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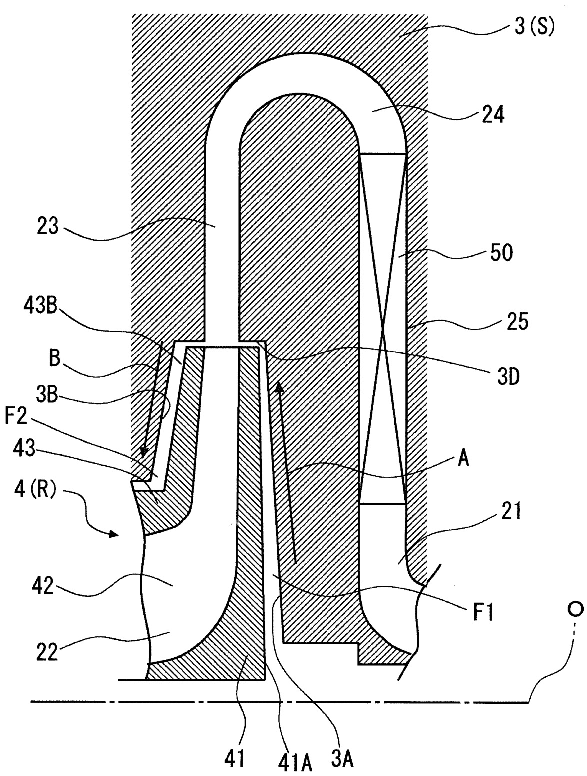
(54) **ROTATING MACHINERY**

(57) There is provided a rotating machinery including: a rotating body R which is rotatable around an axis O and has a first facing surface PI that widens in a plane intersecting the axis O; a stationary body S which faces the first facing surface P1 from the axial direction O, and has a second facing surface P2 forming a flow path Fl through which a fluid flows from a radially inner side toward the radially outer side between the first facing surface PI and the second facing surface P2; and a rotation side projection portion 80 which projects from the first facing surface PI toward the second facing surface P2, has an annular shape around the axis O, and faces the second facing surface P2 via a clearance C.

FIG. 2



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a rotating machinery.

Description of Related Art

[0002] For example, a rotating machinery, such as a centrifugal compressor, a centrifugal pump, a generator, or a turbine, includes a rotor as a rotating body that rotates around an axis, and a casing as a stationary body that covers the rotor from the outside. Between the rotating rotor and the stationary casing, a frictional resistance (disk friction loss) is generated via a working fluid. In particular, in a case of the centrifugal compressor, it is known that the disk friction loss increases because an outer diameter of an impeller increases in order to obtain a high lifting height with respect to a discharge flow rate.

[0003] As a technique for reducing such a disk friction loss, a technique described in Japanese Unexamined Patent Application, First Publication No. H3-11198 is known. In Japanese Unexamined Patent Application, First Publication No. H3-11198, a space on a back surface side is divided into a plurality of spaces by providing a plurality of fences at intervals in a radial direction on an impeller back surface side of the centrifugal compressor. Accordingly, the velocity distribution in each space is controlled, and the disk friction loss can be reduced.

SUMMARY OF THE INVENTION

[0004] However, in an apparatus described in Japanese Unexamined Patent Application, First Publication No. H3-11198, a fluid that flows in the divided space is in contact with an inner surface of the casing which is a stationary body. Therefore, a friction loss exists between the impeller back surface and the casing. In other words, there is still room for improvement in the apparatus described in Japanese Unexamined Patent Application, First Publication No. H3-11198.

[0005] The present invention provides a rotating machinery with improved efficiency by further reducing a friction loss.

[0006] According to an aspect of the present invention, there is provided a rotating machinery including: a rotating body which is rotatable around an axis and has a first facing surface that widens in a plane intersecting the axis; a stationary body has a second facing surface which faces the first facing surface in an axial direction and forms a flow path through which a fluid flows from a radially inner side toward a radially outer side between the first facing surface and the second facing surface; and at least one rotation side projection portion which projects from the first facing surface toward the second facing surface, has an annular shape around the axis, and faces the second facing surface via a clearance.

[0007] According to the configuration, the fluid that flows toward the radially outer side in the flow path flows toward the second facing surface side along the rotation side projection portion provided on the first facing surface. In other words, the flow of the fluid is peeled off from the first facing surface and flows to the stationary body side. Thereafter, the fluid passes through the clearance between the rotation side projection portion and the second facing surface. At this time, a flow velocity of the fluid increases. From the flow of the fluid having a high flow velocity, some components are peeled toward the rotating body side (that is, the first facing surface side). The peeled flow forms a vortex (stagnation) in a region close to the first facing surface and on the radially outer side of the rotation side projection portion. More specifically, the vortex flows toward the radially outer side, and then flows from the radially outer side toward the rotation side projection portion along the first facing surface. By forming such a vortex constantly, the remaining flow components except for the vortex are inhibited by the vortex and flow toward the radially outer side at a position close to the stationary body side (second facing surface side). As a result, a friction loss between the first facing surface and the second facing surface can be reduced.

[0008] In the rotating machinery, positions of a first inner region which is a region on the radially inner side with respect to the at least one rotation side projection portion and a first outer region which is a region on the radially outer side with respect to the at least one rotation side projection portion on the first facing surface, may be the same in the axial direction.

[0009] According to the configuration, the first inner region and the first outer region are provided at the same position in the axial direction. In other words, the first inner region and the first outer region can be formed only by providing the rotation side projection portion on the first facing surface formed in advance in a planar shape. Accordingly, the cost and time required for manufacturing the rotating machinery can be reduced.

[0010] In the rotating machinery, a first outer region which is a region on the radially outer side with respect to the at least one the rotation side projection portion on the first facing surface may widen to a position further away from the second facing surface in the axial direction than a first inner region which is a region on the radially inner side with respect to the at least one rotation side projection portion on the first facing surface.

[0011] According to the configuration, the first outer region positioned on the radially outer side nipping the rotation side projection portion widens to the position further away from the second facing surface than the first inner region positioned on the radially inner side. Therefore, the region where the vortex is formed on the first outer region side can be enlarged. Accordingly, as the remaining flow components except for the vortex are inhibited by the vortex, the remaining flow components flow toward the radially outer side at a position close to the stationary body side (second facing surface side). As a result, friction loss between the first facing surface and the second facing surface can further be reduced.

[0012] In the rotating machinery, the first outer region may extend in a direction gradually spaced apart from the second facing surface as going from the radially inner side toward the radially outer side in a sectional view including the axis.

[0013] According to the configuration, the first outer region may extend in the direction gradually spaced apart from the second facing surface as going toward the radially outer side in a sectional view including the axis. Therefore, the region where the vortex is formed on the first outer region side can further be enlarged. Accordingly, as the remaining flow components except for the vortex are inhibited by the vortex, the remaining flow components flow toward the radially outer side at a position close to the stationary body side (second facing surface side). As a result, a friction loss between the first facing surface and the second facing surface can further be reduced.

[0014] In the rotating machinery, a second outer region which is a region on the radially outer side with respect to the at least one the rotation side projection portion on the second facing surface may extend in a direction gradually spaced apart from the first facing surface as going from the radially inner side toward the radially outer side in a sectional view including the axis.

[0015] According to the configuration, the second outer region on the second facing surface extends in the direction gradually spaced apart from the first facing surface as going toward the radially outer side in a sectional view including the axis. Accordingly, as the flow path sectional area between the second outer region and the first facing surface is gradually enlarged as going toward the radially outer side, an effect as a diffuser can be achieved. As a result, the flow velocity of the fluid that flows through the second outer region decreases, and the formation of the vortex on the first outer region side can be promoted.

[0016] In the rotating machinery, at least one stationary side projection portion which is provided at a position facing the at least one rotation side projection portion on the second facing surface and projects toward the at least one projection portion, may be provided.

[0017] According to the configuration, the stationary side projection portion which projects toward the rotation side projection portion is provided at the position facing the rotation side projection portion on the second facing surface. By providing the stationary side projection portion, the position of the clearance formed between the rotation side projection portion and the stationary side projection portion in the axial direction can be adjusted. Accordingly, the position of the region where the vortex is formed can be adjusted appropriately.

[0018] In the rotating machinery, an end surface facing the first facing surface in the at least one stationary side projection portion may be formed in a planar shape that widens in a plane intersecting the axis.

[0019] According to the configuration, the end surface of the stationary side projection portion is formed in a planar shape that widens in a plane intersecting the axis. Therefore, for example, even in a case where the rotation side projection portion is relatively displaced in the radial direction with respect to the stationary side projection portion, it is possible to reduce a possibility that the size or the opening direction of the clearance between the rotation side projection portion and the stationary side projection portion changes.

[0020] In the rotating machinery, the at least one stationary side projection portion includes a plurality of stationary side projection portions; and the plurality of stationary side projection portions may be arranged at intervals in a circumferential direction and extend to a front side in a rotational direction of the rotating body as going from the radially inner side toward the radially outer side.

[0021] According to the configuration, a plurality of the stationary side projection portions are arranged in a circumferential direction and extend to a front side in a rotational direction of the rotating body as going toward the radially outer side. Accordingly, when the fluid passes between the plurality of stationary side projection portions, it is possible to add a swirl flow component toward the front side in a rotational direction of the rotating body with respect to the fluid. As a result, the peeling of the flow from the second facing surface is promoted, and an increase in the circumferential velocity component of the vortex on the first facing surface side can be promoted.

[0022] In the rotating machinery, a second outer region which is a region on the radially outer side with respect to the at least one the rotation side projection portion may extend in a direction gradually spaced apart from the first facing surface starting from an end edge of the at least one stationary side projection portion on a first facing surface side as going from the radially inner side toward the radially outer side in a sectional view including the axis.

[0023] According to the configuration, the second outer region on the second facing surface extends in the direction gradually spaced apart from the first facing surface starting from the end edge of the stationary side projection portion as going toward the radially outer side in a sectional view including the axis. Accordingly, as the flow path sectional area between the second outer region and the first facing surface is gradually enlarged as going toward the radially outer side, an effect as a diffuser can be achieved. As a result, the flow velocity of the fluid that flows through the second outer region decreases, and the formation of the vortex on the first outer region side can be promoted.

[0024] In the rotating machinery, the at least one rotation side projection portion includes a plurality of rotation side projection portions; and the plurality of rotation side projection portions may be provided at intervals in a radial direction on the first facing surface.

[0025] According to the configuration, since the plurality of rotation side projection portions are provided at intervals in the radial direction on the first facing surface, in a wider region on the first facing surface, the friction loss between the rotating body side and the stationary body side can be reduced uniformly.

[0026] In the rotating machinery, the at least one rotation side projection portion may have a radial dimension that decreases going from the first facing surface side toward the second facing surface side.

[0027] According to the configuration, the rotation side projection portion is formed in a tapered shape as the dimension in radial direction decreases going toward the second facing surface side. Accordingly, the fluid that passes through the clearance can be further accelerated.

[0028] According to another aspect of the present invention, there is provided a rotating machinery including: a rotating body which is rotatable around an axis and has a first facing surface that widens in a plane intersecting the axis; a stationary body has a second facing surface which faces the first facing surface in an axial direction and forms a flow path through which a fluid flows from a radially outer side toward a radially inner side between the first facing surface and the second facing surface; and at least one rotation side projection portion which is provided at a position on the most radially outer side on the first facing surface, projects toward the second facing surface, has an annular shape around the axis, and faces the second facing surface via a clearance.

[0029] According to the configuration, the fluid that flows toward the radially inner side in the flow path flows toward the second facing surface side along the projection portion provided on the first facing surface. In other words, the flow of the fluid is peeled off from the first facing surface and flows to the stationary body side. Thereafter, the fluid passes through the clearance between the rotation side projection portion and the second facing surface. At this time, a flow velocity of the fluid increases. From the flow of the fluid having a high flow velocity, some components are peeled toward the rotating body side (that is, the first facing surface side). The peeled flow forms the vortex (stagnation) in the region close to the first facing surface and on the radially inner side of the rotation side projection portion. More specifically, the vortex flows toward the radially inner side, and then flows from the radially outer side toward the projection portion along the first facing surface. By forming such a vortex constantly, the remaining flow components except for the vortex are inhibited by the vortex and flow toward the radially inner side at a position close to the stationary body side (second facing surface side). As a result, a friction loss between the first facing surface and the second facing surface can be reduced.

[0030] In the rotating machinery, a recess portion provided adjacent to the radially inner side with respect to the at least one rotation side projection portion on the first facing surface and recessed in a direction spaced apart from the second facing surface, may further be provided.

[0031] According to the configuration, the recess portion is formed adjacent to the radially inner side of the rotation side projection portion. By providing the recess portion, the region where the vortex is formed can be enlarged. Accordingly, as the remaining flow components except for the vortex are inhibited by the vortex, the remaining flow components flow toward the radially inner side at a position close to the stationary body side (second facing surface side). As a result, a friction loss between the first facing surface and the second facing surface can further be reduced.

[0032] In the rotating machinery, the bottom surface of the recess portion may extend in a direction gradually spaced apart from the second facing surface as going from a radially inner side toward the radially outer side in a sectional view including the axis.

[0033] According to the configuration, the bottom surface of the recess portion may extend in the direction gradually spaced apart from the second facing surface as going toward the radially inner side in a sectional view including the axis. Therefore, the region where the vortex is formed can be further enlarged. Accordingly, as the remaining flow components except for the vortex are inhibited by the vortex, the remaining flow components flow toward the radially inner side at a position close to the stationary body side (second facing surface side). As a result, a friction loss between the first facing surface and the second facing surface can further be reduced.

[0034] In the rotating machinery, a stationary side recess portion may be provided in a region facing the recess portion on the second facing surface, and recessed in a direction spaced apart from the first facing surface, in which a bottom surface of the stationary side recess portion may extend in a direction gradually spaced apart from the first facing surface as going from the radially outer side toward the radially inner side in a sectional view including the axis.

[0035] According to the configuration, the stationary side recess portion is formed in the region facing the recess portion on the second facing surface. Furthermore, the bottom surface of the stationary side recess portion extends in the direction gradually spaced apart from the first facing surface as going toward the radially inner side in a sectional view including the axis. Accordingly, as the flow path sectional area between the recess portion and the stationary side recess portion is gradually enlarged as going toward the radially inner side, an effect as a diffuser can be achieved. As a result, the flow velocity of the fluid that flows into the recess portion decreases, and the formation of the vortex in the recess portion can be promoted.

[0036] In the rotating machinery, at least one stationary side projection portion which is provided at a position facing the at least one rotation side projection portion on the second facing surface and projects toward the at least one projection portion, may further be provided.

[0037] According to the configuration, the stationary side projection portion which projects toward the rotation side projection portion is provided at the position facing the rotation side projection portion on the second facing surface. By providing the stationary side projection portion, the position of the clearance formed between the projection portion and the stationary side projection portion in the axial direction can be adjusted. Accordingly, the position of the region where the vortex is formed can be adjusted appropriately.

[0038] In the rotating machinery, an end surface facing the first facing surface in the at least one stationary side projection portion may be formed in a planar shape that widens in the radial direction.

[0039] According to the configuration, the end surface of the stationary side projection portion is formed in a planar shape that widens in a plane intersecting the axis. Therefore, for example, even in a case where the rotation side projection portion is relatively displaced in the radial direction with respect to the stationary side projection portion, it is possible to reduce a possibility that the size or the opening direction of the clearance between the rotation side projection portion and the stationary side projection portion changes.

[0040] In the rotating machinery, the at least one stationary side projection portion includes a plurality of stationary side projection portions; and the plurality of stationary side projection portions may be arranged at intervals in a circumferential direction and extend to a front side in a rotational direction of the rotating body as going from the radially outer side toward the radially inner side.

[0041] According to the configuration, a plurality of the stationary side projection portions are arranged in a circumferential direction and extend to a front side in a rotational direction of the rotating body as going toward the radially inner side. Accordingly, when the fluid passes between the plurality of stationary side projection portions, it is possible to add a swirl flow component toward the front side in a rotational direction of the rotating body with respect to the fluid. As a result, the peeling of the flow from the second facing surface is promoted, and an increase in the circumferential velocity component of the vortex on the first facing surface side can further be promoted.

[0042] In the rotating machinery, a region facing the recess portion on the second facing surface may extend in a direction gradually spaced apart from the first facing surface as going from the radially outer side toward the radially inner side in a sectional view including the axis.

[0043] According to the configuration, the region facing the recess portion on the second facing surface extends in the direction gradually spaced apart from the first facing surface as going toward the radially inner side in a sectional view including the axis. Accordingly, as the flow path sectional area between the second facing surface and the recess portion is gradually enlarged as going toward the radially inner side, an effect as a diffuser can be achieved. As a result, the flow velocity of the fluid that flows between the second facing surface and the recess portion decreases, and the formation of the vortex in the recess portion can be promoted.

[0044] In the rotating machinery, the at least one rotation side projection portion includes a plurality of rotation side projection portions; and the plurality of rotation side projection portions may be provided at intervals in the radial direction on the first facing surface.

[0045] According to the configuration, since the plurality of rotation side projection portions are provided at intervals in the radial direction on the first facing surface, in a wider region on the first facing surface, the friction loss between the rotating body side and the stationary body side can be reduced uniformly.

[0046] In the rotating machinery, the at least one rotation side projection portion may have a radial dimension that decreases going from the first facing surface side toward the second facing surface side.

[0047] According to the configuration, the rotation side projection portion is formed in a tapered shape as the dimension in radial direction decreases going toward the second facing surface side. Accordingly, the fluid that passes through the clearance can be further accelerated.

[0048] According to the present invention, it is possible to provide a rotating machinery with improved efficiency by further reducing a friction loss.

BRIEF DESCRIPTION OF THE DRAWINGS

[0049]

FIG. 1 is a sectional view showing a configuration of a centrifugal compressor as a rotating machinery according to a first embodiment of the present invention.

FIG. 2 is an enlarged view showing a configuration around an impeller of the centrifugal compressor according to the first embodiment of the present invention.

FIG. 3 is an enlarged sectional view of a main part of the centrifugal compressor according to the first embodiment of the present invention.

FIG. 4 is an enlarged sectional view of a main part of a centrifugal compressor according to a second embodiment of the present invention.

FIG. 5 is an enlarged sectional view of a main part showing a modification example of the centrifugal compressor according to the second embodiment of the present invention.

FIG. 6 is an enlarged sectional view of a main part of a centrifugal compressor according to a third embodiment of the present invention.

FIG. 7 is an enlarged sectional view of a main part showing a modification example of the centrifugal compressor according to the third embodiment of the present invention.

FIG. 8 is a view when a stationary side projection portion in FIG. 7 is viewed from an axial direction.

FIG. 9 is an enlarged sectional view of a main part of a centrifugal compressor according to a fourth embodiment of the present invention.

FIG. 10 is an enlarged sectional view of a main part of a centrifugal compressor according to a fifth embodiment of the present invention.

FIG. 11 is an enlarged sectional view of a main part of a centrifugal compressor according to a sixth embodiment of the present invention.

FIG. 12 is an enlarged sectional view of a main part of a centrifugal compressor according to a seventh embodiment of the present invention.

FIG. 13 is an enlarged sectional view of a main part of a centrifugal compressor according to an eighth embodiment of the present invention.

FIG. 14 is an enlarged sectional view of a main part of a centrifugal compressor according to a ninth embodiment of the present invention.

FIG. 15 is an enlarged sectional view of a main part of a centrifugal compressor according to a tenth embodiment of the present invention.

FIG. 16 is an enlarged sectional view of a main part of a centrifugal compressor according to an eleventh embodiment of the present invention.

FIG. 17 is an enlarged sectional view of a main part of a centrifugal compressor according to a twelfth embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[First Embodiment]

[0050] A first embodiment of the present invention will be described with reference to FIGS. 1 to 3. In the present embodiment, a multistage centrifugal compressor as a rotating machinery will be described as an example. In addition, it is also possible to apply the configuration of the present embodiment to a single-stage centrifugal compressor, a centrifugal pump, a generator, or a turbine, as a rotating machinery.

[0051] A centrifugal compressor 100 includes a rotating shaft 1 that rotates around an axis, a casing 3 as a stationary body S that forms a fluid flow path 2 by covering the periphery of the rotating shaft 1, and a plurality of impellers 4 as rotating bodies R provided on the rotating shaft 1.

[0052] The casing 3 is formed in a cylindrical shape that extends along an axis O. The rotating shaft 1 extends so as to penetrate the inside of the casing 3 along the axis O. Journal bearings 5 and thrust bearings 6 are provided in both end portions of the casing 3 in the direction of the axis O, respectively. The rotating shaft 1 is supported by the journal bearings 5 and the thrust bearings 6 so as to be rotatable around the axis O.

[0053] An intake port 7 for taking in air as a working fluid G from the outside is provided on one side of the casing 3 in the direction of the axis O. Furthermore, an exhaust port 8 through which the working fluid G compressed inside the casing 3 is exhausted is provided on the other side of the casing 3 in the direction of the axis O.

[0054] Inside the casing 3, an internal space in which the intake port 7 and the exhaust port 8 communicate with each other and which repeats the diameter reduction and the diameter expansion is formed. The internal space accommodates the plurality of impellers 4 and forms a part of the fluid flow path 2. In the following description, a side on which the intake port 7 is positioned on the fluid flow path 2 is referred to as an upstream side. Further, the side on which the exhaust port 8 is positioned on the fluid flow path 2 is referred to as a downstream side.

[0055] The rotating shaft 1 is provided with a plurality (six) of impellers 4 at intervals on the outer circumferential surface in the direction of the axis O. As shown in FIG. 2, each impeller 4 includes a disk 41 having a substantially circular section when viewed from the direction of the axis O, a plurality of blades 42 provided on a surface on the upstream side of the disk 41, and a cover 43 that covers the plurality of blades 42 from the upstream side.

[0056] The disk 41 is formed such that the radial dimension is gradually enlarged as going from one side toward the other side in the direction of the axis O when viewed from the direction intersecting the axis O. Accordingly, the disk 41 has a generally conical shape.

[0057] A plurality of blades 42 are radially arranged toward the radially outer side around the axis O, on the conical surface facing the upstream side of both surfaces of the disk 41 in the direction of the axis O. More specifically, the blades are formed by thin plates that are erected from the surface on the upstream side of the disk 41 toward the upstream side. The plurality of blades 42 are curved from one side toward the other side in the circumferential direction in a case of being viewed from the direction of the axis O.

[0058] The cover 43 is provided at an end edge on the upstream side of the blade 42. In other words, the plurality of blades 42 are sandwiched by the cover 43 and the disk 41 from the direction of the axis O. Accordingly, a space is formed between the cover 43, the disk 41, and a pair of blades 42 adjacent to each other. The space forms a part (compression flow path 22) of a fluid flow path 2 which will be described later.

[0059] The fluid flow path 2 is a space in which the impeller 4 configured as described above and the internal space of the casing 3 communicate with each other. In the present embodiment, description will be made assuming that one fluid flow path 2 is formed for each impeller 4 (for each compression stage). In other words, in the centrifugal compressor 100, five fluid flow paths 2 from the upstream side toward the downstream side are continuously formed corresponding to the five impellers 4 excluding the impeller 4 on the last stage.

[0060] Each fluid flow path 2 has a suction flow path 21, a compression flow path 22, a diffuser flow path 23, a return bend portion 24, and a guide flow path 25. FIG. 2 shows only the impeller 4 on the first stage among the fluid flow path 2 and the impeller 4.

[0061] In the impeller 4 on the first stage, the suction flow path 21 is directly connected to the above-described intake port 7. By the suction flow path 21, the external air is taken into each flow path on the fluid flow path 2 as a working fluid G. More specifically, the suction flow path 21 is gradually curved from the direction of the axis O toward the radially outer side as going from the upstream side toward the downstream side.

[0062] The suction flow path 21 in the impellers 4 on the second and subsequent stages communicates with a downstream end of a guide flow path 25 (will be described later) in the fluid flow path 2 of the previous stage (first stage). In other words, similar to the description above, the flow direction of the working fluid G that has passed through the guide flow path 25 is changed so as to face the downstream side along the axis O.

[0063] The compression flow path 22 is a flow path surrounded by the surface on the upstream side of the disk 41, the surface on the downstream side of the cover 43, and a pair of blades 42 adjacent to each other in the circumferential direction. More specifically, the sectional area of the compression flow path 22 gradually decreases going from the radially inner side toward the radially outer side. Accordingly, the working fluid G which flows in the compression flow path 22 in a state where the impeller 4 is rotating is gradually compressed to become a high-pressure fluid.

[0064] The diffuser flow path 23 is a flow path that extends from the radially inner side of the axis O toward the radially outer side. The end portion on the radially inner side in the diffuser flow path 23 communicates with the end portion on the radially outer side of the compression flow path 22.

[0065] The return bend portion 24 reverses the flow direction of the working fluid G flowing from the radially inner side toward the radially outer side through the diffuser flow path 23, toward the radially inner side. One end side (upstream side) of the return bend portion 24 communicates with the diffuser flow path 23, and the other end side (downstream side) communicates with the guide flow path 25. In the middle of the return bend portion 24, a part positioned on the most radially outer side is a top portion.

[0066] The guide flow path 25 extends toward the radially inner side from the end portion on the downstream side of the return bend portion 24. The end portion on the radially outer side of the guide flow path 25 communicates with the above-described return bend portion 24. The end portion on the radially inner side of the guide flow path 25 communicates with the suction flow path 21 in the fluid flow path 2 on the subsequent stage as described above.

[0067] In the centrifugal compressor 100 configured as described above, a gap is formed between the casing 3 and the impeller 4 in order to realize smooth rotation of the impeller 4. More specifically, the gap is formed between a disk back surface 41A facing the downstream side of the disk 41 and a casing back surface 3A facing the disk back surface 41A. The gap is a flow path F1 which will be described later. In the flow path F1, as indicated by an arrow A in FIG. 2, a high-pressure fluid leaking from the compression flow path 22 on the rear stage side flows from the radially inner side toward the radially outer side.

[0068] Furthermore, a gap is formed between a cover upstream surface 43B facing the upstream side of the cover 43 and a casing upstream surface 3B facing the cover upstream surface 43B. The gap is a flow path F2 which will be described later. In the flow path F2, as indicated by an arrow B in FIG. 2, a high-pressure fluid flowing through the diffuser flow path 23 flows from the radially outer side toward the radially inner side.

[0069] Here, between the impeller 4 as the rotating body R and the casing 3 as the stationary body S, a frictional resistance (disk friction loss) is generated via the fluid flowing through the flow path F1 and the flow path F2. In particular, in a case of the centrifugal compressor 100, since the outer diameter of the impeller 4 increases as the lifting height increases, it is known that the disk friction loss increases.

[0070] Here, in the present embodiment, as shown in FIG. 3, the disk back surface 41A of the impeller 4 is provided with a rotation side projection portion 80 (hereinafter, referred to as a projection portion 80) for controlling the flow of the fluid flowing through the flow path F1. In FIG. 3, the periphery of the disk back surface 41A and the casing back surface 3A is shown in a simplified manner, and in order to generalize the description, the disk back surface 41A is referred to as a first facing surface PI, and the casing back surface 3A is referred to as a second facing surface P2. A space between the first facing surface P1 and the second facing surface P2 corresponds to the above-described flow path F1. The projection portion 80 is provided on the outer side of the position of 50% of the radius of the first facing surface P1.

[0071] The projection portion 80 projects in the direction of the axis O from the first facing surface P1 toward the second facing surface P2. The dimension of the projection portion 80 in the radial direction gradually decreases going from the first facing surface P1 side toward the second facing surface P2 side. Accordingly, the projection portion 80 has a tapered shape in a sectional view including the axis O. A clearance C is formed between a tip end of the projection portion 80 and the second facing surface P2.

[0072] The first facing surface P1 is partitioned into a first inner region P11 on the radially inner side and a first outer region P12 on the radially outer side with the projection portion 80 as a standard. The first inner region P11 is parallel to the second facing surface P2 in a sectional view including the axis O. The first outer region P12 is positioned on the side spaced apart from the second facing surface P2 further than the first inner region P11 in the direction of the axis O. In other words, the distance between the first outer region P12 and the second facing surface P2 is larger than the distance between the first inner region P11 and the second facing surface P2. In addition, the distance between the first outer region

P12 and the second facing surface P2 may be the same as the distance between the first inner region P11 and the second facing surface P2. Further, the distance between the first outer region P12 and the second facing surface P2 may be smaller than the distance between the first inner region P11 and the second facing surface P2.

[0073] The end edge on the radially outer side of the second facing surface P2 is connected to an outer wall surface P3 that widens in the direction of the axis O. The outer wall surface P3 corresponds to a casing inner circumferential surface 3D which is an inner circumferential surface of the casing facing the end edge on the radially outer side of the impeller 4 in FIG. 2.

[0074] Next, the behavior of the fluid in the above-described flow path F1 will be described. As shown in FIG. 3, the fluid flowing toward the radially outer side in the flow path F1 flows toward the second facing surface P2 along the projection portion 80 provided on the first facing surface P1. In other words, the flow of the fluid is peeled off from the first facing surface P1 and flows to the stationary body S side. Thereafter, the fluid passes through the clearance C between the projection portion 80 and the second facing surface P2. At this time, a flow velocity of the fluid increases. From the flow of the fluid having a high flow velocity, some components are separated toward the rotating body R side (that is, the first facing surface P1 side). The peeled flow forms a vortex (stagnation) in a region close to the first facing surface P1 and on the radially outer side of the projection portion 80. More specifically, the vortex flows toward the radially outer side, and then flows from the radially outer side toward the projection portion 80 along the first facing surface P1. By forming such a vortex constantly, the remaining flow components except for the vortex are inhibited by the vortex and flow toward the radially outer side at a position close to the stationary body S side (second facing surface P2 side). As a result, a friction loss between the first facing surface P1 and the second facing surface P2 can be reduced.

[0075] Furthermore, according to the configuration, the first outer region P12 positioned on the radially outer side nipping the projection portion 80 widens to the position further away from the second facing surface P2 than the first inner region P11 positioned on the radially inner side. Therefore, the region where the vortex is formed on the first outer region P12 side can be enlarged. Accordingly, as the remaining flow components except for the vortex are inhibited by the vortex, the remaining flow components flow toward the radially outer side at a position close to the stationary body S side (second facing surface P2 side). As a result, a friction loss between the first facing surface P1 and the second facing surface P2 can further be reduced.

[0076] In addition, in the configuration, the projection portion 80 is provided on the outer side of the position of 50% of the radius of the first facing surface P1. Here, as the position is on the radially outer side of the first facing surface P1 that is the rotating body R, the speed in the rotational direction with respect to the stationary body S increases, and thus, the friction at the position increases. According to the configuration, since the projection portion 80 is provided at a position where the friction is large in this manner, the friction reduction by the projection portion 80 can be realized more effectively.

[0077] The first embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention. For example, the first inner region P11 and the first outer region P12 may have the same position in the direction of the axis O. According to the configuration, the first inner region P11 and the first outer region P12 can be formed only by providing the projection portion 80 on the first facing surface P1 formed in advance in a planar shape. Accordingly, the cost and time required for manufacturing the apparatus can be reduced.

[Second Embodiment]

[0078] Next, a second embodiment of the present invention will be described with reference to FIG. 4. In addition, the same configuration elements as those of the first embodiment will be given the same reference numerals, and the detailed description thereof will be omitted. As shown in FIG. 4, in the present embodiment, a configuration of a first outer region P12' is different from that of the first embodiment. The first outer region P12' extends in the direction gradually spaced apart from the second facing surface P2 as going from the radially inner side toward the radially outer side in a sectional view including the axis O. In other words, the first outer region P12' is inclined with respect to the second facing surface P2. Further, an end edge on the radially inner side of the first outer region P12' is positioned on the side spaced apart from the second facing surface P2 further than the first inner region P11 in the direction of the axis O.

[0079] According to the configuration, the first outer region P12' extends in the direction gradually spaced apart from the second facing surface P2 as going toward the radially outer side in a sectional view including the axis O. Therefore, the region where the vortex is formed on the first outer region P12' side can further be enlarged. Accordingly, as the remaining flow components except for the vortex are inhibited by the vortex, the remaining flow components flow toward the radially outer side at a position close to the stationary body S side (second facing surface P2 side). As a result, a friction loss between the first facing surface P1 and the second facing surface P2 can further be reduced.

[0080] The second embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention. For example, it is also possible to adopt a configuration shown in FIG. 5. In the example of the same drawing, the second outer region P21 which is a region on the radially outer side of the projection portion 80 on the second facing surface P2 extends in a direction gradually spaced apart from the first facing surface P1 as going from the radially inner side toward the radially outer side in a sectional view including the axis O. According to such a configuration, the flow path sectional area between the second outer region P21 and the first facing surface P1 is gradually enlarged toward the radially outer side in the radial direction, and accordingly an effect as a diffuser is achieved. As a result, the flow velocity of the fluid that flows through the second outer region P21 decreases, and the formation of the vortex on the first outer region P12' side can be promoted.

[Third Embodiment]

[0081] Next, a third embodiment of the present invention will be described with reference to FIG. 6. In addition, the same configuration elements as those of each of the embodiments will be given the same reference numerals, and the detailed description thereof will be omitted. As shown in FIG. 6, in the present embodiment, a stationary side projection portion 90 is provided at a position facing the projection portion 80 on the second facing surface P2. The stationary side projection portion 90 projects from the second facing surface P2 toward the first facing surface P1 side. The stationary side projection portion 90 has a rectangular sectional shape in a sectional view including the axis O. In other words, the end surface facing the first facing surface P1 side in the stationary side projection portion 90 is formed in a planar shape that widens in a plane intersecting the axis O. The clearance C is formed between the stationary side projection portion 90 and the projection portion 80.

[0082] According to the configuration, the stationary side projection portion 90 which projects toward the projection portion 80 is provided at the position facing the projection portion 80 on the second facing surface P2. By providing the stationary side projection portion 90, the position of the clearance C formed between the projection portion 80 and the stationary side projection portion 90 in the direction of the axis O can be adjusted. Accordingly, the position of the region where the vortex is formed can be adjusted appropriately.

[0083] Furthermore, according to the configuration, the end surface of the stationary side projection portion 90 is formed in a planar shape that widens in a plane intersecting the axis O. Therefore, for example, even in a case where the projection portion 80 is relatively displaced in the radial direction with respect to the stationary side projection portion 90, it is possible to reduce a possibility that the size or the opening direction of the clearance C between the projection portion 80 and the stationary side projection portion 90 changes.

[0084] The third embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention. For example, the stationary side projection portion 90 described in the third embodiment can also be configured as shown in FIGS. 7 and 8. In the example of the drawings, a plurality of stationary side projection portions 90B is provided at intervals in the circumferential direction with respect to the axis O. Furthermore, each stationary side projection portion 90B has an airfoil shape that extends toward a front side in a rotational direction Dr of the rotating body R as going from the radially inner side toward the radially outer side when viewed from the direction of the axis O. According to the configuration, when the fluid passes between the plurality of stationary side projection portions 90B, a swirl flow component toward the front side in a rotational direction Dr of the rotating body R can be added to the fluid. As a result, the peeling of the flow from the second facing surface P2 is promoted, and an increase in the circumferential velocity component of the vortex on the first facing surface P1 side can be promoted.

[Fourth Embodiment]

[0085] Next, a fourth embodiment of the present invention will be described with reference to FIG. 9. In addition, the same configuration elements as those of each of the embodiments will be given the same reference numerals, and the detailed description thereof will be omitted. As shown in FIG. 9, in the present embodiment, a second outer region P21' which is a region on the radially outer side from the projection portion 80 on the second facing surface P2 extends in a direction gradually spaced apart from the first facing surface P1 starting from an end edge of the stationary side projection portion 90 on the first facing surface P1 side as going from the radially inner side toward the radially outer side in a sectional view including the axis O. In other words, the second outer region P21' is inclined with respect to the first facing surface P1.

[0086] According to the configuration, the second outer region P21' on the second facing surface P2 extends in the direction gradually spaced apart from the first facing surface P1 starting from the end edge of the projection portion 80 as going toward the radially outer side in a sectional view including the axis O. Accordingly, as the flow path sectional area between the second outer region P21' and the first facing surface P1 is gradually enlarged as going toward the radially outer side, an effect as a diffuser can be achieved. As a result, the flow velocity of the fluid that flows along the second outer region P21' decreases, and the formation of the vortex in the vicinity of the second outer region side P21' can be promoted.

[0087] The fourth embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention.

[Fifth Embodiment]

[0088] Next, a fifth embodiment of the present invention will be described with reference to FIG. 10. In addition, the same configuration elements as those of each of the embodiments will be given the same reference numerals, and the detailed description thereof will be omitted. As shown in FIG. 10, in the present embodiment, a plurality (two) of projection portions 80 are provided at intervals in the radial direction on the first facing surface P1. The two projection portions 80 have the same shape.

[0089] According to the configuration, since the plurality of projection portions 80 are provided at intervals in the radial direction on the first facing surface PI, in a wider region on the first facing surface PI, the friction loss between the rotating body R side and the stationary body S side can be reduced uniformly.

[0090] The fifth embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention. For example, in the fifth embodiment, an example in which the two projection portions 80 are provided at intervals in the radial direction has been described. However, the number of the provided projection portions 80 is not limited to the description above, and may be three or more.

[Sixth Embodiment]

[0091] Next, a sixth embodiment of the present invention will be described with reference to FIG. 11. In addition, the same configuration elements as those of each of the embodiments will be given the same reference numerals, and the detailed description thereof will be omitted. In the present embodiment, the periphery of the cover upstream surface 43B and the casing upstream surface 3B described with reference to FIG. 2 in the first embodiment will be described. In FIG. 11, the periphery of the cover upstream surface 43B and the casing upstream surface 3B is shown in a simplified manner, and in order to generalize the description, the cover upstream surface 43B is referred to as the first facing surface P1 and the casing upstream surface 3B is referred to as a second facing surface P2. A space between the first facing surface P1 and the second facing surface P2 corresponds to the flow path F2 described in the first embodiment. In the flow path F2, as indicated by an arrow B in FIG. 2, a high-pressure fluid flowing through the diffuser flow path 23 flows from the radially outer side toward the radially inner side.

[0092] Here, between the impeller 4 as the rotating body R and the casing 3 as the stationary body S, a frictional resistance (disk friction loss) is generated via the fluid flowing through the above-described flow path F2. In particular, in a case of the centrifugal compressor 100, since the outer diameter of the impeller 4 increases as the lifting height increases, it is known that the disk friction loss increases. Here, in the present embodiment, as shown in FIG. 11, on the first facing surface PI, a projection portion 80B is provided for controlling the flow of the fluid flowing through the flow path F2.

[0093] The projection portion 80B is provided at a position on the most radially outer side on the first facing surface P1. The projection portion 80B projects toward the second facing surface P2 and has an annular shape around the axis O. The projection portion 80B faces the second facing surface P2 with a clearance C therebetween.

[0094] According to the configuration, the fluid that flows toward the radially inner side in the flow path F2 flows toward the second facing surface P2 side along the projection portion 80B provided on the first facing surface P1. In other words, the flow of the fluid is peeled off from the first facing surface P1 and flows to the stationary body S side. Thereafter, the fluid passes through the clearance C between the projection portion 80B and the second facing surface P2. At this time, a flow velocity of the fluid increases. From the flow of the fluid having a high flow velocity, some components are separated toward the rotating body R side (that is, the first facing surface P1 side). The peeled flow forms a vortex (stagnation) in a region close to the first facing surface P1 and on the radially inner side of the projection portion 80B. More specifically, the vortex flows toward the radially inner side, and then flows from the radially outer side to the radially inner side toward the projection portion 80B along the first facing surface P1. By forming such a vortex constantly, the remaining flow components except for the vortex are inhibited by the vortex and flow toward the radially inner side at a position close to the stationary body S side (second facing surface P2 side). As a result, a friction loss between the first facing surface P1 and the second facing surface P2 can be reduced.

[0095] The sixth embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention.

[Seventh Embodiment]

[0096] Next, a seventh embodiment of the present invention will be described with reference to FIG. 12. In addition, the same configuration elements as those of each of the embodiments will be given the same reference numerals, and the detailed description thereof will be omitted. As shown in FIG. 12, in the present embodiment, a recess portion 10 is formed at the position adjacent to the radially inner side of the projection portion 80B on the first facing surface P1. The recess portion 10 is recessed in a direction spaced apart from the second facing surface P2. In a sectional view including the axis O, the recess portion 10 has a rectangular sectional shape. A recess portion bottom surface P4 which is a bottom surface (the surface facing the second facing surface P2) of the recess portion 10 widens in the radial direction with respect to the axis O.

[0097] According to the configuration, the recess portion 10 is formed adjacent to the radially inner side of the projection portion 80B. By providing the recess portion 10, the region where the vortex is formed can be enlarged. Accordingly, as the remaining flow components except for the vortex are inhibited by the vortex, the remaining flow components flow toward the radially inner side at a position close to the stationary body S side (second facing surface P2 side). As a result, a friction loss between the first facing surface P1 and the second facing surface P2 can further be reduced.

[0098] The seventh embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention.

[Eighth Embodiment]

[0099] Next, an eighth embodiment of the present invention will be described with reference to FIG. 13. In addition, the same configuration elements as those of each of the embodiments will be given the same reference numerals, and the detailed description thereof will be omitted. As shown in FIG. 13, in the present embodiment, the bottom surface (recess portion bottom surface P4') of the recess portion 10 described in the seventh embodiment is inclined with respect to the radial direction of the axis O. More specifically, the recess portion bottom surface P4' extends in the direction gradually spaced apart from the second facing surface P2 as going from the radially inner side toward the radially outer side in a sectional view including the axis O.

[0100] According to the configuration, the recess portion bottom surface P4' extends in the direction gradually spaced apart from the second facing surface P2 as going toward the radially outer side in a sectional view including the axis O. Therefore, the region where the vortex is formed can be further enlarged. Accordingly, as the remaining flow components except for the vortex are inhibited by the vortex, the remaining flow components flow toward the radially inner side at a position close to the stationary body S side (second facing surface P2 side). As a result, a friction loss between the first facing surface P1 and the second facing surface can further be reduced.

[0101] The eighth embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention.

[Ninth Embodiment]

[0102] Next, a ninth embodiment of the present invention will be described with reference to FIG. 14. In addition, the same configuration elements as those of each of the embodiments will be given the same reference numerals, and the detailed description thereof will be omitted. As shown in FIG. 14, in the present embodiment, a stationary side recess portion 11 is provided in the region facing the recess portion 10 on the second facing surface P2. The stationary side recess portion 11 is recessed in a direction spaced apart from the first facing surface P1. The bottom surface (recess portion bottom surface P5) of the stationary side recess portion 11 extends in the direction gradually spaced apart from the first facing surface P1 as going from the radially outer side toward the radially inner side in a sectional view including the axis O. In other words, the recess portion bottom surface P5 is inclined with respect to the first facing surface P1. Furthermore, the end edge on the radially inner side of the recess portion bottom surface P5 is connected to the end edge on the radially outer side of the second facing surface P2 that widens in the radial direction.

[0103] According to the configuration, the stationary side recess portion 11 is formed in the region facing the recess portion 10 on the second facing surface P2. Furthermore, the bottom surface (recess portion bottom surface P5) of the stationary side recess portion 11 extends in the direction gradually spaced apart from the first facing surface P1 as going toward the radially inner side in a sectional view including the axis O. Accordingly, as the flow path sectional area between the recess portion 10 and the stationary side recess portion 11 is gradually enlarged as going toward the radially inner side, an effect as a diffuser can be achieved. As a result, the flow velocity of the fluid that flows into the recess portion 10 decreases, and the formation of the vortex in the recess portion 10 can be promoted.

[0104] The ninth embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention.

[Tenth Embodiment]

[0105] Next, a tenth embodiment of the present invention will be described with reference to FIG. 15. In addition, the same configuration elements as those of each of the embodiments will be given the same reference numerals, and a detailed description thereof will be omitted. As shown in FIG. 15, in the present embodiment, the stationary side projection portion 90B is provided at a position facing the projection portion 80B on the second facing surface P2. The stationary side projection portion 90B projects toward the projection portion 80B. The stationary side projection portion 90B projects from the second facing surface P2 toward the first facing surface P1 side. The stationary side projection portion 90B has a rectangular sectional shape in a sectional view including the axis O. In other words, the end surface facing the first facing surface P1 side in the stationary side projection portion 90B is formed in a planar shape that widens in a plane intersecting the axis O. The clearance C is formed between the stationary side projection portion 90B and the projection portion 80B.

[0106] According to the configuration, the stationary side projection portion 90B which projects toward the projection portion 80B is provided at the position facing the projection portion 80B on the second facing surface P2. By providing the stationary side projection portion 90B, the position of the clearance C formed between the projection portion 80B and the stationary side projection portion 90B in the direction of the axis O can be adjusted. Accordingly, the position of the region where the vortex is formed can be adjusted appropriately.

[0107] Furthermore, according to the configuration, the end surface of the stationary side projection portion 90B is formed in a planar shape that widens in a plane intersecting the axis O. Therefore, for example, even in a case where the projection portion 80B is relatively displaced in the radial direction with respect to the stationary side projection portion 90B, it is possible to reduce a possibility that the size or the opening direction of the clearance C between the projection portion 80B and the stationary side projection portion 90B changes.

[0108] The tenth embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention. For example, the stationary side projection portion 90B in the tenth embodiment can also be configured as described with reference to FIGS. 7 and 8 as a modification example of the above-described fourth embodiment. In other words, a configuration in which the plurality of stationary side projection portions 90B are arranged at intervals in the circumferential direction, and each stationary side projection portion 90B extends toward the front side in a rotational direction Dr of the rotating body R as going from the radially outer side toward the radially inner side, can be employed.

[Eleventh Embodiment]

[0109] Next, an eleventh embodiment of the present invention will be described with reference to FIG. 16. In addition, the same configuration elements as those of each of the embodiments will be given the same reference numerals, and the detailed description thereof will be omitted. As shown in FIG. 16, the region facing the recess portion 10 on the second facing surface P2 (recess portion facing surface P6) extends in a direction gradually spaced apart from the first facing surface P1 as going from the radially outer side toward the radially inner side in a sectional view including the axis O. More specifically, the recess portion facing surface P6 extends radially inward starting from the tip end of the stationary side projection portion 90B.

[0110] According to the configuration, the recess portion facing surface P6 facing the recess portion 10 on the second facing surface P2 extends in the direction gradually spaced apart from the first facing surface P1 as going toward the radially inner side in a sectional view including the axis O. Accordingly, as the flow path sectional area between the second facing surface P2 and the recess portion 10 is gradually enlarged as going toward the radially inner side, an effect as a diffuser can be achieved. As a result, the flow velocity of the fluid that flows between the second facing surface P2 and the recess portion 10 decreases, and the formation of the vortex in the recess portion 10 can be promoted.

[0111] The eleventh embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention.

[Twelfth Embodiment]

[0112] Next, a twelfth embodiment of the present invention will be described with reference to FIG. 17. In addition, the same configuration elements as those of each of the embodiments will be given the same reference numerals, and the detailed description thereof will be omitted. As shown in FIG. 17, in the present embodiment, the plurality (two) of projection portions 80B are provided at intervals in the radial direction on the first facing surface P1. The two projection portions 80B have the same shape.

[0113] According to the configuration, since the plurality of projection portions 80 are provided at intervals in the radial direction on the first facing surface PI, in a wider region on the first facing surface PI, the friction loss between the rotating body R side and the stationary body S side can be reduced uniformly.

[0114] The twelfth embodiment of the present invention has been described above. In addition, various changes and modifications can be made to the above-described configuration without departing from the gist of the present invention. For example, in the twelfth embodiment, an example in which the two projection portions 80 are provided at intervals in the radial direction has been described. However, the number of the provided projection portions 80 is not limited to the description above, and may be three or more.

Industrial Applicability

[0115] According to the present invention, it is possible to provide a rotating machinery with improved efficiency by further reducing a friction loss.

EXPLANATION OF REFERENCES

[0116]

100 centrifugal compressor (rotating machinery)
1 rotating shaft

2 fluid flow path
3 casing
3A casing back surface
3B casing upstream surface
3D casing inner circumferential surface
4 impeller
5 journal bearing
6 thrust bearing
7 intake port
8 exhaust port
10 recess portion
11 stationary side recess portion
21 suction flow path
22 compression flow path
23 diffuser flow path
24 return bend portion
25 guide flow path
41 disk
41A disk back surface
42 blade
43 cover
43B cover upstream surface
50 return vane
80, 80B projection portion (rotation side projection portion)
90, 90B stationary side projection portion
Dr front side in rotational direction
F1, F2 flow path
O axis
P1 first facing surface
P11 first inner region
P12, P12' first outer region
P2 second facing surface
P21, P21' second outer region
P3 outer wall surface
P4, P4', P5 recess portion bottom surface
P6 recess portion facing surface
R rotating body
S stationary body

Claims

1. A rotating machinery comprising:

   a rotating body which is rotatable around an axis and has a first facing surface that widens in a plane intersecting the axis;
   a stationary body has a second facing surface which faces the first facing surface in an axial direction and forms a flow path through which a fluid flows from a radially inner side toward a radially outer side between the first facing surface and the second facing surface; and
   at least one rotation side projection portion which projects from the first facing surface toward the second facing surface, has an annular shape around the axis, and faces the second facing surface via a clearance.

2. The rotating machinery according to claim 1, wherein positions of a first inner region which is a region on the radially inner side with respect to the at least one rotation side projection portion and a first outer region which is a region on the radially outer side with respect to the at least one rotation side projection portion on the first facing surface, are the same in the axial direction.

3. The rotating machinery according to claim 1, wherein a first outer region which is a region on the radially outer side with respect to the at least one rotation side projection portion on the first facing surface widens to a position further away from the second facing surface in the axial direction than a first inner region which is a region on the radially inner side with respect to the at least one rotation side projection portion on the first facing surface.

4. The rotating machinery according to claim 3, wherein the first outer region extends in a direction gradually spaced apart from the second facing surface as going from the radially inner side toward the radially outer side in a sectional view including the axis.

5. The rotating machinery according to any one of claims 1 to 4,
   wherein a second outer region which is a region on the radially outer side with respect to the at least one rotation side projection portion on the second facing surface extends in a direction gradually spaced apart from the first facing surface as going from the radially inner side toward the radially outer side in a sectional view including the axis.

6. The rotating machinery according to any one of claims 1 to 5, further comprising:
   at least one stationary side projection portion which is provided at a position facing the at least one rotation side projection portion on the second facing surface and projects toward the at least one rotation side projection portion.

7. The rotating machinery according to claim 6, wherein an end surface facing the first facing surface in the at least one stationary side projection portion is formed in a planar shape that widens in a plane intersecting the axis.

8. The rotating machinery according to claim 6, wherein the at least one stationary side projection portion includes a plurality of stationary side projection portions; and
   the plurality of stationary side projection portions are arranged at intervals in a circumferential direction

and extend to a front side in a rotational direction of the rotating body as going from the radially inner side toward the radially outer side.

9. The rotating machinery according to any one of claims 6 to 8,
wherein a second outer region which is a region on the radially outer side with respect to the at least one rotation side projection portion extends in a direction gradually spaced apart from the first facing surface starting from an end edge of the at least one stationary side projection portion on a first facing surface side as going from the radially inner side toward the radially outer side in a sectional view including the axis.

10. The rotating machinery according to any one of claims 1 to 9,

wherein the at least one rotation side projection portion includes a plurality of rotation side projection portions; and
the plurality of rotation side projection portions are provided at intervals in a radial direction on the first facing surface.

11. The rotating machinery according to any one of claims 1 to 10,
wherein the at least one rotation side projection portion has a radial dimension that decreases going from the first facing surface side toward the second facing surface side.

12. A rotating machinery comprising:

a rotating body which is rotatable around an axis and has a first facing surface that widens in a plane intersecting the axis;
a stationary body which has a second facing surface which faces the first facing surface in an axial direction and forms a flow path through which a fluid flows from a radially outer side toward a radially inner side between the first facing surface and the second facing surface; and
at least one rotation side projection portion which is provided in an end portion on the radially outer side on the first facing surface, projects toward the second facing surface, has an annular shape around the axis, and faces the second facing surface via a clearance.

13. The rotating machinery according to claim 12, further comprising:
a recess portion provided adjacent to the radially inner side with respect to the at least one rotation side projection portion on the first facing surface and recessed in a direction spaced apart from the second facing surface.

14. The rotating machinery according to claim 13, wherein a bottom surface of the recess portion extends in a direction gradually spaced apart from the second facing surface as going from a radially inner side toward the radially outer side in a sectional view including the axis.

15. The rotating machinery according to claim 13 or 14, further comprising:

a stationary side recess portion provided in a region facing the recess portion on the second facing surface, and recessed in a direction spaced apart from the first facing surface,
wherein a bottom surface of the stationary side recess portion extends in a direction gradually spaced apart from the first facing surface as going from the radially outer side to the radially inner side in a sectional view including the axis.

16. The rotating machinery according to any one of claims 12 to 15, further comprising:
at least one stationary side projection portion which is provided at a position facing the at least one rotation side projection portion on the second facing surface and projects toward the at least one rotation side projection portion.

17. The rotating machinery according to claim 16, wherein an end surface facing the first facing surface in the at least one stationary side projection portion is formed in a planar shape that widens in a radial direction.

18. The rotating machinery according to claim 16,

wherein the at least one stationary side projection portion includes a plurality of stationary side projection portions; and
the plurality of stationary side projection portions are arranged at intervals in a circumferential direction and extend to a front side in a rotational direction of the rotating body as going from the radially outer side toward the radially inner side.

19. The rotating machinery according to any one of claims 13 to 15,
wherein a region facing the recess portion on the second facing surface extends in a direction gradually spaced apart from the first facing surface as going from the radially outer side to the radially inner side in a sectional view including the axis.

20. The rotating machinery according to any one of claims 12 to 19,

wherein the at least one rotation side projection portion includes a plurality of rotation side pro-

jection portions; and
the plurality of rotation side projection portions are provided at intervals in a radial direction on the first facing surface.

21. The rotating machinery according to any one of claims 12 to 20,
wherein the at least one rotation side projection portion has a radial dimension that decreases going from the first facing surface side toward the second facing surface side.

FIG. 1

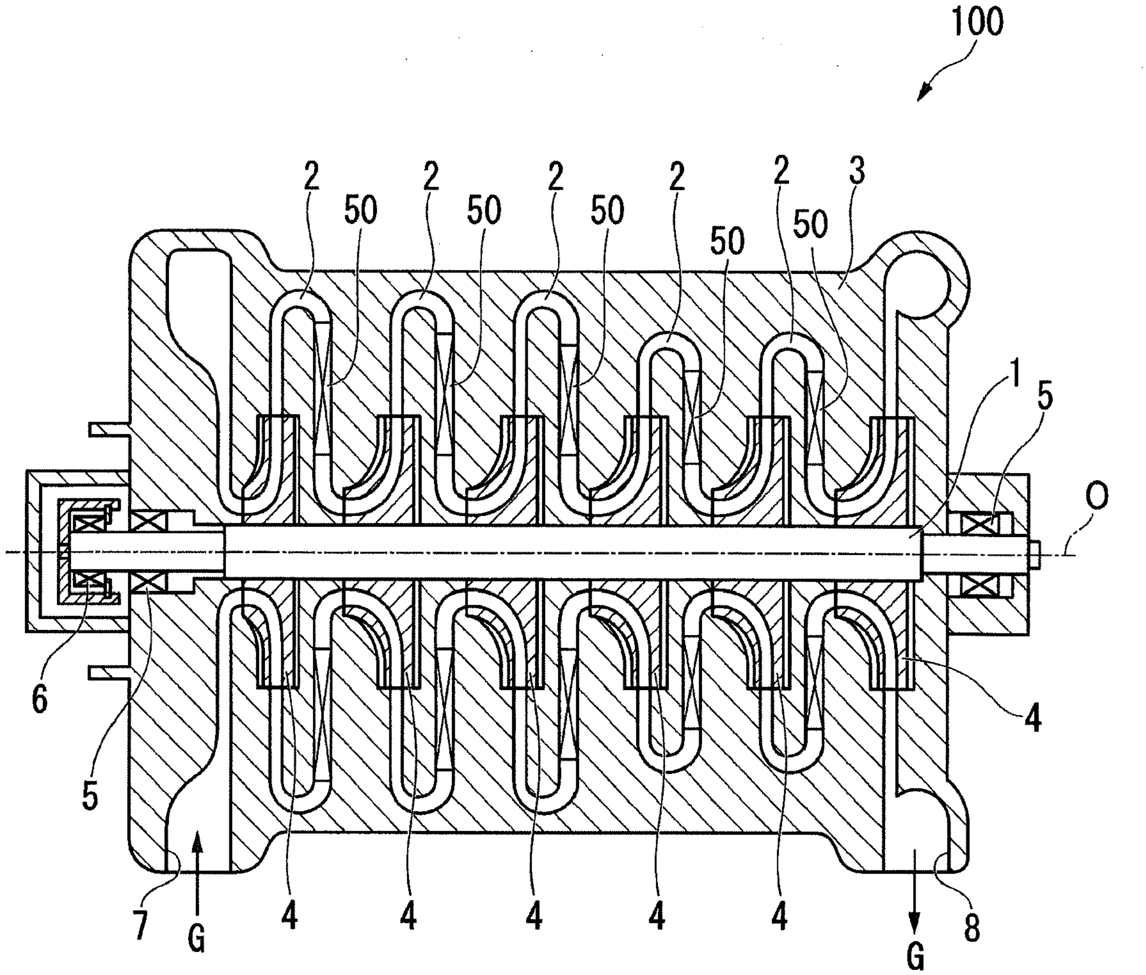


FIG. 2

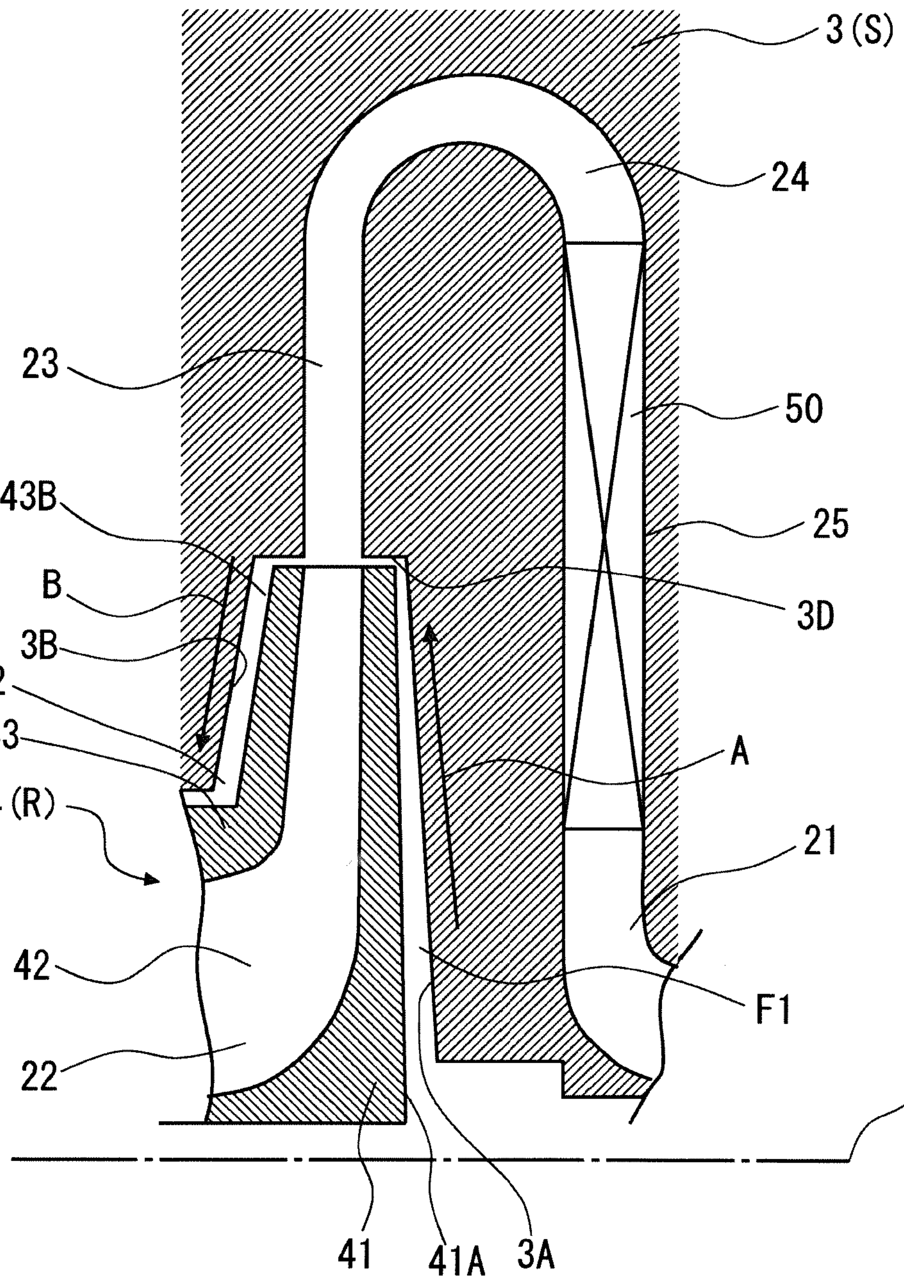


FIG. 3

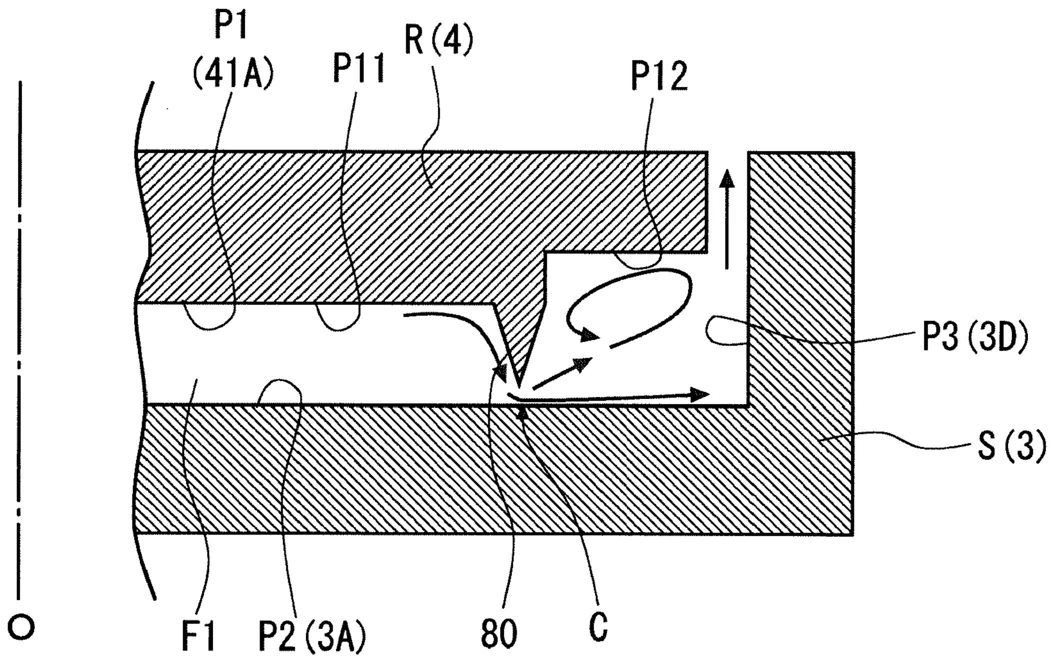

P1
(41A)
P11
R(4)
P12
P3(3D)
S(3)
O
F1
P2(3A)
80
C

FIG. 4

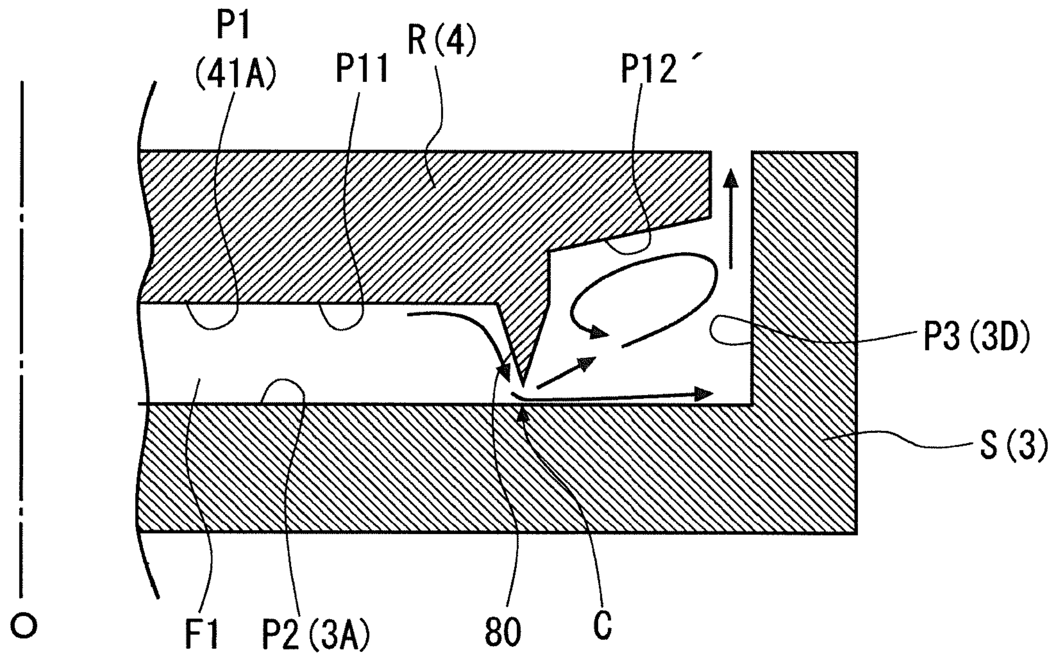

P1
(41A)
P11
R(4)
P12´
P3(3D)
S(3)
O
F1
P2(3A)
80
C

FIG. 5

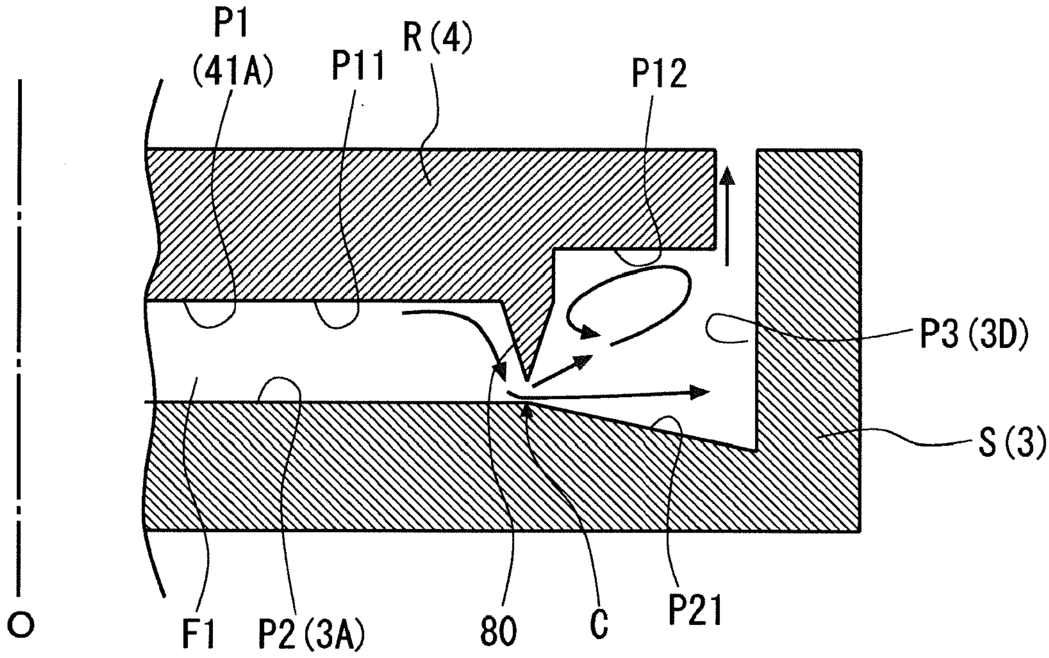

P1
(41A)
P11
R (4)
P12
P3 (3D)
S (3)
O
F1
P2 (3A)
80
C
P21

FIG. 6

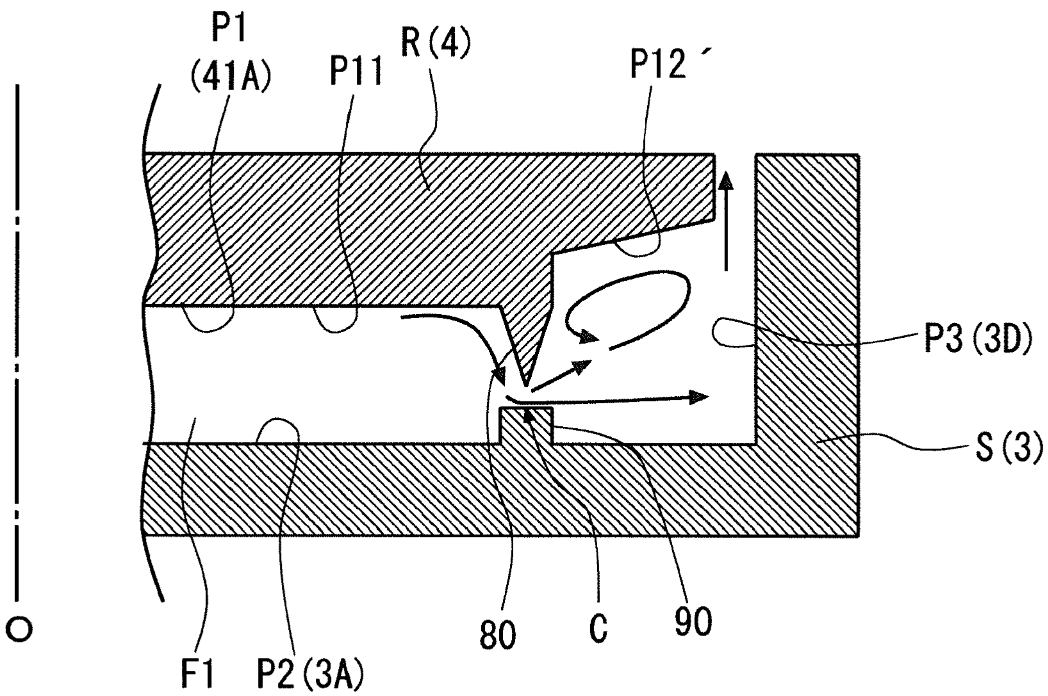

P1
(41A)
P11
R (4)
P12´
P3 (3D)
S (3)
O
F1
P2 (3A)
80
C
90

FIG. 7

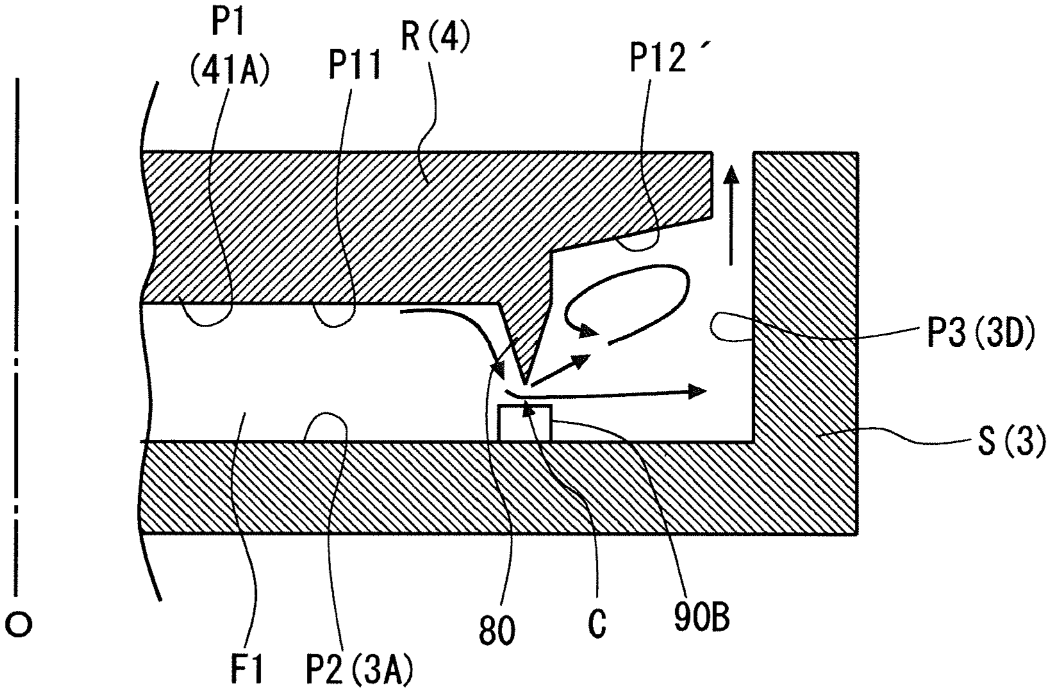


FIG. 8

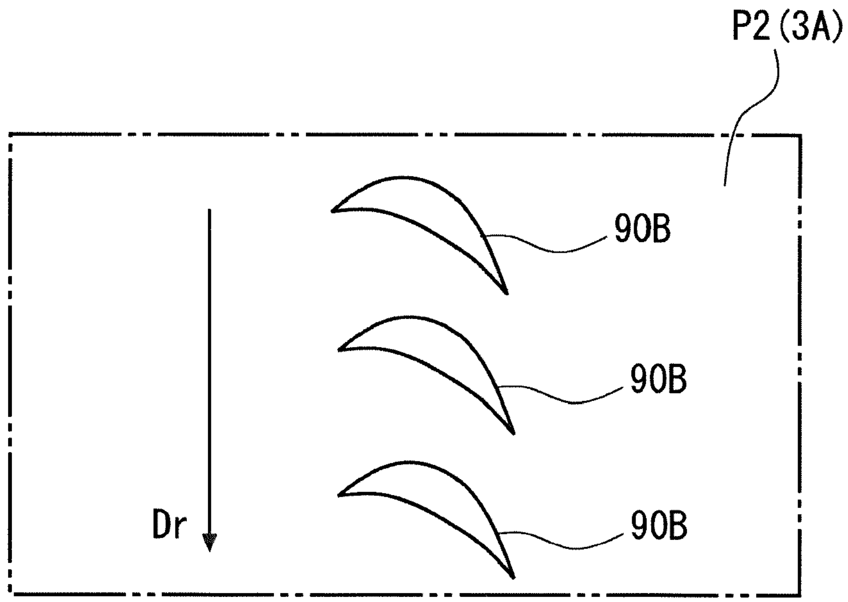


FIG. 9

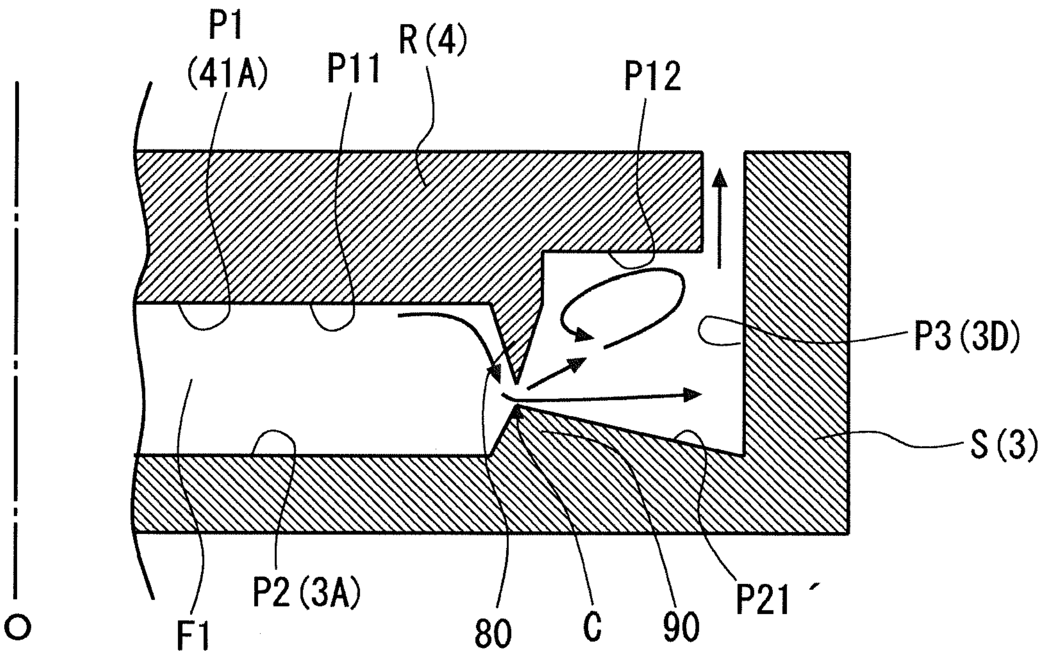

P1
(41A)
P11
R (4)
P12
P3 (3D)
S (3)
O
F1
P2 (3A)
80
C
90
P21´

FIG. 10

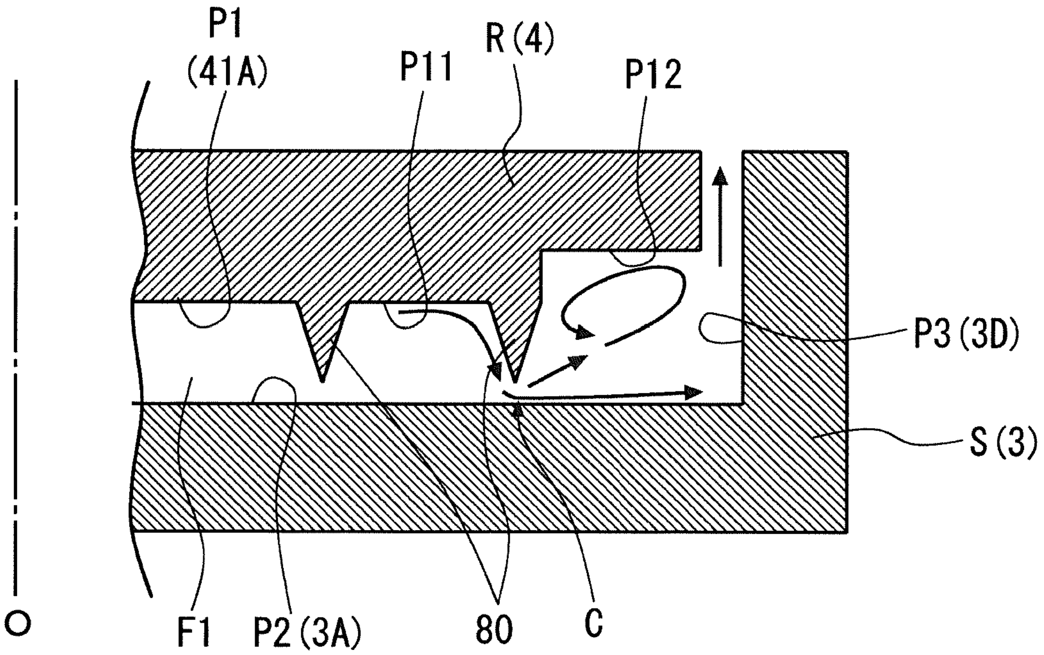

P1
(41A)
P11
R (4)
P12
P3 (3D)
S (3)
O
F1
P2 (3A)
80
C

FIG. 11

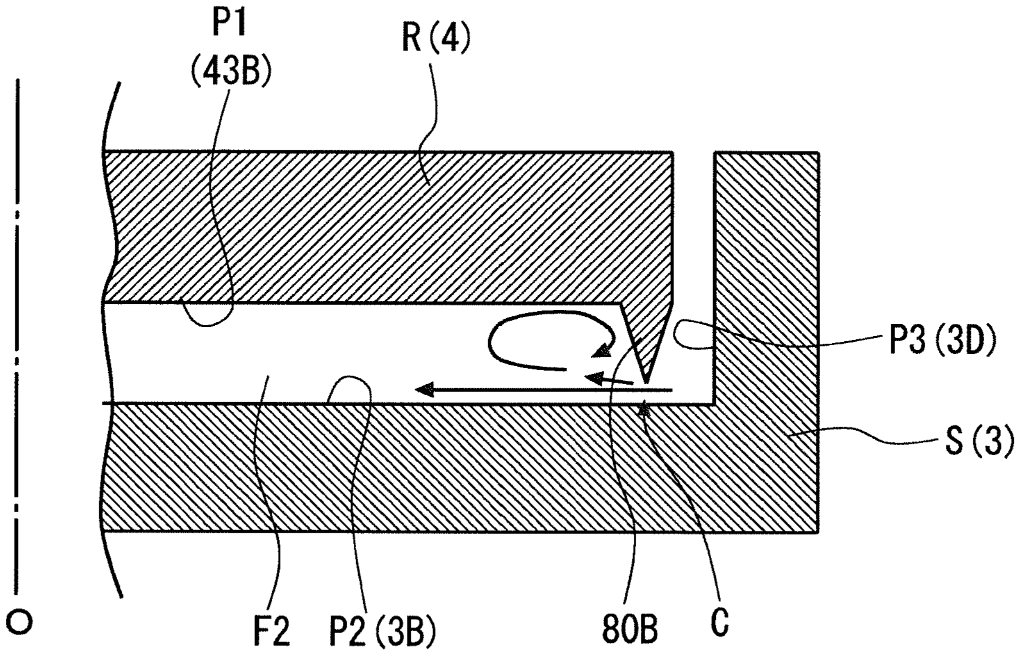

P1
(43B)
R (4)
P3 (3D)
S (3)
O
F2
P2 (3B)
80B
C

FIG. 12

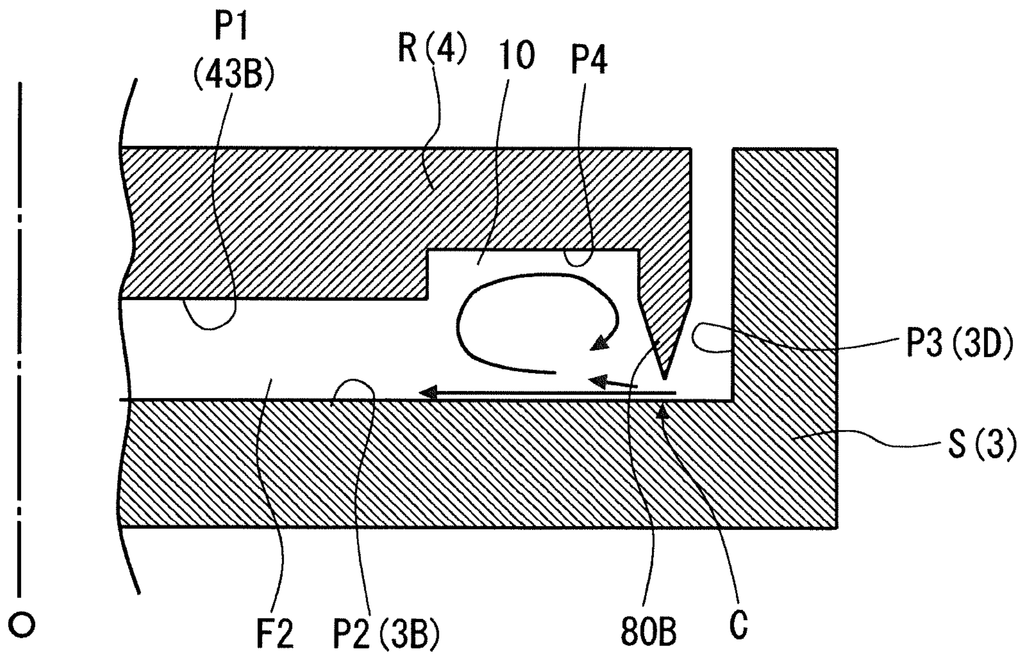

P1
(43B)
R (4)
10
P4
P3 (3D)
S (3)
O
F2
P2 (3B)
80B
C

FIG. 13

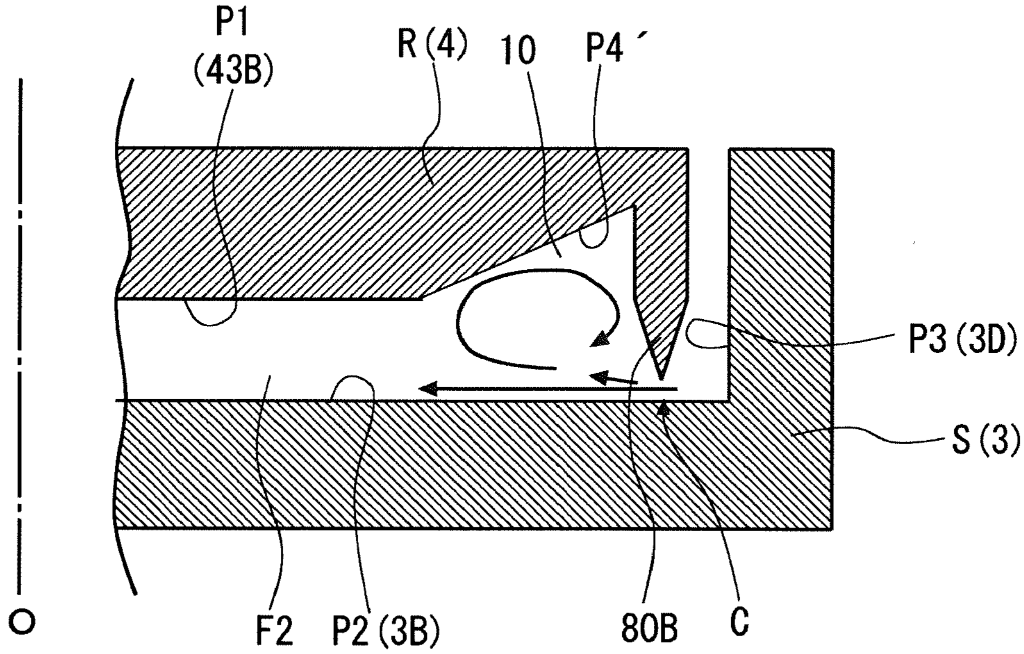

P1
(43B)
R (4)
10
P4´
P3 (3D)
S (3)
O
F2
P2 (3B)
80B
C

FIG. 14

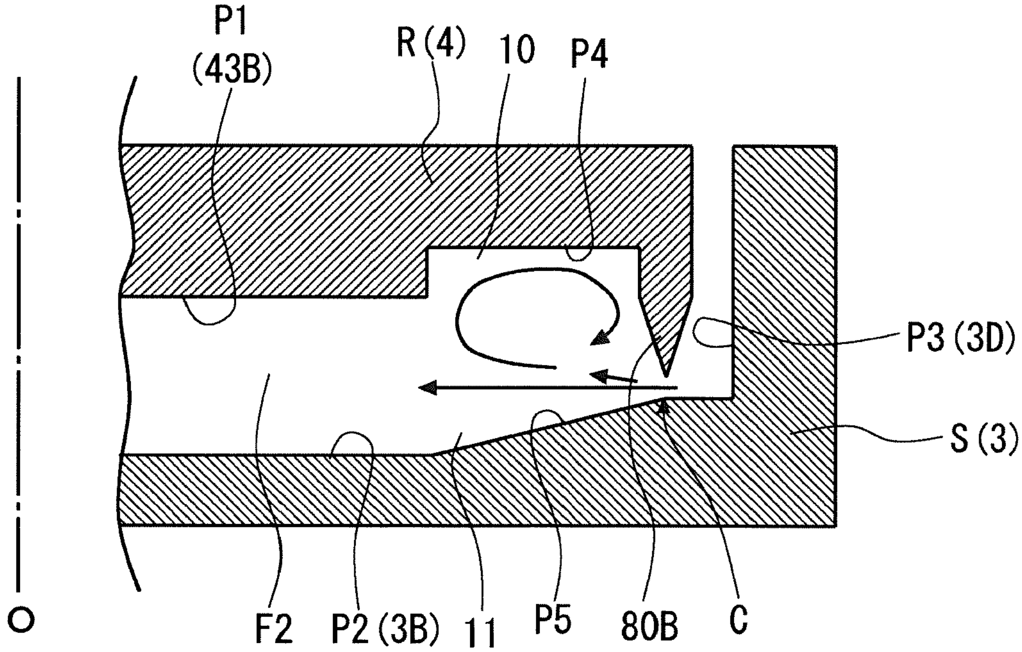

P1
(43B)
R (4)
10
P4
P3 (3D)
S (3)
O
F2
P2 (3B)
11
P5
80B
C

FIG. 15

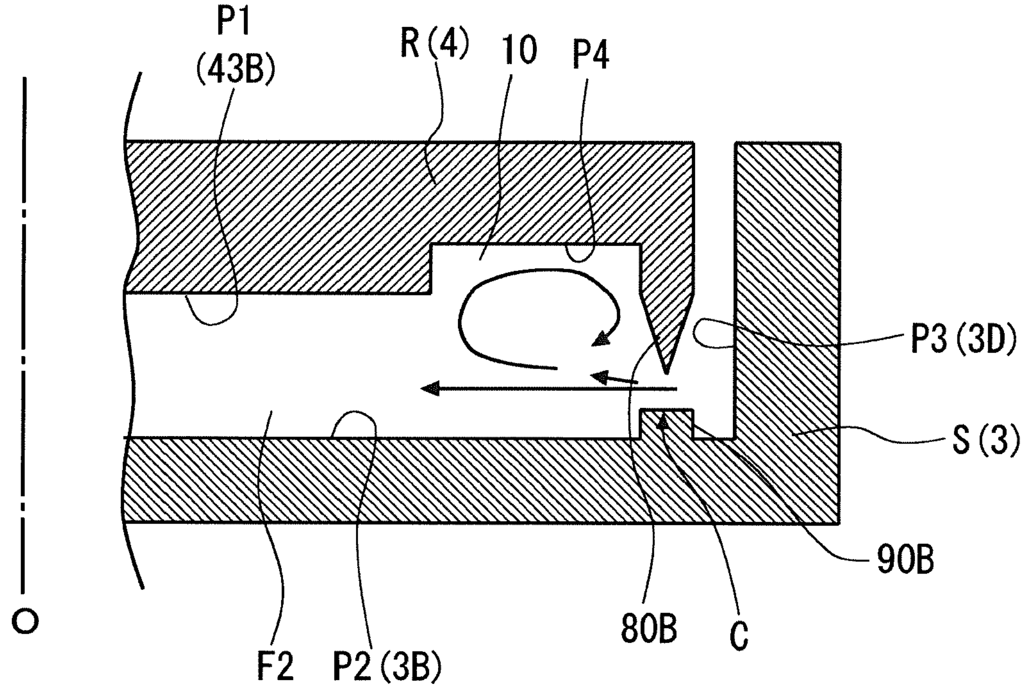

P1
(43B)
R (4)
10
P4
P3 (3D)
S (3)
90B
O
80B
C
F2
P2 (3B)

FIG. 16

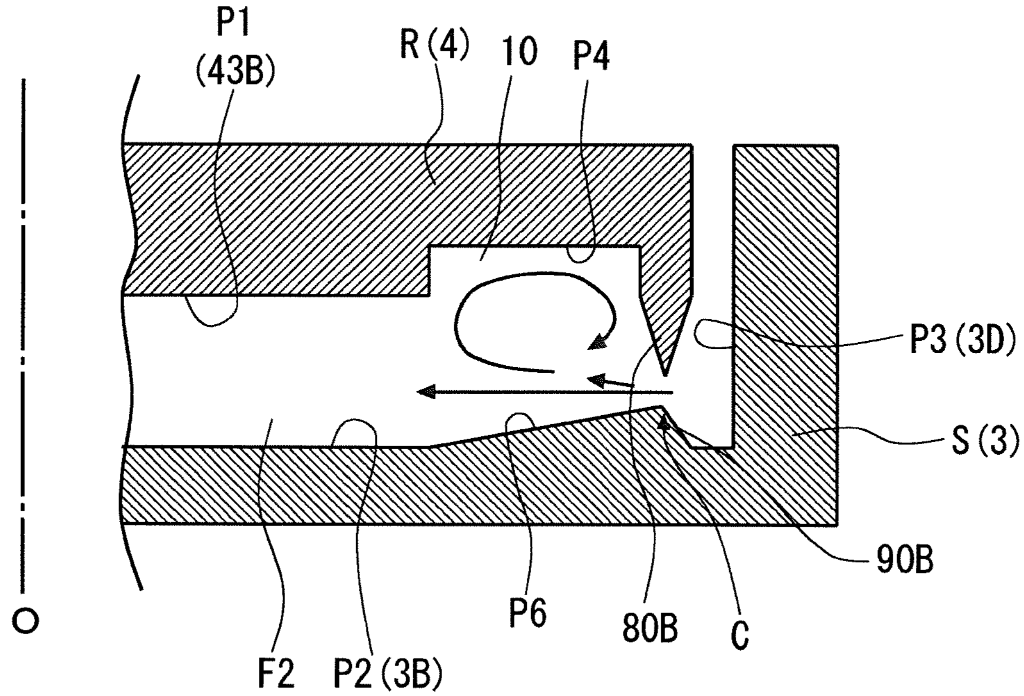
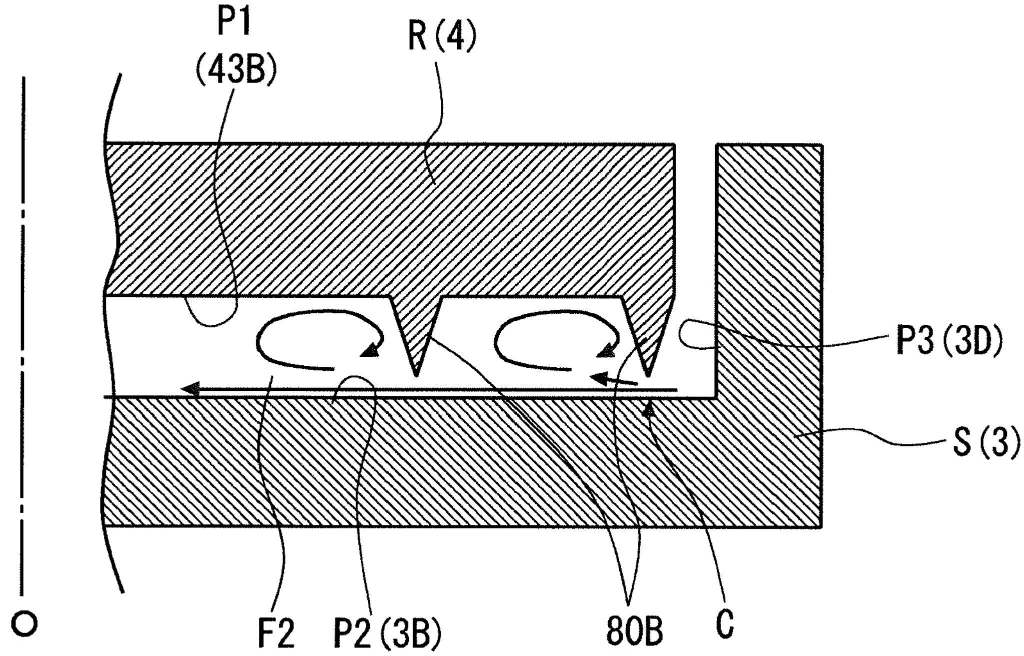

P1
(43B)
R (4)
10
P4
P3 (3D)
S (3)
90B
O
P6
80B
C
F2
P2 (3B)

FIG. 17



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EUROPEAN SEARCH REPORT

Application Number
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X A	US 5 297 928 A (IMAKIIRE KOICHIRO [JP] ET AL) 29 March 1994 (1994-03-29) * column 2, line 21 - line 66 * * figure 2 * -----	1,3-7, 10,11 2,8,9, 12-21	INV. F04D17/12 F04D29/16 F04D29/28 F04D29/42 F04D29/08
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X A	DE 22 49 974 A1 (DEMAG AG) 2 May 1974 (1974-05-02) * page 6, line 1 - line 14 * * figure 1 * -----	1,6,7, 10,11 2-5,8,9, 12-21	
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	14 July 2020	Oliveira, Damien

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