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(71) Applicants:
- **Mitsubishi Heavy Industries, Ltd.**
  Tokyo 108-8215 (JP)
- **Mitsubishi Heavy Industries Compressor Corporation**
  Hiroshima-shi
  Hiroshima
  733-8553 (JP)

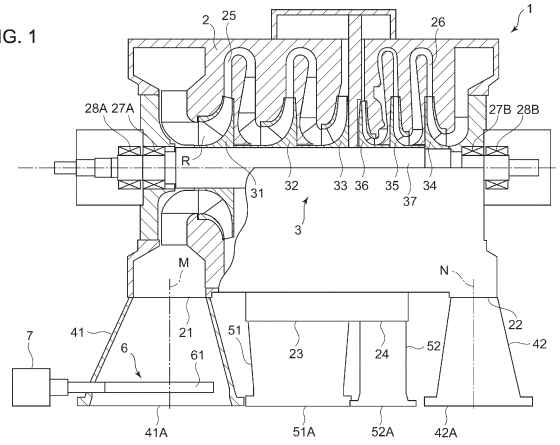
(72) Inventors:
- **NAKANIWA, Akihiro**
  Tokyo 108-8215 (JP)
- **MACHIDA, Yukinori**
  Tokyo 108-8215 (JP)
- **TOKUYAMA, Shinichiro**
  Hiroshima-shi
  Hiroshima 733-8553 (JP)

(74) Representative: **Studio Torta S.p.A.**
Via Viotti, 9
10121 Torino (IT)

(54) CENTRIFUGAL COMPRESSOR

(57) A centrifugal compressor includes: a main casing having an inlet and an outlet; at least one impeller disposed rotatably inside the main casing; an intake casing connected to the inlet, the intake casing having an intake port on a position spaced away from the inlet in a direction of an axis; a cleaning-liquid injection device capable of being disposed on a side of the intake port inside the intake casing; and a cleaning-liquid supply device for supplying a cleaning liquid to the cleaning-liquid injection device. The cleaning-liquid injection device includes: a pipe capable of being disposed so as to extend along a plane which intersects with the direction of the axis, inside the intake casing; and a plurality of injection holes disposed on the pipe.

FIG. 1



EP 3 196 481 A1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a centrifugal compressor.

BACKGROUND ART

[0002] Patent Document 1 discloses a main casing having an inlet and an outlet, and an impeller disposed rotatably inside the main casing. Such a centrifugal compressor further includes a supply pipe for supplying a cleaning liquid for cleaning the impeller, and a cleaning-liquid injection nozzle for injecting the cleaning liquid supplied from the supply pipe to the surface of the impeller, disposed on the inlet side of the main casing. With such a centrifugal compressor, dust adhering to the surface of the impeller is washed off by the cleaning liquid.

Citation List

Patent Literature

[0003] Patent Document 1: JPH8-338397A

SUMMARY

Problems to be Solved

[0004] The centrifugal compressor disclosed in Patent Document 1 includes a cleaning-liquid injection nozzle disposed in the vicinity of an inlet of a main casing, and a cleaning liquid is injected from the single cleaning-liquid injection nozzle. In this case, only one cleaning-liquid injection nozzle is provided, and the distance between the cleaning-liquid injection nozzle and the impeller is short, which makes it difficult for the cleaning liquid injected from the cleaning-liquid injection nozzle to spread out sufficiently before reaching the impeller. Thus, the cleaning liquid is not distributed evenly over the entire region of the flow-path width, and there is a risk that the entire surface of the impeller cannot be cleaned sufficiently and evenly.

[0005] In view of the above issue, an object of at least one embodiment of the present invention is to provide a centrifugal compressor whereby the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surface of the impeller can be cleaned sufficiently and evenly.

Solution to the Problems

[0006]

(1) A centrifugal compressor according to at least one embodiment of the present invention comprises: a main casing having an inlet and an outlet; at least one impeller disposed rotatably inside the main casing; an intake casing connected to the inlet, the intake casing having an intake port on a position spaced away from the inlet in a direction of an axis; a cleaning-liquid injection device capable of being disposed on a side of the intake port inside the intake casing; and a cleaning-liquid supply device for supplying a cleaning liquid to the cleaning-liquid injection device. The cleaning-liquid injection device comprises: a pipe capable of being disposed so as to extend along a plane which intersects with the direction of the axis, inside the intake casing; and a plurality of injection holes disposed on the pipe.

With the above configuration (1), the cleaning liquid is injected through the plurality of injection holes, and thereby it is possible to disperse the cleaning liquid inside the intake casing. Accordingly, the cleaning liquid dispersed inside the intake casing spreads out sufficiently before reaching the impellers, and thereby the cleaning liquid is distributed evenly over the entire region of the flow-path width, which makes it possible to clean the entire surface of the impeller sufficiently and evenly.

(2) In some embodiments, in the above configuration (1), the pipe is capable of reciprocating between an operating position inside the intake casing and a refuge position outside the intake casing.

With the above configuration (2), it is possible to set the pipe in the operation position during cleaning of the impellers, and to let the pipe refuge to the refuge position during normal time, which makes it possible to reduce the flow-path resistance inside the intake casing during normal time as compared to during cleaning of the impeller.

(3) In some embodiments, in the above configuration (1) or (2), the pipe includes an annular portion having an

annular shape in a planar view. The plurality of injection holes is disposed on the annular portion so as to be distributed in a circumferential direction of the annular portion.

With the above configuration (3), the cleaning liquid is injected through the plurality of injection holes disposed on the annular portion so as to be distributed in the circumferential direction of the annular portion, and thereby it is possible to disperse the cleaning liquid in the circumferential direction of the annular portion, inside the intake casing. The cleaning liquid dispersed in the circumferential direction can be diffused before reaching the impeller. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surface of the impeller can be cleaned sufficiently and evenly.

(4) In some embodiments, in the above configuration (3), at least a part of the plurality of injection holes is disposed on an inner peripheral surface of the annular portion.

With the above configuration (4), the cleaning liquid is injected through the plurality of injection holes disposed on the inner peripheral surface of the annular portion toward the center of the annular portion, and thereby it is possible to disperse the cleaning liquid inside the annular portion evenly in the circumferential direction of the annular portion. Since the injection direction of the cleaning liquid intersects with the flow direction of the fluid, the cleaning liquid dispersed evenly in the circumferential direction is spread out by the flow of the fluid. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surface of the impeller can be cleaned sufficiently and evenly. Furthermore, since the cleaning liquid is injected inward in the radial direction from the annular portion, it is possible to suppress adherence of the cleaning liquid to the inner wall surface of the intake casing. In this way, it is possible to reduce the amount of waste cleaning liquid that is not used in cleaning of the impellers.

(5) In some embodiments, in the above configuration (3), at least a part of the plurality of injection holes is disposed on an upstream side of the annular portion.

With the above configuration (5), the cleaning liquid is injected from the plurality of injection holes disposed on the upstream side of the annular portion, and thereby the cleaning liquid is adequately diffused by the fluid flowing inside the intake casing. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surface of the impeller can be cleaned sufficiently and evenly.

(6) In some embodiments, in any one of the above configurations (3) to (5), the pipe includes a small-diameter annular portion having an annular shape in a planar view, the small-diameter annular portion having a smaller diameter than the annular portion and disposed concentrically with the annular portion. At least a part of the plurality of injection holes is disposed on the small-diameter annular portion so as to be distributed in a circumferential direction of the small-diameter annular portion.

With the above configuration (6), the cleaning liquid is injected through the plurality of injection holes disposed on the small-diameter annular portion so as to be distributed in the circumferential direction of the small-diameter annular portion, and thereby it is possible to supply the cleaning liquid to the center region inside the intake casing away from the annular portion. The cleaning liquid injected from the injection holes disposed on the small-diameter annular portion is diffused sufficiently by a fluid flowing in the center region inside the intake casing. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surface of the impeller can be cleaned sufficiently and evenly.

(7) In some embodiments, in any one of the above configurations (3) to (5), the pipe includes at least one linear portion connecting two points on a circumference of the annular portion. At least a part of the plurality of injection holes is disposed on the linear portion so as to be distributed in a longitudinal direction of the at least one linear portion.

With the above configuration (7), the cleaning liquid is injected through the plurality of injection holes distributed in the longitudinal direction of the linear portion connecting two points on the annular portion, and thereby it is possible to supply the cleaning liquid to the center region inside the intake casing away from the annular portion. The cleaning liquid injected from the injection holes disposed on the linear portion is diffused sufficiently by a fluid flowing in the center region inside the intake casing. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers can be cleaned sufficiently and evenly.

(8) In some embodiments, in any one of the above configurations (3) to (5), the pipe includes at least one protruding portion protruding toward a center in a radial direction from the annular portion, and at least a part of the injection holes is disposed on the protruding portion.

With the above configuration (8), the cleaning liquid is injected through the plurality of injection holes disposed on the protruding portion, and thereby it is possible to supply the cleaning liquid reliably to the center region inside the intake casing away from the annular portion. The cleaning liquid injected from the injection holes disposed on the protruding portion is diffused sufficiently by a fluid flowing in the center region inside the intake casing. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers can be cleaned sufficiently and evenly.

(9) In some embodiments, in the above configuration (1) or (2), the pipe includes at least one linear portion having a linear shape. The plurality of injection holes is disposed on the at least one linear portion so as to be distributed

in a longitudinal direction of the at least one linear portion.

With the above configuration (9), the cleaning liquid is injected through the plurality of injection holes disposed so as to be distributed on the linear portion, and thereby it is possible to disperse the cleaning liquid in the longitudinal direction of the linear portion, inside the intake casing. The cleaning liquid dispersed in the longitudinal direction can be diffused before reaching the impellers. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surface of the impeller can be cleaned sufficiently and evenly.

(10) In some embodiments, in the above configuration (9), the plurality of injection holes is disposed on an upstream side of the at least one linear portion.

With the above configuration (10), the cleaning liquid is injected from the plurality of injection holes disposed on the upstream side of the at least one linear portion, and thereby the cleaning liquid is adequately diffused by the fluid flowing inside the intake casing. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surface of the impeller can be cleaned sufficiently and evenly.

(11) In some embodiments, in the above configuration (9) or (10), the plurality of injection holes is disposed on both sides of the at least one linear portion in a width direction of the at least one linear portion.

[0007] With the above configuration (11), the cleaning liquid is injected through the plurality of injection holes disposed on both sides of the at least one linear portion in the width direction of the at least one linear portion, and thereby it is possible to disperse the cleaning liquid in the longitudinal direction of the linear portion, inside the intake casing. The cleaning liquid dispersed evenly along the longitudinal direction of the linear portion can be diffused before reaching the impellers. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surface of the impeller can be cleaned sufficiently and evenly.

Advantageous Effects

[0008] According to at least one embodiment of the present invention, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surface of the impeller can be cleaned sufficiently and evenly.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

FIG. 1 is a vertical cross-sectional view schematically showing a configuration of a centrifugal compressor according to an embodiment of the present invention.

FIG. 2 is a vertical cross-sectional view, in which solid lines show the cleaning-liquid injection device depicted in FIG. 1 advanced to an operation position, and dotted lines show the cleaning-liquid injection device refuged to a refuge position.

FIG. 3 is a top cross-sectional view schematically showing a cleaning-liquid injection device according to an embodiment.

FIG. 4 is a top cross-sectional view schematically showing a cleaning-liquid injection device according to an embodiment.

FIG. 5 is a top cross-sectional view schematically showing a cleaning-liquid injection device according to an embodiment.

FIG. 6 is a top cross-sectional view schematically showing a cleaning-liquid injection device according to an embodiment.

FIG. 7 is a traverse cross-sectional view schematically showing a cleaning-liquid injection device according to an embodiment.

FIG. 8 is a top cross-sectional view schematically showing a cleaning-liquid injection device according to an embodiment.

FIG. 9 is a traverse cross-sectional view schematically showing a cleaning-liquid injection device according to an embodiment.

DETAILED DESCRIPTION

[0010] Embodiments of the present invention will now be described in detail with reference to the accompanying drawings. It is intended, however, that unless particularly specified, dimensions, materials, shapes, relative positions and the like of components described in the embodiments shall be interpreted as illustrative only and not intended to limit the scope of the present invention.

[0011] For instance, an expression of relative or absolute arrangement such as "in a direction", "along a direction",

"parallel", "orthogonal", "centered", "concentric" and "coaxial" shall not be construed as indicating only the arrangement in a strict literal sense, but also includes a state where the arrangement is relatively displaced by a tolerance, or by an angle or a distance whereby it is possible to achieve the same function.

[0012] Further, for instance, an expression of a shape such as a rectangular shape or a cylindrical shape shall not be construed as only the geometrically strict shape, but also includes a shape with unevenness or chamfered corners within the range in which the same effect can be achieved.

[0013] On the other hand, an expression such as "comprise", "include", "have", "contain" and "constitute" are not intended to be exclusive of other components.

[0014] FIG. 1 is a cross-sectional view schematically showing a configuration of a centrifugal compressor 1 according to an embodiment of the present invention.

[0015] As depicted in FIG. 1, the centrifugal compressor 1 according to an embodiment of the present invention is a centrifugal compressor of a single-shaft multi-stage centrifugal type which includes a main casing 2, at least one impeller 3, intake casings 41, 42, discharge casings 51, 52, a cleaning-liquid injection device 6, and a cleaning-liquid supply device 7.

[0016] The main casing 2 includes inlets 21, 22 and outlets 23, 24. The main casing 2 according to the present embodiment includes two inlets 21, 22 and two outlets 23, 24.

[0017] A rotational shaft 37 is disposed rotatably through the main casing 2. Specifically, the rotational shaft 37 is supported rotatably by journal bearings 27A, 27B and thrust bearings 28A, 28B disposed on either side of the main casing 2.

[0018] The inlets 21, 22 and the outlets 23, 24 are arranged along the rotational shaft 37, and the inlet 21, the outlet 23, the outlet 24, and the inlet 22 are arranged in this order from the left in FIG. 1. The inlet 21 and the outlet 23 are adjacent and make a pair, while the inlet 22 and the outlet 24 are adjacent and make another pair. The outlet 23 and the inlet 22 are connected to each other by non-depicted piping.

[0019] The main casing 2 houses at least one impeller 3 disposed rotatably inside thereof, including impellers 31 to 33, and impellers 34 to 36.

[0020] The impellers 31 to 33 and the impellers 34 to 36 are fixed to the rotational shaft 37 concentrically. Specifically, the impellers 31 to 33 are fixed in series to a section of the rotational shaft 37 extending between the inlet 21 and the outlet 23, while the impellers 34 to 36 are fixed in series to a section of the rotational shaft 37 extending between the inlet 22 and the outlet 24.

[0021] Each of the impellers 31 to 33 and the impellers 34 to 36 forms a flow path R inside the main casing 2. Diffusers 25, 26 are disposed inside the main casing 2, serving as a hydrostatic path connecting the flow paths R of the impellers 31 to 33 and of the impellers 34 to 36 in series.

[0022] The intake casings 41, 42 have intake ports 41A, 42A connected to the inlets 21, 22 and disposed separate from the inlets 21, 22 downward, for instance, in the direction of the axes M, N of the intake casings 41, 42. The intake casings 41, 42 are reduced in diameter from the intake ports 41A, 42A toward the inlets 21, 22, and the flow-path cross-sectional areas gradually decrease from the intake ports 41A, 42A toward the inlets 21, 22. In the present embodiment, the intake casings 41, 42 have a flow-path cross-sectional shape gradually changing from a circular shape to a rectangular shape from the side of the intake ports 41A, 42A toward the side of the inlets 21, 22, so that the flow-path cross-sectional shape at the side of the intake ports 41A, 42A has a circular shape and the flow-path cross-sectional shape at the side of the inlets 21, 22 has a rectangular shape.

[0023] The discharge casings 51, 52 have discharge ports 51A, 52A connected to the outlets 23, 24 and disposed separate from the outlets 23, 24 downward, for instance, in axial directions of the discharge casings 51, 52. For instance, directions of the axes M, N of the intake casings 41, 42 and the axial directions of the discharge casings 51, 52 are orthogonal to the axial direction of the rotational shaft 37.

[0024] In the centrifugal compressor 1, in response to rotation of the rotational shaft 37, a fluid to be compressed flows into the intake casing 41 through the intake port 41A. The fluid to be compressed passes through the inlet 21, and then through the flow paths R of the impellers 31 to 33 in rotation, and the diffuser 25, thus being compressed. The compressed fluid passes through the outlet 23 and the discharge casing 51 to be discharged outside the main casing 2 temporarily.

[0025] The fluid discharged from the discharge casing 51 is cooled by a non-depicted cooling device, for instance, and then flows into the intake casing 41 through the intake port 42A. The fluid having flown in passes through the inlet 22, and then through the flow paths R of the impellers 34 to 36 in rotation, and the diffuser 26, thus being compressed. The compressed fluid passes through the outlet 24 and the discharge casing 52 to be discharged outside the main casing 2.

[0026] The cleaning-liquid injection device 6 can be disposed on the side of the intake port 41A inside the intake casing 41, and a cleaning liquid is supplied to the cleaning-liquid injection device 6 from a cleaning-liquid supply device 7.

[0027] The cleaning-liquid injection device 6 is supplied with the cleaning liquid from the cleaning-liquid supply device 7 intermittently while the centrifugal compressor 1 is in operation. The cleaning liquid supplied from the cleaning-liquid injection device 6 is injected into a fluid to be compressed flowing into the casing 41, is dispersed over the fluid to be compressed, and reaches the surfaces of the impellers 31 to 33 with the fluid to be compressed. The cleaning liquid

having reached the surfaces of the impellers 31 to 33 washes off dust adhering to the surfaces of the impellers 31 to 33 and cleans the surfaces of the impellers 31 to 33.

[0028] In some embodiments, the cleaning-liquid injection device 6 includes a pipe 61 capable of being disposed so as to extend along a plane which intersects with the direction of the axis M, and a plurality of injection holes 62 (see FIG. 3) disposed on the pipe 61, inside the intake casing 41.

[0029] With this configuration, the cleaning liquid is injected through the plurality of injection holes 62, and thereby it is possible to disperse the cleaning liquid inside the intake casing 41. Accordingly, the cleaning liquid dispersed inside the intake casing 41 spreads out sufficiently before reaching the impellers 3, and thereby the cleaning liquid is distributed evenly over the entire region of the flow-path width, which makes it possible to clean the entire surfaces of the impellers 31 to 33 sufficiently and evenly.

[0030] FIG. 2 is a vertical cross-sectional view, in which solid lines show the pipe 61 depicted in FIG. 1 in an operation position inside the intake casing 41, and virtual lines (two-dotted chain lines) show the pipe 61 refuged to a refuge position outside the intake casing 41.

[0031] As depicted in FIG. 2, in some embodiments, the pipe 61 is capable of reciprocating between the operation position inside the intake casing 41 and the refuge position outside the intake casing 41.

[0032] With this configuration, it is possible to set the pipe 61 in the operation position during cleaning of the impellers, and to let the pipe 61 refuge to the refuge position during normal time. Accordingly, it is possible to reduce the flow-path resistance inside the intake casing 41 during normal time as compared to during cleaning of the impellers.

[0033] The pipe 61 can be reciprocated manually or by a power device (not depicted). For instance, the pipe 61 can be manually reciprocated by rotating a handle (not depicted), or the pipe 61 can be reciprocated by a power device by operating the power device.

[0034] FIGs. 3 to 6 are top cross-sectional views showing a cleaning-liquid injection device according to an embodiment.

[0035] As depicted in FIGs. 3 to 6, in some embodiments, the pipe 61 includes an annular portion 63 having an annular shape in a top view, and injection holes 62A being at least a part of the plurality of injection holes 62 are disposed on the annular portion 63 so as to be distributed in the circumferential direction of the annular portion 63.

[0036] With this configuration, the cleaning liquid is injected through the plurality of injection holes 62A disposed on the annular portion 63 so as to be distributed in the circumferential direction of the annular portion 63, and thereby it is possible to disperse the cleaning liquid in the circumferential direction of the annular portion 63, inside the intake casing 41. The cleaning liquid dispersed in the circumferential direction can be diffused before reaching the impeller 31. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0037] The diameter and installment position of the annular portion 63 can be set as needed. For instance, the diameter may be large so that the annular portion 63 extends along an inner wall of the intake casing 41, or may be of a size that makes internal contact with the inlet 21 and the annular portion 63 may be set concentrically with the center of the flow path. If the diameter is large so that the annular portion 63 extends along the inner wall of the intake casing 41, the cleaning liquid flows along the inner wall of the intake casing 41, and the cleaning liquid can be distributed to both sides of the flow-path width. On the other hand, if the diameter is of a size that makes internal contact with the inlet 21, and the annular portion 63 is disposed concentric with the center of the flow path (center of the cross section), it is possible to suppress adherence of the cleaning liquid to the inner wall of the intake casing 41, and to reduce the amount of waste cleaning liquid that is not used in cleaning of the impellers 31 to 33.

[0038] As depicted in FIG. 3, in some embodiments, the injection holes 62A being at least a part of the plurality of injection holes 62 are disposed on the inner peripheral surface of the annular portion 63.

[0039] With this configuration, the cleaning liquid is injected through the plurality of injection holes 62A disposed on the inner peripheral surface of the annular portion 63 toward the center of the annular portion 63, and thereby it is possible to disperse the cleaning liquid inside the annular portion 63 evenly in the circumferential direction. Since the injection direction of the cleaning liquid intersects with the flow direction of the fluid, the cleaning liquid dispersed evenly in the circumferential direction is spread out by the flow of the fluid. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly. Furthermore, since the cleaning liquid is injected inward in the radial direction from the annular portion 63, it is possible to suppress adherence of the cleaning liquid to the inner wall surface of the intake casing 41. In this way, it is possible to reduce the amount of waste cleaning fluid that is not used in cleaning of the impellers 31 to 33.

[0040] The circumferential position and diameter of the plurality of injection holes 62A disposed on the inner peripheral surface of the annular portion 63 may be set as needed. For instance, the plurality of injection holes 62A may be distributed evenly in the circumferential direction of the annular portion 63 and formed to have the same diameter so that the cleaning liquid is injected evenly. Alternatively, the plurality of injection holes 62A may be distributed to be less dense in a region closer to a supply part 64 for supplying the cleaning liquid, and more dense in a region farther from the supply part 64, taking account of a pressure decrease inside the annular portion 63. Accordingly, the cleaning liquid is injected evenly inside the intake casing 41, and the cleaning liquid is distributed evenly over the entire region of the flow-path width,

whereby the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0041] FIG. 7 is a traverse cross-sectional view schematically showing a cleaning-liquid injection device according to an embodiment. As depicted in FIG. 7, in some embodiments, injection holes 62B being at least a part the plurality of injection holes 62 are disposed on the upstream side of the annular portion 63, and have openings facing obliquely upward.

[0042] With this configuration, the cleaning liquid is injected obliquely upward from the plurality of injection holes 62B disposed on the upstream side of the annular portion 63, and thereby the cleaning liquid is adequately diffused by the fluid H flowing inside the intake casing 41. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0043] The circumferential position and diameter of the plurality of injection holes 62B disposed on the upstream side of the annular portion 63 may be set as needed. For instance, the plurality of injection holes 62B may be distributed evenly in the annular portion 63 and formed to have the same diameter so that the cleaning liquid is injected evenly. Alternatively, the plurality of injection holes 62A may be distributed to be less dense in a region closer to the supply part 64 for supplying the cleaning liquid, and more dense in a region farther from the supply part 64, taking account of a pressure decrease inside the annular portion 63. Accordingly, the cleaning liquid is injected evenly inside the intake casing 41, and the cleaning liquid is distributed evenly over the entire region of the flow-path width, whereby the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0044] As depicted in FIG. 4, in some embodiments, the pipe 61 includes a small-diameter annular portion 65 having an annular shape in a top view and a smaller diameter than the annular portion 63, disposed concentrically with the annular portion 63, and injection holes 62C being at least a part of the plurality of injection holes 62 are disposed on the small-diameter annular portion 65 so as to be distributed in the circumferential direction of the small-diameter annular portion 65.

[0045] With this configuration, the cleaning liquid is injected through the plurality of injection holes 62C disposed on the small-diameter annular portion 65 so as to be distributed in the circumferential direction of the small-diameter annular portion 65, and thereby it is possible to supply the cleaning liquid to the center region inside the intake casing 41 away from the annular portion 63. The cleaning liquid injected from the injection holes 62C disposed on the small-diameter annular portion 65 is diffused sufficiently by a fluid flowing in the center region inside the intake casing 41. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0046] The diameter of the small-diameter annular portion 65 only needs to be smaller than that of the annular portion 63. Thus, for instance, the diameter of the annular portion 63 may be large so that the annular portion 63 extends along the inner wall of the intake casing 41, and the diameter of the small-diameter annular portion 65 may be of a size that makes internal contact with the inlet 21 and the small-diameter annular portion 63 may be disposed centered at the center of the flow path. Furthermore, the small-diameter annular portion 65 does not need to be flush with the annular portion, and may be disposed downstream of the annular portion 63, for instance.

[0047] Furthermore, the circumferential position and diameter of the plurality of injection holes 62C disposed on the small-diameter annular portion 65 may be set as needed. For instance, the plurality of injection holes 62C may be distributed evenly in the circumferential direction of the small-diameter annular portion 65 and formed to have the same diameter so that the cleaning liquid is injected evenly. Alternatively, the plurality of injection holes 62C may be distributed to be less dense in a region closer to the supply part 64 for supplying the cleaning liquid, and more dense in a region farther from the supply part 64, taking account of a pressure decrease inside the small-diameter annular portion 65. Accordingly, the cleaning liquid is injected evenly inside the intake casing 41, and the cleaning liquid is distributed evenly over the entire region of the flow-path width, whereby the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0048] As depicted in FIG. 5, in some embodiments, the pipe 61 includes at least one linear portion 66 connecting two points on the circumference of the annular portion 63, and injection holes 62D being at least a part of the plurality of injection holes 62 is disposed on the linear portion 66 so as to be distributed in the longitudinal direction of the linear portion 66.

[0049] With this configuration, the cleaning liquid is injected through the plurality of injection holes 62D distributed in the longitudinal direction of the linear portion 66 connecting two points on the annular portion 63, and thereby it is possible to supply the cleaning liquid to the center region inside the intake casing 41 away from the annular portion 63. The cleaning liquid injected from the injection holes 62D disposed on the linear portion 66 is diffused sufficiently by a fluid flowing in the center region inside the intake casing 41. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0050] The circumferential position and diameter of the plurality of injection holes 62D disposed on the linear portion 66 may be set as needed. For instance, the plurality of injection holes 62D may be provided at regular intervals, or to be less dense in a region closer to the supply part 64 and more dense in a region farther from the supply part so that the cleaning liquid is injected evenly. In this case, the plurality of injection holes 62D have the same diameter, and the same flow amount of cleaning liquid is injected from the injection holes 62D. Accordingly, the entire surfaces of the

impellers 31 to 33 can be cleaned sufficiently and evenly.

[0051] Further, in some embodiments, the pipe 61 includes a first linear portion 66A passing through the center of the annular portion, and a second linear portion 66B disposed parallel to the first linear portion 66A on both sides of the first linear portion 66A. The injection holes 62D being at least a part of the plurality of injection holes 62 are disposed on the first linear portion 66A and the second linear portion 66B so as to be distributed in the longitudinal direction of the first linear portion 66A and the second linear portion 66B. Furthermore, the plurality of injection holes 62D are disposed on both sides of the first linear portion 66A at least in the width direction of the first linear portion 66A. With this configuration, the cleaning liquid is injected from the plurality of injection holes 62D disposed so as to be distributed in the longitudinal direction of the first linear portion 66, and thereby the cleaning liquid is adequately diffused by the fluid flowing through the center region inside the intake casing 41. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0052] Furthermore, the circumferential position and diameter of the plurality of injection holes 62D disposed in the longitudinal direction of the first linear portion 66A and the second linear portion 66B may be set as needed. For instance, the plurality of injection holes 62D may be disposed on the first linear portion 66A and the second linear portion 66B so as to be distributed in the longitudinal direction of the first linear portion 66A and the second linear portion 66B so that the cleaning liquid is injected evenly. In this case, the plurality of injection holes 62D have the same diameter, and the same flow amount of cleaning liquid is injected through the injection holes 62D. Accordingly, the cleaning liquid is injected evenly, and the cleaning liquid is distributed evenly over the entire region of the flow-path width, whereby the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0053] As depicted in FIG. 6, in some embodiments, the pipe 61 includes at least one protruding portion 67 protruding toward the center in the radial direction from the annular portion 63, and injection holes 62E being at least a part of the plurality of injection holes 62 are disposed on the protruding portion 67.

[0054] With this configuration, the cleaning liquid is injected through the plurality of injection holes 62E disposed on the protruding portion 67, and thereby it is possible to supply the cleaning liquid reliably to the center region inside the intake casing 41 away from the annular portion 63. The cleaning liquid injected from the injection holes 62E disposed on the protruding portion 67 is diffused sufficiently by a fluid flowing in the center region inside the intake casing 41. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0055] Specifically, the pipe 61 includes four protruding portions 67 protruding toward the center in the radial direction from respective positions that divide the annular portion 63 into four sections in the circumferential direction (the annular portion 63), and injection holes 62E being at least a part of the plurality of injection holes 62 are disposed on the protruding portions 67. More specifically, the injection holes 62E being at least a part of the injection holes 62 is disposed on tips of the protruding portions 67 and on both sides of the protruding portions 67 in the width direction of the protruding portions 67. With this configuration, the cleaning liquid is injected from the plurality of injection holes 62E disposed on the protruding portions 67, and thereby the cleaning liquid is adequately diffused by the fluid flowing through the center region inside the intake casing 41. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0056] FIG. 8 is a top cross-sectional view schematically showing a cleaning-liquid injection device according to an embodiment.

[0057] As depicted in FIG. 8, in some embodiments, the pipe 61 includes at least one linear portion 68 having a linear shape, and a plurality of injection holes 62E is disposed on the at least one linear portion 68 so as to be distributed in the longitudinal direction of the at least one linear portion 68.

[0058] With this configuration, the cleaning liquid is injected through the plurality of injection holes 62E disposed so as to be distributed on the linear portion 68, and thereby it is possible to disperse the cleaning liquid in the longitudinal direction of the linear portion, inside the intake casing 41. The cleaning liquid dispersed in the longitudinal direction can be diffused before reaching the impellers 31 to 33. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0059] The installment position of the linear portion 68 can be set as needed. For instance, the installment position may be set so as to intersect the flow path of the intake casing 41. With the linear portion 88 being disposed so as to intersect the flow path of the intake casing 41, the cleaning liquid is injected evenly to the center of the flow path of the casing 41 as well, thus being distributed evenly over the entire region of the flow-path width, whereby the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0060] FIG. 9 is a traverse cross-sectional view schematically showing a cleaning-liquid injection device according to an embodiment.

[0061] As depicted in FIG. 9, in some embodiments, a plurality of injection holes 62F are disposed on the upstream side of the at least one linear portion 68, and have openings facing obliquely upward.

[0062] With this configuration, the cleaning liquid is injected obliquely upward from the plurality of injection holes 62F disposed on the upstream side of the at least one linear portion 68, and thereby the cleaning liquid is adequately diffused

by the fluid H flowing inside the intake casing 41. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0063] The longitudinal-directional position and diameter of the plurality of injection holes 62F disposed on the upstream side of the linear portion 68 may be set as needed. For instance, the plurality of injection holes 62F may be distributed at regular intervals so that the cleaning liquid is injected evenly. Alternatively, the injection holes 62F may be disposed to be more dense in a central area and less dense in side regions on both sides of the central area, or may be disposed to be less dense in the central area and more dense in the side regions. In this case, the plurality of injection holes 62F have the same diameter, and the same flow amount of cleaning liquid is injected through the injection holes 62F. Accordingly, the cleaning liquid is injected evenly, and the cleaning liquid is distributed evenly over the entire region of the flow-path width, whereby the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0064] As depicted in FIG. 9, in some embodiments, the plurality of injection holes 62F is disposed on both sides of the at least one linear portion 68 in the width direction of the at least one linear portion 68.

[0065] With this configuration, the cleaning liquid is injected through the plurality of injection holes 62F disposed on both sides of the at least one linear portion 68 in the width direction of the at least one linear portion 68, and thereby it is possible to disperse the cleaning liquid in the longitudinal direction of the linear portion 68, inside the intake casing 41. The cleaning liquid dispersed evenly along the longitudinal direction of the linear portion 68 can be dispersed before reaching the impellers 31 to 33. As a result, the cleaning liquid is distributed evenly over the entire region of the flow-path width, and the entire surfaces of the impellers 31 to 33 can be cleaned sufficiently and evenly.

[0066] A cross-sectional shape can be selected with no particular limit for the pipe 61, the annular portion 63, the small-diameter annular portion 65, the linear portion 66, the first linear portion 66A, the second linear portion 66B, the protruding portion 67, and the linear portion 68 described above, as long as the cross-sectional shape is suitable for injection of a cleaning liquid. For instance, a circular shape, an oval shape, an ellipse shape, a streamline shape, or a droplet shape can be selected.

[0067] Furthermore, a flow-path cross-sectional area can be set with no particular limit for the pipe 61, the annular portion 63, the small-diameter annular portion 65, the linear portion 66, the first linear portion 66A, the second linear portion 66B, the protruding portion 67, and the linear portion 68, as long as the flow-path cross-sectional area is suitable for injection of a cleaning liquid. For instance, a flow-path cross-sectional area is set so that the flow amount or pressure of the cleaning liquid injected from the plurality of injection holes 62, 62A, 62B, 62C, 62D, 62E are even. Specifically, if the pipe 61, the annular portion 63, the small-diameter annular portion 65, the linear portion 66, the first linear portion 66A, the second linear portion 66B, the protruding portion 67, and the linear portion 68 have a circular cross-sectional shape, the flow-path cross-sectional area of the pipe 61, the annular portion 63, the small-diameter annular portion 65, the linear portion 66, the first linear portion 66A, the second linear portion 66B, the protruding portion 67, and the linear portion 68 is set to be more than ten times of the cross-sectional area of the injection holes 62A, 62B, 62C, 62D, and 62E.

[0068] Embodiments of the present invention were described in detail above, but the present invention is not limited thereto, and various amendments and modifications may be implemented.

[0069] For instance, the pipe 61 may include the annular portion 63 and the linear portion 68, and the annular portion 63 and the linear portion 68 may be disposed in positions offset in the direction of the axis M. In this case, it is preferable to position the annular portion 63 at the inlet 21, and the linear portion 68 between the annular portion and the inlet 21.

Description of Reference Numerals

[0070]

1	Centrifugal compressor
2	Main casing
21, 22	Inlet
23, 24	Outlet
25, 26	Diffuser
27A, 27B	Journal bearing
28A, 28B	Thrust bearing
3, 31 to	36 Impeller
37	Rotational shaft
6	Cleaning-liquid injection device
7	Cleaning-liquid supply device
41, 42	Intake casing
41A, 42A	Intake port
51, 52	Discharge casing
51A, 52A	Discharge port

61	Pipe
62, 62A, 62B, 62C, 62D, 62E	Injection hole
63	Annular portion
64	Supply part
65	Small-diameter annular portion
66	Linear portion
66A	First linear portion
66B	Second linear portion
67	Protruding portion
68	Linear portion
R	Flow path
M	Axis
N	Axis

Claims

1. A centrifugal compressor, comprising:

a main casing having an inlet and an outlet;
at least one impeller disposed rotatably inside the main casing;
an intake casing connected to the inlet, the intake casing having an intake port on a position spaced away from the inlet in a direction of an axis;
a cleaning-liquid injection device capable of being disposed on a side of the intake port inside the intake casing; and
a cleaning-liquid supply device for supplying a cleaning liquid to the cleaning-liquid injection device,
wherein the cleaning-liquid injection device comprises:

a pipe capable of being disposed so as to extend along a plane which intersects with the direction of the axis, inside the intake casing; and
a plurality of injection holes disposed on the pipe.

2. The centrifugal compressor according to claim 1,
wherein the pipe is capable of reciprocating between an operating position inside the intake casing and a refuge position outside the intake casing.

3. The centrifugal compressor according to claim 1 or 2,
wherein the pipe includes an annular portion having an annular shape in a planar view, and
wherein the plurality of injection holes is disposed on the annular portion so as to be distributed in a circumferential direction of the annular portion.

4. The centrifugal compressor according to claim 3,
wherein at least a part of the plurality of injection holes is disposed on an inner peripheral surface of the annular portion.

5. The centrifugal compressor according to claim 3,
wherein at least a part of the plurality of injection holes is disposed on an upstream side of the annular portion.

6. The centrifugal compressor according to any one of claims 3 to 5,
wherein the pipe includes a small-diameter annular portion having an annular shape in a planar view, the small-diameter annular portion having a smaller diameter than the annular portion and disposed concentrically with the annular portion, and
wherein at least a part of the plurality of injection holes is disposed on the small-diameter annular portion so as to be distributed in a circumferential direction of the small-diameter annular portion.

7. The centrifugal compressor according to any one of claims 3 to 5,
wherein the pipe includes at least one linear portion connecting two points on a circumference of the annular portion, and
wherein at least a part of the plurality of injection holes is disposed on the linear portion so as to be distributed in a

longitudinal direction of the at least one linear portion.

8. The centrifugal compressor according to any one of claims 3 to 5,
wherein the pipe includes at least one protruding portion protruding toward a center in a radial direction from the annular portion, and
wherein at least a part of the injection holes is disposed on the protruding portion.

9. The centrifugal compressor according to claim 1 or 2,
wherein the pipe includes at least one linear portion having a linear shape, and
wherein the plurality of injection holes is disposed on the at least one linear portion so as to be distributed in a longitudinal direction of the at least one linear portion.

10. The centrifugal compressor according to claim 9,
wherein the plurality of injection holes is disposed on an upstream side of the at least one linear portion.

11. The centrifugal compressor according to claim 9 or 10,
wherein the plurality of injection holes is disposed on both sides of the at least one linear portion in a width direction of the at least one linear portion.

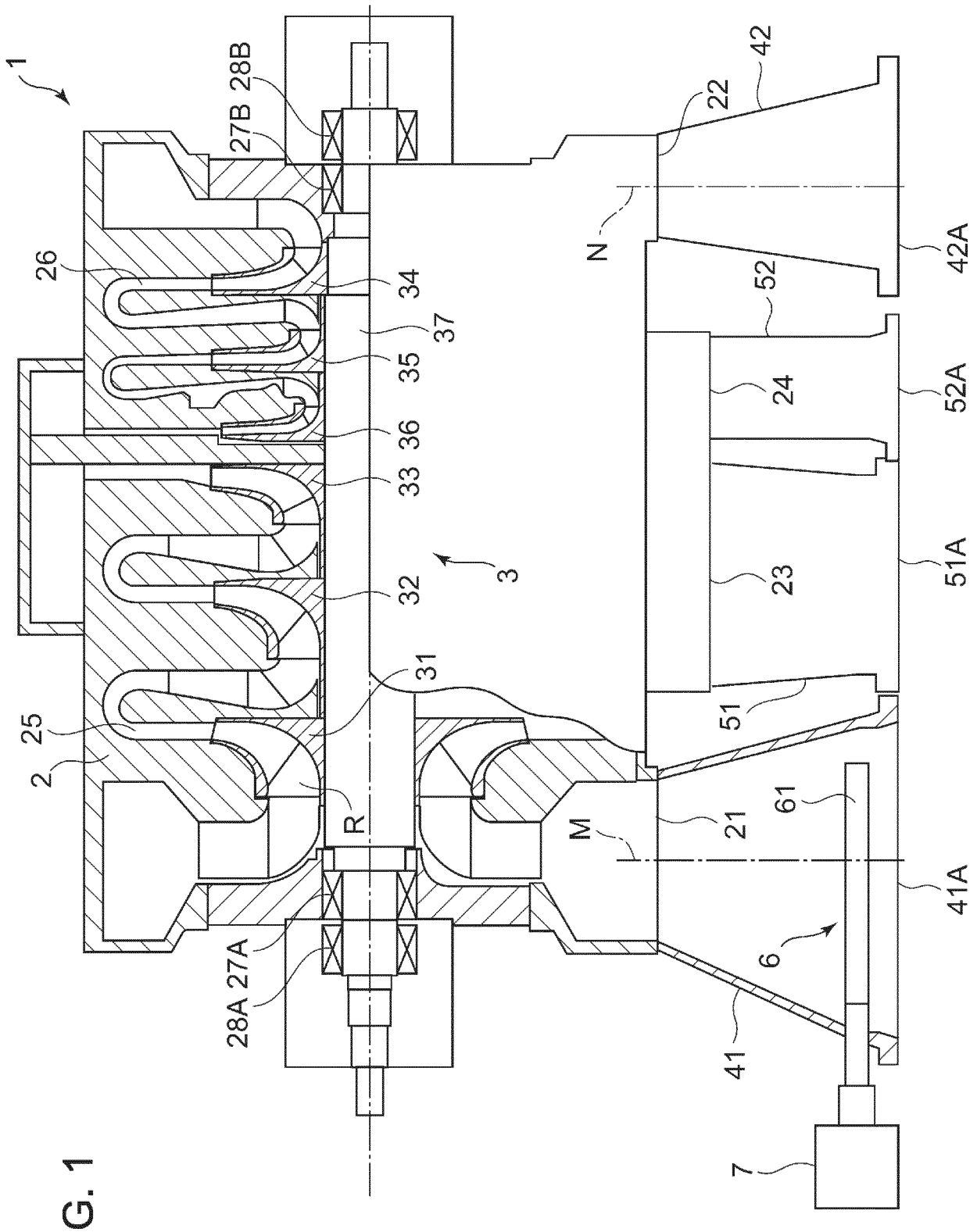

1
27B
28B
22
42
N
42A
26
34
37
52
35
24
52A
36
33
3
23
51A
32
31
51
25
2
R
61
M
21
41A
6
28A
27A
41
7

FIG. 1

FIG. 2

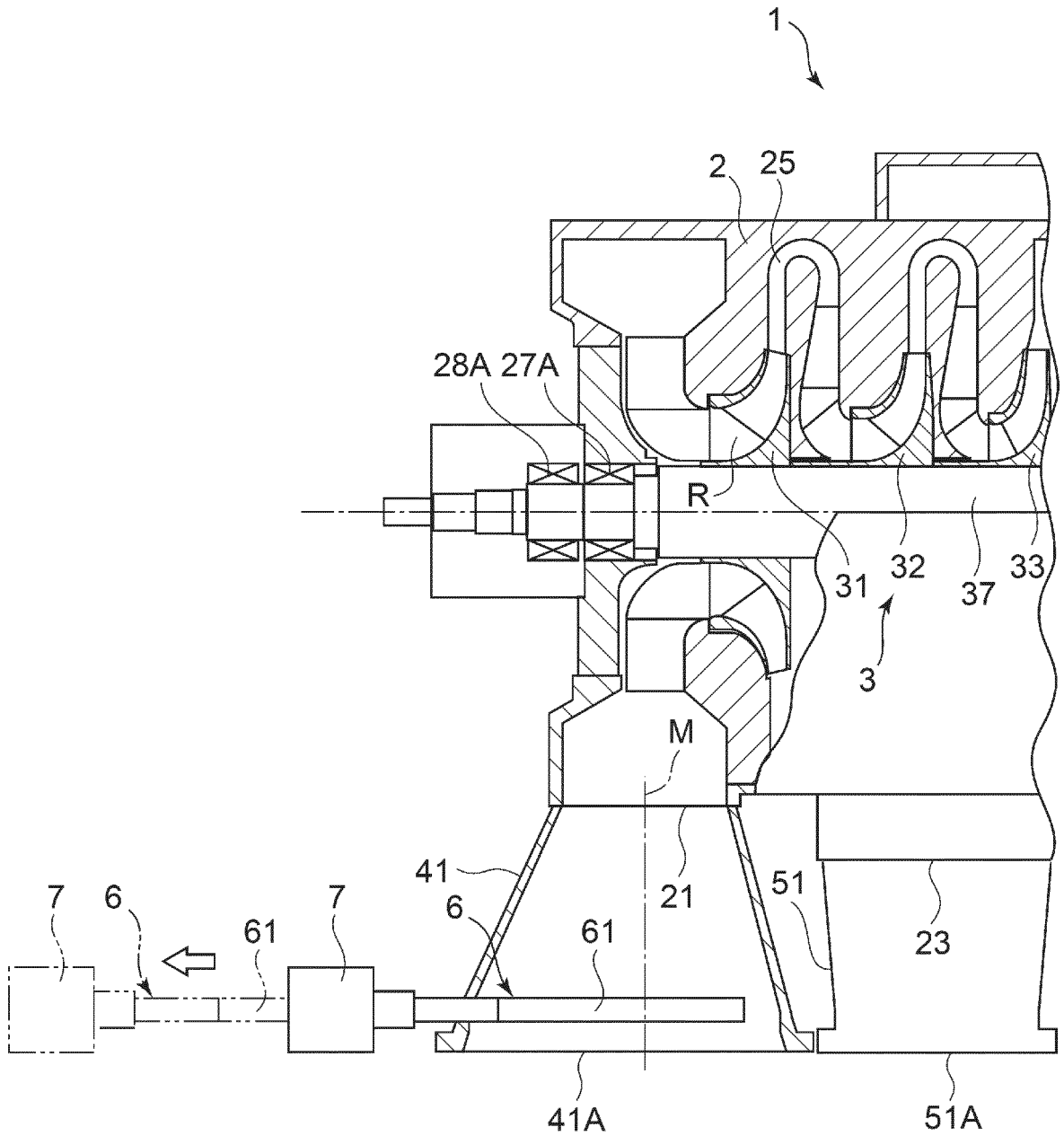


FIG. 3

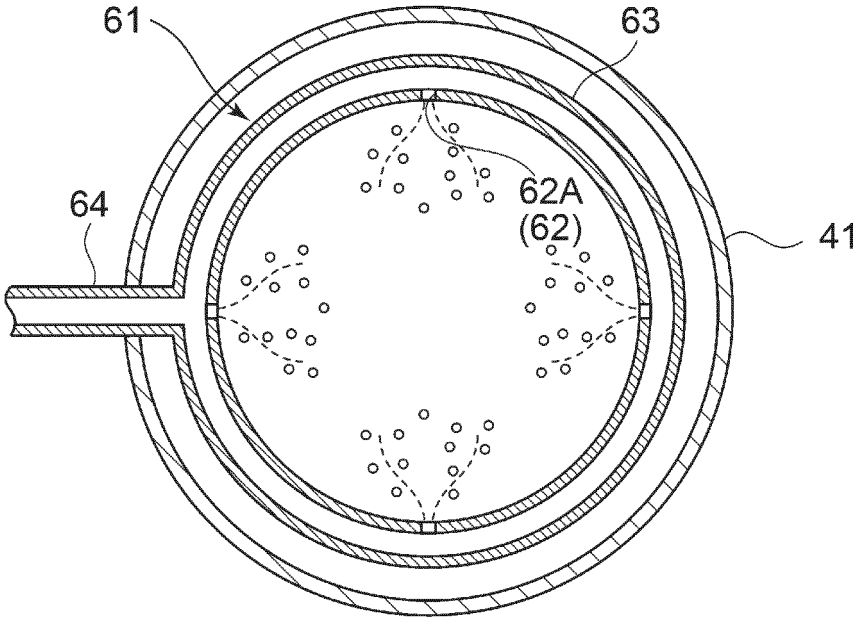


FIG. 4

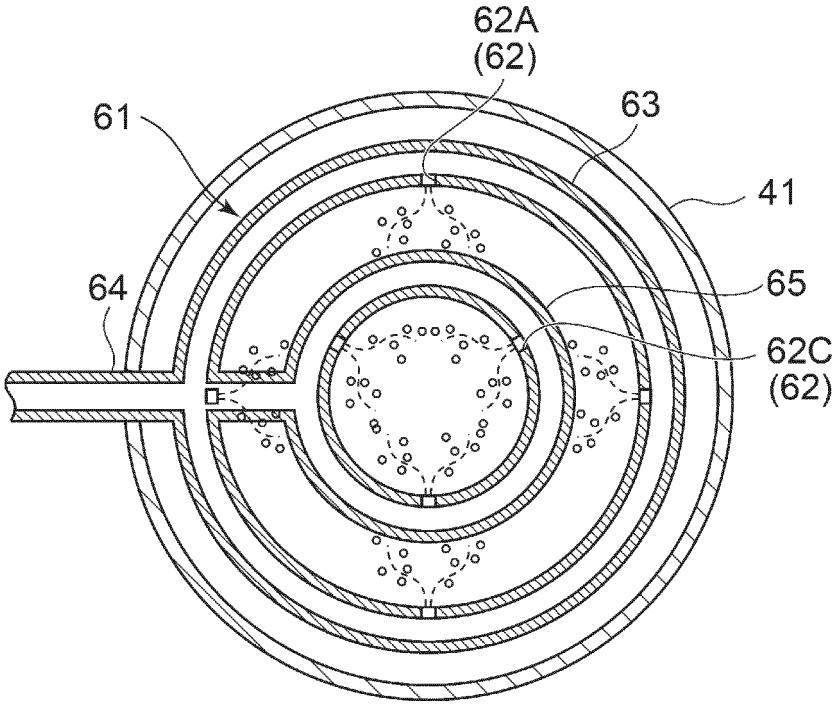


FIG. 5

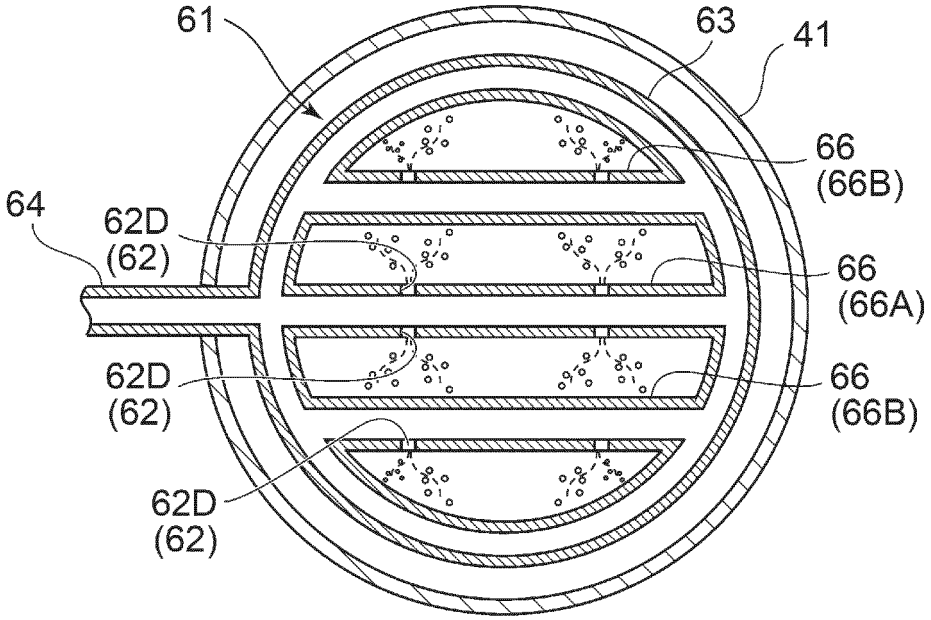

61
63
41
66
(66B)
64
62D
(62)
66
(66A)
62D
(62)
66
(66B)
62D
(62)

FIG. 6

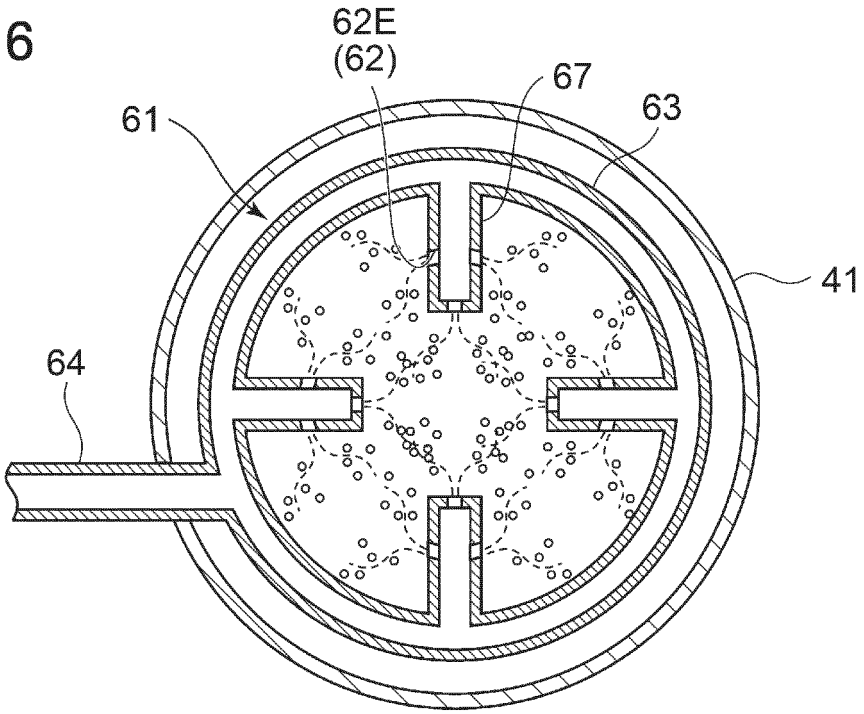

62E
(62)
67
61
63
41
64

FIG. 7

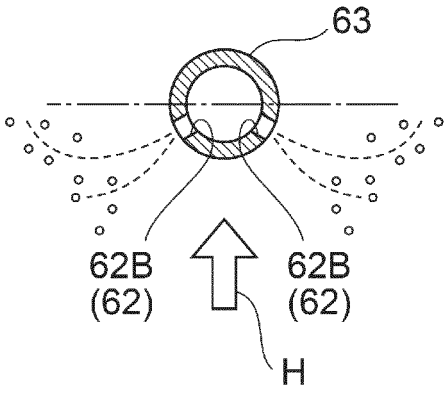


FIG. 8

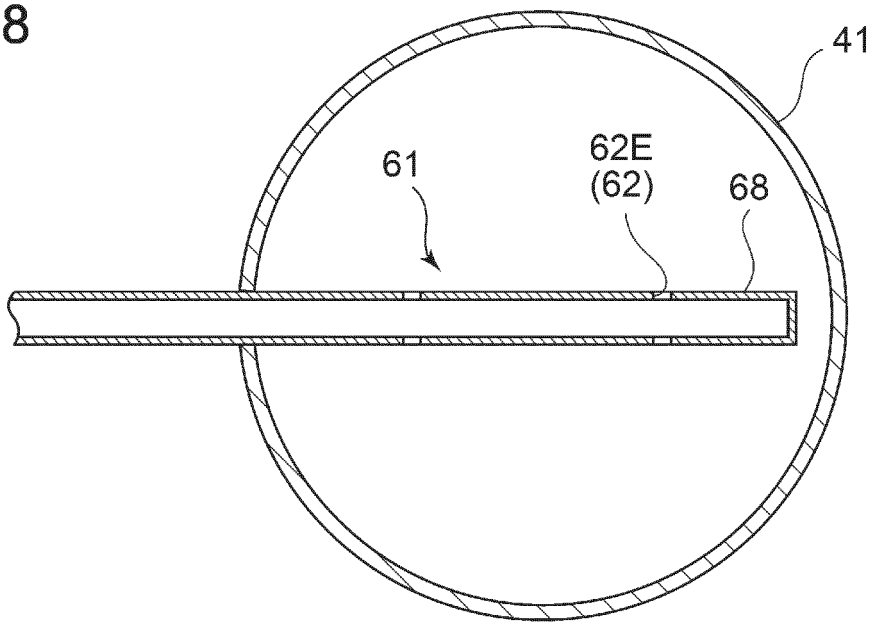
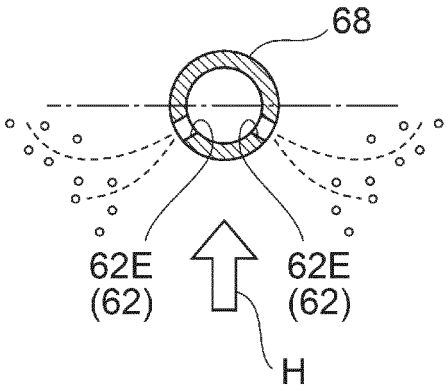


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/061885

A. CLASSIFICATION OF SUBJECT MATTER
F04D29/70(2006.01)i, *B08B3/02*(2006.01)i, *F04D29/62*(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)
F04D29/70, B08B3/02, F04D29/62

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 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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 A	JP 2012-229701 A (Gas Turbine Efficiency Sweden AB), 22 November 2012 (22.11.2012), paragraphs [0059], [0064] & US 2011/0197923 A1 & EP 2286933 A1	1,3,4,6,8 2,5,7,9-11
A	JP 2009-115079 A (Gas Turbine Efficiency Sweden AB), 28 May 2009 (28.05.2009), paragraphs [0019], [0027] & US 2008/0173330 A1 & EP 2243562 A1	1-11
A	JP 2008-69778 A (Gas Turbine Efficiency Sweden AB), 27 March 2008 (27.03.2008), paragraph [0037]; fig. 4 & US 2008/0250769 A1 & EP 2275648 A1	1-11

☒ 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
15 June 2015 (15.06.15)	30 June 2015 (30.06.15)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/061885

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2007-40307 A (General Electric Co.), 15 February 2007 (15.02.2007), claims; fig. 4 & US 2007/0028947 A1	1-11

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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