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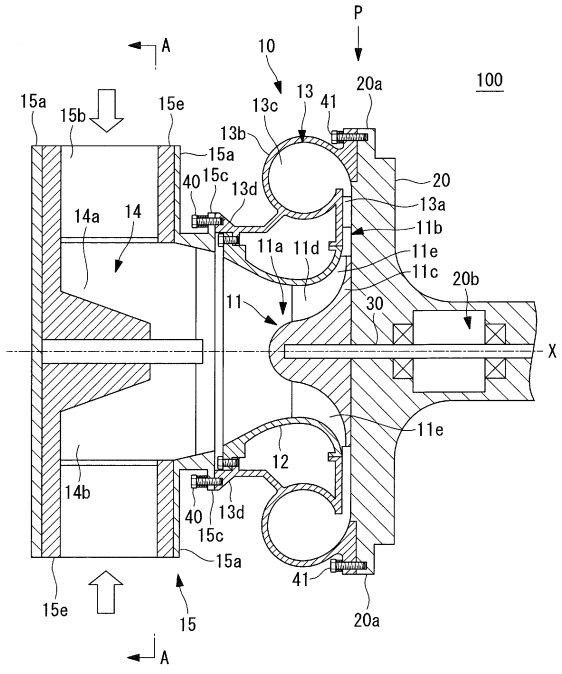
(54) CENTRIFUGAL COMPRESSOR, SUPERCHARGER, AND METHOD FOR MANUFACTURING CENTRIFUGAL COMPRESSOR

(57) There is provided a centrifugal compressor (10) including: an impeller (11) that is mounted on a rotor shaft (30), and compresses air flowing in from an intake (11a), and then discharges the compressed air from a discharge port (11b); an air inlet casing (12) that houses the impeller (11); a scroll section (13) which is disposed on an outer peripheral side with respect to the air inlet casing (12), and into which the compressed air discharged from the discharge port (11b) flows; a plurality of partition plates (14) provided on an upstream side in an air circulation direction with respect to the intake (11a), and each having a predetermined length in a direction of an axial line of the rotor shaft (30); and a silencer (15) having a silencer casing (15a) for housing the plurality of partition plates, wherein the plurality of partition plates (14) are radially disposed about the axial line (X), and each are a rolled steel material having a plate thickness of 4 mm or more and 9 mm or less.

FIG. 1



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Description

{Technical Field}

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

{Background Art}

[0002] Conventionally, as compressors for a supercharger that increases the pressure of air to be supplied to an internal combustion engine used in a vessel or the like above atmospheric pressure, centrifugal compressors are known (refer to Patent Literature 1, for example). The centrifugal compressor includes an impeller mounted on a rotor shaft, an inlet casing that houses the impeller, and a scroll section into which compressed air discharged from the inlet casing flows. While compressing air flowing in from an intake in the direction of an axial line, the centrifugal compressor guides the compressed air in the direction inclined from the direction of the axial line to discharge the compressed air from a discharge port.

[0003] In the centrifugal compressor, there is a possibility that faults occur such as fracture or falling off of one part of the impeller due to the influence of centrifugal force by high-speed rotation. Patent Literature 2 discloses a centrifugal compressor provided with an impact absorbing partition wall that protects a tank housing lubricant such that the lubricant does not leak due to a scattered impeller even in a case where one part of the impeller (compressor impeller) is scattered outward by centrifugal force.

{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 Patent Literature 2, in a case where faults occur such as fracture or falling off of the one part of the impeller due to the influence of centrifugal force by high-speed rotation, the tank housing lubricant is protected.

[0006] However, in a case where all or one part of the impeller is fractured or falls to collide with an inlet casing, there is a possibility that since the impact load is large, the inlet casing is broken, and all or one part of the inlet casing scatters to the outside together with the all or the one part of the impeller. Additionally, even in a case where the inlet casing is not broken, there is a possibility that all or one part of the inlet casing falls from a mounting position, and scatters in the direction away from a scroll section along the axial line of a rotor shaft. In this case, there is a possibility that a gap (opening) is generated in a part of the centrifugal compressor due to scattering of all or one part of the inlet casing, and a part of the broken impeller scatters to the outside from the gap.

[0007] The present invention has been made in view of the above circumstances, and an object of the present invention is to provide a centrifugal compressor capable of suppressing faults such as scattering of all or one part of an impeller to the outside in a case where all or one part of an inlet casing scatters with fracture or falling of the all or the one part of the impeller.

[0008] Additionally, an object of the present invention is to provide a supercharger including the above centrifugal compressor, and a method for manufacturing the above centrifugal compressor.

{Solution to Problem}

[0009] In order to achieve the above objects, the present invention employs the following solutions.

[0010] A centrifugal compressor according to a first aspect of the present invention includes: an impeller that is mounted on a rotor shaft, and compresses fluid flowing in from an intake, and then discharges the compressed fluid from a discharge port; an inlet casing that houses the impeller; a scroll section which is disposed on an outer peripheral side with respect to the inlet casing, and into which the compressed fluid discharged from the discharge port flows; a plurality of partition plates provided on an upstream side in a fluid circulation direction with respect to the intake, and each having a predetermined length in a direction of an axial line of the rotor shaft; and a silencer for housing the plurality of partition plates, wherein the plurality of partition plates are radially disposed about the axial line, and each are a rolled steel material having a plate thickness of 4 mm or more and 9 mm or less.

[0011] According to the centrifugal compressor according to the first aspect of the present invention, in a case where all or one part of the impeller is fractured or falls, the all or the one part of the impeller scatters to collide with the inlet casing. The inlet casing forms a flow passage for guiding the fluid flowing in from the intake in the direction of the axial line of the rotor shaft, in a direction inclined from the direction of the axial line, and leading the fluid to the discharge port. When the all or the one part of the impeller which scatters in the radial direction collides with the inlet casing, impact in the radial direction is applied to the inlet casing. Similarly, when the all or the one part of the impeller which scatters in the direction

of the axial line collides with the inlet casing, impact in the direction of the axial line is applied to the inlet casing. The impact in the direction of the axial line is impact causing the all or the one part of the inlet casing to scatter in the direction away from the scroll section, and therefore there is a possibility that all or one part of the inlet casing falls from a mounting position.

[0012] According to the centrifugal compressor according to the first aspect of the present invention, the plurality of partition plates each having a predetermined length in the direction of the axial line are radially disposed about the axial line on the upstream side in the fluid circulation direction with respect to the intake. Therefore, the all or the one part of the impeller that scatters, or the all or the one part of the inlet casing that scatters in the direction away from the scroll section due to impact resulting from the scattering of the impeller collides with the plurality of partition plates housed in the silencer casing. The plurality of partition plates each are the rolled steel material having a plate thickness of 4 mm or more and 9 mm or less, and therefore the plurality of partition plates are suitably plastically deformed by collision with the all or the one part of the inlet casing, to absorb energy resulting from the collision. Consequently, it is possible to suppress faults such as a gap generated by the scattering of the all or the one part of the inlet casing in a part of the centrifugal compressor, scattering the all or the one part of the impeller to the outside from the gap.

[0013] In the centrifugal compressor of the first aspect of the present invention, the scroll section may have a scroll casing forming a volute chamber into which the compressed fluid discharged from the discharge port flows, the scroll casing and the silencer casing may be fastened to each other at a plurality of first fastening positions in a peripheral direction around the axial line by a plurality of first fastening bolts extending in the direction of the axial line, and the scroll casing and the silencer casing may be fastened to each other in a state where cylindrical first spacer members each having an inner diameter smaller than a diameter of a head section of each of the first fastening bolts are inserted into shaft sections of the first fastening bolts.

[0014] According to the centrifugal compressor having this configuration, when the all or the one part of the inlet casing that scatters in the direction away from the scroll section collides with the silencer casing that houses the partition plates, impact in the direction in which the silencer casing is separated from the scroll casing is applied. This impact is absorbed by contraction of the first spacer members disposed between the head sections of the first fastening bolts and the silencer casing. As each first spacer member, for example, a rolled steel material having ductility resulting in breakage after large plastic deformation is used, so that it is possible to absorb kinetic energy resulting from axial impact. Thus, the impact in the direction of the axial line is absorbed by use of the first spacer members fastened while being inserted into the first fastening bolts, so that faults such as fracture of the first fastening bolts are suppressed. Accordingly, it is possible to suppress faults such as a gap generated by the scattering of the all or the one part of the inlet casing in a part of the centrifugal compressor, scattering the all or the one part of the impeller to the outside from the gap.

[0015] In the centrifugal compressor having the above configuration, the first fastening bolts may each include a male screw formed on an outer peripheral surface of the shaft section from the head section to a tip.

[0016] Consequently, deformations at the respective parts of the outer peripheral surfaces of the shaft sections from the head sections to the tips are made uniform, so that the above failure can be suppressed by use of the first fastening bolts having increased energy absorption of impact.

[0017] The centrifugal compressor having the above configuration may include a bearing pedestal having a bearing section for supporting the rotor shaft, and a flange section for supporting the scroll section, wherein the flange section and the scroll casing may be fastened to each other at a plurality of second fastening positions around the axial line by a plurality of second fastening bolts extending in the direction of the axial line, and the flange section and the scroll casing may be fastened to each other in a state where cylindrical second spacer members each having an inner diameter smaller than a diameter of a head section of each of the second fastening bolts are inserted into shaft sections of the second fastening bolts.

[0018] According to the centrifugal compressor of this aspect, when the all or the one part of the inlet casing that scatters in the direction away from the scroll section collides with the silencer casing that houses the partition plates, impact in the direction in which the scroll casing is separated from the flange section of the bearing pedestal is applied. This impact is absorbed by contraction of the second spacer members disposed between the head sections of the second fastening bolts and the scroll casing. Thus, impact in the direction of the axial line is absorbed by use of the second spacer members fastened while being inserted into the second fastening bolts, so that faults such as fracture of the second fastening bolts are suppressed. Accordingly, it is possible to suppress faults such as a gap generated by the scattering of the all or the one part of the inlet casing in a part of the centrifugal compressor, scattering the all or the one part of the impeller to the outside from the gap.

[0019] In the centrifugal compressor of the above aspect, the second fastening bolts may each include a male screw formed on an outer peripheral surface of the shaft section from the head section to a tip.

[0020] Consequently, deformations at the respective parts of the outer peripheral surfaces of the shaft sections from the head sections to the tips are made uniform, so that the above failure can be suppressed by use of the second fastening bolts having increased energy absorption of impact.

[0021] A centrifugal compressor according to a second aspect of the present invention includes: an impeller that is mounted on a rotor shaft, and compresses fluid flowing in from an intake, and then discharges the compressed fluid from a discharge port; an inlet casing that houses the impeller; a scroll section that is disposed on an outer peripheral side with respect to the inlet casing, and has a scroll casing for forming a volute chamber into which the compressed fluid discharged from the discharge port flows; a bearing pedestal having a bearing section for supporting the rotor shaft, and a flange section for supporting the scroll section; a plurality of flange section fastening bolts that fasten the flange section to the scroll casing at a plurality of fastening positions around the axial line of the rotor shaft, and extend in the direction of the axial line; and a plurality of clamp members having recesses which surround an outer peripheral edge of the flange section and an outer peripheral edge of the scroll casing from an outer peripheral side, and through holes which are opened to the recesses, and extend in the direction of the axial line, wherein one of either the flange section or the scroll casing has a plurality of fastening holes extending in the direction of the axial line, in a peripheral direction around the axial line, one of either the flange section or the scroll casing, and the clamp members are fastened to each other by clamp member fastening bolts inserted into the through holes and the fastening holes, and predetermined gaps are provided between an end face in the direction of the axial line of the other of either the flange section or the scroll casing, and end faces in the direction of the axial line of the recesses.

[0022] According to the centrifugal compressor according to the second aspect of the present invention, even in a case where the plurality of flange section fastening bolts are fractured, and the flange section of the bearing pedestal and the scroll casing are separated from each other, the end face in the direction of the axial line of the other of either the flange section or the scroll casing comes into contact with the end faces in the direction of the axial line of the recesses. Impact caused by this contact is absorbed by the plurality of clamp members mounted in the peripheral direction around the axial line. Consequently, it is possible to suppress faults such as a gap generated by the scattering of all or one part of the impeller in a part of the centrifugal compressor, scattering the all or the one part of the damaged impeller to the outside from the gap.

[0023] In the above aspect, the flange section may have the fastening holes, and is fastened to the clamp members by the third fastening bolts, and predetermined gaps are provided between an end face in the direction of the axial line of the scroll casing, and end faces in the direction of the axial line of the recesses, and the flange section has a stepped section that connects a contact surface that is in contact with the scroll casing, and an end face of the flange section that forms a second flow passage for allowing the compressed fluid to circulate, and is disposed on a side closer to the second flow passage than the contact surface.

[0024] Consequently, in a case where the plurality of flange section fastening bolts are fractured, the flange section of the bearing pedestal and the scroll casing are separated from each other, and the end face in the direction of the axial line of the scroll casing comes into contact with the end faces in the direction of the axial line of the recesses, opening between the flange section and the scroll casing is suppressed by existence of the stepped section.

[0025] Furthermore, a width in the direction of the axial line of the stepped section is wider than a width of each of the predetermined gaps, so that opening can be more reliably suppressed.

[0026] A supercharger according to the present invention includes: a centrifugal compressor described any of the above; and a turbine that is rotated around the axial line by exhaust gas exhausted from an internal combustion engine, and is connected to the rotor shaft.

[0027] The supercharger according to the present invention, it is possible to suppress faults such as a gap generated by the scattering of the inlet casing provided in the centrifugal compressor in a part of the centrifugal compressor, scattering one part of the impeller to the outside from the gap.

[0028] A method for manufacturing a centrifugal compressor according to the present invention includes the steps of: mounting an impeller on a rotor shaft, the impeller for compressing fluid flowing in from an intake and then discharging the compressed fluid from a discharge port; mounting an inlet casing so as to house the impeller, and forming a flow passage for leading the fluid flowing in from the intake to the discharge port; disposing a scroll section, into which the compressed fluid discharged from the discharge port flows, on an outer peripheral side in a radial direction orthogonal to the direction of the axial line with respect to the inlet casing; and providing a plurality of partition plates on an upstream side in a fluid circulation direction with respect to the intake, and radially disposing about the axial line so as to each have a predetermined length in the direction of the axial line, each of the plurality of partition plates having a plate thickness of 4 mm or more and 9 mm or less.

[0029] According to the centrifugal compressor manufactured by the manufacturing method according to the present invention, in a case where all or one part of the impeller is fractured or falls, the all or the one part of the impeller scatters to collide with the inlet casing. The inlet casing forms a flow passage for guiding the fluid flowing in from the intake in the direction of the axial line of the rotor shaft, in a direction inclined from the direction of the axial line, and then leading the fluid to the discharge port. Therefore, when the all or the one part of the impeller which scatters in the radial direction collides with the inlet casing, impact in the radial direction is applied to the inlet casing. Similarly, when the all or the one part of the impeller which scatters in the direction of the axial line collides with the inlet casing, impact in the direction of the

axial line is applied to the inlet casing. The impact in the direction of the axial line is impact causing the all or the one part of the inlet casing to scatter in the direction away from the scroll section, and therefore there is a possibility that all or one part of the inlet casing falls from a mounting position.

[0030] According to the centrifugal compressor manufactured by the manufacturing method according to the present invention, the plurality of partition plates are radially disposed about the axial line on the upstream side in the fluid circulation direction with respect to the intake. Therefore, the all or the one part of the impeller that scatters, or the all or the one part of the inlet casing that scatters in the direction away from the scroll section due to impact resulting from the scattering of the impeller collides with the plurality of partition plates housed in the silencer casing. The plurality of partition plates each are the rolled steel material having a plate thickness of 4 mm or more and 9 mm or less, and therefore the plurality of partition plates are suitably plastically deformed by collision with the all or the one part of the inlet casing, and then absorb energy resulting from the collision. Consequently, it is possible to suppress faults such as a gap generated by the scattering of the all or the one part of the inlet casing in a part of the centrifugal compressor, scattering the all or the one part of the impeller to the outside from the gap.

{Advantageous Effects of Invention}

[0031] According to the present invention, it is possible to provide a centrifugal compressor capable of suppressing faults such as scattering of all or one part of an impeller to the outside in a case where all or one part of an inlet casing scatters with fracture or falling of the all or the one part of the impeller.

[0032] Additionally, according to the present invention, it is possible to provide a supercharger including the above centrifugal compressor, and a method for manufacturing the above centrifugal compressor.

{Brief Description of Drawings}

[0033]

{Fig. 1} Fig. 1 is a longitudinal sectional view illustrating an embodiment of a supercharger.

{Fig. 2} Fig. 2 is a sectional view taken along the A-A arrow of a silencer illustrated in Fig. 1.

{Fig. 3} Fig. 3 is a sectional view taken along the B-B arrow of the silencer illustrated in Fig. 2.

{Fig. 4} Fig. 4 is a partial enlarged view illustrating the vicinity of a fastening position of the silencer casing and a scroll casing illustrated in Fig. 1.

{Fig. 5} Fig. 5 is a partial enlarged view illustrating the vicinity of a fastening position of the scroll casing and a flange section illustrated in Fig. 1.

{Fig. 6} Fig. 6 is a diagram of outer peripheral edges of the scroll casing and the flange section as viewed from the P direction illustrated in Fig. 1.

{Fig. 7} Fig. 7 is a sectional view taken along the C-C arrow of the outer peripheral edges of the scroll casing and the flange section illustrated in Fig. 6, which illustrates a state where the scroll casing and the flange section are in contact with each other.

{Fig. 8} Fig. 8 is a sectional view taken along the C-C arrow of the outer peripheral edges of the scroll casing and the flange section illustrated in Fig. 6, which illustrates a state where the scroll casing and the flange section are separated from each other.

{Description of Embodiments}

[0034] A supercharger 100 of this embodiment will be described with reference to the drawings.

[0035] The supercharger 100 of this embodiment is a device that increases air (gas) to be supplied to a marine diesel engine (internal combustion engine) used in a vessel to atmospheric pressure or more, and improves combustion efficiency of the marine diesel engine.

[0036] As illustrated in Fig. 1, the supercharger 100 of this embodiment includes a centrifugal compressor 10, a turbine (not illustrated), and a bearing pedestal 20. The centrifugal compressor 10 and the turbine are connected to a rotor shaft 30. The rotor shaft 30 is supported by the bearing pedestal 20 while being rotatable around an axial line X.

[0037] The centrifugal compressor 10 is a device that compresses air flowing in from the outside of the supercharger 100, and then supplies, to an intake manifold (not illustrated) communicated with the inside of a cylinder liner (not illustrated) forming the marine diesel engine, air that has been compressed (hereinafter, referred to as compressed air (compressed fluid)). The centrifugal compressor 10 includes an impeller 11, an air inlet casing 12 (inlet casing), a scroll section 13, partition plates 14, and a silencer 15.

[0038] The supercharger 100 of this embodiment leads exhaust gas exhausted from the marine diesel engine to the turbine to rotate a turbine disc mounted with a turbine blade around the axial line X. The impeller 11 connected through the rotor shaft 30 rotates with the rotation of the turbine disc, air flowing in from an intake 11a is compressed, and the compressed air is discharged from a discharge port 11b. The compressed air discharged from the discharge port 11b flows in the scroll section 13 to be led to the intake manifold of the marine diesel engine.

[0039] The air inlet casing 12 and the scroll section 13 are formed of a metal member manufactured by casting in order to form a complicated shape. As this metal member, for example, cast iron that is a Fe-C based alloy containing iron as a main component and containing 2% or more of carbon is used. As the cast iron, various materials such as gray cast iron can be used. However, ductile cast iron (FCD: Ferrum Casting Ductile) where black smoke is spheroidized in a basic structure is preferably

used. The metal material by casting is easily formed in a complicated shape by casting, but has a brittle characteristic.

[0040] Now, respective components included in the centrifugal compressor 10 will be described.

[0041] As illustrated in Fig. 1, the impeller 11 is mounted on the rotor shaft 30 extending along the axial line X, and rotates about the axial line X with the rotation of the rotor shaft 30 around the axial line X. The impeller 11 rotates around the axial line X, so that air flowing in from the intake 11a is compressed to be discharged from the discharge port 11b.

[0042] As illustrated in Fig. 1, the impeller 11 includes a hub 11c mounted on the rotor shaft 30, blades 11d mounted on an outer peripheral surface of the hub 11c, and a flow passage 11e. The impeller 11 is provided with a space defined by the outer peripheral surface of the hub 11c and an inner peripheral surface of the air inlet casing 12, and this space is partitioned into a plurality of spaced by a plurality of the blades 11d. The impeller 11 applies radial centrifugal force to air flowing in from the intake 11a in the direction of the axial line X to discharge the air in the direction orthogonal to the direction of the axial line X (radial direction of the impeller 11), and allows compressed air discharged from the discharge port 11b to flow into a diffuser 13a.

[0043] The air inlet casing 12 is a member that houses the impeller 11 and discharges, from the discharge port 11b, air flowing in from the intake 11a in the direction of the axial line X of the rotor shaft 30. The air inlet casing 12 forms the flow passage 11e for guiding air flowing in from the intake 11a along the axial line X in the radial direction orthogonal to the axial line X, and then leading the air to the discharge port 11b, together with the impeller 11.

[0044] The scroll section 13 is a device in which compressed air discharged from the discharge port 11b flows, and which converts kinetic energy (dynamic pressure) applied to the compressed air into pressure energy (static pressure). The scroll section 13 is disposed on the outer peripheral side in the radial direction orthogonal to the direction of the axial line X with respect to the air inlet casing 12.

[0045] The scroll section 13 includes the diffuser 13a, a scroll casing 13b, and a volute chamber 13c. The volute chamber 13c is a space formed by the scroll casing 13b. As illustrated in Fig. 2, the scroll casing 13b is connected to a flange section 20a of the bearing pedestal 20 by fastening bolts 41.

[0046] The diffuser 13a is an airfoil member disposed on the downstream side of the discharge port 11b of the impeller 11, and forms a flow passage for leading compressed air from the discharge port 11b to the volute chamber 13c. The diffuser 13a is provided so as to surround the discharge port 11b for compressed air provided on the whole periphery of the impeller 11.

[0047] The diffuser 13a decelerates the flow velocity of the compressed air discharged from the discharge port 11b of the impeller 11, so that kinetic energy (dynamic pressure) applied to the compressed air is converted into the pressure energy (static pressure). The compressed air whose flow velocity is decelerated when passing through the diffuser 13a flows in the volute chamber 13c communicated with the diffuser 13a. The working fluid flowing in the volute chamber 13c is discharged to a discharge pipe (not illustrated).

[0048] The partition plates 14 are plate members provided on the upstream side in the air circulation direction with respect to the intake 11a, and have predetermined lengths in the direction of the axial line X. As illustrated in Fig. 2, the partition plates 14 are formed by four partition plates 14a, 14b, 14c, 14d. The four partition plates 14a, 14b, 14c, 14d are radially disposed about the axial line X. The partition plates 14 are devised so as to function as an impact absorbing material for absorbing impact due to collision with all or one part of the air inlet casing 12. Additionally, the partition plates 14 support a silencer casing 15a of the silencer 15, and each function as a straightening vane for straightening air circulating inside the silencer 15.

[0049] As illustrated in Fig. 3, the partition plate 14b is formed in a rectangle whose cross-section along the axial line X is long in the direction of the axial line X. Fig. 3 illustrates only the partition plate 14b, but other partition plates 14a, 14c, 14d each have a similar sectional shape.

[0050] The partition plates 14 are each formed of a metal member manufactured by rolling. As this metal member, for example, a rolled steel material that is a Fe-C based alloy containing iron as a main component and containing a slight amount (about 0.2%) of carbon is used. As the rolled steel material, various materials can be used. However, a rolled steel material for general structural use (JIS G 3101; ASTM A283), called SS400, is preferably used.

[0051] The metal material by rolling is composed of a composition suitable for a rolling process, and has ductility resulting in 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 elongation up to breakage which is smaller than the elongation up to breakage of the metal material by rolling. Thus, the metal material by rolling has larger elongation up to breakage than the metal material by casting, that is, has high ductility. Accordingly, the metal material by rolling has higher breaking strength against impact than the metal material by casting.

[0052] For example, the ductile cast iron material and the SS400 material each have the tensile strength of 400 N/mm^2 to 500 N/mm^2 at a normal temperature. On the other hand, the ductile cast iron material has elongation of about 10% in breakage, the S400 material has elongation of 20% or more in breakage. Accordingly, the SS400 material has higher ductility than the ductile cast iron material.

[0053] In the centrifugal compressor 10 of this embodiment, all or one part of the blades 11d of the impeller 11

is fractured or falls to scatter in the radial direction, and collides with the air inlet casing 12. The flow passage 11e of the centrifugal compressor 10 is a flow passage that gradually inclines from the intake 11a toward the discharge port 11b in the direction of the axial line X. Therefore, radial impact force, and impact force in the direction of the axial line X are applied to the air inlet casing 12. The impact force in the direction of the axial line X is impact force of scattering the air inlet casing 12 in the direction away from the scroll section 13, and therefore there is a possibility that the air inlet casing 12 formed of the metal member manufactured by casting is damaged to fall from a mounting position.

[0054] In a case where the all or the one part of the air inlet casing 12 falls from the mounting position, and scatters toward the silencer 15, the all or the one part of the air inlet casing 12 collides with the partition plates 14 disposed inside the silencer 15. Accordingly, the partition plates 14 each formed of the metal member by rolling have large plastic deformation ductility resulting in breakage, and therefore when impact load is generated, kinetic energy of impact is absorbed by plastic deformation. Consequently, it is possible to make the all or the one part of the air inlet casing 12 to stop scattering. That is, the partition plates 14 are intentionally deformably damaged to absorb impact, so that it is possible to suppress the scattering of the air inlet casing 12 to the outside of the supercharger 100, or suppress failure such as generation of a gap (opening) due to impact applied to other part.

[0055] The plate thickness of each partition plate 14 of this embodiment is in the range of 4 mm to 9 mm. Additionally, the plate thickness of each partition plate 14 is more desirably in the range of 5 mm to 7 mm, and particularly, the plate thickness is preferably 6 mm. In a case where the rigidity of the partition plates 14 is too low, even when the partition plates 14 are largely deformed by the impact load of the all or the one part of the air inlet casing 12 which has been damaged to scatter, the partition plates 14 cannot sufficiently absorb the impact load, and the all or the one part of the air inlet casing 12 scatters outside the supercharger 100.

[0056] On the other hand, when the rigidity of the partition plates 14 is too high, deformations of the partition plates 14 against the impact load of the all or the one part of the air inlet casing 12 which has scattered are reduced. Then, the partition plates 14 cannot sufficiently absorb the impact load, and the impact load is propagated to other part, so that a gap (opening) is generated.

[0057] The inventors perform experiments while changing the plate thickness of each partition plate 14, and obtain knowledge that a plate thickness which does not cause the air inlet casing 12 to scatter to the outside, and does not cause the generation of the gap (opening) in other part is in the range of 4 mm to 9 mm, and therefore the plate thickness of each partition plate 14 is set in this range.

[0058] The silencer 15 illustrated in Fig. 1 is a device that lowers a level of noise generated in the centrifugal compressor 10. As illustrated in Fig. 1, the silencer 15 includes the silencer casing 15a. The silencer casing 15a defines a flow passage 15b for leading, to the intake 11a of the air inlet casing 12, air flowing in from the direction illustrated by the arrow in Fig. 1 (direction orthogonal to the axial line X). A noise reduction material 15e is disposed around the flow passage 15b so as to surround the flow passage 15b. This noise reduction material 15e absorbs a part of the noise generated in the centrifugal compressor 10, and the level of the noise is lowered.

[0059] As illustrated in Fig. 1, the silencer casing 15a houses inside the partition plates 14. An end of each partition plate 14 is connected to the silencer casing 15a. Accordingly, each partition plate 14 functions as a support member for supporting the silencer casing 15a as well.

[0060] Now, a structure of fastening positions at which the silencer casing 15a is fastened to the scroll casing 13b will be described.

[0061] As described above, when all or one part of the air inlet casing 12 falls from the mounting position to scatter, the all or the one part of the air inlet casing 12 collides with the partition plates 14. In the above description, the partition plates 14 each formed of the rolled steel material absorb and stop kinetic energy of impact by plastically deforming when impact load is generated. In the following description, a structure in which the kinetic energy of the impact is absorbed by a part other than the partition plates 14 will be described.

[0062] As illustrated in Fig. 4, a flange section 13d provided in an end, on a side close to the silencer 15, of the scroll casing 13b, and a flange section 15c provided in an end, on a side close to the scroll casing 13b, of the silencer casing 15a are fastened to each other at fastening positions (first fastening positions) illustrated in Fig. 4 by fastening bolts 40 (first fastening bolts).

[0063] Only one fastening position is illustrated in Fig. 4, but a plurality of fastening positions are provided in the peripheral direction around the axial line X at constant intervals. At the plurality of fastening positions, the flange section 13d is fastened to the flange section 15c by the fastening bolts 40.

[0064] As the fastening bolts 40, chromium molybdenum steel containing a carbon amount of 0.33% to 0.38%, called SCM435, is preferably used. The SCM435 is excellent in high strength, and a large elongation amount up to fracture when tensile load is applied.

[0065] The flange section 15c is provided with fastening holes 15d extending along the axial line X. Additionally, the flange section 13d is provided with fastening holes 13e extending along the axial line X. Inner peripheral surfaces of these fastening holes 15d, 13e are formed with female screws. On the other hand, an outer peripheral surface of a shaft section 40b of each fastening bolt 40 extending along the axial line X is formed with a male screw on a whole surface from the vicinity of a boundary section between a head section 40a and the

shaft section 40b to the vicinity of a tip of the shaft section 40b.

[0066] Deformations at the respective parts of the outer peripheral surfaces of the shaft sections 40b are made uniform, so that tensile load is generated in the fastening bolts 40. Even in a case where plastic deformation is performed until the elongation amount increases, stress is hardly locally concentrated on the bolts 40, and therefore fracture is not caused until large elongation, which is suitable.

[0067] The flange section 13d and the flange section 15c are fastened to each other in a state where cylindrical spacers 50 (first spacer members) each having an inner diameter d1 smaller than the diameter d2 of the head section 40a of each fastening bolt 40, and having a predetermined length are inserted into the shaft sections 40b of the fastening bolts 40. In this state, the male screw formed on the shaft section 40b of each fastening bolt 40 meshes with the female screws formed on the inner peripheral surfaces of the fastening holes 15d, 13e.

[0068] The spacers 50 are each formed of a metal member manufactured by rolling. As this metal member, for example, a rolled steel material that is a Fe-C based alloy containing iron as a main component and containing a slight amount (about 0.2%) of carbon is used. As the rolled steel material, various materials can be used. However, a rolled steel material for general structural use (JIS G 3101; ASTM A283), called SS400, is preferably used.

[0069] The metal material by rolling has ductility resulting in breakage after large plastic deformation, and therefore has higher breaking strength against impact than the metal material by casting.

[0070] As illustrated in Fig. 4, the air inlet casing 12 and the scroll casing 13b are fastened to each other by fastening bolts 42 inserted into through holes provided in a flange section 12a of the air inlet casing 12. Only one fastening position is illustrated in Fig. 4, but a plurality of fastening positions are provided in the peripheral direction around the axial line X at constant intervals. At the plurality of fastening positions, the air inlet casing 12 is fastened to the scroll casing 13b by the fastening bolts 42.

[0071] In the above description, the plastic deformations of the partition plates 14 absorb and stop kinetic energy of impact. Herein, a structure in which the kinetic energy of the impact can be absorbed by the fastening bolts 40 and the spacers 50 other than the partition plates 14 will be described.

[0072] As described above, when all or one part of the air inlet casing 12 falls from the mounting position to scatter, the all or the one part of the air inlet casing 12 collides with the partition plates 14. By this collision, impact in the direction separated from the scroll casing 13b is applied to the silencer casing 15a. This impact acts on the fastening positions of the fastening bolts 40, the flange section 15c, and the flange section 13d.

[0073] As illustrated in Fig. 4, the reason why fastening is performed in a state where each spacer 50 is inserted into the shaft section 40b of the fastening bolt 40 is that the length in the direction of the axial line X of each fastening bolt 40 is increased and a large elongation amount is ensured. The predetermined length of each spacer 50 is made longer than at least the diameter of the shaft section 40b of each fastening bolt 40, and is set to a length so as not to cause a trouble on fastening work. The elongation amounts are increased, so that the fastening bolts 40 are prevented from being fractured, and kinetic energy of impact due to collision with the all or the one part of the air inlet casing 12 that falls from the mounting position to scatter can be absorbed by the elongation of the fastening bolts 40.

[0074] As illustrated in Fig. 4, the reason why the spacers 50 are provided is that kinetic energy of impact is absorbed by the spacers 50 formed of the rolled steel materials having ductility. The lengths in the direction of the axial line X of the spacers 50 disposed between the head sections 40a of the fastening bolts 40 and the flange section 15c are contracted by impact that acts on the fastening positions of the fastening bolts 40 and the flange section 15c. The spacers 50 formed of the rolled steel materials have ductility resulting in breakage after large plastic deformation, and therefore the spacers 50 are contracted in the direction of the axial line X, so that it is possible to absorb the kinetic energy due to the above impact.

[0075] Now, a structure of fastening positions at which the scroll casing 13b is fastened to the bearing pedestal 20 will be described.

[0076] As illustrated in Fig. 1, the bearing pedestal 20 of this embodiment includes flange section 20a for supporting the scroll section 13, and a bearing section 20b for supporting the rotor shaft 30.

[0077] As illustrated in Fig. 5, a flange section 13f provided in an end, on a side close to the bearing pedestal 20, of the scroll casing 13b, and a flange section 20a provided in an end, on a side close to the scroll casing 13b, of the bearing pedestal 20 are fastened to each other at fastening positions (second fastening positions) illustrated in Fig. 5 by fastening bolts 41 (second fastening bolts).

[0078] As the fastening bolts 41, chromium molybdenum steel containing a carbon amount of 0.33% to 0.38%, called SCM435, is preferably used. The SCM435 is excellent in high strength, and a large elongation amount.

[0079] The flange section 13f is provided with fastening holes 13g extending along the axial line X. Additionally, the flange section 20a is provided with fastening holes 20c extending along the axial line X. Inner peripheral surfaces of these fastening holes 13g, 20c are formed with female screws. On the other hand, an outer peripheral surface of a shaft section 41b of each fastening bolt 41 extending along the axial line X is formed with a male screw on a whole surface from a head section 41a and a tip.

[0080] The flange section 13f and the flange section 20a are fastened to each other in a state where cylindrical spacers 51 (second spacer members) each having an

inner diameter d3 smaller than the diameter d4 of the head section 41a of each fastening bolt 41 are inserted into the shaft sections 41b of the fastening bolts 41. In this state, the male screw formed on the shaft section 41b of each fastening bolt 41 meshes with the female screws formed on the inner peripheral surfaces of the fastening holes 13g, 20c.

[0081] The spacers 51 are each formed of a metal member manufactured by rolling. As this metal member, for example, a rolled steel material that is a Fe-C based alloy containing iron as a main component and containing a slight amount (about 0.2%) of carbon is used. As the rolled steel material, various materials can be used. However, a rolled steel material for general structural use (JIS G 3101; ASTM A283), called SS400, is preferably used.

[0082] The metal material by rolling has ductility resulting in breakage after large plastic deformation, and therefore has higher breaking strength against impact than the metal material by casting.

[0083] As described above, when all or one part of the air inlet casing 12 falls from the mounting position, the all or the one part of the air inlet casing 12 collides with the partition plates 14. By this collision, impact in the direction in which the scroll casing 13b is separated from the bearing pedestal 20 is applied. This impact acts on the fastening positions of the fastening bolts 41, the flange section 13f, and the flange section 20a.

[0084] As illustrated in Fig. 5, the reason why fastening is performed in a state where each spacer 51 is inserted into shaft section 41b of the fastening bolt 41 is that the length in the direction of the axial line X of each fastening bolt 41 is increased and a large elongation amount is ensured. The elongation amounts are increased, so that the fastening bolts 41 are prevented from being fractured, and kinetic energy of impact due to collision with the all or the one part of the air inlet casing 12 that falls from the mounting position to scatter can be absorbed by the elongation of the fastening bolts 41.

[0085] As illustrated in Fig. 5, the reason why the spacers 51 are provided is that kinetic energy of impact is absorbed by the spacers 51 formed of the rolled steel materials having ductility. The lengths in the direction of the axial line X of the spacers 51 disposed between the head sections 41a of the fastening bolts 41 and the flange section 13f are contracted by impact that acts on the fastening positions of the fastening bolts 41 and the flange section 13f. The spacers 51 formed of the rolled steel materials have ductility resulting in breakage after large plastic deformation, and therefore the spacers 51 are contracted in the direction of the axial line X, so that it is possible to absorb the kinetic energy due to the above impact.

[0086] Now, scroll clamp members 60 mounted on outer peripheral edges of the casing 13b and the bearing pedestal 20 will be described. The vicinity of the fastening position of the flange section 13f of the scroll casing 13b, and the flange section 20a of the bearing pedestal 20 is illustrated in Fig. 6. Fig. 6 is a diagram of the outer peripheral edges of the flange section 13f of the scroll casing 13b and the flange section 20a as viewed from the P direction illustrated in Fig. 1.

[0087] As illustrated in Fig. 6, a plurality of the clamp members 60 are mounted between a plurality of the fastening positions (second fastening positions) by the fastening bolts 41, in the peripheral direction around the axial line X.

[0088] As illustrated in Fig. 7, the clamp members 60 have respective recesses 60a that surround the outer peripheral edge of the flange section 20a and the outer peripheral edge of the flange section 13f of the scroll casing 13b from the outer peripheral side. Additionally, the clamp members 60 have respective through holes 60b which are opened to the recesses 60a, and extend in the direction of the axial line X.

[0089] As illustrated in Fig. 7, the flange section 20a has fastening holes 20d extending in the direction of the axial line X. Only one fastening hole 20d is illustrated in Fig. 7, but a plurality of fastening positions are provided in the peripheral direction around the axial line X at equal intervals. On inner peripheral surfaces of the fastening holes 20d, female screws are formed. On the other hand, on outer peripheral surfaces of shaft sections of fastening bolts 43 (third fastening bolts) inserted into the through holes 60b and the fastening holes 20d, male screws are formed. The male screws of the fastening bolts 43 meshes with the female screws of the fastening holes 20d, so that the flange section 20a and the clamp members 60 are fastened to each other.

[0090] In a state where the clamp members 60 are fastened to the flange section 20a, predetermined gaps 60c are provided between an end face 13i in the direction of the axial line X of the scroll casing 13b, and end faces 60e in the direction of the axial line X of the recesses 60a. The width along the axial line X of each gap 60c is denoted by d5.

[0091] The flange section 20a includes a contact surface 20e that is in contact with the scroll casing 13b, an end face 20f that forms a flow passage 13h (second flow passage) for allowing compressed air to circulate, and a stepped section 20g that connects the contact surface 20e and the end face 20f. As illustrated in Fig. 7, the end face 20f is disposed on a side closer to the flow passage 13h than the contact surface 20e.

[0092] The width d6 in the direction of the axial line X of the stepped section 20g is wider than the width d5 of each gap 60c.

[0093] As described above, when the air inlet casing 12 falls from the mounting position, the air inlet casing 12 collides with the partition plates 14. By this collision, impact in the direction in which the scroll casing 13b is separated from the bearing pedestal 20 is applied. This impact force acts on the fastening positions of the fastening bolts 41, the flange section 13f, and the flange section 20a.

[0094] As illustrated in Fig. 7, the reason why the predetermined gaps 60c are provided is that in a case where

impact in the direction of the axial line X due to scattering of all or one part of the impeller 11 cannot be sufficiently absorbed, and the fastening bolts 41 are fractured and the scroll casing 13b is separated from the bearing pedestal 20, the clamp members 60 absorb impact caused by the separated scroll casing 13b.

[0095] In a case where the predetermined gaps 60c are provided, fastening force in the vicinities of the clamp members 60 increases, and the fastening bolts 41 are hardly fractured. In this case, while fracture of the fastening bolts 41 can be prevented, there is a possibility that load is applied to other part (for example, the scroll casing 13b), and the part to which the load is applied is fractured.

[0096] When the fastening bolts 41 are fractured, and the scroll casing 13b is separated from the bearing pedestal 20, the scroll casing 13b is brought into the state illustrated in Fig. 8 from the state illustrated in Fig. 7.

[0097] When the scroll casing 13b is brought into the state illustrated in Fig. 8, the end face 13i in the direction of the axial line X of the scroll casing 13b comes into contact with the end faces 60e in the direction of the axial line X of the recesses 60a. In this state, on the contact surface 20e, a gap 60d having a width d5 in the direction of the axial line X is formed. When this gap 60d is communicated with the flow passage 13h to cause the gap (opening), there is a possibility that a part of the damaged blades 11d scatters from the flow passage 13h to the outside.

[0098] In this embodiment, as illustrated in Fig. 8, the width d6 in the direction of the axial line X of the stepped section 20g is wider than the width d5 of the gap 60d. Therefore, faults are prevented such as the gap 60d brought into communication with the flow passage 13h, causing a gap (opening) for allowing a damaged member to pass.

[0099] In this embodiment, the gaps 60c are intentionally provided between the end face 13i in the direction of the axial line X of the scroll casing 13b and the end faces 60e in the direction of the axial line X of the recesses 60a, so that fracture at a position other than the fastening positions of the fastening bolts 41 is prevented. Then, in a case where the fastening bolts 41 are fractured, the impact caused by separation of the scroll casing 13b from the bearing pedestal 20 is absorbed by the clamp members 60.

[0100] Now, a method for manufacturing the centrifugal compressor of this embodiment will be described.

[0101] In a method for manufacturing the centrifugal compressor 10 of this embodiment, the centrifugal compressor 10 is manufactured by the following steps.

[0102] In a first step, the impeller 11 that compresses air flowing in from the intake 11a, and then discharges the compressed air from the discharge port 11b is mounted on the rotor shaft 30.

[0103] In a second step, the flow passage for guiding the air flowing in from the intake 11a in the direction of the axial line X of the rotor shaft 30, in the direction inclined from the direction of the axial line X, and then leading the air to the discharge port 11b is formed by mounting the air inlet casing 12 so as to house the impeller 11.

[0104] In a third step, the scroll section 13 in which the compressed air discharged from the discharge port 11b flows is disposed on the outer peripheral side in the radial direction orthogonal to the direction of the axial line X with respect to the air inlet casing 12.

[0105] In a fourth step, a plurality of the partition plates 14 each having a plate thickness of 4 mm or more and 9 mm or less are provided on the upstream side in the air circulation direction with respect to the intake 11a, and are radially disposed about the axial line X so as to have predetermined lengths in the direction of the axial line X.

[0106] By the above steps, the centrifugal compressor 10 of this embodiment is manufactured.

[0107] Operation and effects exerted by the centrifugal compressor 10 provided in the supercharger 100 of this embodiment described above will be described.

[0108] According to the centrifugal compressor 10 provided in the supercharger 100 of this embodiment, in a case where all or one part of the impeller 11 is fractured or falls, all or one part of the impeller 11 scatters in the radial direction to collide with the air inlet casing 12.

[0109] The air inlet casing 12 forms the flow passage 11e for guiding air flowing in from the intake 11a in the direction of the axial line X of the rotor shaft 30, in the direction inclined from the direction of the axial line X, and leading the air to the discharge port 11b. When all or one part of the impeller 11 which scatters in the radial direction collides with the air inlet casing 12, impact in the radial direction is applied to the air inlet casing 12. Similarly, when all or one part of the impeller 11 which scatters in the radial direction collides with the air inlet casing 12, impact in the direction of the axial line X is applied to the air inlet casing 12. The impact in the direction of the axial line X is impact causing the all or the one part of the air inlet casing 12 to scatter in the direction away from the scroll section 13, and therefore there is a possibility that the all or the one part of the air inlet casing 12 falls from the mounting position.

[0110] According to the centrifugal compressor 10 of this embodiment, the plurality of partition plates 14 each having a predetermined length in the direction of the axial line X are radially disposed about the axial line X on the upstream side in the air circulation direction with respect to the intake 11a. Therefore, the all or the one part of the impeller 11 that scatters, or the all or the one part of the air inlet casing 12 that scatters in the direction away from the scroll section 13 collides with the plurality of partition plates 14 due to impact resulting from the scattering of the impeller 11.

[0111] The plurality of partition plates 14 each are a rolled steel material having a plate thickness of 4 mm or more and 9 mm or less. Therefore, the plurality of partition plates 14 are suitably plastically deformed by collision with the all or the one part of the air inlet casing 12, and

then absorbs energy resulting from the collision. Consequently, it is possible to suppress faults such as a gap generated by the scattering of the all or the one part of the air inlet casing 12 in a part of the centrifugal compressor 10, scattering the all or the one part of the impeller 11 to the outside from the gap.

[0112] According to the centrifugal compressor 10 of this embodiment, when the all or the one part of the air inlet casing 12 that scatters in the direction away from the scroll section 13 collides with the silencer casing 15a that houses the partition plates 14, impact is applied in the direction in which the silencer casing 15a is separated from the scroll casing. This impact is absorbed by contraction of the spacers 50 disposed between the head sections 40a of the fastening bolts 40 and the silencer casing 15a. Thus, the impact in the direction of the axial line is absorbed by use of the spacers 50 fastened while being inserted into the fastening bolts 40, so that faults such as fracture of the fastening bolts 40 are suppressed. Accordingly, it is possible to suppress faults such as a gap generated by the scattering of the all or the one part of the air inlet casing 12 in a part of the centrifugal compressor 10, scattering the all or the one part of the impeller 11 to the outside from the gap.

[0113] In the centrifugal compressor 10 of this embodiment, the fastening bolts 40 include male screws formed on the outer peripheral surfaces of the shaft sections 40b from the head sections 40a to the tips. Consequently, deformations at the respective parts of the outer peripheral surfaces of the shaft sections 40b from the head sections 40a to the tips are made uniform, so that the above failure can be suppressed by use of the fastening bolts 40 having increased energy absorption of impact.

[0114] According to the centrifugal compressor 10 of this embodiment, when the all or the one part of the air inlet casing 12 that scatters in the direction away from the scroll section 13 collides with the silencer casing 15a that houses the partition plates 14, impact in the direction in which the scroll casing 13b is separated from the flange section 20a of the bearing pedestal 20 is applied. This impact is absorbed by contraction of the spacers 51 disposed between the head sections 41a of the fastening bolts 41 and the scroll casing 14b. Thus, impact in the direction of the axial line X is absorbed by use of the spacers 51 fastened while being inserted into the fastening bolts 41, so that faults such as fracture of the fastening bolts 41 are suppressed. Accordingly, it is possible to suppress faults such as a gap generated by the scattering of the all or the one part of the air inlet casing 12 in a part of the centrifugal compressor 10, scattering the all or the one part of the impeller 11 to the outside from the gap.

[0115] In the centrifugal compressor 10 of this embodiment, the fastening bolts 41 include male screws formed on the outer peripheral surfaces of the shaft sections 40b from the head sections 41a to the tips. Consequently, deformations at the respective parts of the outer peripheral surfaces of the shaft sections 40b from the head sections 41a to the tips are made uniform, so that the above failure can be suppressed by use of the fastening bolts 41 having increased energy absorption of impact.

[0116] The centrifugal compressor 10 of this embodiment includes a plurality of the clamp members 60 having recesses 60a that surround the outer peripheral edge of the flange section 20a and the outer peripheral edge of the scroll casing 13b from the outer peripheral side, and the through holes 60b that are opened to the recesses 60a, and extend in the direction of the axial line X. The flange section 20a has a plurality of the fastening holes 20d extending in the direction of the axial line X, in the peripheral direction around the axial line X. Then, the flange section 20a and the clamp members 60 are fastened to each other by the fastening bolts 43 inserted into the through holes 60b and the fastening holes 20d. Furthermore, the predetermined gaps 60c are provided between the end face 13i in the direction of the axial line X of the scroll casing 13b, and the end faces 60e in the direction of the axial line X of the recesses 60a.

[0117] Consequently, even in a case where the plurality of fastening bolts 41 are fractured, and the flange section 20a of the bearing pedestal 20 and the scroll casing 13b are separated from each other, the end face 13i in the direction of the axial line X of the scroll casing 13b comes into contact with the end faces 60e in the direction of the axial line X of the recesses 60a. Impact caused by this contact is absorbed by the plurality of clamp members 60 mounted in the peripheral direction around the axial line X. Consequently, it is possible to suppress faults such as a gap generated by the scattering of the air inlet casing 12 in a part of the centrifugal compressor 10, scattering the all or the one part of the damaged impeller 11 to the outside from the gap.

[0118] In this embodiment, the flange section 20a is fastened to the clamp members 60 by the fastening bolts 43, and the predetermined gaps 60c are provided between the end face 13i in the direction of the axial line X of the scroll casing 13b, and the end faces 60e in the direction of the axial line X of the recesses 60a. Additionally, the flange section 20a has the stepped section 20g that connects the contact surface 20e that is in contact with the scroll casing 13b, and the end face 20f of the flange section 20a that forms the flow passage 13h for allowing compressed air to circulate, and is disposed on the side closer to the flow passage 13h than the contact surface 20e.

[0119] Consequently, in a case where the plurality of fastening bolts 41 are fractured, the flange section 20a of the bearing pedestal 20 and the scroll casing 13b are separated from each other, and the end face 13i in the direction of the axial line X of the scroll casing 13b comes into contact with the end faces 60e in the direction of the axial line X of the recesses 60a, opening between the flange section 20a and the scroll casing 13b is suppressed by existence of the stepped section 20g. Furthermore, the width d6 in the direction of the axial line X of the stepped section 20g is wider than the width d5 of the predetermined gap 60d, and therefore a communi-

cated gap is not generated, and opening can be more reliably suppressed.

Other Embodiment

[0120] In the above description, the rotor shaft 30 connected to the impeller 11 provided in the centrifugal compressor 10 rotates around the axial line X by a turbine (not illustrated) rotated by exhaust gas exhausted from the marine diesel engine. However, other aspect may be employed. For example, the rotor shaft 30 may be rotated by other power source other than a motor connected to the rotor shaft 30, or the like.

[0121] In the above description, the four partition plates 14 are disposed at intervals of 90 degrees about the axial line X. However, other aspect may be employed. An arbitrary number of partition plates may be disposed. For example, six partition plates may be radially disposed at intervals of 60 degrees about the axial line X, or eight partition plates may be disposed at intervals of 45 degrees about the axial line X.

[0122] In the above description, the clamp members 60 are fastened to the flange section 20a of the bearing pedestal 20. However, other aspect may be employed. For example, the clamp members 60 may be fastened to the flange section 13e of the scroll casing 13b. In this case, the flange section 13e of the scroll casing 13b has a plurality of fastening holes extending in the direction of the axial line X, in the peripheral direction around the axial line X. Additionally, the fastening bolts 43 are fastened to the plurality of fastening holes, so that the clamp members 60 are fastened to the flange section 13e of the scroll casing 13b. In this case, the gaps 60c described above are provided between the end face in the direction of the axial line X of the flange section 20a of the bearing pedestal 20, and the end face in the direction of the axial line X of the recesses of the clamp members 60.

{Reference Signs List}

[0123]

10 centrifugal compressor
11 impeller
11a intake
11b discharge port
11d blade
11e flow passage
12 air inlet casing (inlet casing)
13 scroll section
13b scroll casing
13d flange section
13f flange section
13h flow passage (second flow passage)
13i end face
14 partition plate
15 silencer
15a silencer casing
15b flow passage (first flow passage)
15c flange section
20 bearing pedestal
20a flange section
20e contact surface
20f end face
20g stepped section
30 rotor shaft
40 fastening bolt (first fastening bolt)
41 fastening bolt (second fastening bolt; flange section fastening bolt)
43 fastening bolt (third fastening bolts; clamp member fastening bolt)
50 spacer (first spacer member)
51 spacer (second spacer member)
60 clamp members
60a recess
60b through hole
60c gap
60d gap
60e end face
100 supercharger

Claims

1. A centrifugal compressor comprising:

an impeller that is mounted on a rotor shaft, and compresses fluid flowing in from an intake, and then discharges the compressed fluid from a discharge port;
an inlet casing that houses the impeller;
a scroll section which is disposed on an outer peripheral side with respect to the inlet casing, and into which the compressed fluid discharged from the discharge port flows;
a plurality of partition plates provided on an upstream side in a fluid circulation direction with respect to the intake, and each having a predetermined length in a direction of an axial line of the rotor shaft; and
a silencer having a silencer casing for housing the plurality of partition plates, wherein

the plurality of partition plates are radially disposed about the axial line, and each are a rolled steel material having a plate thickness of 4 mm or more and 9 mm or less.

2. The centrifugal compressor according to claim 1, wherein
the scroll section has a scroll casing forming a volute chamber into which the compressed fluid discharged from the discharge port flows,
the scroll casing and the silencer casing are fastened to each other at a plurality of first fastening positions in a peripheral direction around the axial line by a

plurality of first fastening bolts extending in the direction of the axial line, and
the scroll casing and the silencer casing are fastened to each other in a state where cylindrical first spacer members each having an inner diameter smaller than a diameter of a head section of each of the first fastening bolts are inserted into shaft sections of the first fastening bolts.

3. The centrifugal compressor according to claim 2, wherein
the first fastening bolts each include a male screw formed on an outer peripheral surface of the shaft section from the head section to a tip.

4. The centrifugal compressor according to claim 2 or 3, comprising
a bearing pedestal having a bearing section for supporting the rotor shaft, and a flange section for supporting the scroll section, wherein
the flange section and the scroll casing are fastened to each other at a plurality of second fastening positions around the axial line by a plurality of second fastening bolts extending in the direction of the axial line, and
the flange section and the scroll casing are fastened to each other in a state where cylindrical second spacer members each having an inner diameter smaller than a diameter of a head section of each of the second fastening bolts are inserted into shaft sections of the second fastening bolts.

5. The centrifugal compressor according to claim 4, wherein
the second fastening bolts each include a male screw formed on an outer peripheral surface of the shaft section from the head section to a tip.

6. A centrifugal compressor comprising:

an impeller that is mounted on a rotor shaft, and compresses fluid flowing in from an intake, and then discharges the compressed fluid from a discharge port;
an inlet casing that houses the impeller;
a scroll section that is disposed on an outer peripheral side with respect to the inlet casing, and has a scroll casing forming a volute chamber into which the compressed fluid discharged from the discharge port flows;
a bearing pedestal having a bearing section for supporting the rotor shaft, and a flange section for supporting the scroll section;
a plurality of flange section fastening bolts that fasten the flange section to the scroll casing at a plurality of fastening positions around the axial line of the rotor shaft, and extend in the direction of the axial line; and
a plurality of clamp members having recesses which surround an outer peripheral edge of the flange section and an outer peripheral edge of the scroll casing from an outer peripheral side, and through holes which are opened to the recesses, and extend in the direction of the axial line, wherein

one of either the flange section or the scroll casing has a plurality of fastening holes extending in the direction of the axial line, in a peripheral direction around the axial line,
one of either the flange section or the scroll casing, and the clamp members are fastened to each other by clamp member fastening bolts inserted into the through holes and the fastening holes, and
predetermined gaps are provided between an end face in the direction of the axial line of the other of either the flange section or the scroll casing, and end faces in the direction of the axial line of the recesses.

7. The centrifugal compressor according to claim 6, wherein
the flange section has the fastening holes, and is fastened to the clamp members by the clamp member fastening bolts,
predetermined gaps are provided between an end face in the direction of the axial line of the scroll casing, and end faces in the direction of the axial line of the recesses, and
the flange section has a stepped section that connects a contact surface that is in contact with the scroll casing, and an end face of the flange section that forms a second flow passage for allowing the compressed fluid to circulate, and is disposed on a side closer to the second flow passage than the contact surface.

8. The centrifugal compressor according to claim 7, wherein a width in the direction of the axial line of the stepped section is wider than a width of each of the predetermined gaps.

9. A supercharger comprising:

a centrifugal compressor according to any one of claims 1 to 8; and
a turbine that is rotated around the axial line by exhaust gas exhausted from an internal combustion engine, and is connected to the rotor shaft.

10. A method for manufacturing a centrifugal compressor comprising the steps of:

mounting an impeller on a rotor shaft, the impeller for compressing fluid flowing in from an intake and then discharging the compressed fluid from

a discharge port;
mounting an inlet casing so as to house the impeller, and forming a flow passage for leading the fluid flowing in from the intake to the discharge port;
disposing a scroll section, into which the compressed fluid discharged from the discharge port flows, on an outer peripheral side in a radial direction orthogonal to the direction of the axial line with respect to the inlet casing; and
providing a plurality of partition plates on an upstream side in a fluid circulation direction with respect to the intake, and radially disposing about the axial line so as to each have a predetermined length in the direction of the axial line, each of the plurality of partition plates having a plate thickness of 4 mm or more and 9 mm or less.

Amended claims under Art. 19.1 PCT

1. A centrifugal compressor comprising:

an impeller that is mounted on a rotor shaft, and compresses fluid flowing in from an intake, and then discharges the compressed fluid from a discharge port;
an inlet casing that houses the impeller;
a scroll section which is disposed on an outer peripheral side with respect to the inlet casing, and into which the compressed fluid discharged from the discharge port flows;
a plurality of partition plates provided on an upstream side in a fluid circulation direction with respect to the intake, and each having a predetermined length in a direction of an axial line of the rotor shaft; and
a silencer having a silencer casing for housing the plurality of partition plates, wherein

the plurality of partition plates are radially disposed about the axial line, and each are a rolled steel material having a plate thickness of 4 mm or more and 9 mm or less.

2. The centrifugal compressor according to claim 1, wherein
the scroll section has a scroll casing forming a volute chamber into which the compressed fluid discharged from the discharge port flows,
the scroll casing and the silencer casing are fastened to each other at a plurality of first fastening positions in a peripheral direction around the axial line by a plurality of first fastening bolts extending in the direction of the axial line, and
the scroll casing and the silencer casing are fastened to each other in a state where cylindrical first spacer members each having an inner diameter smaller than a diameter of a head section of each of the first fastening bolts are inserted into shaft sections of the first fastening bolts.

3. The centrifugal compressor according to claim 2, wherein
the first fastening bolts each include a male screw formed on an outer peripheral surface of the shaft section from the head section to a tip.

4. The centrifugal compressor according to claim 2 or 3, comprising
a bearing pedestal having a bearing section for supporting the rotor shaft, and a flange section for supporting the scroll section, wherein
the flange section and the scroll casing are fastened to each other at a plurality of second fastening positions around the axial line by a plurality of second fastening bolts extending in the direction of the axial line, and
the flange section and the scroll casing are fastened to each other in a state where cylindrical second spacer members each having an inner diameter smaller than a diameter of a head section of each of the second fastening bolts are inserted into shaft sections of the second fastening bolts.

5. The centrifugal compressor according to claim 4, wherein
the second fastening bolts each include a male screw formed on an outer peripheral surface of the shaft section from the head section to a tip.

6. A centrifugal compressor comprising:

an impeller that is mounted on a rotor shaft, and compresses fluid flowing in from an intake, and then discharges the compressed fluid from a discharge port;
an inlet casing that houses the impeller;
a scroll section that is disposed on an outer peripheral side with respect to the inlet casing, and has a scroll casing forming a volute chamber into which the compressed fluid discharged from the discharge port flows;
a bearing pedestal having a bearing section for supporting the rotor shaft, and a flange section for supporting the scroll section;
a plurality of flange section fastening bolts that fasten the flange section to the scroll casing at a plurality of fastening positions around the axial line of the rotor shaft, and extend in the direction of the axial line; and
a plurality of clamp members having recesses which surround an outer peripheral edge of the flange section and an outer peripheral edge of the scroll casing from an outer peripheral side,

and through holes which are opened to the recesses, and extend in the direction of the axial line, wherein

one of either the flange section or the scroll casing has a plurality of fastening holes extending in the direction of the axial line, in a peripheral direction around the axial line,
one of either the flange section or the scroll casing, and the clamp members are fastened to each other by clamp member fastening bolts inserted into the through holes and the fastening holes, and
predetermined gaps are provided between an end face in the direction of the axial line of the other of either the flange section or the scroll casing, and end faces in the direction of the axial line of the recesses.

7. The centrifugal compressor according to claim 6, wherein
the flange section has the fastening holes, and is fastened to the clamp members by the clamp member fastening bolts,
predetermined gaps are provided between an end face in the direction of the axial line of the scroll casing, and end faces in the direction of the axial line of the recesses, and
the flange section has a stepped section that connects a contact surface that is in contact with the scroll casing, and an end face of the flange section that forms a second flow passage for allowing the compressed fluid to circulate, and is disposed on a side closer to the second flow passage than the contact surface.

8. The centrifugal compressor according to claim 7, wherein
a width in the direction of the axial line of the stepped section is wider than a width of each of the predetermined gaps.

9. A supercharger comprising:

a centrifugal compressor according to any one of claims 1 to 8; and
a turbine that is rotated around the axial line by exhaust gas exhausted from an internal combustion engine, and is connected to the rotor shaft.

10. A method for manufacturing a centrifugal compressor comprising the steps of:

mounting an impeller on a rotor shaft, the impeller for compressing fluid flowing in from an intake and then discharging the compressed fluid from a discharge port;
mounting an inlet casing so as to house the impeller, and forming a flow passage for leading the fluid flowing in from the intake to the discharge port;
disposing a scroll section, into which the compressed fluid discharged from the discharge port flows, on an outer peripheral side in a radial direction orthogonal to the direction of the axial line with respect to the inlet casing; and
providing a plurality of partition plates on an upstream side in a fluid circulation direction with respect to the intake, and radially disposing about the axial line so as to each have a predetermined length in the direction of the axial line, each of the plurality of partition plates having a plate thickness of 4 mm or more and 9 mm or less.

11. A silencer that is mounted on a centrifugal compressor, the centrifugal compressor including an impeller that is mounted on a rotor shaft, and compresses fluid flowing in from an intake, and then discharges the compressed fluid from a discharge port; a guide cylinder that houses the impeller; a scroll section which is disposed on an outer peripheral side with respect to the guide cylinder, and into which the compressed fluid discharged from the discharge port flows, the silencer comprising:

a plurality of partition plates provided on an upstream side in a fluid circulation direction with respect to the intake, and each having a predetermined length in a direction of an axial line of the rotor shaft; and
a silencer casing for housing the plurality of partition plates, **characterized in that**:

the plurality of partition plates are radially disposed about the axial line, and each are a rolled steel material having a plate thickness of 4 mm or more and 9 mm or less.

FIG. 1

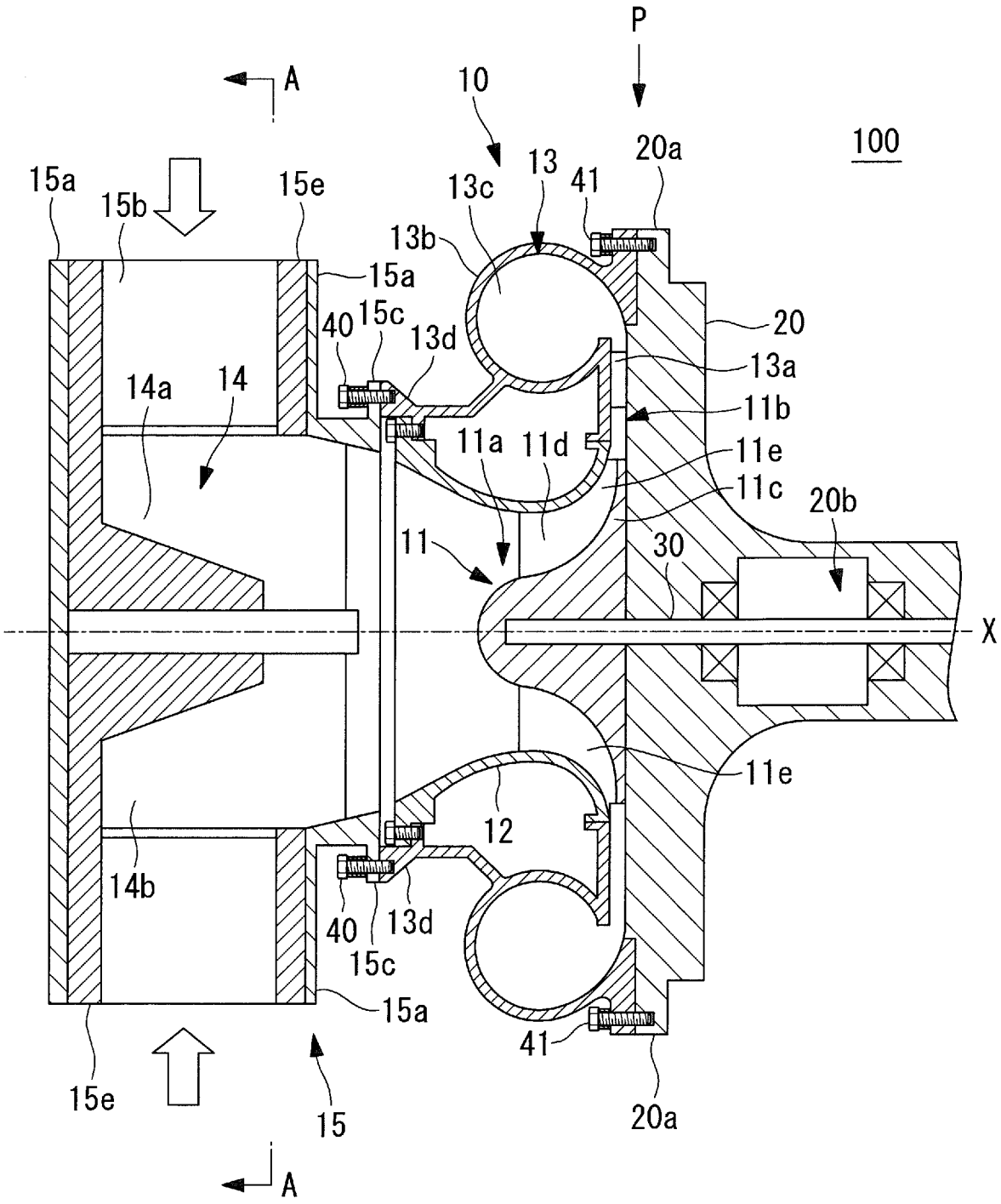
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FIG. 2

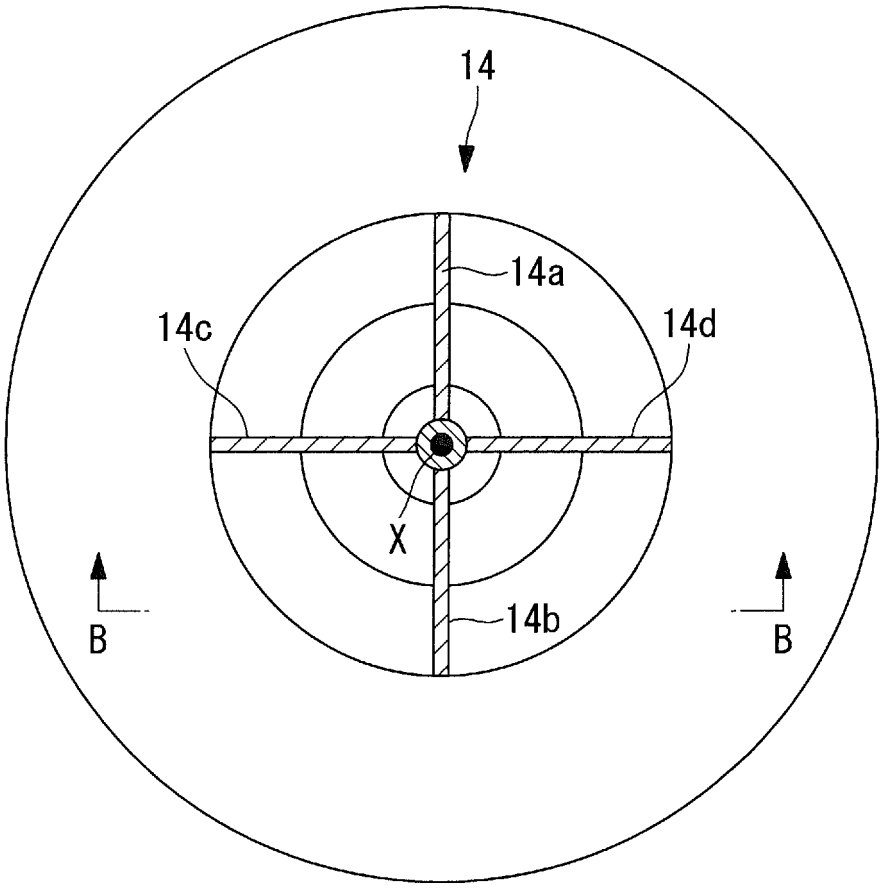

FIG. 3

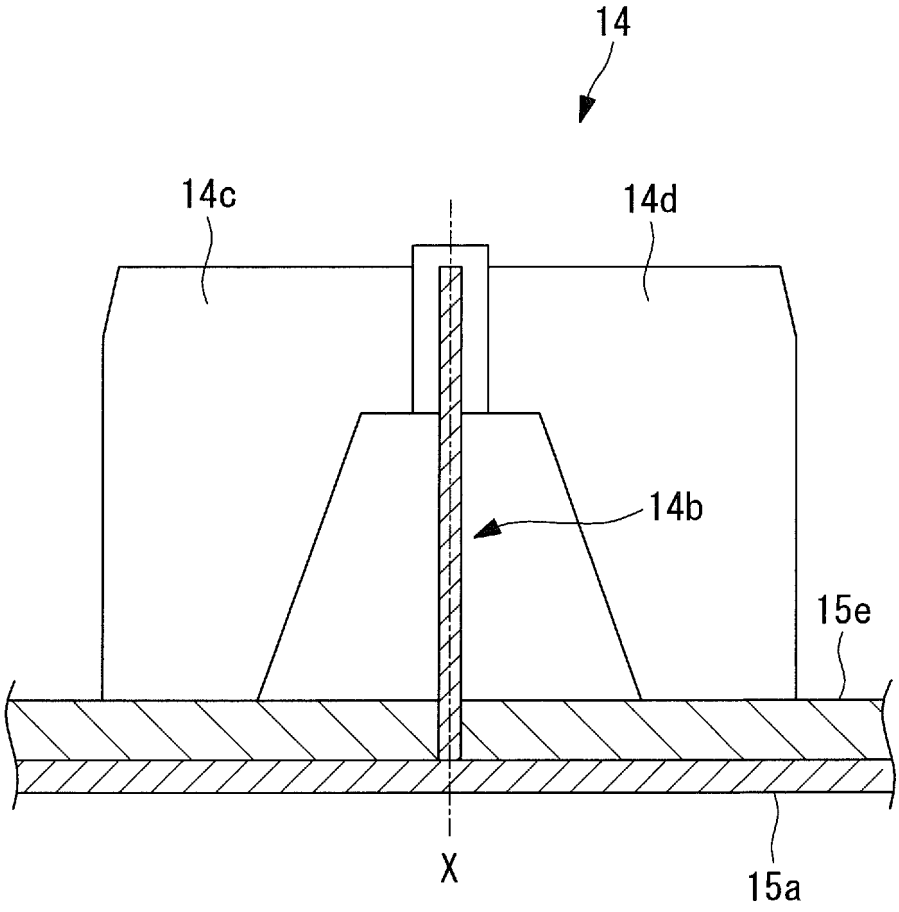

FIG. 4

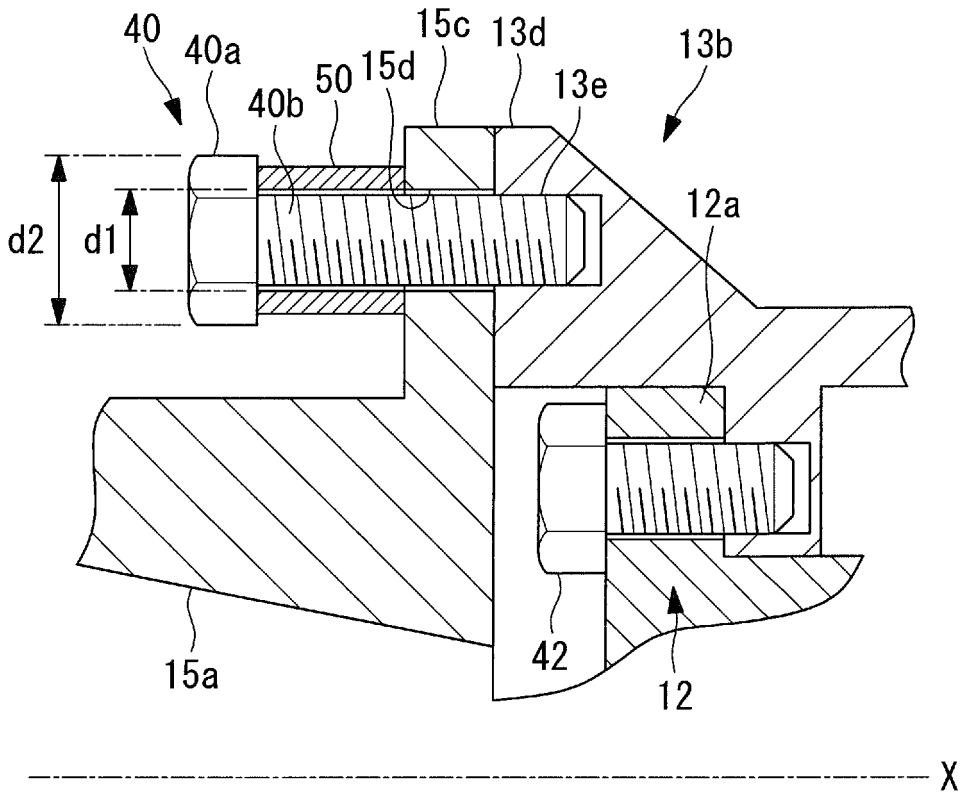

FIG. 5

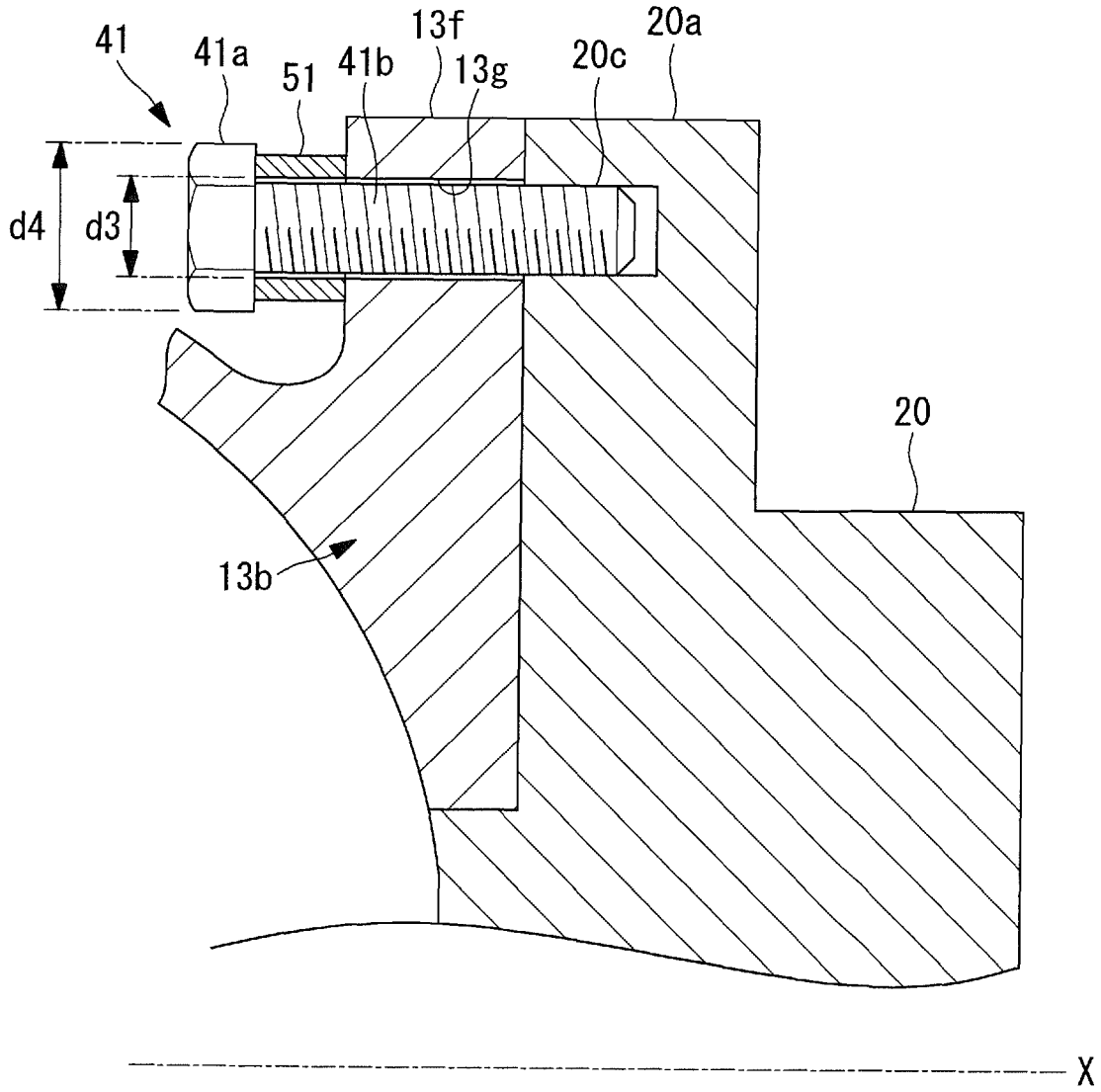

FIG. 6

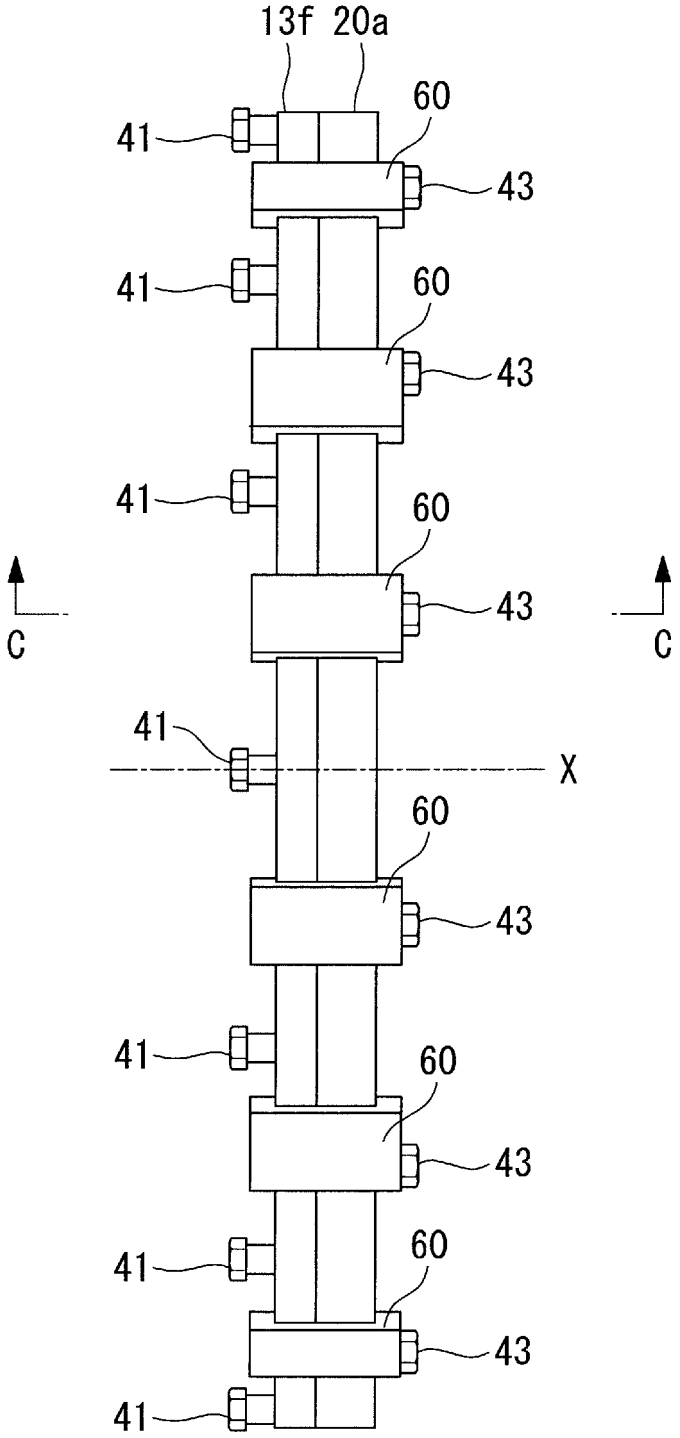

FIG. 7

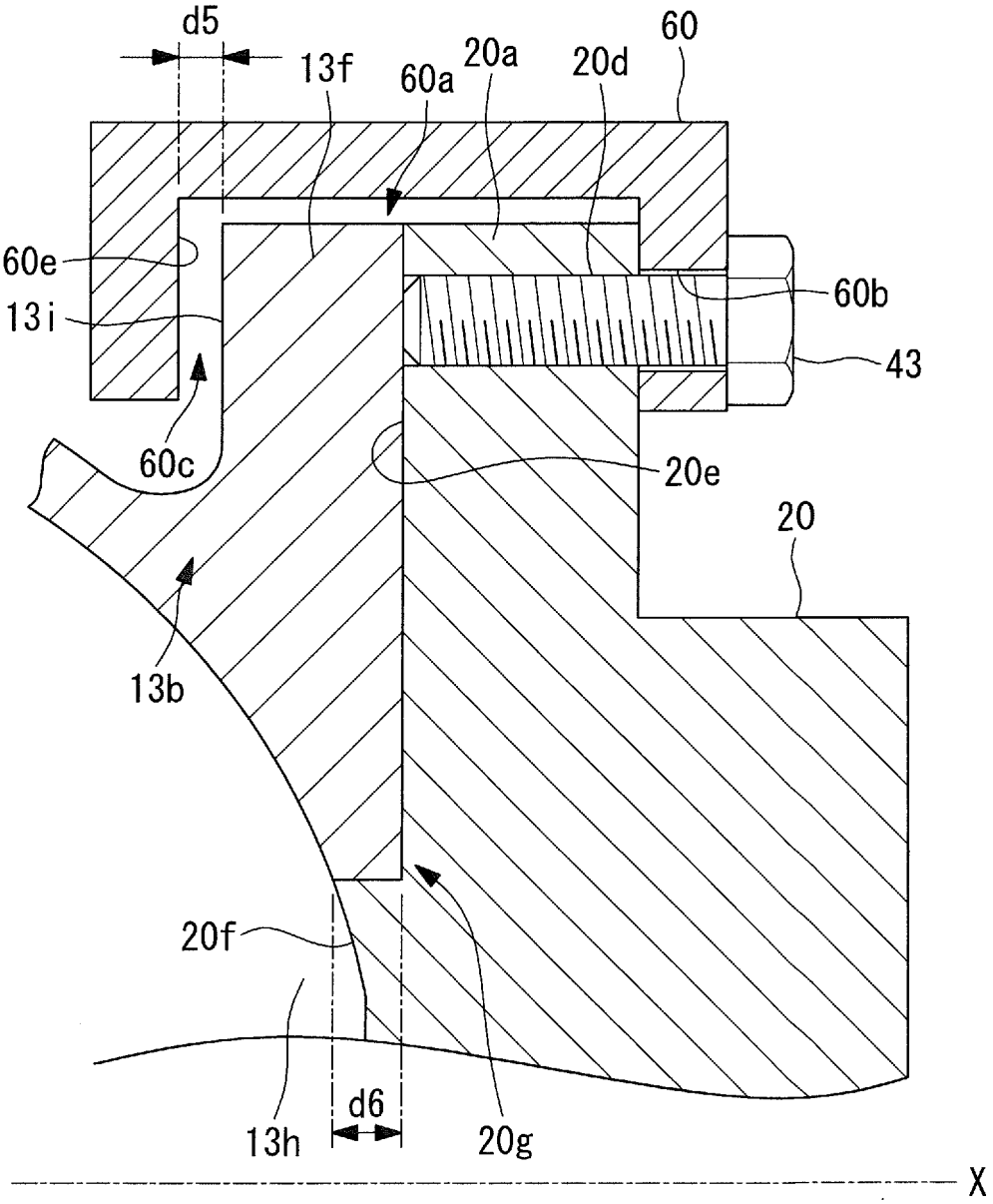
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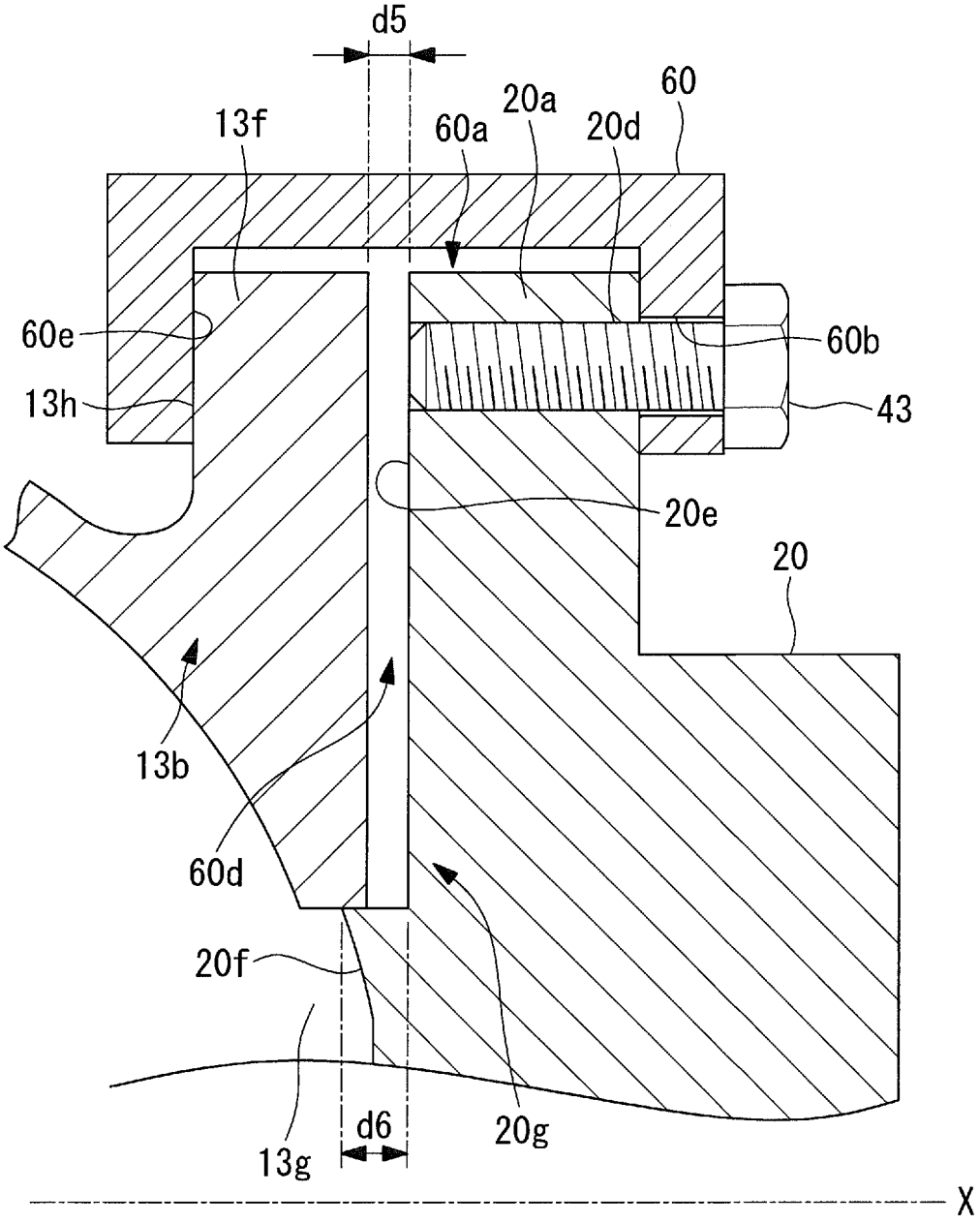
FIG. 8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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/055240

A. CLASSIFICATION OF SUBJECT MATTER
F04D29/44(2006.01)i, *F04D29/42*(2006.01)i, *F04D29/66*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04D29/44, F04D29/42, F04D29/66

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.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 108798/1987(Laid-open No. 13299/1989) (Nissan Motor Co., Ltd.), 24 January 1989 (24.01.1989), specification, page 2, line 5 to page 3, line 3; fig. 3 to 5 (Family: none)	1-10
A	JP 2010-127240 A (Mitsubishi Heavy Industries, Ltd.), 10 June 2010 (10.06.2010), paragraphs [0015] to [0019]; fig. 1 (Family: none)	1-10

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 May 2015 (14.05.15)	02 June 2015 (02.06.15)

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

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/055240

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2001/0016161 A1 (Alexander RIPPL), 23 August 2001 (23.08.2001), paragraph [0018]; fig. 1, 2 & DE 10002581 A1	1-10

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/055240

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/055240

Continuation of Box No.III of continuation of first sheet(2)

Supplementation of BOX No. III:

Claim 1 and claim 6 have a common technical feature, i.e., "a centrifugal compressor including: an impeller which is mounted on a rotor shaft and which compresses an inflow of fluid through an inlet port and discharges the resulting fluid through a discharge port; a cylindrical guide for accommodating the impeller; and a scroll part which is disposed outside the outer circumference of the cylindrical guide and into which the compressed fluid discharged through the discharge port flows."

However, the above-said technical feature cannot be considered to be a special technical feature, since the technical feature does not make a contribution over the prior art in the light of the contents disclosed in the document (JP 2010-127240 A (Mitsubishi Heavy Industries, Ltd.), 10 June 2010 (10.06.2010), paragraphs [0015] to [0019], fig. 1).

Further, there is no other same or corresponding special technical feature between these inventions.

Accordingly, claims are classified into two inventions each of which has a special technical feature indicated below.

(Invention 1) claims 1-5, 9 (referring to claims 1-5) and 10

"A centrifugal compressor including: a plurality of partitions which are provided upstream of an inlet port in the direction of flow of a fluid and which has a predetermined length in the axial direction of a rotor shaft; and a silencer having a silencer casing for accommodating the plurality of partitions, wherein the plurality of partitions are disposed radially about the axial line and each made of rolled steel in a thickness of 4 mm to 9 mm (both inclusive)."

(Invention 2) claims 6-8 and 9 (referring to claims 6-8)

"A centrifugal compressor with a plurality of clamps, each clamp including: a recess which surrounds, radially from outside, both the outer circumferential edge of a flange and the outer circumferential edge of a scroll casing; and a through-hole which is opened to the recess and extends in the axial direction. The centrifugal compressor is adapted such that either one of the flange or the scroll casing has a plurality of fastening holes extending in the axial direction which are disposed about the axial line in the circumferential direction; either one of the flange or the scroll casing and the clamp are fastened together with a clamp fastening bolt which is inserted into the through-hole and the fastening hole; and a predetermined gap is provided between the axial end face of the other of the flange or the scroll casing and the axial end face of the recess."

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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