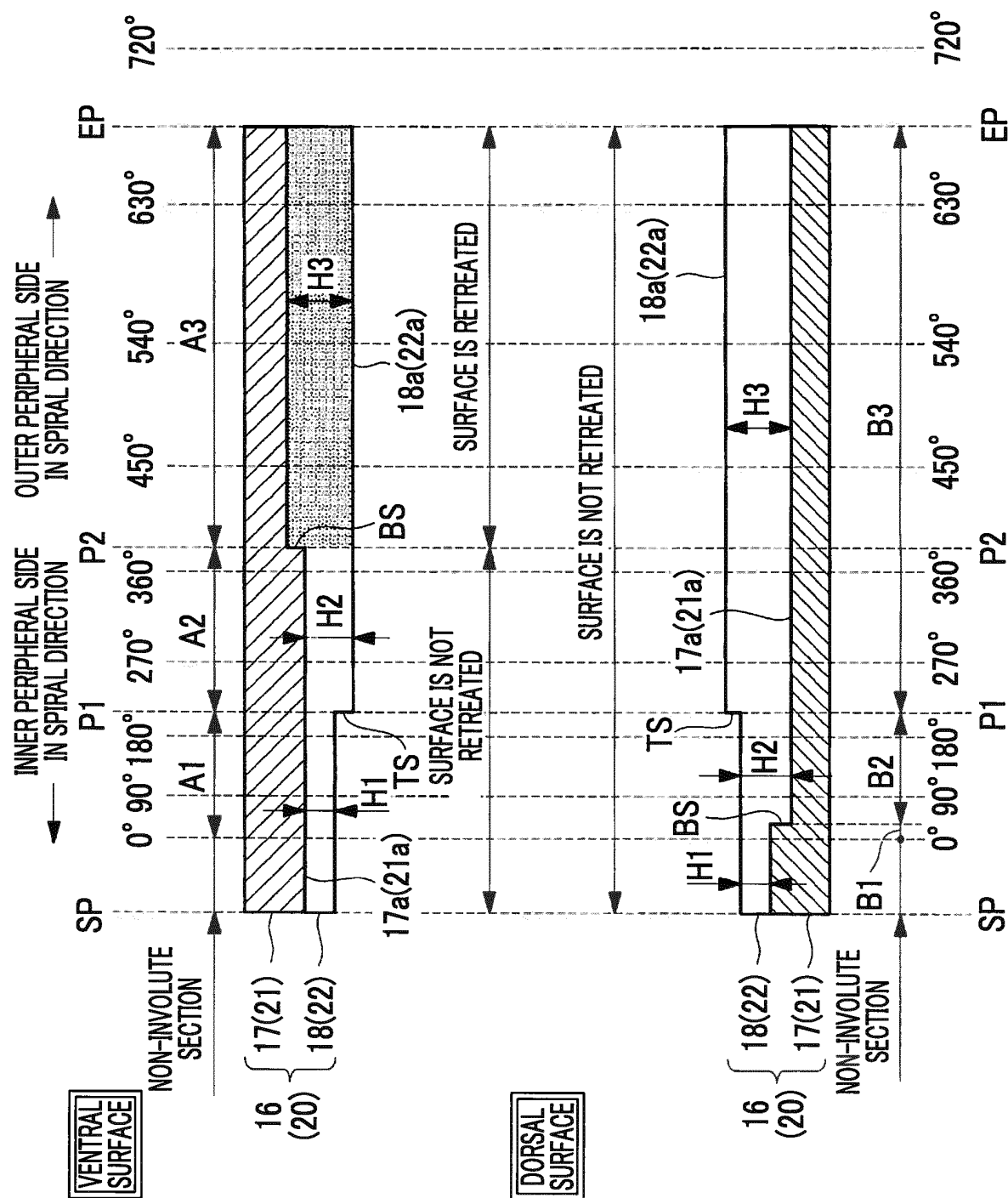
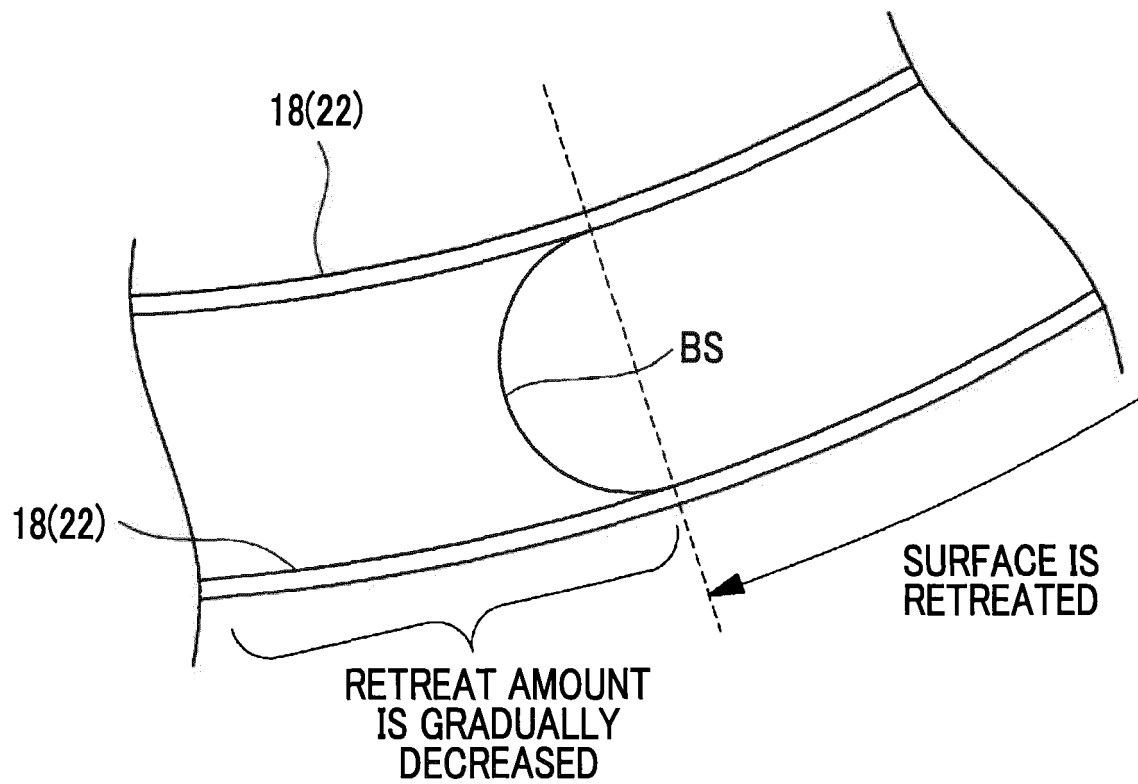


FIG. 13



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/023425

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	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-255191 A (Mitsubishi Heavy Industries, Ltd.), 04 October 2007 (04.10.2007), paragraphs [0026] to [0062]; fig. 1 to 24 & US 2007/0217934 A1 paragraphs [0070] to [0157]; fig. 1 to 24 & EP 1837526 A2 & CN 101042135 A	1-11
Y	JP 2000-170671 A (Tokico, Ltd.), 20 June 2000 (20.06.2000), paragraphs [0048] to [0122]; fig. 1 to 7 & US 6224357 B1 column 5, line 11 to column 17, line 4; fig. 1 to 7	1, 3, 5-6, 8, 10

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

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Date of the actual completion of the international search
20 July 2017 (20.07.17)

Date of mailing of the international search report
01 August 2017 (01.08.17)

Name and mailing address of the ISA/
Japan Patent Office
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Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/023425

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2011-74884 A (Mitsubishi Heavy Industries, Ltd.), 14 April 2011 (14.04.2011), paragraphs [0029] to [0051]; fig. 1 to 9 & EP 2484909 A1 paragraphs [0030] to [0052]; fig. 1 to 9 & WO 2011/040341 A1	2, 4-7, 9, 11
Y	JP 2014-152748 A (Panasonic Corp.), 25 August 2014 (25.08.2014), paragraph [0010] (Family: none)	6

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REFERENCES CITED IN THE DESCRIPTION

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