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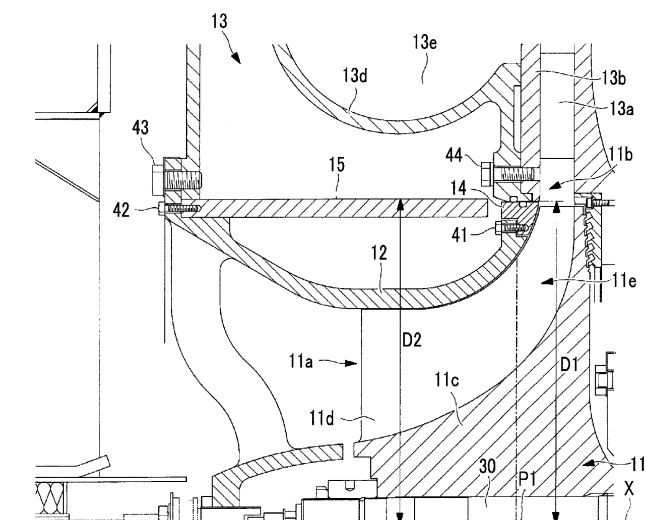
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(54) **CENTRIFUGAL COMPRESSOR, SUPERCHARGER, AND METHOD FOR MANUFACTURING CENTRIFUGAL COMPRESSOR**

(57) Provided is a centrifugal compressor, provided with: a delivery fan (11) for compressing air flowing in from an intake port (11a) and discharging the air from a discharge port (11b), the delivery fan (11) being attached to a rotor shaft (30); an air-guiding cylinder (12) for accommodating the delivery fan (11); a scroll part (13) into which the compressed air discharged from the discharge

port (11b) flows, the scroll part (13) being arranged farther out toward the periphery than is the air-guiding cylinder (12); and a first containment ring (14) attached to a linking position between the air-guiding cylinder (12) and the scroll part (13) so as to encircle the delivery fan (11) about an axis line (X) of the rotor shaft (30).

FIG. 2



Description

Technical Field

[0001] The present invention relates to a centrifugal compressor, a turbocharger, and a method for manufacturing a centrifugal compressor.

Background Art

[0002] In the related art, as a compressor of a turbocharger which increases the pressure of air which is supplied to an internal combustion engine which is used in a ship or the like, to atmospheric pressure or more, a centrifugal compressor is known (refer to, for example, PTL 1). The centrifugal compressor is provided with a delivery fan which is mounted on a rotor shaft, a guide cylinder which accommodates the delivery fan, and a scroll part into which compressed air which is discharged from the guide cylinder flows. The centrifugal compressor discharges compressed air from a discharge port by guiding the compressed air from a direction of an axis line to an inclined direction while compressing air which flows in the direction of the axis line from an intake port.

[0003] In the centrifugal compressor, there is a possibility that a problem that the whole or a part of the delivery fan breaks or falls off due to the influence of a centrifugal force caused by high-speed rotation may occur. PTL 2 discloses a centrifugal compressor which is provided with a shock-absorbing partition wall which protects a tank accommodating lubricating oil such that even in a case where the whole or a part of a delivery fan (a compressor delivery fan) is thrown to the outside by a centrifugal force, the lubricating oil does not leak out due to the thrown delivery fan.

Citation List

Patent Literature

[0004]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2011-117417

[PTL 2] Japanese Unexamined Patent Application Publication No. 2001-132465

Summary of Invention

Technical Problem

[0005] In the centrifugal compressor disclosed in PTL 2, in a case where a problem in that the whole or a part of the delivery fan breaks or falls off due to the influence of a centrifugal force caused by high-speed rotation occurs, the tank accommodating the lubricating oil is protected.

[0006] However, in a case where the whole or a part

of the delivery fan breaks or falls off, thereby being thrown in a radial direction orthogonal to a direction of an axis line of a rotor shaft, there is a possibility that the whole or a part of the delivery fan may break a guide cylinder which is located outside and be thrown to the outside. Further, there is a possibility that the whole or a part of the delivery fan may collide with the guide cylinder, thereby causing a gap (a port opening) in a part of the centrifugal compressor, and the whole or a part of the delivery fan which has been broken may be thrown from the gap to the outside.

[0007] The present invention has been made in view of such circumstances and has an object to provide a centrifugal compressor in which in a case where the whole or a part of a delivery fan breaks or falls off, thereby being thrown in a radial direction orthogonal to a direction of an axis line of a rotor shaft, it is possible to prevent a problem in that the whole or a part of the delivery fan is thrown to the outside.

[0008] Further, the present invention has an object to provide a turbocharger provided with the above-described centrifugal compressor, and a method for manufacturing the above-described centrifugal compressor.

Solution to Problem

[0009] In order to achieve the above objects, the present invention adopts the following means.

[0010] According to an aspect of the present invention, there is provided a centrifugal compressor including: a delivery fan which is mounted on a rotor shaft and compresses a fluid flowing in from an intake port and discharges a compressed fluid from a discharge port; a guide cylinder which accommodates the delivery fan; a scroll part which is disposed further toward the outer periphery side than is the guide cylinder, and into which the compressed fluid discharged from the discharge port flows; and an annular member which is mounted at a linking position between the discharge port side of the guide cylinder and the scroll part so as to surround the delivery fan around an axis line of the rotor shaft.

[0011] In the delivery fan of the centrifugal compressor, the outer diameter of a blade is made to be larger on the discharge port side than on the intake port side. Therefore, the center of gravity of the delivery fan is located on the discharge port side. Further, the linking position between the discharge port side of the guide cylinder and the scroll part is at a position corresponding to the center of gravity of the delivery fan (hereinafter referred to as a position of the center of gravity) in the axis line, or in the vicinity of the position of the center of gravity.

[0012] When the whole or a part of the delivery fan breaks or falls off at the position of the center of gravity or in the vicinity of the position of the center of gravity, the broken or fallen-off portion has a large weight, and thus an impact force when being thrown in the radial direction orthogonal to the direction of the axis line is large.

[0013] Therefore, in the aspect of the present inven-

tion, the annular member is provided at the linking position and disposed such that the whole or a part of the delivery fan which has been broken or fallen off collides therewith even in a case of being thrown in the radial direction orthogonal to the direction of the axis line from the position of the center of gravity of the delivery fan. Even in a case where the guide cylinder is subjected to brittle fracture due to the collision of the whole or a part of the delivery fan which has been broken or fallen off, in the collision with the annular member, the annular member is restricted to undergoing plastic deformation without this leading to brittle fracture. Accordingly, it is possible to prevent a problem in that the whole or a part of the delivery fan which has been broken or fallen off is thrown to the outside.

[0014] In the centrifugal compressor according to the above aspect of the present invention, the annular member may be configured of a material having a higher ductility than that of the guide cylinder.

[0015] In this way, in a case where the whole or a part of the delivery fan which has been broken or fallen off collides with the annular member having high ductility, the annular member can more reliably be restricted to undergoing plastic deformation without this leading to brittle fracture.

[0016] Here, the expression, ductility being high, indicates having characteristics in which large plastic deformation involves breakage, and indicates that the brittleness which leads to breakage in a situation where plastic deformation is small is small. Specifically, by comparing tensile fracture strength leading to breakage with elongation (rate), it can be confirmed that ductility is high.

[0017] In the centrifugal compressor according to the above aspect of the present invention, a configuration is also acceptable in which the centrifugal compressor further includes a tubular member which is disposed coaxially with the rotor shaft further toward the outer periphery side in the radial direction orthogonal to the axis line than is the guide cylinder and further toward the inner periphery side in the radial direction than is the scroll part.

[0018] According to the centrifugal compressor having this configuration, in a case where the whole or a part of the delivery fan breaks or falls off, the whole or a part of the delivery fan is thrown in the radial direction orthogonal to the direction of the axis line of the rotor shaft, thereby colliding with the guide cylinder. A part of the delivery fan which has collided with the guide cylinder may cause brittle fracture of the guide cylinder and be further thrown to the outside in the radial direction, thereby reaching the tubular member. Even in a case where the guide cylinder is subjected to brittle fracture, the tubular member is plastically deformed, thereby a problem of a part of the delivery fan being thrown to the outside being prevented.

[0019] In the centrifugal compressor having the above configuration, an end portion on the discharge port side of the tubular member and an end portion on the intake port side of the annular member may be disposed at positions overlapping in the radial direction and close to

each other in the radial direction.

[0020] In this way, in a case where a broken member is thrown to the outside, thereby colliding with either of the tubular member or the annular member, which is disposed on the inner periphery side in the radial direction, the member on one side which has received an impact moves toward the outer periphery side in the radial direction, thereby colliding with the member on the other side. In this way, a gap is prevented from occurring between the tubular member and the annular member.

[0021] In the centrifugal compressor having the above configuration, the tubular member may be configured of a material having a higher ductility than that of the guide cylinder, a diameter of the annular member and a diameter of the tubular member may coincide with each other with respect to the axis line, and an end face in a direction of the axis line of the annular member and an end face in the direction of the axis line of the tubular member may be spaced apart from each other with a predetermined distance therebetween in the direction of the axis line.

[0022] According to the centrifugal compressor having this configuration, the diameter of the annular member and the diameter of the tubular member coincide with each other, and therefore, the annular member and the tubular member form one cylindrical surface surrounding the guide cylinder around the rotor shaft. The whole or a part of the delivery fan which causes brittle fracture of the guide cylinder and is thrown to the outside in the radial direction collides with either of the annular member or the tubular member which form one cylindrical surface. One cylindrical surface is formed, and therefore, a gap occurring in a case where the diameter of the outer peripheral surface of the annular member and the diameter of the outer peripheral surface of the tubular member are different from each other is not formed. For this reason, a problem in that the whole or a part of the delivery fan is thrown from a gap which is formed due to a difference between the diameters of the outer peripheral surfaces of the annular member and the tubular member to the outside is prevented.

[0023] Further, according to the centrifugal compressor having this configuration, the end face in the direction of the axis line of the annular member and the tubular member are spaced apart from each other with a predetermined distance therebetween in the direction of the axis line. In a case where the annular member and the tubular member are connected or are formed as a single member, if a difference in thermal elongation amount due to a difference in temperature occurs in both end portions in the direction of the axis line of the member, there is a concern that the member may be deformed or become broken. Therefore, in this aspect, the annular member and the tubular member are configured as separate members and are spaced apart from each other with a predetermined distance therebetween in the direction of the axis line, whereby even if a difference in thermal elongation amount due to a difference in temperature occurs between the respective members, deformation or break-

age does not occur in either of the annular member or the tubular member.

[0024] In the centrifugal compressor according to the above aspect of the present invention, a configuration is also acceptable in which a position of the center of gravity in the direction of the axis line of the delivery fan exists in a position range in the direction of the axis line, in which the annular member is disposed.

[0025] When the whole or a part of the delivery fan has been broken or fallen off at the position of the center of gravity of the delivery fan or in the vicinity of the position of the center of gravity, the broken or fallen-off portion has a large weight, and thus an impact force when being thrown in the radial direction orthogonal to the direction of the axis line is large.

[0026] Therefore, in this configuration, a configuration is made such that the position of the center of gravity in the direction of the axis line of the delivery fan exists in the position range in the direction of the axis line, in which the annular member is disposed. In this way, when the whole or a part of the delivery fan has been broken or fallen off at the position of the center of gravity of the delivery fan or in the vicinity of the position of the center of gravity, the broken or fallen-off portion is able to collide with the annular member, whereby it is possible to prevent a problem in that the whole or a part of the delivery fan is thrown to the outside.

[0027] In the centrifugal compressor according to the above aspect of the present invention, a configuration is also acceptable in which the annular member forms, along with the guide cylinder, a flow path wall of a flow path through which the compressed fluid which is discharged from the discharge port flows, the annular member has an annular projection portion protruding inward in the radial direction, on the outer periphery side in the radial direction orthogonal to the axis line and the flow path side in the direction of the axis line, the guide cylinder at the linking position has an annular step portion on the outer periphery side in the radial direction and the flow path side in the direction of the axis line, and the guide cylinder and the annular member are connected in a state where the annular projection portion is disposed at the annular step portion.

[0028] According to the centrifugal compressor having this configuration, a pressure that the annular member receives from the compressed fluid increases as the pressure of the compressed fluid which is discharged from the discharge port increases due to an increase in the rotational frequency of the rotor shaft. The annular projection portion that the annular member has on the flow path side is disposed at the annular step portion that the guide cylinder has on the flow path side. For this reason, a contact force between the annular projection portion and the annular step portion increases as the pressure that the annular member receives from the compressed fluid increases. In this way, a problem in that the compressed fluid leaks out at the connecting location between the annular member and the guide cylinder is pre-

vented.

[0029] According to another aspect of the present invention, there is provided a turbocharger including: the centrifugal compressor according to any one of the above aspects; and a turbine which is rotated around the axis line by exhaust gas discharged from an internal combustion engine and is connected to the rotor shaft.

[0030] According to the turbocharger according to this aspect of the present invention, in a case where the whole or a part in the vicinity of the position of the center of gravity of the delivery fan breaks or falls off, thereby being thrown in the radial direction orthogonal to the direction of the axis line of the rotor shaft, it is possible to prevent a problem in that the whole or a part of the delivery fan is thrown to the outside.

[0031] According to still another aspect of the present invention, there is provided a method for manufacturing a centrifugal compressor including: a process of mounting a delivery fan which compresses a fluid flowing in from an intake port and discharges a compressed fluid from a discharge port on a rotor shaft; a process of mounting a guide cylinder so as to accommodate the delivery fan, thereby forming a flow path which leads the fluid flowing in from the intake port to the discharge port; a process of disposing a scroll part into which the compressed fluid discharged from the discharge port flows, further toward the outer periphery side in a radial direction orthogonal to a direction of an axis line of the rotor shaft than is the guide cylinder; and a process of mounting an annular member at a linking position between the guide cylinder and the scroll part so as to surround the delivery fan around the axis line.

[0032] According to the centrifugal compressor which is manufactured by the manufacturing method according to this aspect of the present invention, in a case where the whole or a part in the vicinity of the position of the center of gravity of the delivery fan breaks or falls off, the whole or a part of the delivery fan is thrown in the radial direction orthogonal to the direction of the axis line of the rotor shaft, thereby reaching the linking position between the guide cylinder and the scroll part. The annular member is mounted at the linking position so as to surround the delivery fan, and therefore, the whole or a part of the delivery fan which has been thrown collides with the annular member. Even in a case where the guide cylinder is subjected to brittle fracture, the annular member is plastically deformed, whereby a problem in which the whole or a part of the delivery fan is thrown to the outside is prevented.

Advantageous Effects of Invention

[0033] According to the present invention, it is possible to provide a centrifugal compressor in which in a case where the whole or a part in the vicinity of the position of the center of gravity of a delivery fan breaks or falls off, thereby being thrown in a radial direction orthogonal to a direction of an axis line of a rotor shaft, it is possible to

prevent a problem in that the whole or a part of the delivery fan is thrown to the outside.

[0034] Further, according to the present invention, it is possible to provide a turbocharger provided with the above-described centrifugal compressor, and a method for manufacturing the above-described centrifugal compressor.

Brief Description of Drawings

[0035]

Fig. 1 is a vertical cross-sectional view showing a turbocharger of a first embodiment.

Fig. 2 is an enlarged view of a main section of a centrifugal compressor shown in Fig. 1.

Fig. 3 is an enlarged view of a main section in the vicinity of a first containment ring shown in Fig. 2.

Fig. 4 is a vertical cross-sectional view showing a turbocharger of a second embodiment.

Fig. 5 is an enlarged view of a main section of a centrifugal compressor shown in Fig. 4.

Fig. 6 is an enlarged view of a main section in the vicinity of a discharge port shown in Fig. 5.

Fig. 7 is an enlarged view of a main section in the vicinity of a discharge port of a centrifugal compressor of a modification example of the second embodiment.

Fig. 8 is an enlarged view of a main section in the vicinity of a discharge port of a centrifugal compressor of a modification example of the second embodiment.

Fig. 9 is an enlarged view of a main section in the vicinity of a discharge port of a centrifugal compressor of a modification example of the second embodiment. Description of Embodiments

[First Embodiment]

[0036] Hereinafter, a turbocharger of a first embodiment will be described with reference to the drawings.

[0037] A turbocharger 100 of this embodiment is a device for increasing the pressure air (gas) which is supplied to a ship diesel engine (internal combustion engine) which is used in a ship, to atmospheric pressure or more, thereby enhancing the combustion efficiency of the ship diesel engine.

[0038] As shown in Fig. 1, the turbocharger 100 of this embodiment is provided with a centrifugal compressor 10 and a turbine 20. Each of the centrifugal compressor 10 and the turbine 20 is connected to a rotor shaft 30.

[0039] The centrifugal compressor 10 is a device for compressing air flowing in from the outside of the turbocharger 100 and supplying the compressed air (hereinafter referred to as compressed air (compressed fluid)) to an intake manifold (not shown) which communicates with the inside of a cylinder liner (not shown) configuring the ship diesel engine.

[0040] The centrifugal compressor 10 is provided with a delivery fan 11, an air-guiding cylinder 12, a scroll part 13, a first containment ring 14 (an annular member), a second containment ring 15 (a tubular member), and a silencer 16.

[0041] Each of the air-guiding cylinder 12 and the scroll part 13 is made of a metal member manufactured by casting in order to form a complicated shape. As this metal member, for example, cast iron which is a Fe-C-based alloy containing iron as its main component and containing 2% or more of carbon is used. If it is cast iron, it is possible to use various materials such as gray cast iron. However, it is preferable to use ductile cast iron (FCD: Ferrum Cast Ductile) in which black smoke in a base structure is spheroidized.

[0042] A metal material by casting easily forms a complicated shape by pouring formation but has a brittle characteristic.

[0043] Each of the first containment ring 14 and the second containment ring 15 is made of a metal member manufactured by rolling. As this metal member, for example, an iron and steel material which is a Fe-C-based alloy containing iron as its main component and containing a trace (about 0.2%) of carbon is used. If it is an iron and steel material, it is possible to use various materials. However, it is preferable to use rolled steel for a general structure (JIS G 3101; ASTM A283) called SS400.

[0044] A metal material by rolling is composed of a composition suitable for a rolling process and has ductility which leads to breakage after large plastic deformation. On the other hand, the metal material by casting is composed of a composition suitable for a casting process and has smaller elongation which leads to breakage than the metal material by rolling. In this manner, in the metal material by rolling, the elongation which leads to breakage is larger than in the metal material by casting, that is, ductility is high. Therefore, the metal material by rolling has a characteristic in which breaking strength against impact is higher than in the metal material by casting.

[0045] For example, tensile strength at normal temperature is in a range of 400 N/mm² to 500 N/mm² in both the ductile cast iron material and the SS400 material. On the other hand, in the ductile cast iron, elongation at break is about 10%, whereas in the SS400 material, elongation at break is greater than or equal to 20%. Therefore, the SS400 material has higher ductility than the ductile cast iron material.

[0046] The turbine 20 is provided with a turbine housing 21, turbine blades 22, a turbine disk 23, and turbine nozzles 24. The turbine housing 21 is a hollow tubular member which is disposed around an axis line X, and accommodates the turbine blades 22, the turbine disk 23, and the turbine nozzles 24 inside thereof. Exhaust gas which is discharged from the ship diesel engine flows into the turbine housing 21 along an arrow shown on the right side of Fig. 1.

[0047] The exhaust gas led to the turbine housing 21 performs static pressure expansion when passing

through the turbine nozzle 24 and is led to the turbine blade 22. The turbine blades 22 are mounted at regular intervals around the axis line on the outer peripheral surface of the approximately circular plate-shaped turbine disk 23 fixed to the rotor shaft 30. The exhaust gas which has performed static pressure expansion passes through the turbine blades 22, whereby a rotating force around the axis line X is applied to the turbine disk 23. The rotating force serves as power which rotates the rotor shaft 30, and rotates the delivery fan 11 connected to the rotor shaft 30 around the axis line X.

[0048] In this manner, in the turbocharger 100 of this embodiment, the exhaust gas which is discharged from the ship diesel engine is led to the turbine 20, thereby rotating the turbine disk 23 with the turbine blades 22 mounted thereon around the axis line X. The delivery fan 11 connected to the turbine disk 23 through the rotor shaft 30 rotates according to the rotation of the turbine disk 23, whereby air flowing in from an intake port 11a is compressed and the compressed air is discharged from a discharge port 11b. The compressed air discharged from the discharge port 11b flows into the scroll part 13 and is led to the intake manifold of the ship diesel engine.

[0049] The silencer 16 is a device for reducing a level of noise which is generated in the centrifugal compressor 10. As shown in Fig. 1, the silencer 16 defines a flow path which leads air flowing in from a direction orthogonal to the axis line X to the intake port 11a of the air-guiding cylinder 12. A sound-deadening material 16a is disposed around the flow path. Some of the noise which is generated in the centrifugal compressor 10 is absorbed by the sound-deadening material 16a, and thus a level of the noise is reduced.

[0050] Next, each configuration which the centrifugal compressor 10 has will be described.

[0051] As shown in Fig. 2, the delivery fan 11 is mounted on the rotor shaft 30 extending along the axis line X and rotates around the axis line X according to the rotation of the rotor shaft 30 around the axis line X. The delivery fan 11 rotates around the axis line X, thereby compressing air flowing in from the intake port 11a, and then discharging the compressed air from the discharge port 11b.

[0052] As shown in Fig. 2, the delivery fan 11 is provided with a hub 11c which is mounted on the rotor shaft 30, a blade 11d which is mounted on the outer peripheral surface of the hub 11c, and a flow path 11e. A space which is formed by the outer peripheral surface of the hub 11c and the inner peripheral surface of the air-guiding cylinder 12 is provided in the delivery fan 11, and the space is partitioned into a plurality of spaces by a plurality of blades 11d. Further, the delivery fan 11 applies a centrifugal force in a radial direction to air flowing in from the intake port 11a along a direction of the axis line X, thereby discharging the air in a direction (an inclined direction; a radial direction of the delivery fan 11) orthogonal to the direction of the axis line X and making the compressed air discharged from the discharge port 11b flow into a

diffuser 13a.

[0053] The air-guiding cylinder 12 is a member for accommodating the delivery fan 11 and discharging air flowing in from the intake port 11a along the direction of the axis line X of the rotor shaft 30, from the discharge port 11b. The air-guiding cylinder 12 forms, along with the delivery fan 11, the flow path 11e which guides air flowing in from the intake port 11a along the axis line X, in the radial direction orthogonal to the axis line X, thereby leading the air to the discharge port 11b.

[0054] The scroll part 13 is a device into which the compressed air discharged from the discharge port 11b flows and which converts kinetic energy (dynamic pressure) applied to the compressed air to pressure energy (static pressure). The scroll part 13 is disposed further toward the outer periphery side in the radial direction orthogonal to the direction of the axis line X than is the air-guiding cylinder 12.

[0055] The scroll part 13 is provided with the diffuser 13a, a diffuser disk 13b, an outer scroll casing 13c (refer to Fig. 1), an inner scroll casing 13d, and a vortex-shaped chamber 13e. The vortex-shaped chamber 13e is a space which is defined by the outer scroll casing 13c and the inner scroll casing 13d.

[0056] As shown in Fig. 2, the inner scroll casing 13d is connected to the air-guiding cylinder 12 by a fastening bolt 43.

[0057] The diffuser 13a is a blade-shaped member which is disposed on the downstream side of the discharge port 11b of the delivery fan 11, and forms a flow path which leads the compressed air from the discharge port 11b to the vortex-shaped chamber 13e. The diffusers 13a are provided at a plurality of locations in a circumferential direction of the circular ring-shaped diffuser disk 13b which is disposed coaxially with the rotor shaft 30. The diffusers 13a are provided so as to surround the discharge port 11b for the compressed air, which is provided on the entire circumference of the delivery fan 11.

[0058] As shown in Fig. 2, the diffuser disk 13b is connected to the inner scroll casing 13d by a fastening bolt 44.

[0059] The diffuser 13a converts kinetic energy (dynamic pressure) applied to the compressed air to pressure energy (static pressure) by reducing the flow velocity of the compressed air discharged from the discharge port 11b of the delivery fan 11. The compressed air with the flow velocity reduced when passing through the diffuser 13a flows into the vortex-shaped chamber 13e which communicates with the diffuser 13a. A working fluid which has flowed into the vortex-shaped chamber 13e is discharged to a discharge pipe (not shown).

[0060] The first containment ring 14 is an annular member which is mounted at a linking position between the discharge port 11b side of the air-guiding cylinder 12 and the inner scroll casing 13d so as to surround the delivery fan 11 around the axis line X. As shown in Fig. 1, the first containment ring 14 is disposed coaxially with the rotor shaft 30. As shown in Fig. 2, the first containment ring

14 is connected to the air-guiding cylinder 12 by a fastening bolt 41.

[0061] The second containment ring 15 is a tubular member which is disposed further toward the outer periphery side in the radial direction than is the air-guiding cylinder 12 and further toward the inner periphery side in the radial direction than is the scroll part 13. As shown in Fig. 1, the second containment ring 15 is disposed coaxially with the rotor shaft 30. As shown in Fig. 2, the second containment ring 15 is connected to the air-guiding cylinder 12 by a fastening bolt 42.

[0062] Each of the first containment ring 14 and the second containment ring 15 is made of a metal member manufactured by rolling and has higher ductility than that of the air-guiding cylinder 12 made of a metal member manufactured by casing.

[0063] Here, the expression, ductility being high, indicates that large plastic deformation involves breakage and the brittleness which leads to breakage in a situation where plastic deformation is small is small. For this reason, when an impact load is generated, a material having high ductility is plastically deformed, thereby being able to absorb and restrain the kinetic energy of impact. For this reason, it becomes possible for the material to remain in plastic deformation without leading to breakage even with respect to an impact load.

[0064] In this embodiment, in the ductile cast iron material which is used as the metal material manufactured by casting, tensile strength at normal temperature is in a range of 400 N/mm² to 500 N/mm² and elongation is about 10%. On the other hand, in the SS400 material which is used as the metal material manufactured by rolling, tensile strength at normal temperature is likewise in a range of 400 N/mm² to 500 N/mm² and elongation is about 20% or more. Therefore, from a difference in elongation, it can be confirmed that the SS400 material is a material having higher ductility than the ductile cast iron material.

[0065] In this manner, the first containment ring 14 and the second containment ring 15 have higher ductility than that of the air-guiding cylinder 12. For this reason, even when the delivery fan 11 is broken down or falls off, the first containment ring 14 and the second containment ring 15 prevent the whole or a part of the delivery fan 11 from being thrown to the outside, in a case where the whole or a part of the delivery fan 11 is thrown in the radial direction, thereby colliding with the air-guiding cylinder 12.

[0066] That is, even in a case where the air-guiding cylinder 12 is subjected to brittle fracture due to the collision of the whole or a part of the delivery fan 11, the first containment ring 14 and the second containment ring 15 are plastically deformed, thereby preventing a problem in that the whole or a part of the delivery fan is thrown to the outside.

[0067] As shown in Fig. 2, a radius D1 of the outer peripheral surface of the first containment ring 14 and a radius D2 of the outer peripheral surface of the second

containment ring 15 coincide with each other. Making the radius D1 and the radius D2 coincide with each other is for preventing a gap occurring in a case where the diameter of the outer peripheral surface of the first containment ring 14 and the diameter of the outer peripheral surface of the second containment ring 15 are different from each other, from being formed. If this gap is formed, there is a possibility that the whole or a part of the delivery fan 11 may be thrown to the outside.

[0068] Further, even in a case where the radius D1 of the outer peripheral surface of the first containment ring 14 and the radius D2 of the outer peripheral surface of the second containment ring 15 do not coincide with each other, if the gap between an end portion of the first containment ring 14 in the direction of the axis line X and an end portion of the second containment ring 15 in the direction of the axis line X is very small, it is possible to reduce a possibility that the whole or a part of the delivery fan 11 which is thrown in the radial direction may be thrown to the outside.

[0069] Therefore, the radius D1 of the outer peripheral surface of the first containment ring 14 and the radius D2 of the outer peripheral surface of the second containment ring 15 may not necessarily be made to coincide with the same diameter.

[0070] Further, as shown in Fig. 3, an end face 14a in the direction of the axis line X of the first containment ring 14 and an end face 15a in the direction of the axis line X of the second containment ring 15 are spaced apart from each other with a predetermined distance W therebetween in the direction of the axis line X. In a case where the first containment ring 14 and the second containment ring 15 are connected or are formed as a single member, if a difference in thermal elongation amount due to a difference in temperature occurs in both end portions in the direction of the axis line X of the member, there is a concern that the member may be deformed or broken down.

[0071] Therefore, in this embodiment, the first containment ring 14 and the second containment ring 15 are spaced apart from each other with the predetermined distance W therebetween in the direction of the axis line X, whereby even if a difference in thermal elongation amount due to a difference in temperature occurs between the respective members, deformation or breakage does not occur in either of the first containment ring 14 or the second containment ring 15.

[0072] As shown in Fig. 2, the position in the direction of the axis line X, at which the first containment ring 14 is disposed, is a position P1. The position P1 coincides with the position of the center of gravity in the direction of the axis line of the delivery fan 11.

[0073] As shown in Figs. 1 and 2, in the delivery fan 11 of the centrifugal compressor 10 of this embodiment, the outer diameter of a blade is made to be larger on the discharge port 11b side than on the intake port 11a side. Therefore, the position of the center of gravity of the delivery fan 11 is at the position P1 closer to the discharge port 11b side than the intake port 11a side.

[0074] In a case where the delivery fan 11 rotates at a high speed around the axis line X (for example, a case where the delivery fan 11 rotates at a 10,000 or more revolutions per minute), there is a case where the whole or a part of the delivery fan 11 breaks or falls off. An impact force in the radial direction orthogonal to the direction of the axis line X at the time of falling-off of the delivery fan 11 becomes particularly large at the position of the center of gravity. In this embodiment, the position P1 in the direction of the axis line X, at which the first containment ring 14 is disposed, coincides with the position of the center of gravity in the direction of the axis line of the delivery fan 11.

[0075] For this reason, even if the delivery fan 11 which has been broken or fallen off at the position of the center of gravity is thrown in the radial direction, it collides with the first containment ring 14. Then, the first containment ring 14 having high ductility is plastically deformed, whereby it is possible to prevent a problem in that the whole or a part of the delivery fan 11 is thrown to the outside.

[0076] As shown in Fig. 2, the first containment ring 14 forms, along with the air-guiding cylinder 12, a flow path wall on the outer periphery side of the flow path 11e through which the compressed air which is discharged from the discharge port 11b flows.

[0077] As shown in Fig. 3, the first containment ring 14 has an annular projection portion 14b protruding inward in the radial direction, on the outer periphery side in the radial direction and the flow path 11e side in the direction of the axis line X.

[0078] Further, as shown in Fig. 3, the air-guiding cylinder 12 has an annular step portion 12a on the outer periphery side in the radial direction and the flow path 11e side in the direction of the axis line X. The air-guiding cylinder 12 and the first containment ring 14 are connected in a state where the annular projection portion 14b is disposed at the annular step portion 12a. A gap is provided between the annular step portion 12a and the annular projection portion 14b. Due to this gap, even if there is thermal expansion of the air-guiding cylinder 12, it is possible to prevent deformation from propagating to the first containment ring 14 by thermal expansion.

[0079] An inner periphery-side end face 13f of the inner scroll casing 13d and an outer periphery-side end face 14c in the radial direction of the first containment ring 14 are disposed so as to face each other, at a linking position at which the inner scroll casing 13d and the air-guiding cylinder 12 are connected.

[0080] An endless annular groove portion 13g extending in the circumferential direction around the axis line X is formed in the inner periphery-side end face 13f. An O-ring 13h (an annular seal member) is fitted in the annular groove portion 13g. Further, an endless annular groove portion 14d extending in the circumferential direction around the axis line X is formed in the outer periphery-side end face 14c. An O-ring 14e (an annular seal member) is fitted in the annular groove portion 14d.

[0081] The O-ring 13h comes into contact with the outer periphery-side end face 14c and the O-ring 14e comes into contact with the inner periphery-side end face 13f, whereby outflow of the compressed air from the flow path 11e is cut off at the position at which the inner periphery-side end face 13f and the outer periphery-side end face 14c face each other.

[0082] Next, a method for manufacturing the centrifugal compressor of this embodiment will be described.

[0083] In the method for manufacturing the centrifugal compressor 10 of this embodiment, the centrifugal compressor 10 is manufactured by the following processes.

[0084] In a first process, the delivery fan 11 which compresses air flowing in from the intake port 11a and then discharges the compressed air from the discharge port 11b is mounted on the rotor shaft 30.

[0085] In a second process, the air-guiding cylinder 12 is mounted so as to accommodate the delivery fan 11, thereby forming a flow path which guides air flowing in from the intake port 11a along the direction of the axis line X of the rotor shaft 30, from the direction of the axis line X to the inclined direction, thereby leading the air to the discharge port 11b.

[0086] In a third process, the scroll part 13 into which the compressed air discharged from the discharge port 11b flows is disposed further toward the outer periphery side in the radial direction orthogonal to the direction of the axis line X than is the air-guiding cylinder 12.

[0087] In a fourth process, the first containment ring 14 which is mainly configured of an iron and steel material having higher ductility than cast iron configuring the air-guiding cylinder 12 or the scroll part 13 is mounted at the linking position between the air-guiding cylinder 12 and the scroll part 13 so as to surround the delivery fan 11 around the axis line X.

[0088] In a fifth process, the second containment ring 15 which is mainly configured of an iron and steel material having higher ductility than cast iron configuring the air-guiding cylinder 12 or the scroll part 13 is mounted further toward the outer periphery side in the radial direction than is the air-guiding cylinder 12 and further toward the inner periphery side than is the scroll part 13.

[0089] By the above processes, the centrifugal compressor 10 of this embodiment is manufactured.

[0090] An operation and the effects which the turbocharger 100 of this embodiment described above exhibits will be described.

[0091] A compressor which the turbocharger 100 of this embodiment has is a centrifugal compressor. For this reason, in the delivery fan 11, the outer diameter of the blade is made to be larger on the discharge port 11b side than on the intake port 11a side. Therefore, the position of the center of gravity of the delivery fan 11 is at the position P1 on the discharge port 11b side. Further, the linking position between the discharge port 11b side of the air-guiding cylinder 12 and the scroll part 13 is at the position of the center of gravity of the delivery fan 11 in the axis line X.

[0092] When the whole or a part of the delivery fan breaks or falls off at the position of the center of gravity, the broken or fallen-off portion has a large weight, and thus an impact force when being thrown in the radial direction orthogonal to the direction of the axis line is large.

[0093] Therefore, in this embodiment, the first containment ring 14 (the annular member) which is mainly configured of an iron and steel material having higher ductility than cast iron configuring the air-guiding cylinder 12 and the scroll part 13 as a main body is provided at the linking position and disposed such that the whole or a part of the delivery fan 11 which has been broken or fallen off collides therewith even in a case of being thrown in the radial direction orthogonal to the direction of the axis line X from the position of the center of gravity of the delivery fan 11. Even in a case where the air-guiding cylinder 12 is subjected to brittle fracture due to the collision of the whole or a part of the delivery fan 11 which has been broken or fallen off, in the collision with the first containment ring 14 having high ductility, the first containment ring 14 is restricted to undergoing plastic deformation without this leading to brittle fracture. Accordingly, it is possible to prevent a problem in that the whole or a part of the delivery fan 11 which has been broken or fallen off is thrown to the outside of the turbocharger 100.

[0094] According to the centrifugal compressor 10 of this embodiment, the diameter of the outer peripheral surface of the first containment ring 14 and the diameter of the outer peripheral surface of the second containment ring 15 coincide with each other. For this reason, the first containment ring 14 and the second containment ring 15 form one cylindrical surface surrounding the air-guiding cylinder 12 around the rotor shaft 30.

[0095] The whole or a part of the delivery fan 11 which causes brittle fracture of the air-guiding cylinder 12 and is then thrown to the outside in the radial direction collides with either of the first containment ring 14 or the second containment ring 15 which form one cylindrical surface. One cylindrical surface is formed, and therefore, a gap occurring in a case where the diameter of the outer peripheral surface of the first containment ring 14 and the diameter of the outer peripheral surface of the second containment ring 15 are different from each other is not formed. For this reason, a problem in that the whole or a part of the delivery fan 11 is thrown from a gap which is formed due to a difference between the diameters of the outer peripheral surfaces of the first containment ring 14 and the second containment ring 15 to the outside of the turbocharger 100 is prevented.

[0096] Further, according to the centrifugal compressor 10 which the turbocharger 100 of this embodiment has, the end face 14a in the direction of the axis line X of the first containment ring 14 and the end face 15a in the direction of the axis line X of the second containment ring 15 are spaced apart from each other with the predetermined distance W therebetween in the direction of the axis line X. In a case where the first containment ring 14 and the second containment ring 15 are connected

or are formed as a single member, if a difference in thermal elongation amount due to a difference in temperature occurs in both end portions in the direction of the axis line X of the member, there is a concern that the member may be deformed or broken down.

[0097] Therefore, in this embodiment, the first containment ring 14 and the second containment ring 15 are configured as separate members and are spaced apart from each other with the predetermined distance W therebetween in the direction of the axis line X. In this way, even if a difference in thermal elongation amount due to a difference in temperature occurs between the respective members, deformation or breakage does not occur in either of the first containment ring 14 or the second containment ring 15.

[0098] According to the centrifugal compressor 10 which the turbocharger 100 of this embodiment has, pressure that the first containment ring 14 receives from the compressed air increases as the pressure of the compressed air which is discharged from the discharge port 11b increases due to an increase in the rotational frequency of the rotor shaft 30. The annular projection portion 14b that the first containment ring 14 has on the flow path 11e side is disposed at the annular step portion 12a that the air-guiding cylinder 12 has on the flow path 11e side. For this reason, a contact force between the annular projection portion 14b and the annular step portion 12a increases as the pressure that the first containment ring 14 receives from the compressed air increases. In this way, a problem in that the compressed air leaks out at the connecting location between the first containment ring 14 and the air-guiding cylinder 12 is prevented.

[0099] According to the centrifugal compressor 10 which the turbocharger 100 of this embodiment has, the O-ring 13h and the O-ring 14e (the annular seal members) are disposed between the inner periphery-side end face 13f in the radial direction of the scroll part 13 and the outer periphery-side end face 14c in the radial direction of the first containment ring 14 at the linking position. In this way, a problem in that the compressed air leaks out at the position at which the scroll part 13 and the first containment ring 14 face each other is prevented.

[0100] Each of the air-guiding cylinder 12 and the scroll part 13 of this embodiment is formed of a metal member manufactured by casting. As this metal member, it is preferable to use gray cast iron or ductile cast iron in which a complicated shape is easily manufactured. Further, each of the first containment ring 14 and the second containment ring 15 is formed of a metal member manufactured by rolling. As this metal member, it is preferable to use rolled steel for a general structure called SS400 which has higher ductility than a cast iron material and does not easily lead to breakage by being plastically deformed even with respect to an impact load.

[0101] In this way, it is possible to make the ductility of the first containment ring 14 and the second containment ring 15 which are the metal members manufactured by rolling higher than the ductility of the air-guiding cylinder

12 and the scroll part 13 which are the metal members manufactured by casting.

[Second Embodiment]

[0102] Hereinafter, a turbocharger of a second embodiment will be described with reference to the drawings.

[0103] A turbocharger 200 of the second embodiment is a modification of the turbocharger 100 of the first embodiment. With respect to configurations which are the same as those in the turbocharger 100 of the first embodiment except for a case as specifically described in the following and are denoted by the same reference numerals, description thereof is omitted.

[0104] In the turbocharger 100 of the first embodiment, the first containment ring 14 and the second containment ring 15 are spaced apart from each other with the predetermined distance W therebetween in the direction of the axis line X. In contrast, in the turbocharger 200 of the second embodiment, a first containment ring 14' and a second containment ring 15' are made so as to be disposed at positions overlapping in the radial direction and close to each other in the radial direction.

[0105] As shown in Fig. 4, the centrifugal compressor 10 is provided with the first containment ring 14' (an annular member) and the second containment ring 15' (a tubular member). The first containment ring 14' and the second containment ring 15' are made of the same metal members as those of the first containment ring 14 and the second containment ring 15 of the first embodiment.

[0106] As shown in Fig. 5, the first containment ring 14' is an annular member which is mounted at the linking position between the discharge port 11b side of the air-guiding cylinder 12 and the inner scroll casing 13d so as to surround the delivery fan 11 around the axis line X. As shown in Fig. 5, the first containment ring 14' is disposed coaxially with the rotor shaft 30. As shown in Fig. 5, the first containment ring 14' is connected to the air-guiding cylinder 12 by the fastening bolt 41.

[0107] The second containment ring 15' is a tubular member which is disposed further toward the outer periphery side in the radial direction than is the air-guiding cylinder 12 and further toward the inner periphery side in the radial direction than is the scroll part 13. As shown in Fig. 4, the second containment ring 15' is disposed coaxially with the rotor shaft 30. As shown in Fig. 5, the second containment ring 15' is connected to the air-guiding cylinder 12 by the fastening bolt 42.

[0108] As shown in Fig. 5, a radius D1 of the outer peripheral surface of the first containment ring 14' and a radius D2 of the outer peripheral surface of the second containment ring 15' coincide with each other. Making the radius D1 and the radius D2 coincide with each other is for preventing a gap occurring in a case where the diameter of the outer peripheral surface of the first containment ring 14' and the diameter of the outer peripheral surface of the second containment ring 15' are different from each other, from being formed. If this gap is formed,

there is a possibility that the whole or a part of the delivery fan 11 may be thrown to the outside.

[0109] Further, as shown in Fig. 6, an end portion 15a' on the discharge port 11b side of the second containment ring 15' and an end portion 14a' on the intake port 11a side of the first containment ring 14' are disposed at positions overlapping in the radial direction and close to each other in the radial direction.

[0110] A gap in the radial direction between the end portion 14a' which is disposed on the inner periphery side and the end portion 15a' which is disposed on the outer periphery side is set so as to maintain a distance to the extent that these members do not come into contact with each other due to thermal expansion. In this way, a problem in that the end portion 14a' of the first containment ring 14' and the end portion 15a' of the second containment ring 15' which is disposed on the outer periphery side come into contact with each other due to thermal expansion, thereby being respectively deformed or broken down, is prevented.

[0111] Further, the gap in the radial direction between the end portion 14a' which is disposed on the inner periphery side and the end portion 15a' which is disposed on the outer periphery side is set so as to become a distance to the extent that the end portion 14a' comes into contact with the end portion 15a' when the end portion 14a' is plastically deformed by impact caused by a broken member. In this way, the end portion 14a' comes into contact with the end portion 14a' when being plastically deformed by impact caused by the broken member, whereby the impact caused by the broken member can be absorbed by both the first containment ring 14' and the second containment ring 15'.

[0112] As shown in Fig. 5, the position in the direction of the axis line X, at which the first containment ring 14' is disposed, is the position P1. The position P1 coincides with the position of the center of gravity in the direction of the axis line of the delivery fan 11. The position P1 is a position which coincides with the end face on the intake port 11a side of the annular projection portion 14b of the first containment ring 14' shown in Fig. 6.

[0113] As shown in Figs. 5 and 6, in the delivery fan 11 of the centrifugal compressor 10 of this embodiment, the outer diameter of the blade is made to be larger on the discharge port 11b side than on the intake port 11a side. Therefore, the position of the center of gravity of the delivery fan 11 is at the position P1 closer to the discharge port 11b side than the intake port 11a side.

[0114] In a case where the delivery fan 11 rotates at a high speed around the axis line X (for example, a case where the delivery fan 11 rotates at a 10,000 or more revolutions per minute), there is a case where the whole or a part of the delivery fan 11 breaks or falls off. An impact force in the radial direction orthogonal to the direction of the axis line X at the time of falling-off of the delivery fan 11 becomes particularly large at the position of the center of gravity. In this embodiment, the position P1 in the direction of the axis line X, at which the first

containment ring 14' is disposed, coincides with the position of the center of gravity in the direction of the axis line of the delivery fan 11.

[0115] For this reason, in a case where the delivery fan 11 which has been broken or fallen off at the position of the center of gravity is thrown in the radial direction, thereby breaking the air-guiding cylinder 12, and is further thrown in the radial direction, the delivery fan 11 collides with the first containment ring 14'. Then, the first containment ring 14' having high ductility is plastically deformed, whereby it is possible to prevent a problem in that the whole or a part of the delivery fan 11 is thrown to the outside.

[0116] As shown in Fig. 5, the first containment ring 14' forms, along with the air-guiding cylinder 12, a flow path wall on the outer periphery side of the flow path 11e through which the compressed air which is discharged from the discharge port 11b flows.

[0117] As shown in Fig. 6, the first containment ring 14' has the annular projection portion 14b protruding inward in the radial direction, on the inner periphery side in the radial direction and the flow path 11e side in the direction of the axis line X.

[0118] Further, as shown in Fig. 6, the air-guiding cylinder 12 has the annular step portion 12a on the outer periphery side in the radial direction and the flow path 11e side in the direction of the axis line X. The air-guiding cylinder 12 and the first containment ring 14' are connected in a state where the annular projection portion 14b is disposed at the annular step portion 12a. A gap is provided between the annular step portion 12a and the annular projection portion 14b. Due to this gap, even if there is thermal expansion of the air-guiding cylinder 12, it is possible to prevent deformation from propagating to the first containment ring 14' by thermal expansion.

[0119] The inner periphery-side end face 13f of the inner scroll casing 13d and the outer periphery-side end face 14c in the radial direction of the first containment ring 14' are disposed so as to face each other, at the linking position at which the inner scroll casing 13d and the air-guiding cylinder 12 are connected.

[0120] An operation and the effects which the turbocharger 200 of this embodiment described above exhibits will be described.

[0121] A compressor which the turbocharger 200 of this embodiment has is a centrifugal compressor. For this reason, in the delivery fan 11, the outer diameter of the delivery fan blade is made to be larger on the discharge port 11b side than on the intake port 11a side. Therefore, the position of the center of gravity of the delivery fan 11 is at the position P1 on the discharge port 11b side. Further, the linking position between the discharge port 11b side of the air-guiding cylinder 12 and the scroll part 13 is at the position of the center of gravity of the delivery fan 11 in the axis line X.

[0122] When the whole or a part of the delivery fan breaks or falls off at the position of the center of gravity, the broken or fallen-off portion has a large weight, and

thus an impact force when being thrown in the radial direction orthogonal to the direction of the axis line is large.

[0123] Therefore, in this embodiment, the first containment ring 14' (the annular member) which is mainly configured of an iron and steel material having higher ductility than cast iron configuring the air-guiding cylinder 12 and the scroll part 13 as a main body is provided at the linking position and disposed such that the whole or a part of the delivery fan 11 which has been broken or fallen off (the broken member) collides therewith even in a case of being thrown in the radial direction orthogonal to the direction of the axis line X from the position of the center of gravity of the delivery fan 11. Even in a case where the air-guiding cylinder 12 is subjected to brittle fracture due to the collision of the broken member, in the collision with the first containment ring 14' having high ductility, the first containment ring 14' is restricted to undergoing plastic deformation without this leading to brittle fracture. Accordingly, it is possible to prevent a problem in that the broken member is thrown to the outside of the turbocharger 200.

[0124] Further, in this embodiment, the second containment ring 15' which is configured of a material having higher ductility than that of the air-guiding cylinder 12 is disposed further toward the outer periphery side in the radial direction than is the air-guiding cylinder 12 and further toward the inner periphery side in the radial direction than is the scroll part 13. The end portion 15a' on the discharge port 11b side of the second containment ring 15' and the end portion 14a' on the intake port 11a side of the first containment ring 14' are disposed at positions overlapping in the direction of the axis line X and close to each other in the radial direction.

[0125] For this reason, in a case where the broken member is thrown to the outside, thereby colliding with the first containment ring 14' which is disposed on the inner periphery side in the radial direction, the end portion 14a' which has received an impact moves toward the outer periphery side in the radial direction, thereby colliding with the end portion 15a' of the second containment ring 15. In this way, a gap is prevented from occurring between the second containment ring 15' and the first containment ring 14'. Both the second containment ring 15' and the first containment ring 14' have higher ductility than that of the air-guiding cylinder 12, and therefore, the impact caused by the collision is absorbed by the plastic deformation of both the second containment ring 15' and the first containment ring 14'.

[0126] In this embodiment, the position of the center of gravity P1 in the direction of the axis line X of the delivery fan 11 exists in a position range in the direction of the axis line X, in which the first containment ring 14' is disposed.

[0127] When the whole or a part at the position of the center of gravity P1 of the delivery fan 11 or in the vicinity of the position of the center of gravity P1 has been broken or fallen off, the broken or fallen-off portion has a large weight, and thus an impact force when being thrown in

the radial direction orthogonal to the direction of the axis line X is large.

[0128] Therefore, in this embodiment, a configuration is made such that the position of the center of gravity P1 in the direction of the axis line X of the delivery fan 11 exists in the position range in the direction of the axis line X, in which the first containment ring 14' is disposed. In this way, when the whole or a part at the position of the center of gravity P1 of the delivery fan 11 or in the vicinity of the position of the center of gravity P1 has been broken or fallen off, the broken or fallen-off portion is made to collide with the first containment ring 14', whereby it is possible to prevent a problem in that the whole or a part of the delivery fan 11 is thrown to the outside.

[0129] According to the centrifugal compressor 10 which the turbocharger 200 of this embodiment has, pressure that the first containment ring 14' receives from the compressed air increases as the pressure of the compressed air which is discharged from the discharge port 11b increases due to an increase in the rotational frequency of the rotor shaft 30. The annular projection portion 14b that the first containment ring 14' has on the flow path 11e side is disposed at the annular step portion 12a that the air-guiding cylinder 12 has on the flow path 11e side. For this reason, a contact force between the annular projection portion 14b and the annular step portion 12a increases as the pressure that the first containment ring 14' receives from the compressed air increases. In this way, a problem in that the compressed air leaks out at the connecting location between the first containment ring 14' and the air-guiding cylinder 12 is prevented.

[0130] According to the centrifugal compressor 10 which the turbocharger 200 of this embodiment has, the O-ring 13h and the O-ring 14e (the annular seal members) are disposed between the inner periphery-side end face 13f in the radial direction of the scroll part 13 and the outer periphery-side end face 14c in the radial direction of the first containment ring 14' at the linking position. In this way, a problem in that the compressed air leaks out at the position at which the scroll part 13 and the first containment ring 14' face each other is prevented.

[0131] Each of the air-guiding cylinder 12 and the scroll part 13 of this embodiment is formed of a metal member manufactured by casting. As this metal member, it is preferable to use gray cast iron or ductile cast iron in which a complicated shape is easily manufactured. Further, each of the first containment ring 14' and the second containment ring 15' is formed of a metal member manufactured by rolling. As this metal member, it is preferable to use rolled steel for a general structure called SS400 which has higher ductility than a cast iron material and does not easily lead to breakage by being plastically deformed even with respect to an impact load.

[0132] In this way, it is possible to make the ductility of the first containment ring 14' and the second containment ring 15' which are the metal members manufactured by rolling higher than the ductility of the air-guiding cylinder 12 and the scroll part 13 which are the metal members

manufactured by casting.

[Other Embodiments]

[0133] In the above description, the rotor shaft 30 to which the delivery fan 11 that the centrifugal compressor 10 has is connected is rotated around the axis line X by the turbine 20 which is rotated by exhaust gas which is discharged from the ship diesel engine. However, other aspects are also acceptable. For example, the rotor shaft 30 may be rotated by other power sources such as a motor connected to the rotor shaft 30.

[0134] In the above description, the position P1 in the direction of the axis line X, at which the first containment ring 14 or 14' is disposed, is set to be a position coinciding with the position of the center of gravity of the delivery fan 11. The expression "coinciding" in the above description does not mean that the position P1 and the position of the center of gravity strictly coincide with each other. Even in a case where the position P1 is disposed in the vicinity of the position of the center of gravity, it is assumed that the position P1 coincides with the position of the center of gravity of the delivery fan 11. That is, if the position P1 is a position at which it is possible to receive the impact force in the radial direction by the delivery fan 11 which becomes particularly large at the position of the center of gravity, it is assumed that the position P1 coincides with the position of the center of gravity of the delivery fan 11.

[0135] Further, in the above description, the radius D1 of the outer peripheral surface of the first containment ring 14 or 14' and the radius D2 of the outer peripheral surface of the second containment ring 15 or 15' are set to coincide with each other. The expression "coinciding" in the above description does not mean that the radius D1 and the radius D2 strictly coincide with each other. Even in a case where the radius D1 and the radius D2 are different from each other, in a case where a gap to the extent that the broken member does not pass there-through is provided between the first containment ring 14 or 14' and the second containment ring 15 or 15', it is assumed that the radius D1 and the radius D2 coincide with each other.

[0136] In the second embodiment, the shape of the first containment ring 14' and the shape of the second containment ring 15' are as shown in Fig. 6. However, other aspects are also acceptable.

[0137] For example, as shown in Fig. 7, a configuration may be made in which the end portion 14a' of the first containment ring 14' has a tapered shape in which the outer diameter thereof is gradually reduced toward the intake port 11a side and the end portion 15a' of the second containment ring 15' has a tapered shape in which the inner diameter thereof gradually increases toward the discharge port 11b side. In this way, it is possible to easily perform assembling.

[0138] Further, for example, as shown in Fig. 8, the shape of the end portion 15a' of the second containment

ring 15' may be the same as the shape of a portion other than the end portion 15a'. In this case, the second containment ring 15' has a approximately constant plate thickness in the radial direction orthogonal to the axis line X from the end portion on the intake port 11a side to the end portion on the discharge port 11b side.

[0139] In this way, even if the broken member collides at any position in the direction of the axis line X, the amount of plastic deformation according to the impact force caused by the collision becomes approximately the same. Accordingly, the second containment ring 15' can exert constant shock absorption performance at any position in the direction of the axis line X.

[0140] Further, for example, as shown in Fig. 9, a configuration may be made in which the end portion 14a' of the first containment ring 14' is disposed on the outer periphery side and the end portion 15a' of the second containment ring 15' is disposed on the inner periphery side.

Reference Signs List

[0141]

10:	centrifugal compressor
11:	delivery fan
11a:	intake port
11b:	discharge port
11e:	flow path
12:	air-guiding cylinder (guide cylinder)
12a:	annular step portion
13:	scroll part
13a:	diffuser
13c:	outer scroll casing
13d:	inner scroll casing
14, 14':	first containment ring (annular member)
14b:	annular projection portion
15, 15':	second containment ring (tubular member)
30:	rotor shaft
100, 200:	turbocharger

Claims

1. A centrifugal compressor comprising:
 - a delivery fan which is mounted on a rotor shaft and compresses a fluid flowing in from an intake port and discharges a compressed fluid from a discharge port;
 - a guide cylinder which accommodates the delivery fan;
 - a scroll part which is disposed further toward the outer periphery side than is the guide cylinder, and into which the compressed fluid discharged from the discharge port flows; and
 - an annular member which is mounted at a linking position between the discharge port side of the

guide cylinder and the scroll part so as to surround the delivery fan around an axis line of the rotor shaft.

2. The centrifugal compressor according to Claim 1, wherein the annular member is configured of a material having higher ductility than that of the guide cylinder.
3. The centrifugal compressor according to Claim 1 or 2, further comprising:
 - a tubular member which is disposed coaxially with the rotor shaft further toward the outer periphery side in a radial direction orthogonal to the axis line than is the guide cylinder and further toward the inner periphery side in the radial direction than is the scroll part.
4. The centrifugal compressor according to Claim 3, wherein an end portion on the discharge port side of the tubular member and an end portion on the intake port side of the annular member are disposed at positions overlapping in the radial direction and close to each other in the radial direction.
5. The centrifugal compressor according to Claim 3, wherein the tubular member is configured of a material having higher ductility than that of the guide cylinder,
 - a diameter of the annular member and a diameter of the tubular member coincide with each other with respect to the axis line, and
 - an end face in a direction of the axis line of the annular member and an end face in the direction of the axis line of the tubular member are spaced apart from each other with a predetermined distance therebetween in the direction of the axis line.
6. The centrifugal compressor according to any one of Claims 1 to 5, wherein a position of the center of gravity in the direction of the axis line of the delivery fan exists in a position range in the direction of the axis line, in which the annular member is disposed.
7. The centrifugal compressor according to any one of Claims 1 to 6, wherein the annular member forms, along with the guide cylinder, a flow path wall of a flow path through which the compressed fluid which is discharged from the discharge port flows,
 - the annular member has an annular projection portion protruding inward in the radial direction, on the outer periphery side in the radial direction orthogonal to the axis line and the flow path side in the direction of the axis line,
 - the guide cylinder at the linking position has an annular step portion on the outer periphery side in the radial direction and the flow path side in the direction

of the axis line, and
the guide cylinder and the annular member are connected in a state where the annular projection portion is disposed at the annular step portion.

8. A turbocharger comprising:

the centrifugal compressor according to any one of Claims 1 to 7; and
a turbine which is rotated around the axis line by exhaust gas discharged from an internal combustion engine and is connected to the rotor shaft.

9. A method for manufacturing a centrifugal compressor comprising:

a process of mounting a delivery fan which compresses a fluid flowing in from an intake port and discharges a compressed fluid from a discharge port on a rotor shaft;

a process of mounting a guide cylinder so as to accommodate the delivery fan, thereby forming a flow path which leads the fluid flowing in from the intake port to the discharge port;

a process of disposing a scroll part into which the compressed fluid discharged from the discharge port flows, further toward the outer periphery side in a radial direction orthogonal to a direction of an axis line of the rotor shaft than is the guide cylinder; and

a process of mounting an annular member at a linking position between the guide cylinder and the scroll part so as to surround the delivery fan around the axis line.

through which the compressed fluid which is discharged from the discharge port flows.

2. The centrifugal compressor according to Claim 1, wherein the annular member is configured of a material having higher ductility than that of the guide cylinder.

3. The centrifugal compressor according to Claim 1 or 2, further comprising:

a tubular member which is disposed coaxially with the rotor shaft further toward the outer periphery side in a radial direction orthogonal to the axis line than is the guide cylinder and further toward the inner periphery side in the radial direction than is the scroll part.

4. The centrifugal compressor according to Claim 3, wherein an end portion on the discharge port side of the tubular member and an end portion on the intake port side of the annular member are disposed at positions overlapping in the radial direction and close to each other in the radial direction.

5. The centrifugal compressor according to Claim 3, wherein the tubular member is configured of a material having higher ductility than that of the guide cylinder,

a diameter of the annular member and a diameter of the tubular member coincide with each other with respect to the axis line, and

an end face in a direction of the axis line of the annular member and an end face in the direction of the axis line of the tubular member are spaced apart from each other with a predetermined distance therebetween in the direction of the axis line.

6. The centrifugal compressor according to any one of Claims 1 to 5, wherein a position of the center of gravity in the direction of the axis line of the delivery fan exists in a position range in the direction of the axis line, in which the annular member is disposed.

7. (Amended) The centrifugal compressor according to any one of Claims 1 to 6, wherein the annular member has an annular projection portion protruding inward in the radial direction, on the inner periphery side in the radial direction orthogonal to the axis line and the flow path side in the direction of the axis line, the guide cylinder at the linking position has an annular step portion on the outer periphery side in the radial direction and the flow path side in the direction of the axis line, and

the guide cylinder and the annular member are connected in a state where the annular projection portion is disposed at the annular step portion.

Amended claims under Art. 19.1 PCT

1. (Amended) A centrifugal compressor comprising:

a delivery fan which is mounted on a rotor shaft and compresses a fluid flowing in from an intake port and discharges a compressed fluid from a discharge port;

a guide cylinder which accommodates the delivery fan;

a scroll part which is disposed further toward the outer periphery side than is the guide cylinder, and into which the compressed fluid discharged from the discharge port flows; and

an annular member which is mounted at a linking position between the discharge port side of the guide cylinder and the scroll part so as to surround the delivery fan around an axis line of the rotor shaft,

wherein the annular member forms, along with the guide cylinder, a flow path wall of a flow path

8. A turbocharger comprising:

the centrifugal compressor according to any one of Claims 1 to 7; and
 a turbine which is rotated around the axis line by exhaust gas discharged from an internal combustion engine and is connected to the rotor shaft.

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9. (Amended) A method for manufacturing a centrifugal compressor comprising:

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a process of mounting a delivery fan which compresses a fluid flowing in from an intake port and discharges a compressed fluid from a discharge port on a rotor shaft;
 a process of mounting a guide cylinder so as to accommodate the delivery fan, thereby forming a flow path which leads the fluid flowing in from the intake port to the discharge port;
 a process of disposing a scroll part into which the compressed fluid discharged from the discharge port flows, further toward the outer periphery side in a radial direction orthogonal to a direction of an axis line of the rotor shaft than is the guide cylinder; and
 a process of mounting an annular member at a linking position between the guide cylinder and the scroll part so as to surround the delivery fan around the axis line,
 wherein the mounting process is to mount the annular member at the linking position so as to form, along with the guide cylinder, a flow path wall of a flow path through which the compressed fluid which is discharged from the discharge port flows.

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FIG. 1

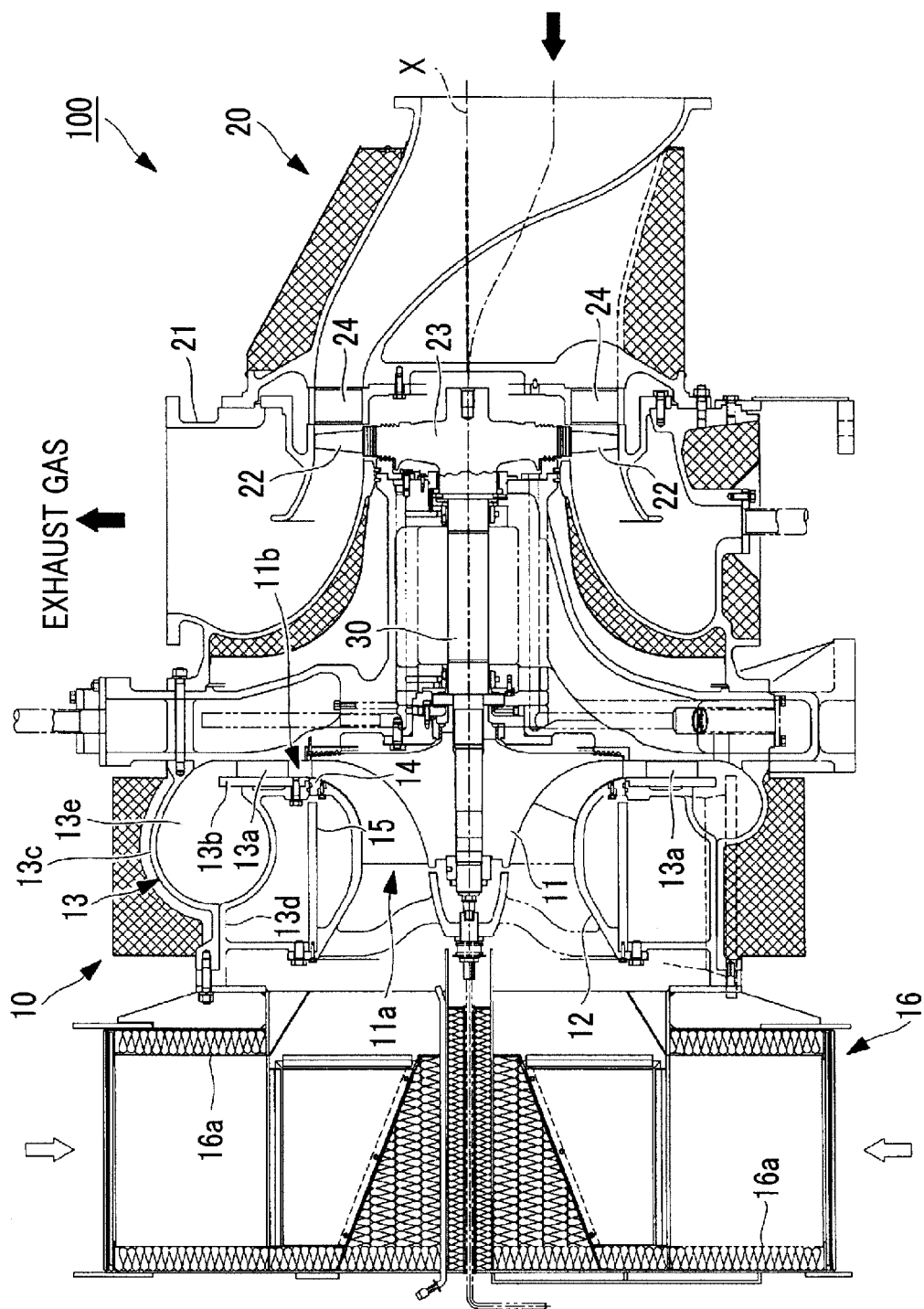


FIG. 2

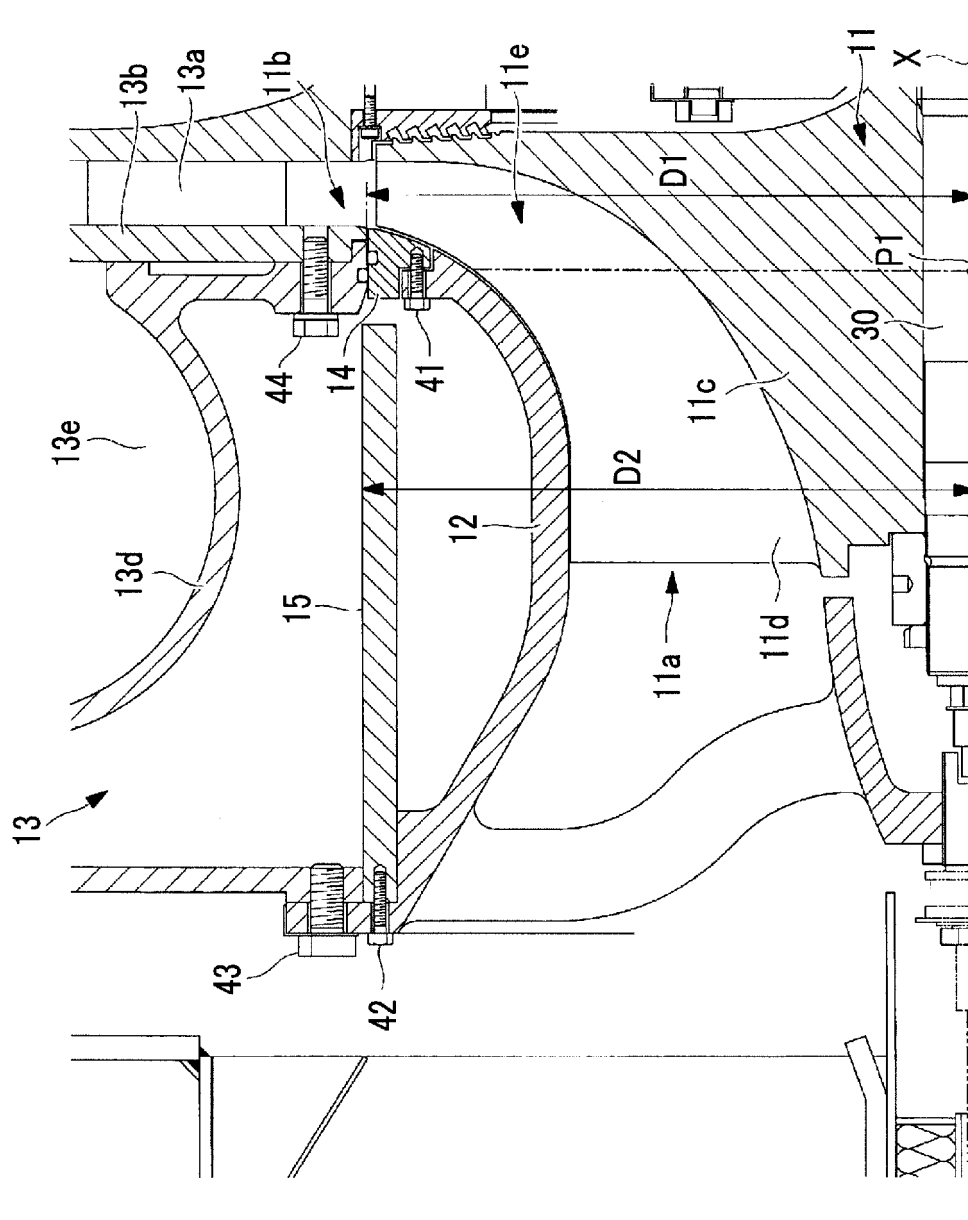


FIG. 3

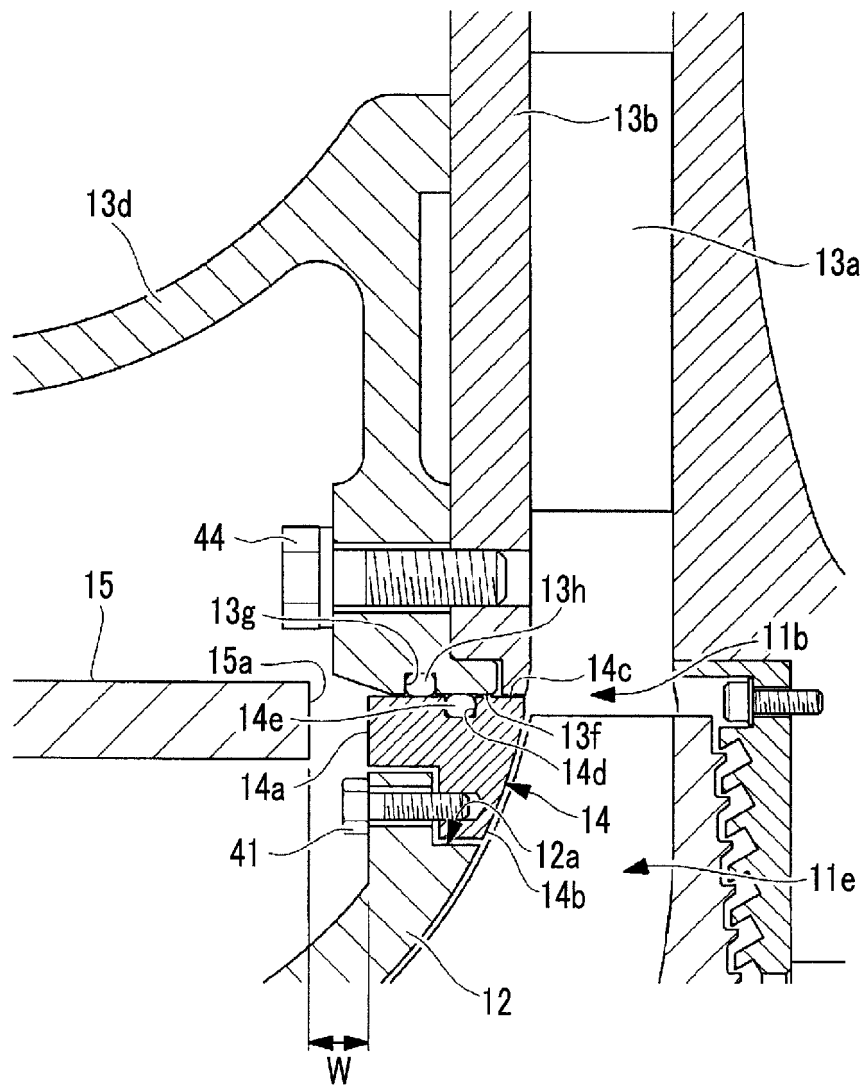


FIG. 4

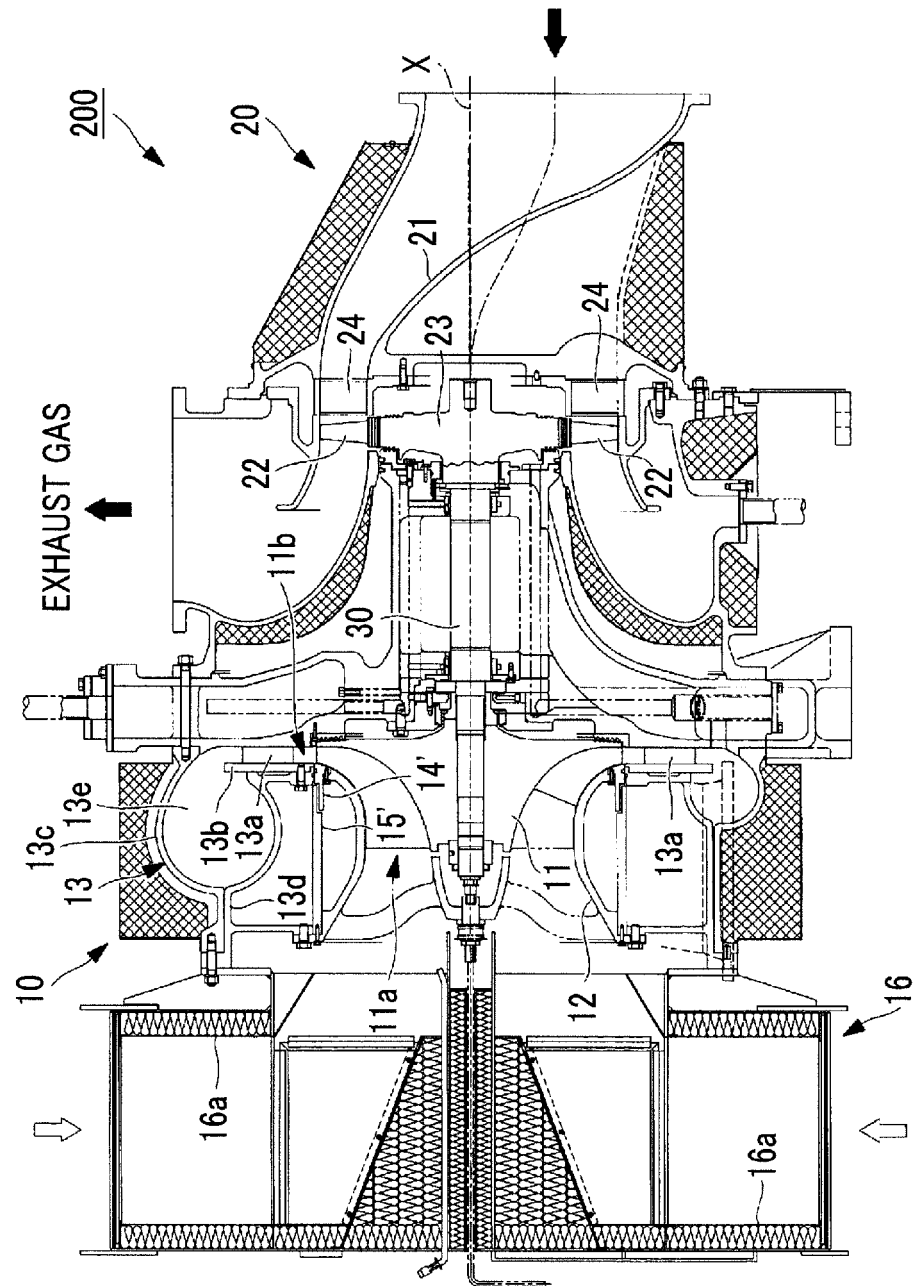


FIG. 5

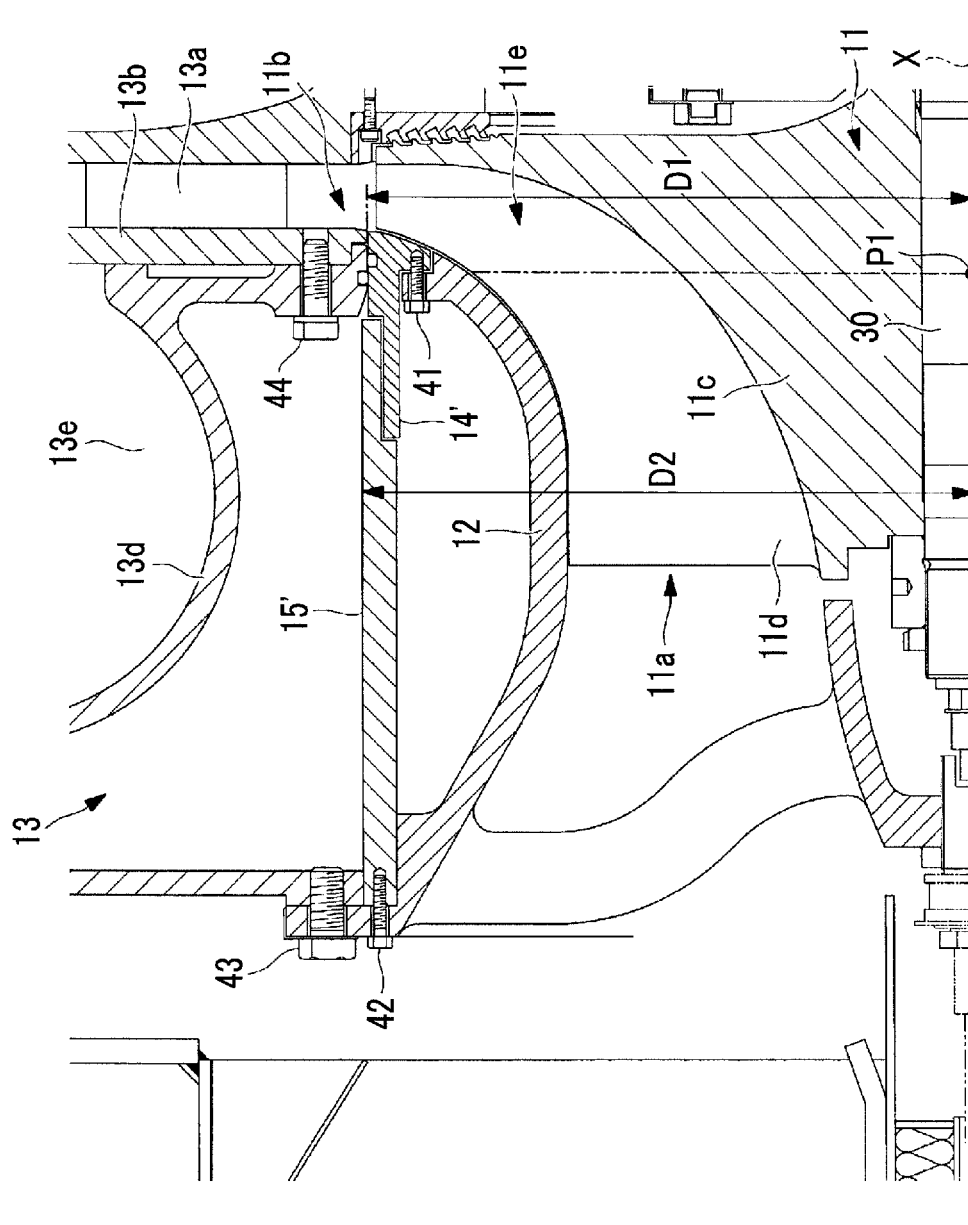


FIG. 6

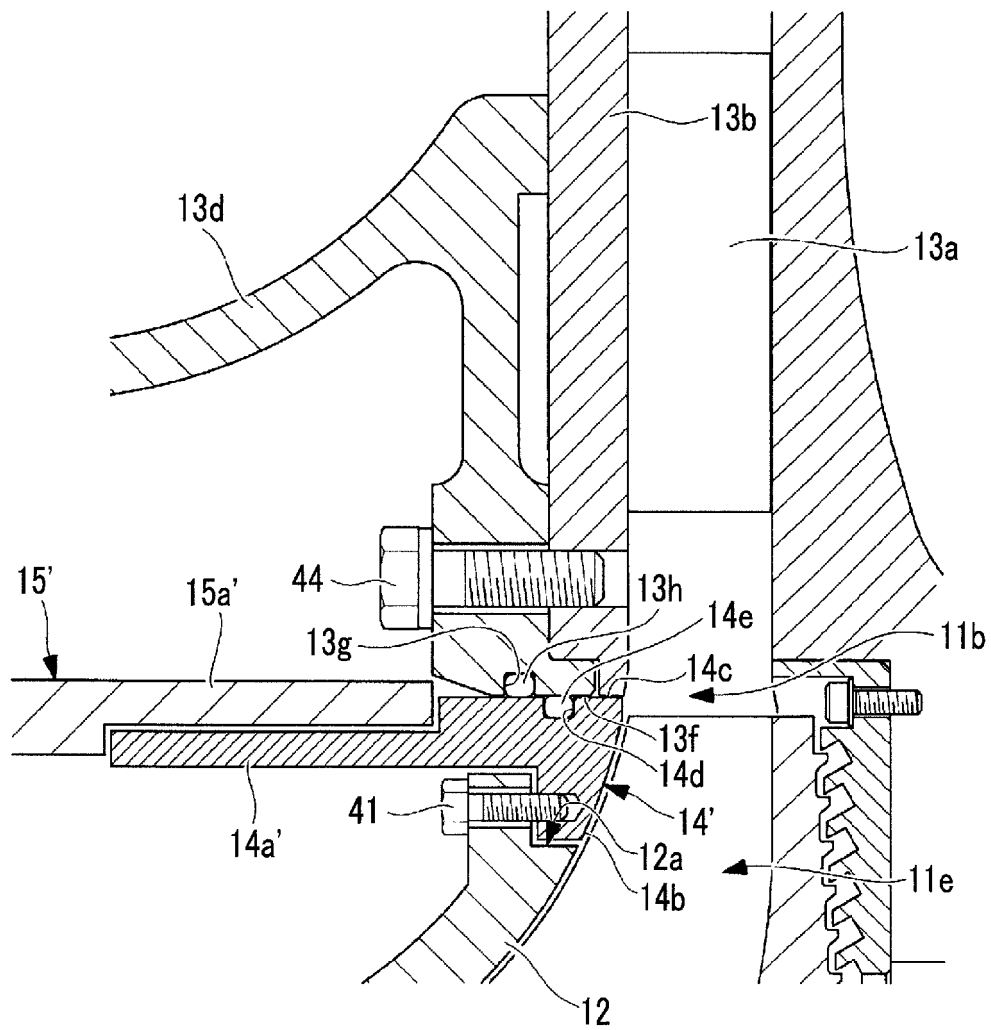


FIG. 7

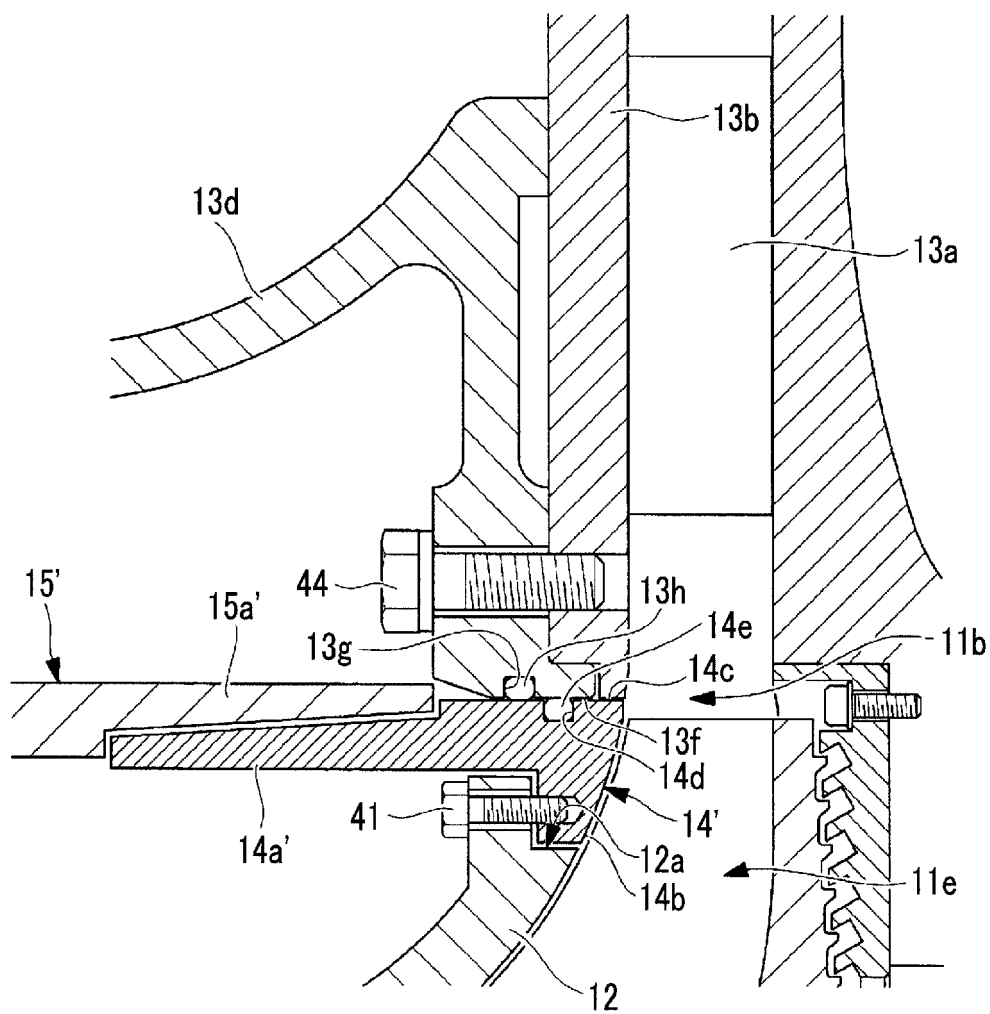


FIG. 8

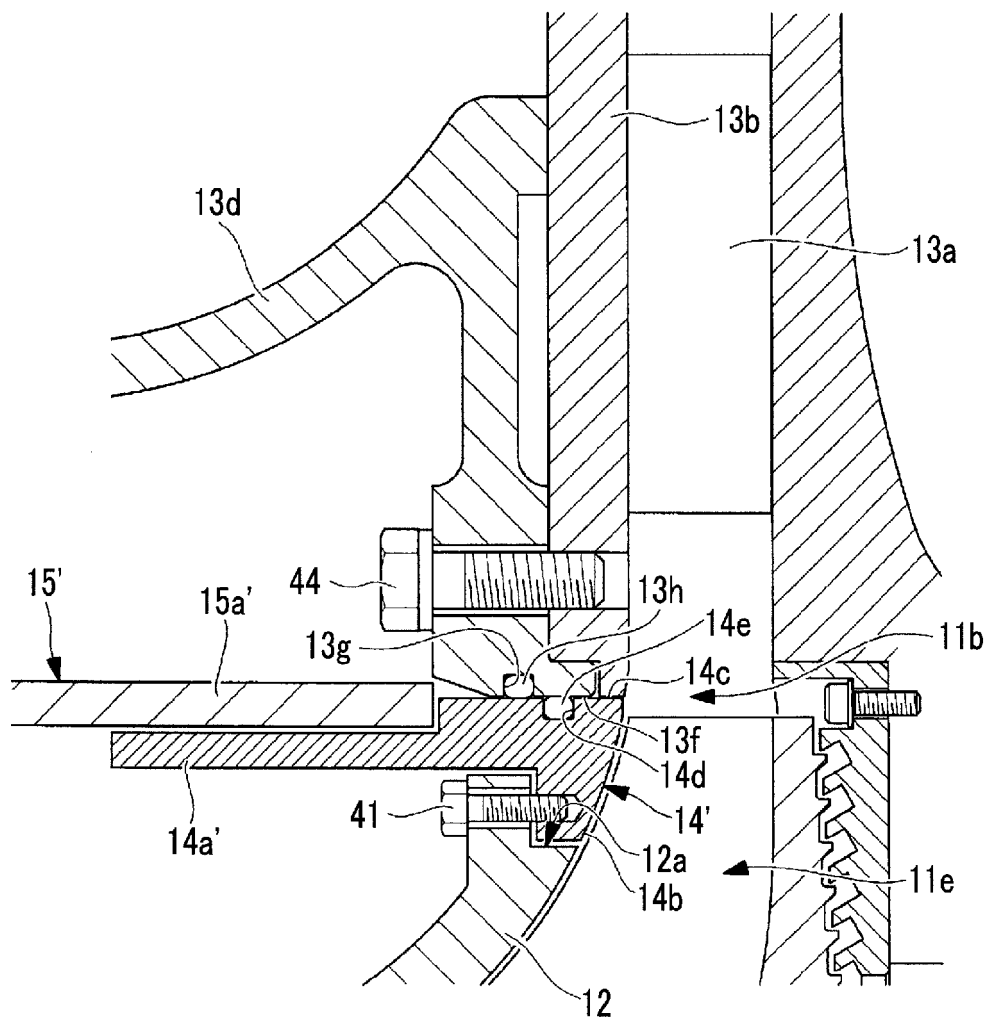
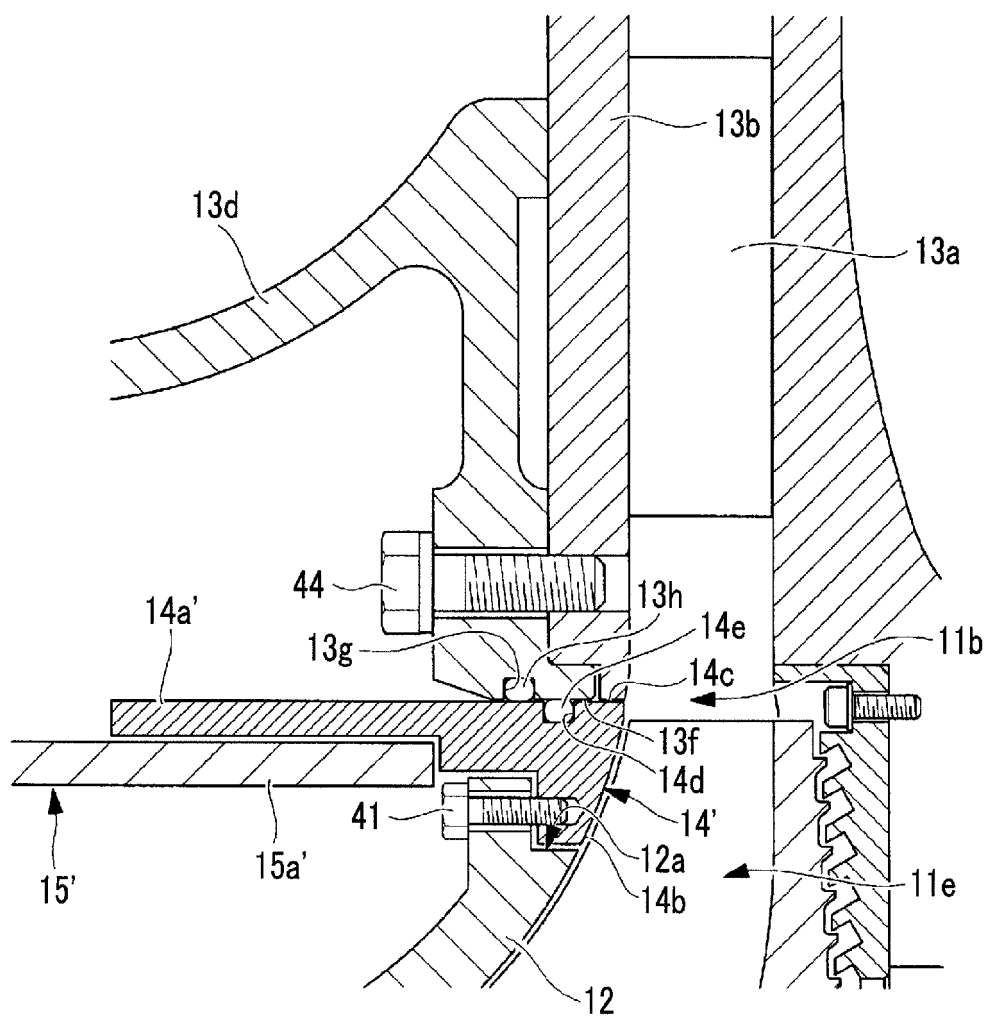


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/058355

A. CLASSIFICATION OF SUBJECT MATTER

F04D29/42(2006.01)i, F02B39/00(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)

F04D29/42, F02B39/00

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 2012-137091 A (IHI Corp.), 19 July 2012 (19.07.2012), paragraphs [0027], [0028], [0034] to [0038]; fig. 2 (Family: none)	1, 8, 9 2-7
X A	JP 62-243997 A (Ebara Corp.), 24 October 1987 (24.10.1987), page 2, upper right column, line 8 to lower right column, line 6; fig. 1, 2 (Family: none)	1, 8, 9 2-7
A	JP 10-110622 A (Asea Brown Boveri AG.), 28 April 1998 (28.04.1998), paragraphs [0015], [0016]; fig. 1, 2 & EP 834646 A1 & DE 19640654 A1	1-9

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

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Date of the actual completion of the international search
11 June 2015 (11.06.15)Date of mailing of the international search report
23 June 2015 (23.06.15)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)

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- JP 2011117417 A [0004]
- JP 2001132465 A [0004]