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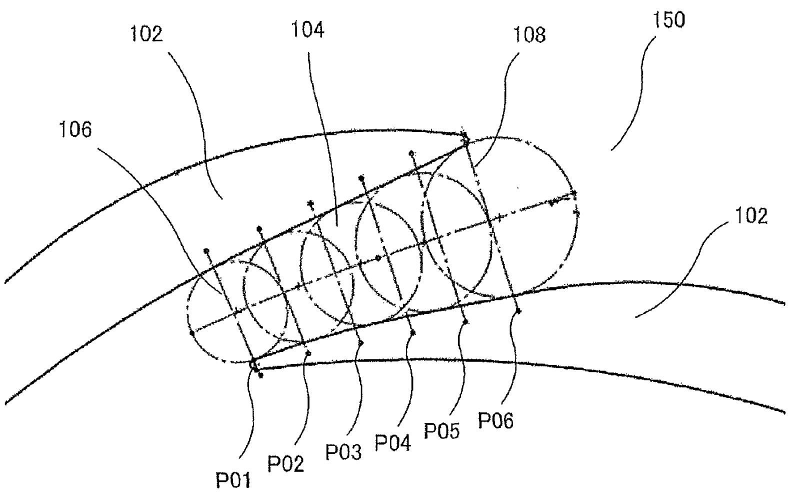
(54) FLUID MACHINE EQUIPPED WITH DIFFUSER

(57) In a fluid machine, there is provided each diffuser flow passage for making uniform a flow in a downstream of a diffuser.

The fluid machine is provided, and it has the diffuser for converting kinetic energy of a fluid into pressure energy. The diffuser has first and second diffuser flow passages configured so that the fluid passes through them, and shapes of the first and second diffuser flow passages are different from each other.

FIG. 5



EP 3 279 479 A1

Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] As a fluid machine including a diffuser, for example, a diffuser pump that transports water has been known. Generally, the diffuser pump can give water kinetic energy by an impeller that is rotatable component of a diffuser pump, can convert the kinetic energy into pressure energy by a diffuser provided on a discharge side of the impeller, and can transport the water under high pressure.

[0003] As one example, a high-pressure multi-stage diffuser pump includes a plurality of impellers fixed to a rotatable shaft. A diffuser is mounted outside the impeller of each stage in a radial direction. Diffuser vanes that define a plurality of diffuser flow passages configured such that a fluid discharged from the impellers passes through them are fixed in the diffuser. The fluid having passed through the diffuser flow passages is guided to the impeller of a next stage.

[0004] In the diffuser pump, the diffuser is designed so that a pressure loss of the fluid that passes through the pump is reduced, a flow is made uniform, and that pump efficiency is improved. Conventionally, various shapes of diffuser flow passages have been developed in order to improve pump efficiency of a diffuser pump (Patent Literature 1). Although a diffuser pump generally includes a plurality of diffuser flow passages, conventional diffuser flow passages all have the same shape.

CITATION LIST

PATENT LITERATURE

[0005] Patent Literature 1: Japanese Patent Laid-Open No. 2013-209883

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0006] Conventionally, although diffuser flow passages are all designed to have the same shape, a flow of a fluid discharged from a diffuser is not always uniform in some cases depending on shapes of flow passages located on a downstream of the diffuser. When the flow of the fluid discharged from the diffuser enters an impeller of a next stage without being appropriately rectified, pump efficiency may be lowered.

[0007] One object of the present disclosure is to provide each diffuser flow passage for reducing a pressure loss as a whole. In addition, one object of the present disclosure is to provide each diffuser flow passage for making uniform a flow on a downstream of a diffuser.

SOLUTION TO PROBLEM

[0008] According to one aspect of the present disclosure, a fluid machine is provided, and the fluid machine has a diffuser for converting kinetic energy of a fluid into pressure energy. The diffuser has first and second diffuser flow passages configured such that the fluid passes through the first and second diffuser flow passages. The first and second diffuser flow passages have different shapes.

[0009] According to one aspect of the present disclosure, in the fluid machine, each of the first and second diffuser flow passages has an inlet. In at least a part of each of the first and second diffuser flow passages, a cross sectional area perpendicular to each of flow passage centers at a position with an equal distance from each of the inlets of the first and second diffuser flow passages is different from each other.

[0010] According to one aspect of the present disclosure, in the fluid machine, the fluid machine has a first rotatable impeller for giving the fluid kinetic energy, and the first and second diffuser flow passages are located on a downstream of the first impeller in a flow direction of the fluid.

[0011] According to one aspect of the present disclosure, in the fluid machine, each of the first and second diffuser flow passages has an outlet. The fluid machine has: a first confluence flow passage fluidly connected to each of the outlets of the first and second diffuser flow passages; a first crossover flow passage fluidly connected to the first confluence flow passage, the first crossover flow passage running in a direction of a rotatable shaft of the first impeller; and a first return flow passage for supplying the fluid to a second impeller of a next stage, the second impeller located on a downstream of the first impeller in a flow direction of the fluid, the first return flow passage being fluidly connected to the first crossover flow passage. The first return flow passage runs in a radially inward direction to a rotatable shaft of the first impeller.

[0012] According to one aspect of the present disclosure, in the fluid machine, the second diffuser flow passage is located closer to the first crossover flow passage than the first diffuser flow passage, and a cross sectional area of the second diffuser flow passage is larger than that of the first diffuser flow passage.

[0013] According to one aspect of the present disclosure, in the fluid machine, the first and second diffuser flow passages are configured such that each of the cross sectional areas are increased from the inlets toward the outlets of the respective diffuser flow passages. The second diffuser flow passage has a relatively large region, small region, and large region in increase rates of the cross sectional areas from the inlet toward the outlet of the diffuser flow passage.

[0014] According to one aspect of the present disclosure, in the fluid machine, the diffuser has third and fourth diffuser flow passages configured such that the fluid passes through the third and fourth diffuser flow passages. The third and fourth diffuser flow passages are located on the downstream of the first impeller in the flow direction of the fluid. Each of the third and fourth diffuser flow passages has an outlet. The fluid machine has: a second confluence flow passage fluidly connected to each of the outlets of the third and fourth diffuser flow passages; a second crossover flow passage fluidly connected to the second confluence flow passage, the second crossover flow passage running in a direction of a rotatable shaft of the first impeller; and a second return flow passage for supplying the fluid to the second impeller, the second return flow passage being fluidly connected to the second crossover flow passage. The second return flow passage runs in a radially inward direction to a rotatable shaft of the first impeller.

[0015] According to one aspect of the present disclosure, in the fluid machine, the third and fourth diffuser flow passages have shapes of rotation symmetry of the first and second diffuser flow passages, respectively.

[0016] According to one aspect of the present disclosure, in the fluid machine, the third and fourth diffuser flow passages are configured such that each of the cross sectional areas are increased from inlets toward the outlets of the respective diffuser flow passages. The fourth diffuser flow passage has a relatively large region, small region, and large region in increase rates of the cross sectional areas from the inlet toward the outlet of the diffuser flow passage.

BRIEF DESCRIPTION OF DRAWINGS

[0017]

FIG. 1 is a cross-sectional view showing an overall configuration of a multi-stage diffuser pump according to one embodiment;
FIG. 2 is a cross-sectional view of a periphery of impellers and diffuser vanes of a multi-stage diffuser pump according to one embodiment;
FIG. 3 is a perspective view of a cross section cut out along a line segment A-A and a direction of a rotatable shaft of FIG. 2;
FIG. 4 is a view of a cross-section cut out along the line segment A-A of FIG. 2;
FIG. 5 is a plan view showing a diffuser flow passage according to one embodiment;
FIG. 6 is a graph showing a relative size of a cross-sectional area in each position of each diffuser flow passage according to one embodiment;
FIG. 7 is a perspective view of a cross section of a diffuser flow passage according to one embodiment;
FIG. 8 is a view showing cross-sectional shapes in positions P01 to P06 of the diffuser flow passage shown in FIG. 7;
FIG. 9 is a graph showing relative flow rates of a fluid in each diffuser flow passage according to one embodiment and each diffuser flow passage according to a comparative example;
FIG. 10 is a view showing pressure losses of each diffuser flow passage and each confluence flow passage according to one embodiment, and of each diffuser flow passage and each confluence flow passage of the comparative example;
FIG. 11 is a view showing a flow velocity of a fluid in each of cross-sectional positions P01 to P06 of a diffuser flow passage 104-5 according to the comparative example; and
FIG. 12 is a view showing a flow velocity of a fluid in each of the cross-sectional positions P01 to P06 of the diffuser flow passage 104-5 according to one embodiment.

DESCRIPTION OF EMBODIMENTS

[0018] Hereinafter, exemplary embodiments of the present invention will be explained along with accompanying drawings. Note that in the accompanying drawings, the same symbols are attached to the same or similar components, and overlapping explanation is omitted. In addition, features shown in each embodiment can be applied to other embodiments, unless they conflict with each other.

[0019] FIG. 1 is a cross-sectional view showing an overall configuration of a multi-stage diffuser pump 1A according to one embodiment of the present disclosure. The multi-stage diffuser pump 1A includes a rotatable member 30 and a stationary member 40.

[0020] The rotatable member 30 includes a rotatable shaft 10 whose both ends are supported. First to seventh impellers I1 to I7 are attached to impeller attaching parts 10a to 10g of the rotatable shaft 10. The rotatable member 30 is mounted rotatably in the stationary member 40.

[0021] The stationary member 40 has an outer body part 25. The outer body part 25 has a cylindrical member 20 including a suction opening Wi and a discharge opening Wo. In addition, the outer body part 25 has a suction side plate 18 and a discharge side plate 22 that close both ends of the cylindrical member 20. The stationary member 40 further has an inner body part 2A. Diffuser vanes V1 to V7 that form pumps P1 to P7 of each stage along with the impellers I1 to I7 are formed at the inner body part 2A.

[0022] The first pump P1 is located in a low-pressure chamber R1 that communicates with the suction opening Wi, and includes the impeller I1 and the diffuser vane V1. The second to seventh pumps P2 to P7 include the impellers I2 to I7 and the diffuser vanes V2 to V7. The seventh pump P7 communicates with a high-pressure chamber R2 that communicates with the discharge port Wo.

[0023] FIG. 2 is cross-sectional view of a periphery of the impellers I1 and 12, and the diffuser vanes V1 and V2 of a multi-stage diffuser pump according to one embodiment of the present disclosure. In the embodiment shown in FIG. 2, the impellers I1 and 12 fixed to the rotatable shaft 10 each have: a plurality of impeller blades 50; a hub 52 at which the impeller blades 50 have been arranged at equal intervals; and a shroud 54 that covers a front surface of the impeller blades 50. A diffuser part 100 is formed on a downstream side of the impellers I1 and 12, i.e., outside in a radial direction.

[0024] FIG. 3 is a perspective view of a cross section cut out along a line segment A-A and a direction of the rotatable shaft of FIG. 2. FIG. 4 is a view of a cross-section cut out along the line segment A-A of FIG. 2. Note that in FIGS. 3 and 4, the impeller I and the rotatable shaft 10 are omitted in order to make clear illustration of the diffuser part 100.

[0025] As shown in FIGS. 2 and 3, the diffuser part 100 has a plurality of diffuser vanes 102. Diffuser flow passages 104 are defined by a wall surface 109 at a hub 52 side, a wall surface 110 at a shroud 54 side, and each diffuser vane 102, respectively. As will be mentioned in detail later, each diffuser flow passage 104 is formed so that a cross-sectional area thereof is increased from an inlet 106 toward an outlet 108 of the diffuser flow passage 104. In addition, at least some diffuser flow passages 104 have shapes different from each other. Note that arrows indicate a flow direction of a fluid in FIG. 3.

[0026] As shown in FIGS. 3 and 4, a confluence flow passage 150 that fluidly communicates with the diffuser flow passage 104 is formed on a downstream side of the outlet 108 of the diffuser flow passage 104, i.e., outside in the radial direction. In the embodiment shown in FIG. 4, the four diffuser flow passages 104 fluidly communicate with the one confluence flow passage 150, and two sets of the four diffuser flow passages 104 and the one confluence flow passage 150 are formed. In the illustrated embodiment, the confluence flow passage 150 is located in the same flat surface as the diffuser flow passage 104. Note that the number of the diffuser flow passages 104 and the confluence flow passages 150 can be arbitrary. For example, in the other embodiment, three diffuser flow passages may fluidly communicate with one confluence flow passage, and three sets of them may be formed.

[0027] The fluid to which kinetic energy has been given by the impeller I1 and that has been discharged enters the diffuser flow passage 104, and the kinetic energy is converted into pressure energy. The fluid having come out of the outlet 108 of the each diffuser flow passage 104 enters the confluence flow passage 150 formed on a downstream of the outlet 108 of the diffuser flow passage 104. In the diffuser pump according to the embodiment of the present disclosure, shapes of the plurality of diffuser flow passages 104 are designed in consideration of a shape of the confluence flow passage 150 located on the downstream so that the pressure loss of the fluid discharged from the diffuser flow passages 104 is minimized.

[0028] In one embodiment, a crossover flow passage 200 that fluidly communicates with the confluence flow passage 150 is formed in a downstream of the confluence flow passage 150. In the illustrated embodiment, the crossover flow passage 200 extends in a direction of the rotatable shaft 10 as a whole.

[0029] In one embodiment, a return flow passage 250 that fluidly communicates with the crossover flow passage 200 is formed in a downstream of the crossover flow passage 200. The return flow passage 250 extends in radially inward direction to the rotatable shaft 10 as a whole. The impeller I2 of a next stage is formed on a downstream of the return flow passage 250.

[0030] In the illustrated embodiment, the fluid having come out of the impeller I1 passes through the diffuser flow passages 104, and is subsequently supplied to the impeller I2 of the next stage through the confluence flow passage 150, the crossover flow passage 200, and the return flow passage 250.

[0031] As mentioned above, each diffuser flow passage 104 is formed so that the cross-sectional area thereof is increased from the inlet 106 toward the outlet 108 of the diffuser flow passage 104. In addition, at least some diffuser flow passages 104 have the shapes different from each other. Hereinafter, the shapes of the diffuser flow passages 104 in one embodiment will be explained in detail.

[0032] FIG. 4 is a plan view showing the diffuser flow passages 104 and the confluence flow passages 150 cut out along the line segment A-A of FIG. 2. In the illustrated embodiment, the eight diffuser flow passages 104 are defined among the eight diffuser vanes 102. Diffuser flow passages 104-1, 104-8, 104-7, and 104-6 fluidly communicate with a confluence flow passage 150-1. Diffuser flow passages 104-2, 104-3, 104-4, and 104-5 fluidly communicate with a confluence flow passage 150-2. Conveniently, the diffuser flow passages 104-1, 104-8, 104-7, and 104-6 are set to be a group 1, and the diffuser flow passages 104-2, 104-3, 104-4, and 104-5 are set to be a group 2. The fluid having passed through the diffuser flow passages 104 of the groups 1 and 2 passes through the respective confluence flow passages 150, crossover flow passages 200, and return flow passages 250, and is supplied to the impeller of the next stage.

[0033] FIG. 5 is a plan view showing one of the diffuser flow passages 104 according to one embodiment. As shown in FIG. 5, a curved line that connects centers of circles inscribed in the two diffuser vanes 102 is defined as a flow passage center of the diffuser flow passage 104. In addition, a cross section perpendicular to the flow passage center located on an upstream-most side (a left side in FIG. 5) is defined as the inlet 106 of the diffuser flow passage 104. In addition, a cross section perpendicular to the flow passage center located on a downstream-most side (a right side in FIG. 5) is defined as the outlet 108 of the diffuser flow passage 104.

[0034] In the embodiment shown in FIG. 5, a flow passage cross-sectional area of the diffuser flow passage 104 is increased from the inlet 106 toward the outlet 108 of the diffuser flow passage 104. In the one embodiment of the present disclosure, at least a part of the plurality of diffuser flow passages 104 in the same group has a shape different from the other diffuser flow passages 104 in the same group. More specifically, levels of increase of the flow passage cross-sectional areas of the diffuser flow passages 104 are different from each other. For example, the areas of the cross sections of the diffuser flow passages 104 perpendicular to the flow passage center with the same distance from the inlet 106 of the each diffuser flow passage 104 are different from each other.

[0035] In one embodiment, the diffuser flow passage 104 can be configured so that the level of increase of the flow passage cross-sectional area becomes larger as the diffuser flow passage 104 is located closer to the crossover flow passage 200 that fluidly communicates with the confluence flow passage 150. In the embodiment shown in FIGS. 3 and 4, the crossover flow passage 200 is located close to the diffuser flow passages 104-1 and 104-5. Therefore, the diffuser flow passages 104-1 and 104-5 close to the crossover flow passage 200 are larger than the other diffuser flow passages 104-2, 104-3, 104-4, 104-6, 104-7, and 104-8 in the levels of increase of the flow passage cross-sectional areas.

[0036] FIG. 6 is a graph showing a relative size of a cross-sectional area of each position of each of the diffuser flow passages 104-1 to 104-8. A horizontal axis represents each of the positions P01 to P06 of the diffuser flow passage shown in FIG. 5. Note that the position P01 corresponds to the inlet 106 of the diffuser flow passage 104, and that the position P06 corresponds to the outlet 108 of the diffuser flow passage 104. A vertical axis of the graph of FIG. 6 represents a relative flow passage cross-sectional area in a case where the cross-sectional area of the position P01 of the one diffuser flow passage 104 used as a comparative example is set to be 100.

[0037] In the one embodiment, as for the cross-sectional areas of the diffuser flow passage 104 close to the crossover flow passage 200, the diffuser flow passage 104 has a relatively large region, small region, and large region in increase rates of the cross-sectional areas from the inlet 106 toward the outlet 108 of the diffuser flow passage 104. For example, in the graph of FIG. 6, an increase rate of a cross-sectional area of the diffuser flow passage 104-5 close to the crossover flow passage 200 is large from the positions P01 to P02, becomes relatively smaller from the positions P02 to P03, and becomes larger again from the positions P03 to P04. The diffuser flow passage 104 is configured as described above, and thereby a mixing loss can be reduced when the fluids from the other diffuser flow passages 104 are made to join each other in the confluence flow passage 150.

[0038] As the other embodiment, the diffuser flow passages 104-1, 104-8, 104-7, 104-6 of the group 1 and the diffuser flow passages 104-5, 104-4, 104-3, and 104-2 of the group 2 may be formed in shapes of rotation symmetry, respectively.

[0039] FIGS. 7 and 8 are views showing one example of cross-sectional shapes of the diffuser flow passage 104 according to one embodiment. FIG. 7 is a perspective view of a cross section of the diffuser flow passage 104, and schematically shows the cross-sectional shapes in the positions P01 to P06. Note that the diffuser vanes 102 of a front side are shown by broken lines in FIG. 7. FIG. 8 shows the each cross-sectional shape in the positions P01 to P06 shown in FIG. 7, respectively. In FIGS. 7 and 8, an upper side is the shroud 110 side, and a lower side is the hub 109 side.

[0040] As shown in FIGS. 7 and 8, in the one embodiment, in the diffuser flow passage 104, convex portions are provided in the direction of the rotatable shaft 10, and sizes of the cross-sectional areas are changed. As shown in FIGS. 7 and 8, in the one embodiment, the wall surface 110 at the shroud side of the diffuser flow passage 104 has the convex portion at the positions P01 and P02, the wall surface 109 at the hub side has the convex portion at the position P03, and the wall surfaces 109, 110 at the hub side and the shroud side have the convex portions at the positions P04 to P06. The cross-sectional shape in each position of the diffuser flow passage 104 can be arbitrary, and can be set to be a different one in the other embodiment. For example, as a non-limiting example, the cross-sectional shape of the diffuser flow passage 104 can be set to be an arbitrary one to have the convex portion only on the wall surface 110 at the shroud side, have the convex portion only on the wall surface 109 at the hub side, and to have the convex portions on both of the wall surfaces 109, 110 at the shroud side and the hub side, from the inlet 106 toward the outlet 108 of the diffuser flow passage 104.

EXAMPLE

[0041] A graph shown in FIG. 9 shows a result of having determined a flow rate per unit time of each diffuser flow passage by a Computational Fluid Dynamics (CFD) in a pump including a diffuser flow passage according to one embodiment of the present invention, and a pump including a diffuser flow passage according to a comparative example. In the graph of FIG. 9, a horizontal axis indicates the diffuser flow passages 104-1 to 104-8 shown in FIG. 4, and a vertical axis represents a relative flow rate in each of the diffuser flow passages 104-1 to 104-8. When the relative flow rate is 1, it means that the fluid with the same flow rate flows through all the diffuser flow passages 104-1 to 104-8. In the comparative example, all the diffuser flow passages have the same cross sections as those of the comparative example shown in FIG. 6, and confluence flow passages are the same as those of an example shown in FIG. 9. In the graph of FIG. 9, cross sections of each of the diffuser flow passages 104-1 to 104-8 in the example of the present invention are formed as shown in FIG. 6.

[0042] As shown in the graph of FIG. 9, as in the embodiment of the present disclosure, the cross-sectional shape is changed for each of the diffuser flow passages

104-1 to 104-8, and thereby variation in the flow rates in the respective diffuser flow passages 104-1 to 104-8 is small. Namely, a mixing loss in the confluence flow passage 150 located on the downstream of the diffuser flow passage 104 is decreased in the embodiment of the present disclosure, compared with the case of the comparative example where all shapes of the diffuser flow passages 104 are the same as each other.

[0043] FIG. 10 is a view showing a result indicating pressure losses of the diffuser flow passage 104 and the confluence flow passage 150 by the above-described CFD. In FIG. 10, magnitude of the pressure loss is shown by a gray scale, and a deeper gray scale indicates that a larger pressure loss is present. As is understood from FIG. 10, the pressure loss of the embodiment of the present disclosure is smaller as a whole than that of the case of the comparative example.

[0044] FIG. 11 is a view showing a flow velocity of the fluid in each of the cross-sectional positions P01 to P06 of the diffuser flow passage 104-5 according to the comparative example. FIG. 12 is a view showing a flow velocity of the fluid in each of the cross-sectional positions P01 to P06 of the diffuser flow passage 104-5 according to the embodiment of the present disclosure. In FIGS. 11 and 12, the flow velocity in each of the cross-sectional positions P01 to P06 is shown by iso-flow velocity lines, and the iso-flow velocity lines indicates that the closer to a center of the cross section, the larger the flow velocity is there. As is understood from FIGS. 11 and 12, in the embodiment of the present disclosure, distortion of the iso-flow velocity line is smaller than that of the comparative example, and the graph in FIG. 12 shows a distribution of the flow velocities in which regularly distributed curves are overlapped. Therefore, in the embodiment of the present disclosure, a flow of the fluid that passes through the diffuser flow passage is uniform, and a rectifying effect is improved. According to the embodiment of the present disclosure, noise and vibration in the pump can be reduced by enhancing the lowering of the pressure loss and the rectifying effect.

[0045] Although the embodiments of the invention in the present application have been explained as described above, the present invention is not limited to the above-mentioned embodiments. In addition, respective features of the above-mentioned embodiments can be combined or exchanged, unless they conflict with each other.

REFERENCE SIGNS LIST

[0046]

I1 to I7	impeller
100	diffuser part
104	diffuser flow passage
106	inlet of diffuser flow passage
108	outlet of diffuser flow passage
150	confluence flow passage
200	crossover flow passage
250	return flow passage

Claims

1. A fluid machine comprising:

a diffuser for converting kinetic energy of a fluid into pressure energy, wherein the diffuser has a first diffuser flow passage and a second diffuser flow passage configured such that the fluid passes through the first and second diffuser flow passages, and wherein the first and second diffuser flow passages have different shapes.

2. The fluid machine according to claim 1, wherein each of the first and second diffuser flow passages has an inlet, and wherein in at least a part of each of the first and second diffuser flow passages, a cross sectional area perpendicular to each of flow passage centers at a position with an equal distance from each of the inlets of the first and second diffuser flow passages is different from each other.

3. The fluid machine according to claim 1 or 2, wherein the fluid machine has a first rotatable impeller for giving a fluid kinetic energy, and wherein the first diffuser flow passage and the second diffuser flow passage are located on a downstream of the first impeller in a flow direction of the fluid.

4. The fluid machine according to claim 3, wherein each of the first and second diffuser flow passages has an outlet, the fluid machine has:

a first confluence flow passage fluidly connected to each of the outlets of the first and second diffuser flow passages;

a first crossover flow passage fluidly connected to the first confluence flow passage, the first crossover flow passage running in a direction of a rotatable shaft of the first impeller; and

a first return flow passage for supplying the fluid to a second impeller of a next stage, the second impeller located on a downstream of the first impeller in a flow direction of the fluid, the first return flow passage being fluidly connected to the first crossover flow passage, and wherein

the first return flow passage runs in a radially inward direction to a rotatable shaft of the first impeller.

5. The fluid machine according to claim 4, wherein the second diffuser flow passage is located closer to the first crossover flow passage than the first diffuser flow passage, and the cross sectional area of the second diffuser flow passage is larger than that of the first diffuser flow passage.

6. The fluid machine according to claim 5, wherein
the first diffuser flow passage and the second diffuser flow passage are configured such that each of the cross sectional areas are increased from the inlets toward the outlets of the respective diffuser flow passages, and wherein
the second diffuser flow passage has a relatively large region, small region, and large region in increase rates of the cross sectional areas from the inlet toward the outlet of the diffuser flow passage.

7. The fluid machine according to any one of claims 4 - 6, wherein
the diffuser has a third diffuser flow passage and a fourth diffuser flow passage configured such that the fluid passes through the third and fourth diffuser flow passages, and the third and fourth diffuser flow passages are located on the downstream of the first impeller in the flow direction of the fluid,
each of the third and fourth diffuser flow passages has an outlet,
the fluid machine has:

a second confluence flow passage fluidly connected to each of the outlets of the third and fourth diffuser flow passages;

a second crossover flow passage fluidly connected to the second confluence flow passage, the second crossover flow passage running in a direction of a rotatable shaft of the first impeller; and

a second return flow passage for supplying the fluid to the second impeller, the second return flow passage being fluidly connected to the second crossover flow passage, and wherein

the second return flow passage runs in a radially inward direction to a rotatable shaft of the first impeller.

8. The fluid machine according to claim 7, wherein the third diffuser flow passage and the fourth diffuser flow passage have shapes of rotation symmetry of the first diffuser flow passage and the second diffuser flow passage, respectively.

9. The fluid machine according to claim 7 or 8, wherein the third diffuser flow passage and the fourth diffuser flow passage are configured such that each of the cross sectional areas are increased from inlets toward outlets of the respective diffuser flow passages, and wherein
the fourth diffuser flow passage has a relatively large region, small region, and large region in increase rates of the cross sectional areas from the inlet toward the outlet of the diffuser flow passage.

FIG. 1

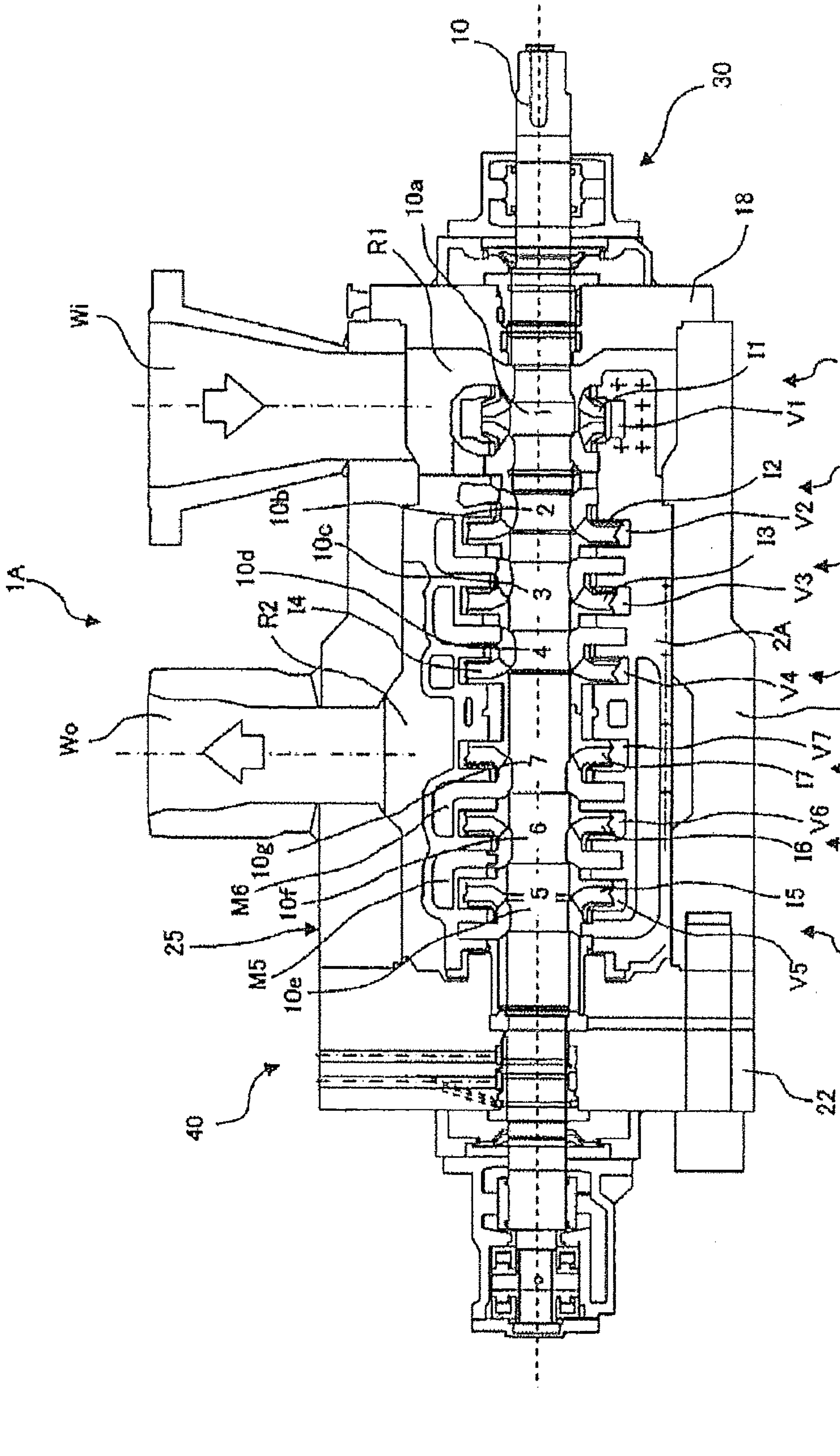

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FIG. 2

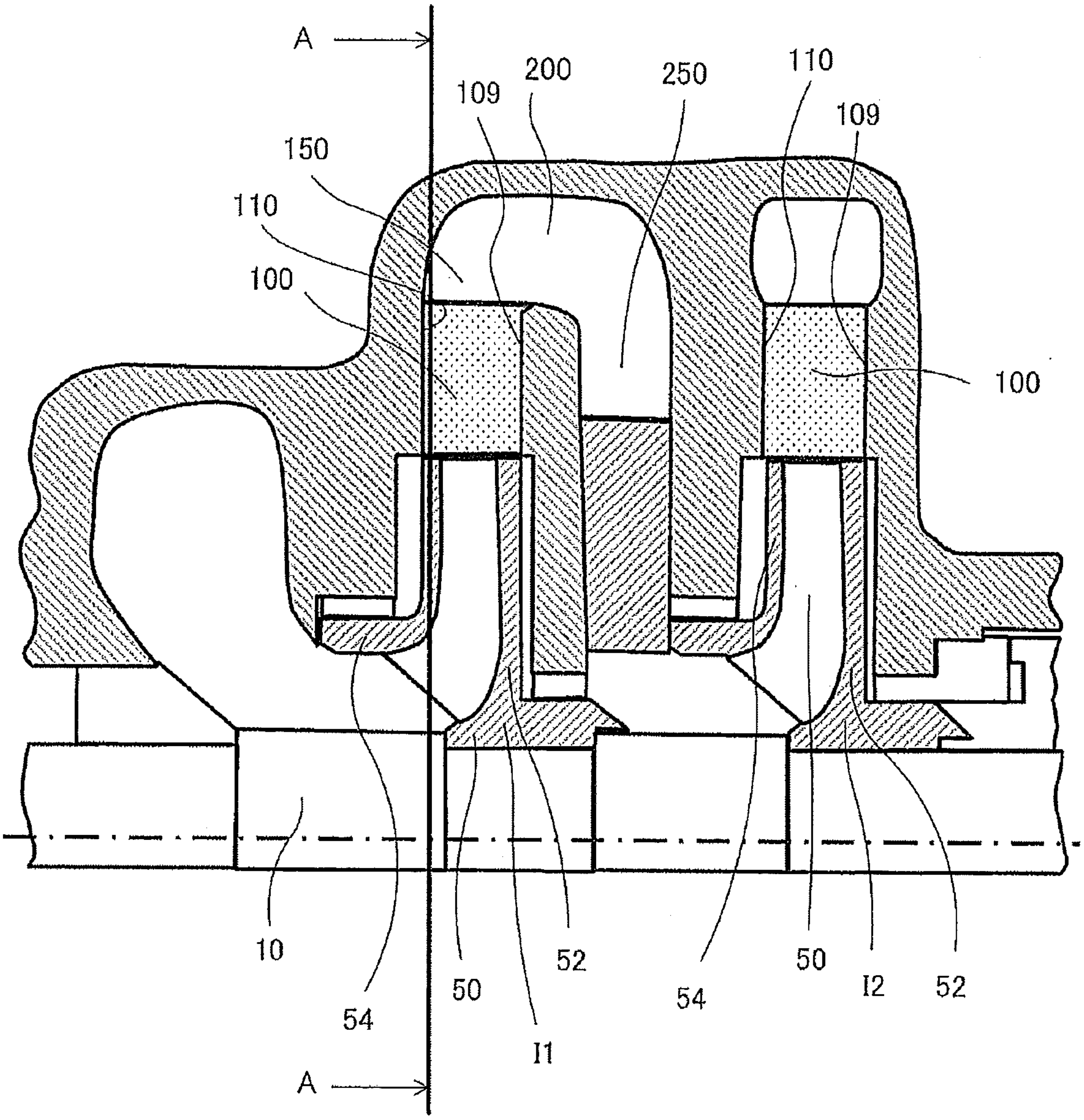

FIG. 3

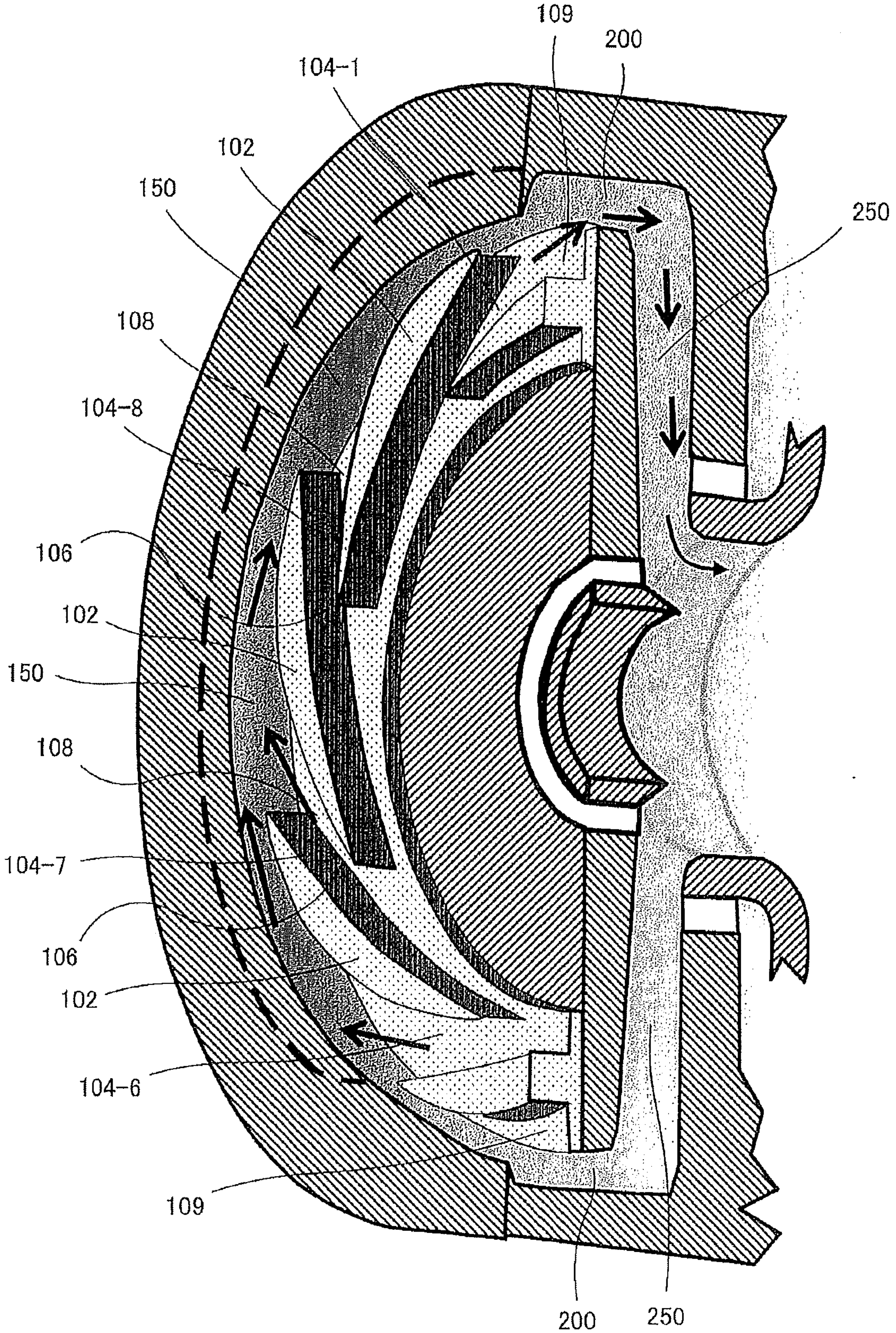
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FIG. 4

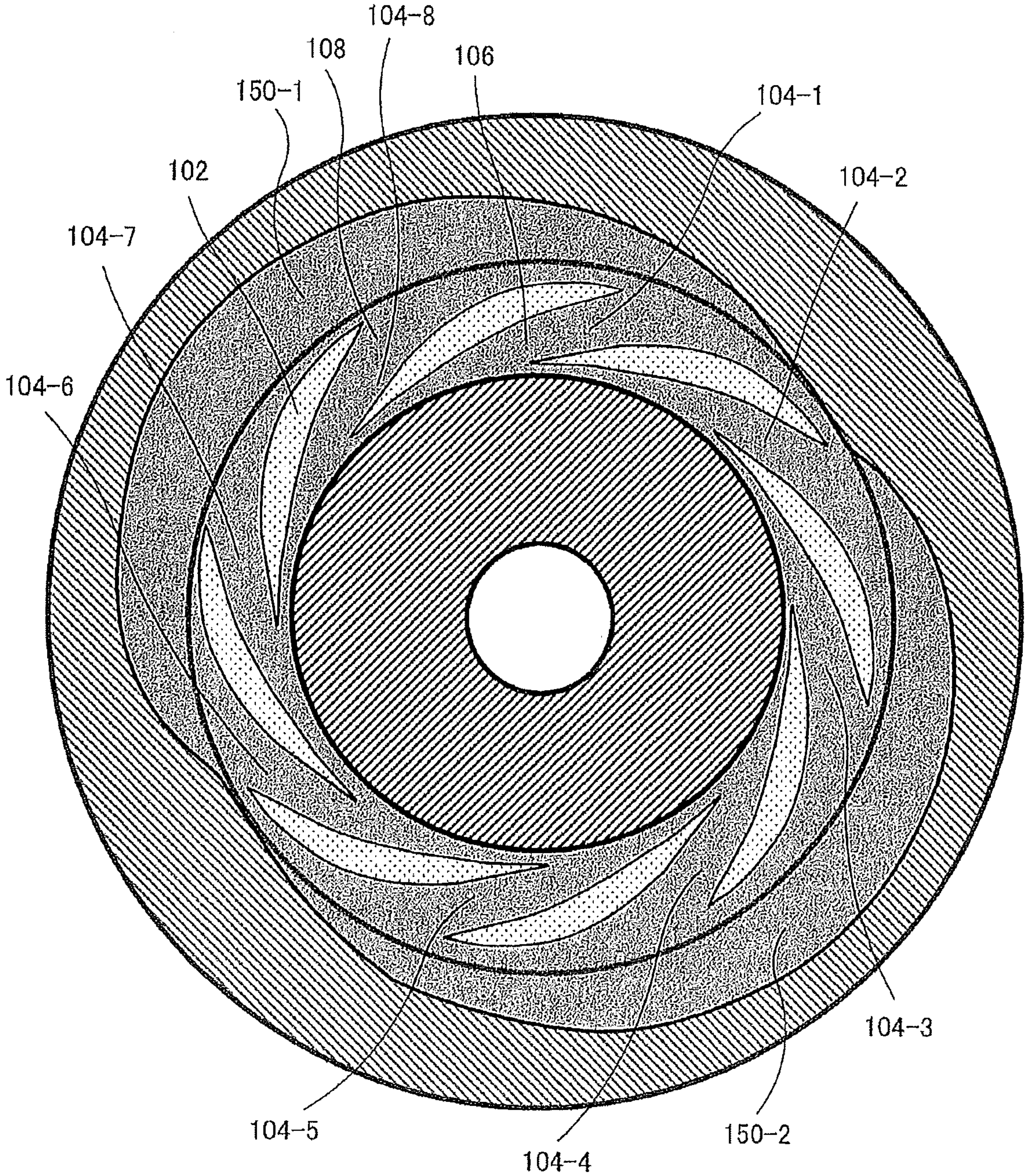
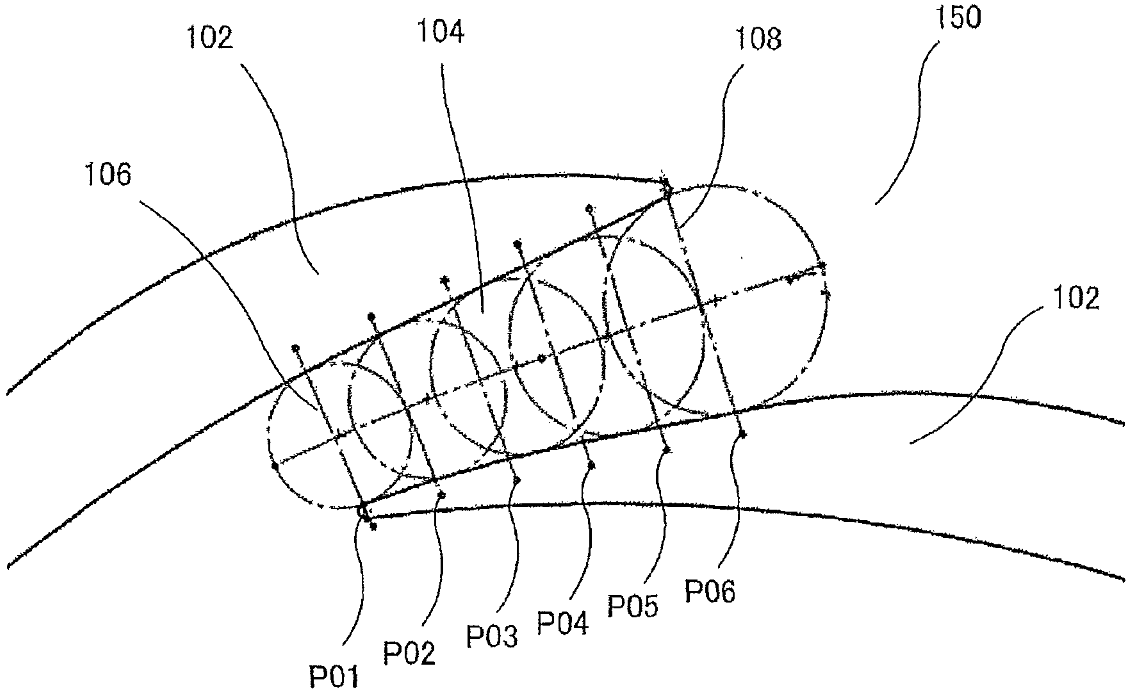


FIG. 5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104
108
150
106
102
P01
P02
P03
P04
P05
P06

FIG. 6

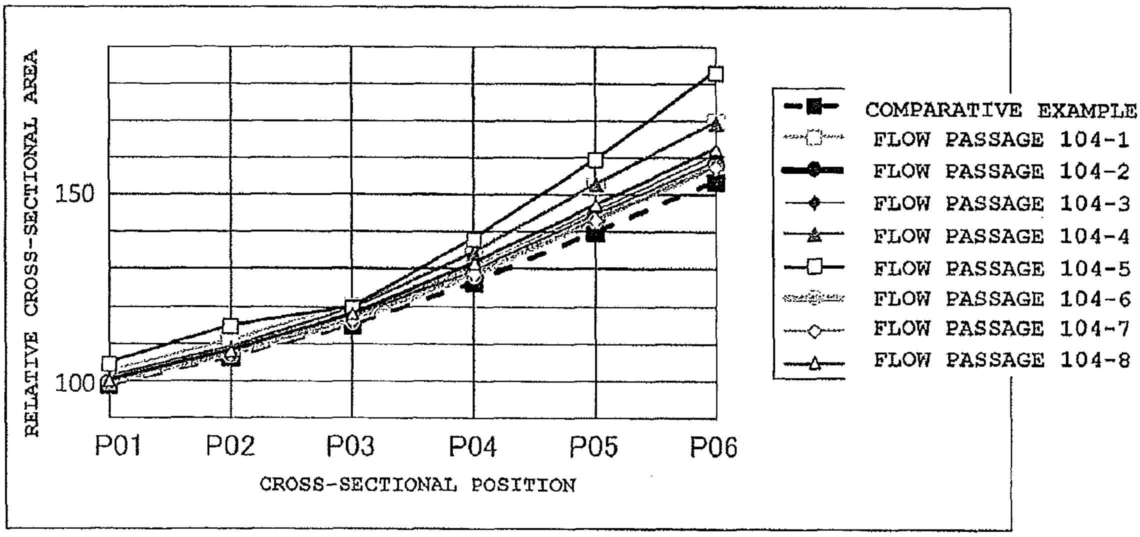

RELATIVE CROSS-SECTIONAL AREA
150
100
P01
P02
P03
P04
P05
P06
CROSS-SECTIONAL POSITION
COMPARATIVE EXAMPLE
FLOW PASSAGE 104-1
FLOW PASSAGE 104-2
FLOW PASSAGE 104-3
FLOW PASSAGE 104-4
FLOW PASSAGE 104-5
FLOW PASSAGE 104-6
FLOW PASSAGE 104-7
FLOW PASSAGE 104-8

FIG. 7

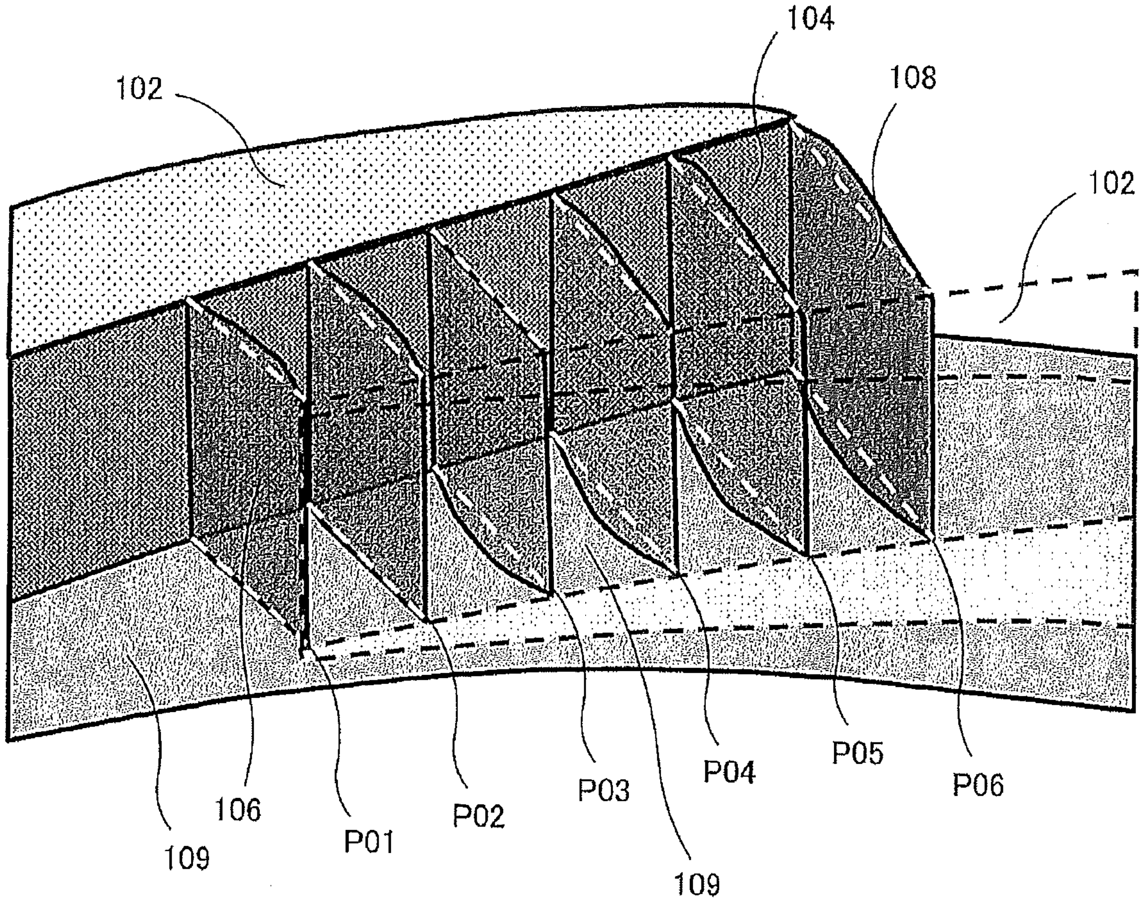

104
102
108
102
106
109
P01
P02
P03
109
P04
P05
P06

FIG. 8

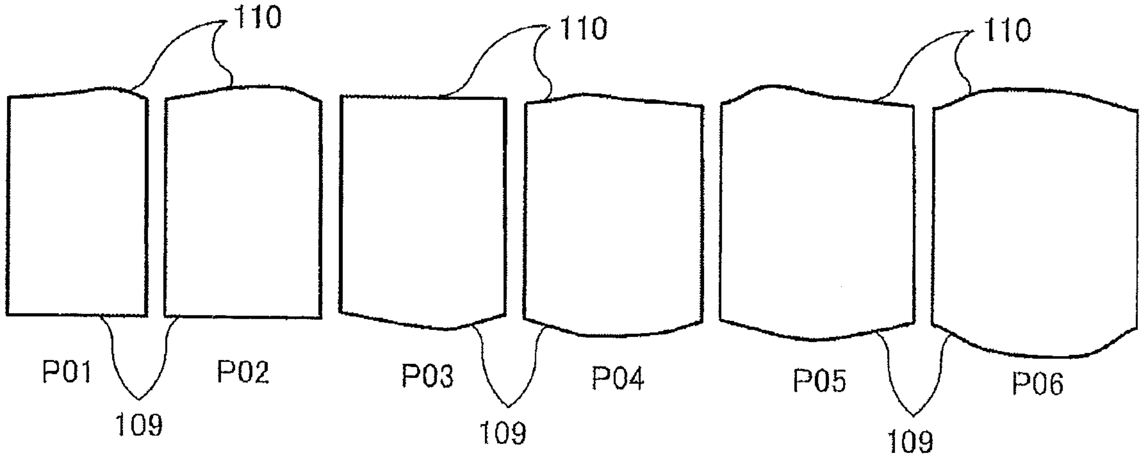

110
110
110
P01
P02
P03
P04
P05
P06
109
109
109

FIG. 9

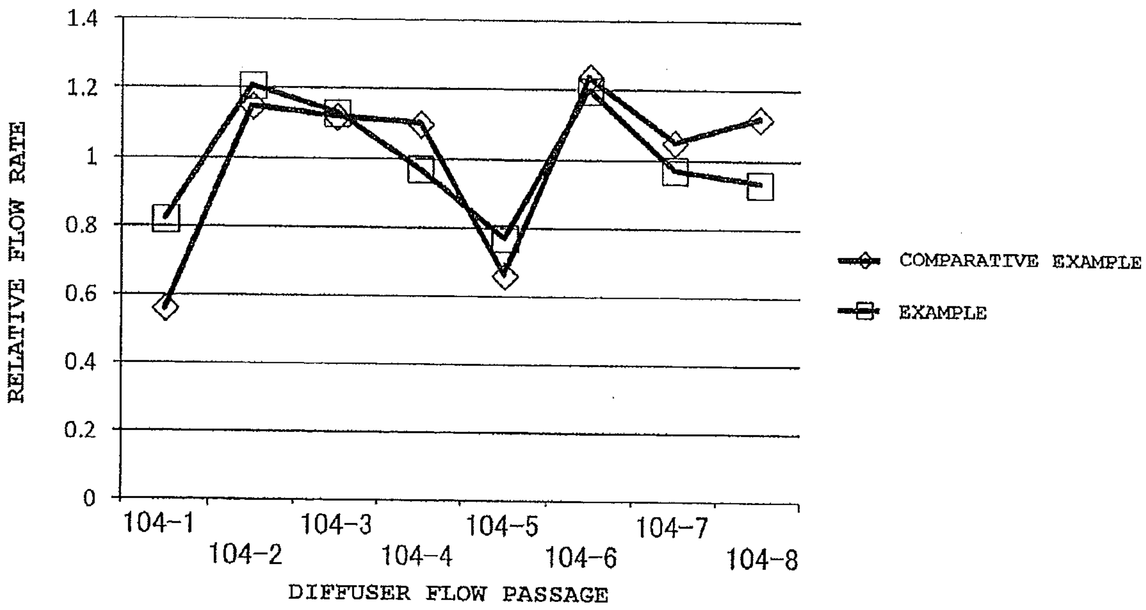

1.4
1.2
1
0.8
0.6
0.4
0.2
0
RELATIVE FLOW RATE
104-1
104-2
104-3
104-4
104-5
104-6
104-7
104-8
DIFFUSER FLOW PASSAGE
COMPARATIVE EXAMPLE
EXAMPLE

FIG. 10

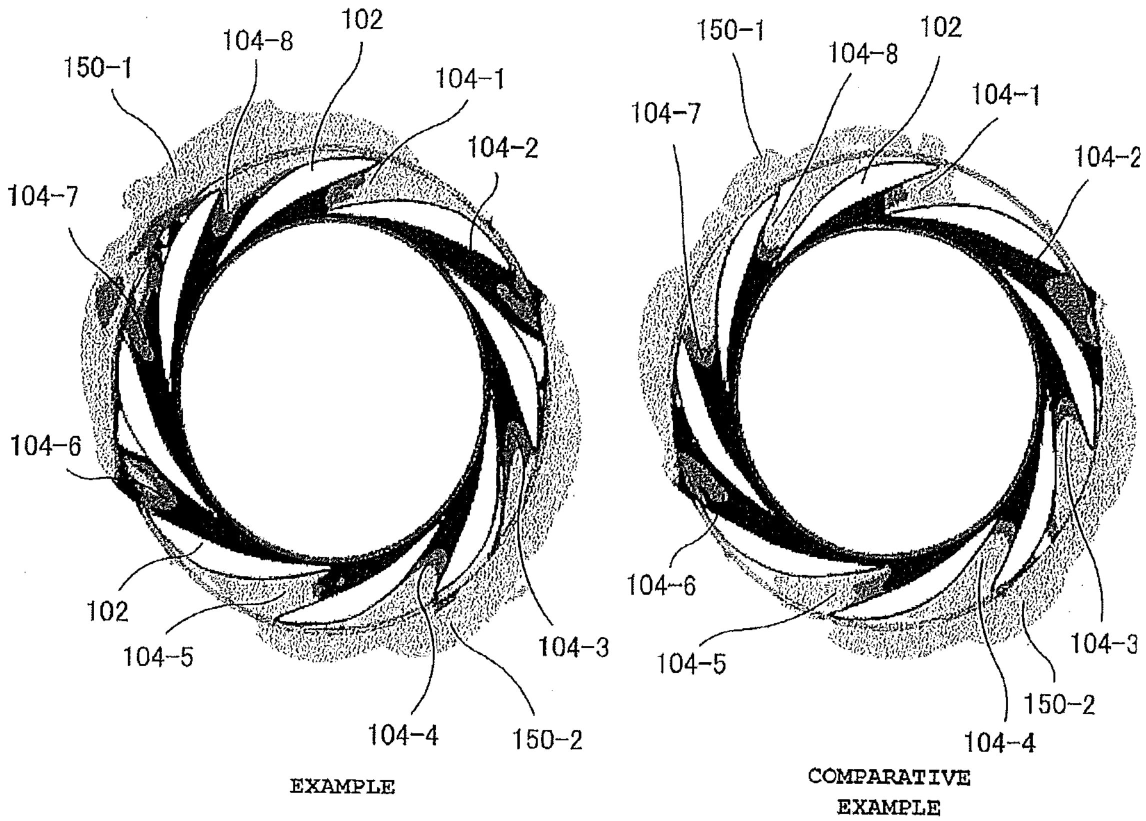

102
104-8
150-1
104-1
104-2
104-7
104-6
102
104-5
104-3
104-4
150-2
EXAMPLE
150-1
104-8
102
104-7
104-1
104-2
104-6
104-5
104-3
150-2
104-4
COMPARATIVE EXAMPLE

FIG. 11

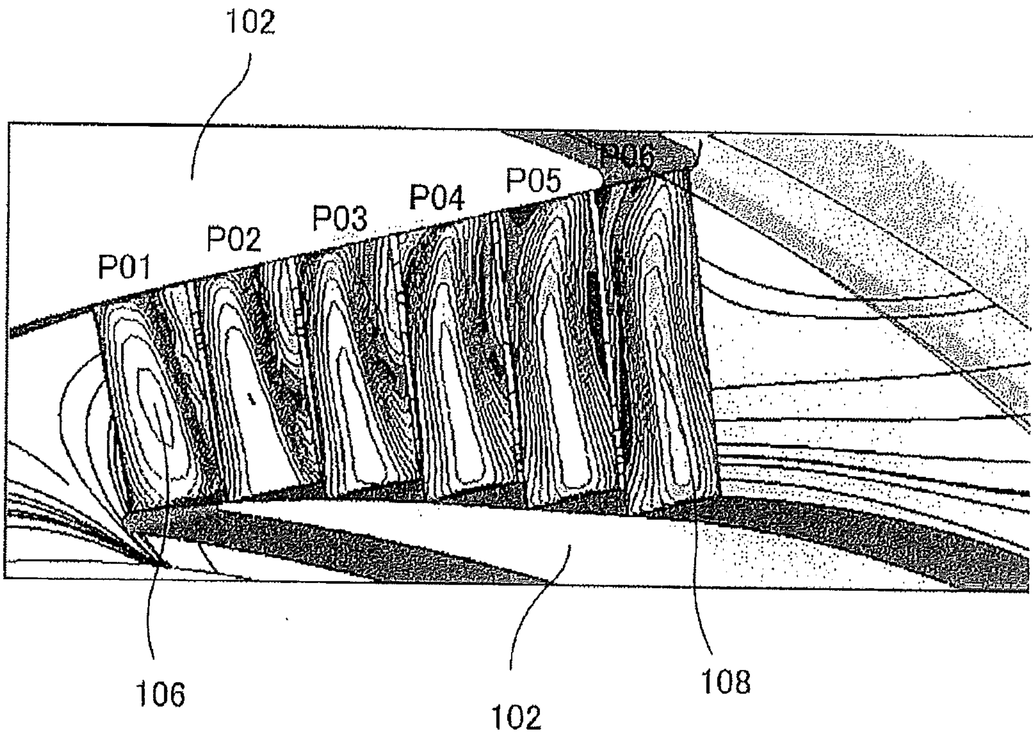
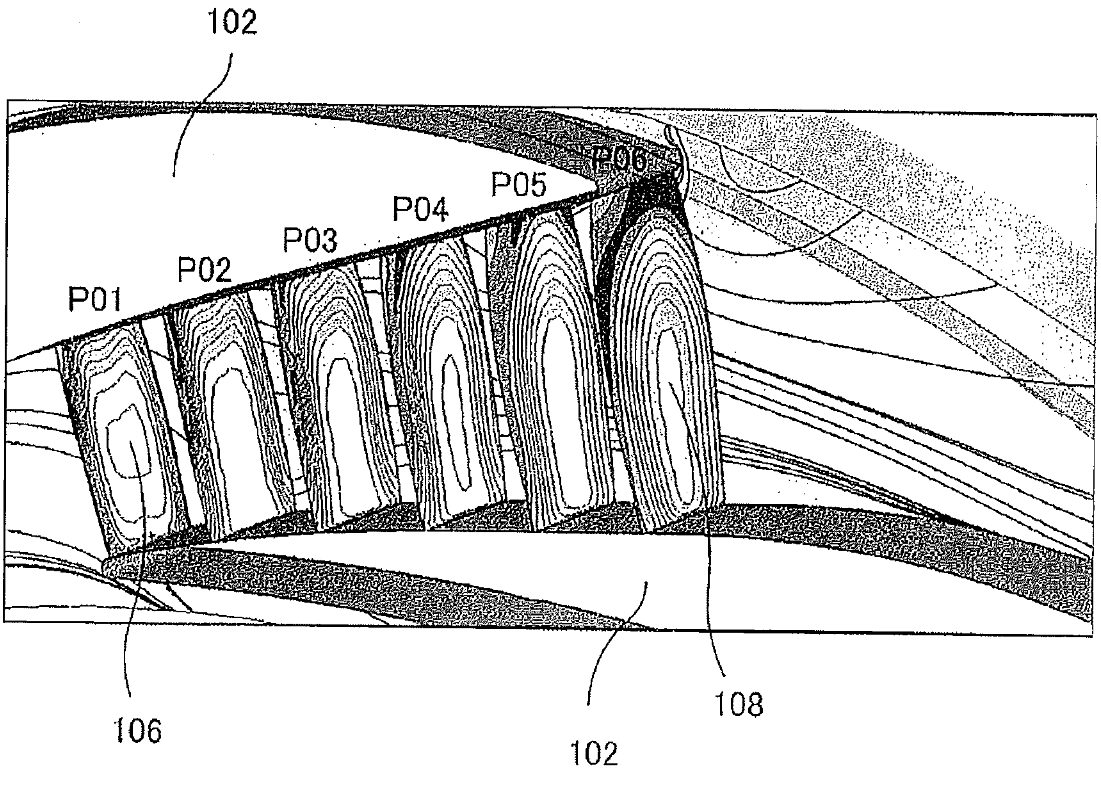

102
P01
P02
P03
P04
P05
P06
106
102
108

FIG. 12


102
P01
P02
P03
P04
P05
P06
106
102
108

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/059302

A. CLASSIFICATION OF SUBJECT MATTER
F04D29/44(2006.01)i, *F04D1/08*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04D29/44, F04D1/08

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	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 11-303797 A (Hitachi, Ltd.), 02 November 1999 (02.11.1999), paragraphs [0021] to [0030]; fig. 1 to 4 (Family: none)	1-3 4,7 5-6,8-9
X Y A	JP 2010-71241 A (Mitsubishi Heavy Industries, Ltd.), 02 April 2010 (02.04.2010), paragraphs [0022] to [0030]; fig. 1 to 3 (Family: none)	1-3 4,7 5-6,8-9

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 June 2016 (17.06.16)	28 June 2016 (28.06.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2013209883 A **[0005]**