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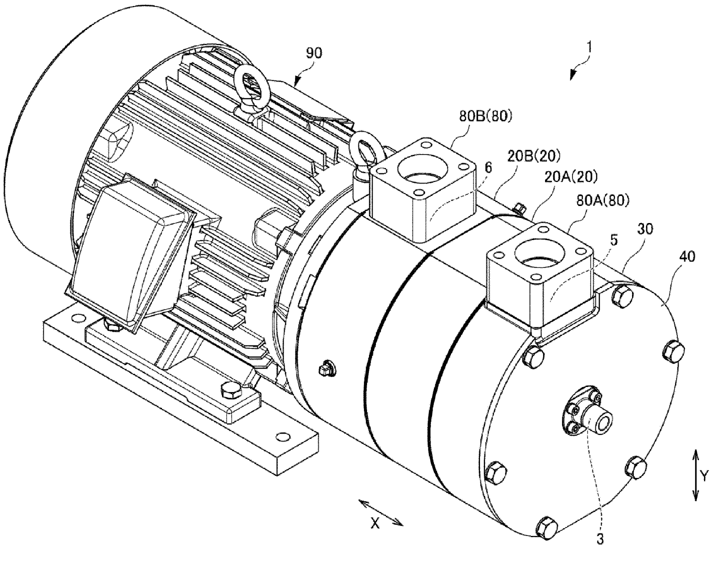
(54) **WATER RING VACUUM PUMP**

(57) Water ring vacuum pump including an impeller (10) coupled to a rotary shaft (92) of a motor (90) and rotating about an axis (94), a pump casing (20) forming a pump chamber in which the impeller (10) is housed, a water supply port provided to supply seal water to the pump chamber, a suction port (5) provided to suck gas into the pump chamber, and an exhaust port (6) provided to discharge gas from the pump chamber. The pump casing (20) is made of synthetic resin, and includes a metal ring member (14) covering at least part of a rotation region for the impeller (10).

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a water ring vacuum pump.

BACKGROUND ART

[0002] There has been known a water ring vacuum pump that injects water called seal water into a pump casing to form a water ring by centrifugal force accompanied by rotation of an impeller and changes a spatial volume between the water ring and the impeller to generate a vacuum state. For example, a water ring vacuum pump called an elmo pump operates such that gas suction in a spatial volume expansion process and gas discharge in a spatial volume compression process are repeated in every half-turn of an impeller eccentric with a pump casing. JP-A-5-133369 discloses a two-stage type water ring vacuum pump including a suction side casing and an exhaust side casing such that an impeller is housed in each of the suction side casing and the exhaust side casing.

DISCLOSURE OF THE INVENTION

[0003] Use of tap water which is fresh water has been recommended as the seal water to be injected into the pump casing, but the tap water often contains residual chlorine and corrosive ions (chloride ions and sulfate ions). For this reason, in order to prevent corrosion of a liquid-contacting portion, a metal material (e.g., austenite-based stainless steel) having a high corrosion resistance is generally used for the pump casing.

[0004] In a case where the metal material having the high corrosion resistance is used for the pump casing, a product cost increases as the number of stages of pump chambers increases, and in addition, a weight also increases. For this reason, an extra transportation cost is required. Thus, the inventor(s) et al. of the present application have conducted study on reduction in corrosion of the liquid-contacting portion and the weight of the pump casing by use of a synthetic resin material for the pump casing. However, it has been found that in a case of using the synthetic resin pump casing, vibration and noise of a pump body are greater.

[0005] Thus, the present invention is intended to provide a water ring vacuum pump capable of reducing vibration and noise of a pump body even in a case of using a synthetic resin pump casing.

[0006] The water ring vacuum pump according to the present invention includes an impeller coupled to a rotary shaft of a motor and rotating about an axis, a pump casing forming a pump chamber in which the impeller is housed, a water supply port provided to supply seal water to the pump chamber, a suction port provided to suck gas into the pump chamber, and an exhaust port provided to discharge gas from the pump chamber. The pump casing is made of synthetic resin, and includes a metal ring member covering at least part of a rotation region for the impeller.

[0007] According to the present invention, the water ring vacuum pump can be provided, which is capable of reducing vibration and noise of the pump body even in a case of using the synthetic resin pump casing.t

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is a perspective view of a water ring vacuum pump of the present embodiment;
Fig. 2 is an exploded perspective view of the water ring vacuum pump of the present embodiment;
Fig. 3 is a perspective view of a second pump casing;
Fig. 4 is a plan view of a first pump casing;
Fig. 5 is a graph showing a noise value;
Fig. 6 is a perspective view of a suction side casing;
Fig. 7 is a perspective view of a water ring vacuum pump of another embodiment;
Fig. 8 is a sectional view taken along II-II line in Fig. 7; and
Fig. 9 is a plan view of a joint of Fig. 7.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0009] A mode for carrying out the invention will be described with reference to the drawings. Fig. 1 is a perspective view of a water ring vacuum pump 1 of the present embodiment. As shown in Fig. 1, the water ring vacuum pump 1 includes a motor 90, a pump casing 20, and a suction side casing 30. The water ring vacuum pump 1 of the present embodiment is a two-stage type water ring vacuum pump. The two-stage type pump has a form with two impellers described later and two pump chambers in each of which the impeller is arranged. Since the water ring vacuum pump 1 is of the two-stage type, the pump casing 20 includes a first pump casing 20A and a second pump casing 20B. The impeller is arranged inside each of the first pump casing 20A and the second pump casing 20B.

[0010] A joint 80 is arranged on each of the suction side casing 30 and the second pump casing 20B. The joint 80 is a component functioning as a link when an external pipe is connected to the water ring vacuum pump 1. The joint 80 arranged on the suction side casing 30 will be referred to as a first joint 80A. The joint 80 arranged on the second pump casing 20B will be referred to as a second joint 80B.

[0011] In the water ring vacuum pump 1 of the present embodiment, the pump casing 20 and the suction side casing 30 are made of synthetic resin. The synthetic resin to be used for these components suitably includes engineering plastic such as polyphenylene sulfide (PPS), polyphenylether (PPE), modified polyphenylether (m-

PPE), and polyetheretherketone (PEEK). The synthetic resin examples may be reinforced with, e.g., glass fibers or carbon fibers.

[0012] Arrangement of main components of the water ring vacuum pump 1 will be described based on Fig. 2. Fig. 2 is an exploded perspective view of the water ring vacuum pump 1 of the present embodiment. Rotation of the motor 90 is transmitted to impellers 10 via a rotary shaft 92 of the motor 90. A dashed line 94 in Fig. 2 indicates the axis of the rotary shaft 92. A direction parallel with the axis 94 will be referred to as an X-direction. A Y-direction in Fig. 2 is a direction perpendicular to the X-direction. In a case where the X-direction is the horizontal direction, the Y-direction is a height direction.

[0013] In the water ring vacuum pump 1, the second pump casing 20B, the first pump casing 20A, and the suction side casing 30 are arranged in this order from the rotary shaft 92 along the axis 94. The second pump casing 20B, the first pump casing 20A, and the suction side casing 30 are fastened and fixed to the surface of the protruding rotary shaft 92 of the motor 90 with a predetermined number of long bolts 50.

[0014] The positions of fastening with the long bolts 50 are on a concentric circle centered on the axis 94, and are set such that a center angle between adjacent ones of the fastening positions is equal among the fastening positions. For example, four to ten long bolts 50 are used according to the size of the casing, and in the present embodiment, six long bolts 50 are used. A force of fastening the casings to each other is increased by adjustment of the number of long bolts 50 to be used and the fastening torque thereof so that occurrence of vibration due to, e.g., insufficient fixing can be reduced. Thus, an effect of reducing a noise value can be expected.

(Second Pump Casing)

[0015] The second pump casing 20B is a component corresponding to the second stage of the two-stage type water ring vacuum pump 1. A pump chamber 60 is formed inside the second pump casing 20B. The pump chamber 60 formed in the second pump casing 20B will be referred to as a second pump chamber 60B. The shape of the second pump chamber 60B is substantially a cylindrical shape.

[0016] The impeller 10 is arranged in the second pump chamber 60B. The impeller 10 arranged in the second pump chamber 60B will be referred to as a second impeller 10B. In the pump chamber 60, a region where the impeller 10 rotates will be referred to as a rotation region 12. In the second pump chamber 60B, a region where the second impeller 10B rotates is a rotation region 12.

[0017] A metal ring member 14 is arranged in the second pump casing 20B of the present embodiment. The metal ring member 14 is arranged so as to cover at least part of the rotation region 12. The metal ring member 14 is arranged on an inner peripheral portion 24 of the second pump casing 20B. The metal ring member 14 is formed in a shape along the inner peripheral portion 24. In the present embodiment, the shape of the metal ring member 14 is a cylindrical shape. The metal ring member 14 will be described later.

[0018] An exhaust port 6 is formed in an outer peripheral portion 25 of the second pump casing 20B. The exhaust port 6 is a through-hole connecting the outside of the second pump casing 20B and the second pump chamber 60B to each other. Gas in the second pump chamber 60B is discharged through the exhaust port 6.

[0019] The second joint 80B is arranged on the outer peripheral portion 25 of the second pump casing 20B. The second joint 80B is arranged so as to cover the exhaust port 6. The joint 80 will be described later.

(First Pump Casing)

[0020] In the direction of the axis 94, the first pump casing 20A is arranged on the opposite side of the second pump casing 20B from the motor 90. The first pump casing 20A is a component corresponding to the first stage of the two-stage type water ring vacuum pump 1. An opening 26 of the second pump chamber 60B is closed with the first pump casing 20A.

[0021] The pump chamber 60 is formed inside the first pump casing 20A. The pump chamber 60 formed in the first pump casing 20A will be referred to as a first pump chamber 60A. The shape of the first pump chamber 60A is substantially a cylindrical shape.

[0022] A flow hole 22 is formed in the first pump casing 20A. The flow hole 22 is formed in the surface of the first pump casing 20A facing the opening 26 of the second pump casing 20B. The flow hole 22 is a through-hole. The first pump chamber 60A is connected to the second pump chamber 60B through the flow hole 22.

[0023] The impeller 10 is arranged in the first pump chamber 60A. The impeller 10 arranged in the first pump chamber 60A will be referred to as a first impeller 10A. In the first pump chamber 60A, a region where the first impeller 10A rotates is a rotation region 12.

[0024] As in the above-described second pump casing 20B, a metal ring member 14 that covers at least part of the rotation region 12 is arranged in the first pump casing 20A of the present embodiment. The metal ring member 14 is arranged on an inner peripheral portion 24 of the first pump casing 20A. The shape of the metal ring member 14 is a cylindrical shape.

[0025] Unlike the second pump casing 20B, no joint 80 is arranged on an outer peripheral portion 25 of the first pump casing 20A.

(Suction Side Casing)

[0026] In the direction of the axis 94, the suction side casing 30 is arranged on the opposite side of the first pump casing 20A from the second pump casing 20B. The opening 26 of the second pump chamber 60B is closed with the suction side casing 30.

[0027] A suction port 5 to be connected to the first pump chamber 60A is formed in an outer peripheral portion 25 of the suction side casing 30. The suction port 5 is a through-hole for sucking gas into the first pump chamber 60A.

[0028] The first joint 80A is arranged on the outer peripheral portion 25 of the suction side casing 30. The first joint 80A is arranged so as to cover the suction port 5.

[0029] A water supply port 3 penetrating the suction side casing 30 in the X-direction is formed in the suction side casing 30. The water supply port 3 is a through-hole for supplying seal water to the first pump chamber 60A.

[0030] A metal cover 40 is attached to the suction side casing 30 on the opposite side of the suction side casing 30 from the first pump casing 20A. The surface of the suction side casing 30 to which the metal cover 40 is attached will be referred to as a metal cover attachment surface 32. The metal cover 40 will be described later.

(Metal Ring Member)

[0031] Hereinafter, the features of the water ring vacuum pump 1 of the present embodiment will be sequentially described. First, the metal ring member 14 will be described. Fig. 3 is a perspective view of the second pump casing 20B. As shown in Fig. 3, the metal ring member 14 is arranged on the inner peripheral portion 24 of the second pump casing 20B.

[0032] As described based on Fig. 2, the metal ring member 14 is also arranged on the inner peripheral portion 24 of the first pump casing 20A. Fig. 4 is a view of the first pump casing 20A and the metal ring member 14 in the direction of an arrow I shown in Fig. 2.

[0033] As shown in Fig. 4, the shape of the metal ring member 14 is the cylindrical shape. The metal ring member 14 is arranged along the inner peripheral portion 24.

[0034] The shape of the metal ring member 14 is a shape corresponding to the shape of the inner peripheral portion 24. The shape corresponding to the shape of the inner peripheral portion 24 means, for example, such a shape that the metal ring member 14 can be fitted in the inner peripheral portion 24 with almost no clearance therebetween. In the present embodiment, the shape of the inner peripheral portion 24 is a cylindrical shape. Thus, the shape of the metal ring member 14 is the cylindrical shape.

[0035] Here, a space occupied by rotation of the impeller 10 is the rotation region 12. The metal ring member 14 is arranged on the inner peripheral portion 24 of the second pump casing 20B to cover at least part of the rotation region 12 for the second impeller 10B. Similarly, the metal ring member 14 is arranged on the inner peripheral portion 24 of the first pump casing 20A to cover at least part of the rotation region 12 for the first impeller 10A.

[0036] The shape of the rotation region 12 is generally a circular columnar shape. The metal ring member 14 covers at least part of the side surface of the circular columnar rotation region 12. The side surface indicates the surface of the circular columnar shape other than two opposing surfaces. That is, the metal ring member 14 covers at least part of a curved portion of the surface of the rotation region 12.

[0037] In a case where the pump casing 20 is made of the synthetic resin, vibration and noise of the water ring vacuum pump 1 tend to be great. In the water ring vacuum pump 1 of the present embodiment, the metal ring member 14 is arranged so as to cover at least part of the rotation region 12. Thus, even in a case where the first pump casing 20A and the second pump casing 20B are made of the synthetic resin, vibration and noise of the water ring vacuum pump 1 can be reduced. This is because the metal ring member 14 reduces occurrence of vibration and also reduces propagation of noise.

[0038] Fig. 5 is a graph showing the noise value in a case where the metal ring member 14 is arranged and a case where no metal ring member 14 is arranged. The horizontal axis of the graph of Fig. 5 indicates a suction pressure [kPa], and the vertical axis indicates the noise value [dB]. Blank triangles in Fig. 5 indicate the absence of the metal ring member, and black circles indicate the presence of the metal ring member.

[0039] Fig. 5 shows that the noise value is reduced by arrangement of the metal ring member 14. For example, the noise value is reduced by about 2.7 dB at around a suction pressure of 100 kPa.

[0040] The material of the metal ring member 14 may be, for example, stainless steel. Seal water to be injected into the pump casing may contain residual chlorine and corrosive ions. For this reason, a material having a high corrosion resistance, such as austenite-based stainless steel, is used as the material of the metal ring member 14 so that the durability of the metal ring member 14 can be improved.

[0041] In the embodiment shown in Fig. 3, the metal ring member 14 is arranged on the inner peripheral portion 24 of the second pump casing 20B. The position at which the metal ring member 14 is arranged is not limited to the inner peripheral portion 24 of the second pump casing 20B. The metal ring member 14 can be arranged at an arbitrary position as long as the metal ring member 14 covers at least part of the rotation region 12 for the second impeller 10B. For example, the metal ring member 14 may be arranged at a position between the inner peripheral portion 24 and outer peripheral portion 25 of the second pump casing 20B. Alternatively, the metal ring member 14 may be arranged outside the outer peripheral portion 25 of the second pump casing 20B.

[0042] A method for arranging the metal ring member 14 in the second pump casing 20B is not particularly limited. For example, the second pump casing 20B is first molded, and thereafter, the metal ring member 14 is fitted in the second pump casing 20B. In this manner, the metal ring member 14 can be arranged in the second pump casing 20B. Alternatively, for example, when the second pump casing 20B is molded using, e.g., an insert molding method, the second pump casing 20B and the metal ring member 14 may be integrally molded. In a case where the metal ring member 14 is arranged on the inner peripheral portion 24 of the second pump casing 20B, the metal ring member 14 is easily fitted in the second pump casing 20B, and the second pump casing 20B and the metal ring member 14 are easily integrally molded.

[0043] In description above, the second pump casing 20B has been described as an example regarding the arrangement position of the metal ring member 14 and the method for arranging the metal ring member 14. The contents described above also similarly apply to the first pump casing 20A. In the case of the first pump casing 20A, the second pump casing 20B in description above is replaced with the first pump casing 20A, and the second impeller 10B is replaced with the first impeller 10A.

[0044] In a case where the water ring vacuum pump 1 is the two-stage type water ring vacuum pump including the two impellers, vibration and noise of the water ring vacuum pump tend to be great. However, according to the water ring vacuum pump 1 of the present embodiment, the metal ring members 14 are each arranged in the first pump casing 20A and the second pump casing 20B. Thus, even in a case where the water ring vacuum pump is of the two-stage type, vibration and noise can be reduced.

[0045] Note that the water ring vacuum pump 1 is not limited to the two-stage type. For example, even in a case where the water ring vacuum pump 1 is of a single-stage type, the metal ring member 14 is arranged in the pump casing 20 so that vibration and noise can be reduced.

(Metal Cover)

[0046] The metal cover 40 will be described. As shown in Figs. 1 and 2, in the water ring vacuum pump 1 of the present embodiment, the metal cover 40 is attached to the suction side casing 30 on the opposite side of the suction side casing 30 from the first pump casing 20A. That is, the metal cover 40 is arranged on the metal cover attachment surface 32 of the suction side casing 30.

[0047] The metal cover 40 is a metal plate having substantially a discoid shape. The planar shape of the metal cover 40 as viewed in the X-direction is substantially the same as the planar shape of the suction side casing 30 as viewed in the X-direction. Since the shape of the metal cover 40 is substantially the same as the shape of the suction side casing 30 as viewed in plane, the metal cover 40 can cover substantially the entirety of one end surface of the suction side casing 30.

[0048] In the water ring vacuum pump 1 of the present embodiment, the surface of the suction side casing 30 on the opposite side of the suction side casing 30 from the first pump casing 20A, i.e., the exposed end surface of the water ring vacuum pump 1, is covered with the metal cover 40. Thus, vibration of the end surface of the water ring vacuum pump 1 and leakage of noise from the end surface can be reduced. As a result, vibration and noise of the water ring vacuum pump 1 can be reduced.

[0049] For example, in a case where the thickness of the metal cover 40 is 6 mm, the noise value is reduced by about 2 dB.

[0050] Fig. 6 is a perspective view of the suction side casing 30. As shown in Fig. 6, the metal cover attachment surface 32 to which the metal cover 40 is attached is substantially flat. Specifically, the region of the metal cover attachment surface 32 to which the metal cover 40 is attached is substantially flat.

[0051] The portion of the metal cover attachment surface 32 contacting the metal cover 40 is flat so that adhesion between the end surface of the water ring vacuum pump 1 and the metal cover 40 can be improved. As a result, vibration and noise can be further reduced.

[0052] Note that in order to improve the adhesion to the suction side casing 30, for example, a cutout 42 corresponding to the shape of the suction side casing 30 may be formed in the metal cover 40 as shown in Fig. 2.

[0053] Moreover, in the metal cover 40, a through-hole 44 is formed at a position corresponding to the water supply port 3 of the suction side casing 30.

[0054] The metal cover 40 can reduce damage of the suction side casing 30 in addition to vibration and noise. In a case where the suction side casing 30 is made of the synthetic resin, there is a probability that when the temperature of the suction side casing 30 increases, the suction side casing 30 is thermally expanded and is damaged due to stress concentration on the fastening locations of the long bolts 50. The metal cover 40 attached to the suction side casing 30 can disperse the stress on the fastening locations of the long bolts 50 even in a case where the suction side casing 30 is thermally expanded. As a result, the metal cover 40 can reduce damage of the suction side casing 30.

[0055] The material forming the metal cover 40 is not particularly limited. The material forming the metal cover 40 may be, for example, stainless steel.

[0056] The configuration in which the metal cover 40 is attached to the metal cover attachment surface 32 of the suction side casing 30 has been described above. The configuration in which the metal cover 40 is included in the suction side casing 30 is not limited thereto. The metal cover 40 may be included in the suction side casing 30 in such a manner that the metal cover 40 is integrated with the suction side casing 30, for example, by insert molding when the suction side casing 30 is molded.

(Joint)

[0057] The joint 80 will be described. As described above, the joint 80 is arranged on each of the second pump casing 20B and the suction side casing 30. The joint 80 arranged on the second pump casing 20B is the second joint 80B. The joint 80 arranged on the suction side casing 30 is the first joint 80A. The second joint 80B is shown in detail in Fig. 3. The first joint 80A is shown in detail in Fig. 6.

[0058] The shape of the joint 80 shown in Figs. 3 and 6 is substantially a rectangular parallelepiped shape. The joint 80 includes a flange 82 and a port 83. The port 83 is a portion in which a cylindrical through-hole 84 is formed. The flange 82 is a portion surrounding the port 83. The flange 82 is used for fixing the joint 80 to the second pump casing 20B or the suction side casing 30. Bolt through-holes 86 are formed in the flange 82. The joint 80 is attached to the second pump casing 20B or the suction side casing 30 with hexagon socket head cap screws (see Fig. 7) inserted into the through-holes 86.

[0059] The second joint 80B will be described as an example of the joint 80 based on Fig. 3. The second joint 80B is arranged on the top of the outer peripheral portion 25 of the second pump casing 20B in the height direction Y. The exhaust port 6 is formed in the top of the outer peripheral portion 25 of the second pump casing 20B in the height direction Y. The exhaust port 6 is a through-hole connecting the second pump chamber 60B and the outside of the second pump casing 20B to each other and formed in the second pump casing 20B. An end portion of the exhaust port 6 on the outer peripheral portion 25 side in the second pump casing 20B is an inlet/outlet 7.

[0060] The second joint 80B is arranged on the outer peripheral portion 25 such that the opening of the through-hole 84 of the port 83 is coincident with the inlet/outlet 7. The second joint 80B is fixed to the second pump casing 20B with the hexagon socket head cap screws (not shown) inserted into the through-holes 86 of the flange 82.

[0061] As described above, the joint 80 includes the flange 82 to be joined to the periphery of the inlet/outlet 7 and the port 83 formed in a tubular shape extending with the flange 82 as a base end and having the through-hole 84 communicating with the inlet/outlet 7.

[0062] Here, it is assumed that the thickness of the flange 82 is A. The thickness of the flange 82 means the length of the flange 82 along the direction of extension of the through-hole 86. Moreover, it is assumed that the maximum inner diameter of the through-hole 84 is B. In the water ring vacuum pump 1 of the present embodiment, the thickness A of the flange 82 is great. The thickness A of the flange 82 is great so that vibration of the joint 80 and noise from the joint 80 can be reduced.

[0063] Note that description of the second joint 80B above based on Fig. 3 also applies to the first joint 80A shown in Fig. 6. The second pump casing 20B of Fig. 3 corresponds to the suction side casing 30 of Fig. 6, and the exhaust port 6 of Fig. 3 corresponds to the suction port 5 of Fig. 6.

[0064] The thickness A of the flange 82 of the joint 80 and the maximum inner diameter B of the through-hole 84 of the port 83 will be described based on Figs. 7 to 9. Fig. 7 is a perspective view of a water ring vacuum pump 1 of another embodiment. Fig. 8 is a sectional view taken along II-II line in Fig. 7. Fig. 9 is a view of the joint 80 shown in Fig. 7 from the direction of an arrow III shown in Fig. 7.

[0065] In a case where the thickness of the flange 82 is A and the maximum inner diameter of the through-hole 84 is B as described above, the ratio of both values preferably satisfies a condition of $0.1 \leq A/B \leq 2.0$. Moreover, the ratio of both values more preferably satisfies a condition of $0.2 \leq A/B \leq 1.0$.

[0066] In a case where both values satisfy the above-described condition, the thickness A of the flange 82 is a thickness of at least 10% or more of the maximum inner diameter B of the through-hole 84. A great maximum inner diameter B of the through-hole 84 generally means a great amount of gas passing through the through-hole 84. A great amount of gas passing through the through-hole 84 means a great output of the water ring vacuum pump 1. As the output of the water ring vacuum pump 1 increases, vibration and noise of the water ring vacuum pump 1 become greater. Moreover, vibration and noise tend to be greater in the vicinity of the joint 80.

[0067] Here, the thickness A of the flange 82 of the present embodiment is adjusted so as to increase with an increase in the maximum inner diameter B of the through-hole 84 according to the above-described condition. Thus, even in a case where the output of the water ring vacuum pump 1 is great, vibration and noise of the joint can be reduced. This is because vibration accompanied by suction/discharge of gas is reduced by an increase in the thickness A of the flange 82 and a sound transmission loss is increased.

[0068] The thickness A of the flange 82 of the present embodiment is at least 10% or more of the maximum inner diameter B of the through-hole 84 and preferably a thickness of 20% or more. The thickness A of the flange 82 of the present embodiment is greater than a thickness normally set for the flange 82 in terms of, e.g., strength. Thus, vibration of the joint and noise from the joint can be reliably reduced.

[0069] In a case where both values satisfy the above-described condition, the thickness A of the flange 82 is twice as great as the maximum inner diameter B of the through-hole 84 or less and preferably one time or less. In a case where the thickness A of the flange 82 is too great, vibration of the joint may be increased. The thickness A of the flange 82 of the present embodiment does not exceed twice as great as the maximum inner diameter B of the through-hole 84 at most. Thus, the thickness A of the flange 82 can be set within a proper range, and occurrence of an adverse effect due to an increase in the thickness of the flange 82 can be reduced.

[0070] The material forming the joint 80 may be, for example, metal such as stainless steel.

(Rib Structure)

[0071] In the second pump casing 20B shown in Fig. 3, recesses 27 are provided at multiple locations in the circumferential direction in the surface of the second pump casing 20B on the side on which the second pump chamber 60B opens in order to prevent sink upon resin molding. These recesses 27 are provided in the surface of the inner peripheral portion 24 of the second pump casing 20B and the surface of the outer peripheral portion 25 of the second pump casing 20B. For the recesses 27, ribs 28 are provided at multiple locations for the purpose of strength enhancement and deformation prevention. The ribs 28 are present in gaps between the recesses 27 so that occurrence of vibration due to, e.g., deformation can be reduced. Thus, the noise value can be reduced.

[0072] As shown in Fig. 4, the above-described recesses 27 and ribs 28 are also provided in the inner peripheral portion 24 and outer peripheral portion 25 of the first pump casing 20A. The recesses 27 and the ribs 28 may also be provided in the metal cover attachment surface 32 of the suction side casing 30 as shown in Fig. 6. The rib structure is provided in the multiple casings so that a synergetic effect for vibration reduction can be obtained. For example, in a case where the rib structure is provided in each of the first pump casing 20A and the second pump casing 20B, the noise value is reduced by about 1.3 dB.

[0073] The embodiment of the present invention has been described above, but the present invention is not limited to the above-described embodiment and various changes, modifications, and combinations may be made.

<1> A water ring vacuum pump including

an impeller coupled to a rotary shaft of a motor and rotating about an axis,
a pump casing forming a pump chamber in which the impeller is housed,
a water supply port provided to supply seal water to the pump chamber,
a suction port provided to suck gas into the pump chamber, and
an exhaust port provided to discharge gas from the pump chamber,
the pump casing being made of synthetic resin and including a metal ring member covering at least part of a rotation region for the impeller.

<2> The water ring vacuum pump according to <1>, in which

the impeller includes a first impeller and a second impeller coupled to the rotary shaft and synchronously rotating about the axis,
the pump casing includes

a first pump casing forming a first pump chamber in which the first impeller is housed, and
a second pump casing forming a second pump chamber in which the second impeller is housed,

the first pump chamber and the second pump chamber communicate with each other through a flow hole for fluid inside,
the water supply port and the suction port are provided for the first pump chamber,
the exhaust port is provided for the second pump chamber, and
the metal ring member is included in at least one of the first pump casing or the second pump casing.

<3> The water ring vacuum pump according to <1> or <2>, in which
the metal ring member is arranged on an inner peripheral portion of the pump casing.

<4> The water ring vacuum pump according to any one of <1> to <3>, in which

the pump casing has an opening of the pump chamber on a side opposite to a motor arrangement side,
the opening is closed with a suction side casing having the water supply port and the suction port, and
a metal cover is attached to the suction side casing on the opposite side of the suction side casing from the pump casing.

<5> The water ring vacuum pump according to <4>, in which

the metal cover has a flat shape, and
a region of the suction side casing to which the metal cover is attached is flat.

<6> The water ring vacuum pump according to any one of <1> to <5>, in which

a joint is provided for an inlet/outlet of at least one of the suction port or the exhaust port,
the joint includes

a flange to be joined to the periphery of the inlet/outlet, and
a port formed in a tubular shape extending with the flange as a base end and having a through-hole communicating with the inlet/outlet inside, and

in a case where the thickness of the flange is A and the maximum inner diameter of the through-hole is B, the ratio of A to B satisfies a condition of $0.1 \leq A/B \leq 2.0$.

<7> The water ring vacuum pump according to any one of <1> to <6>, in which

the pump casing is provided with recesses at multiple locations in a surface of the pump cas-

ing on a side on which the pump chamber opens, and
a rib is provided for the recesses.

Claims

1. A water ring vacuum pump comprising:

   an impeller coupled to a rotary shaft of a motor and rotating about an axis;
   a pump casing forming a pump chamber in which the impeller is housed;
   a water supply port provided to supply seal water to the pump chamber;
   a suction port provided to suck gas into the pump chamber; and
   an exhaust port provided to discharge gas from the pump chamber,
   wherein the pump casing is made of synthetic resin, and includes a metal ring member covering at least part of a rotation region for the impeller.

2. The water ring vacuum pump according to claim 1, wherein

   the impeller includes a first impeller and a second impeller coupled to the rotary shaft and synchronously rotating about the axis,
   the pump casing includes

      a first pump casing forming a first pump chamber in which the first impeller is housed, and
      a second pump casing forming a second pump chamber in which the second impeller is housed,

   the first pump chamber and the second pump chamber communicate with each other through a flow hole for fluid inside,
   the water supply port and the suction port are provided for the first pump chamber,
   the exhaust port is provided for the second pump chamber, and
   the metal ring member is included in at least one of the first pump casing or the second pump casing.

3. The water ring vacuum pump according to claim 1 or 2, wherein
   the metal ring member is arranged on an inner peripheral portion of the pump casing.

4. The water ring vacuum pump according to claim 1 or 2, wherein

   the pump casing has an opening of the pump chamber on a side opposite to a motor arrangement side,
   the opening is closed with a suction side casing having the water supply port and the suction port, and
   a metal cover is attached to the suction side casing on an opposite side of the suction side casing from the pump casing.

5. The water ring vacuum pump according to claim 4, wherein

   the metal cover has a flat shape, and
   a region of the suction side casing to which the metal cover is attached is flat.

6. The water ring vacuum pump according to claim 1 or 2, wherein

   a joint is provided for an inlet/outlet of at least one of the suction port or the exhaust port,
   the joint includes

      a flange to be joined to a periphery of the inlet/outlet, and
      a port formed in a tubular shape extending with the flange as a base end and having a through-hole communicating with the inlet/outlet inside, and

   in a case where a thickness of the flange is A and a maximum inner diameter of the through-hole is B, a ratio of A to B satisfies a condition of $0.1 \leq A/B \leq 2.0$.

7. The water ring vacuum pump according to claim 1 or 2, wherein

   the pump casing is provided with recesses at multiple locations in a surface of the pump casing on a side on which the pump chamber opens, and
   a rib is provided for the recesses.

FIG. 1

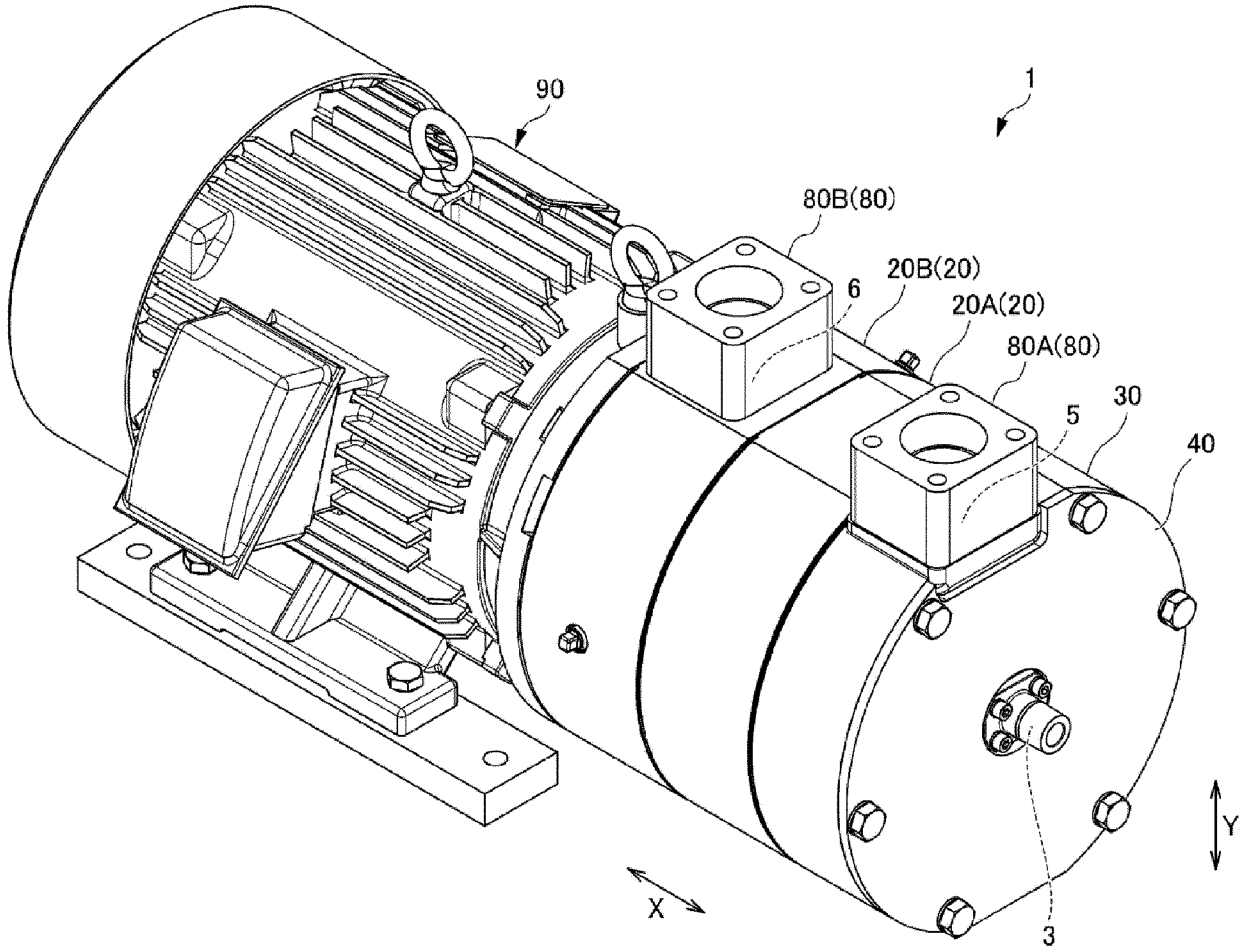
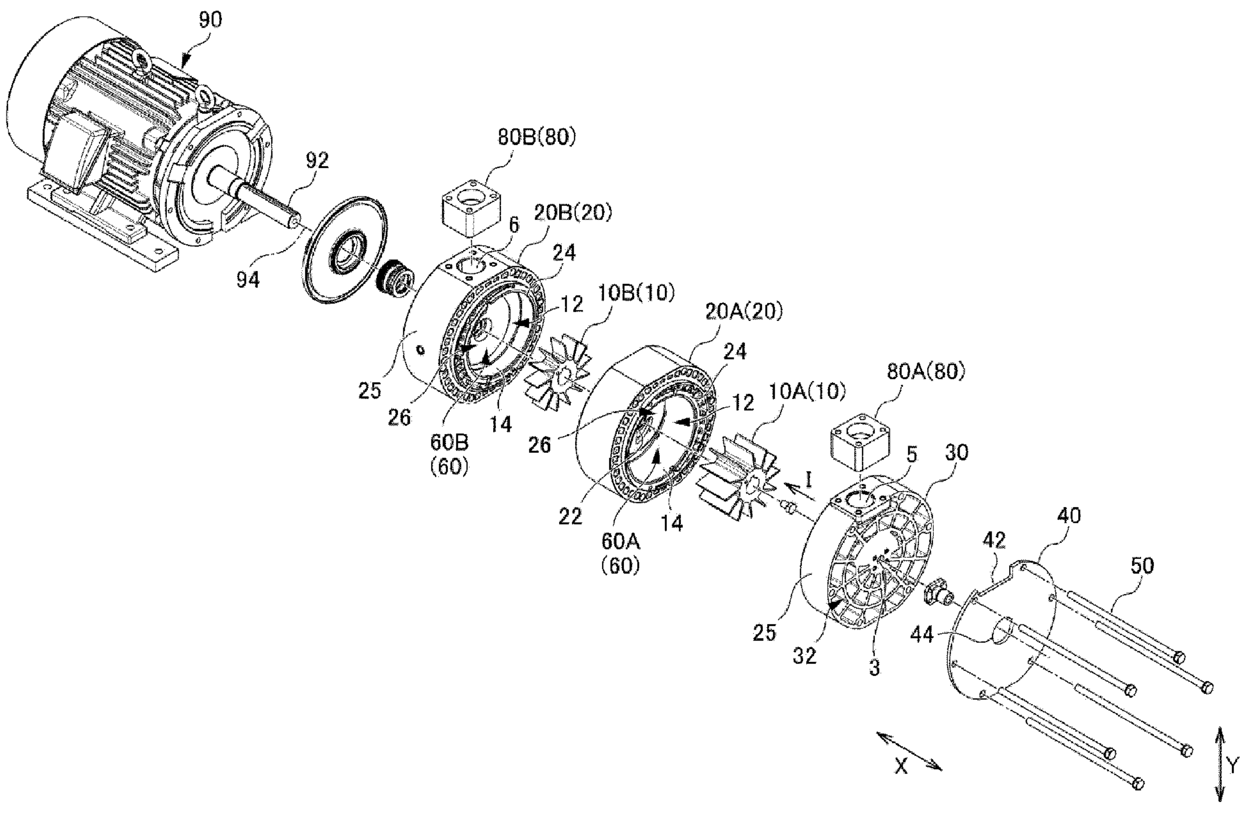


FIG. 2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(60)
14
80A(80)
12
10A(10)
26
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I
22
60A
(60)
14
40
42
50
25
44
32
3
X
Y

FIG. 3

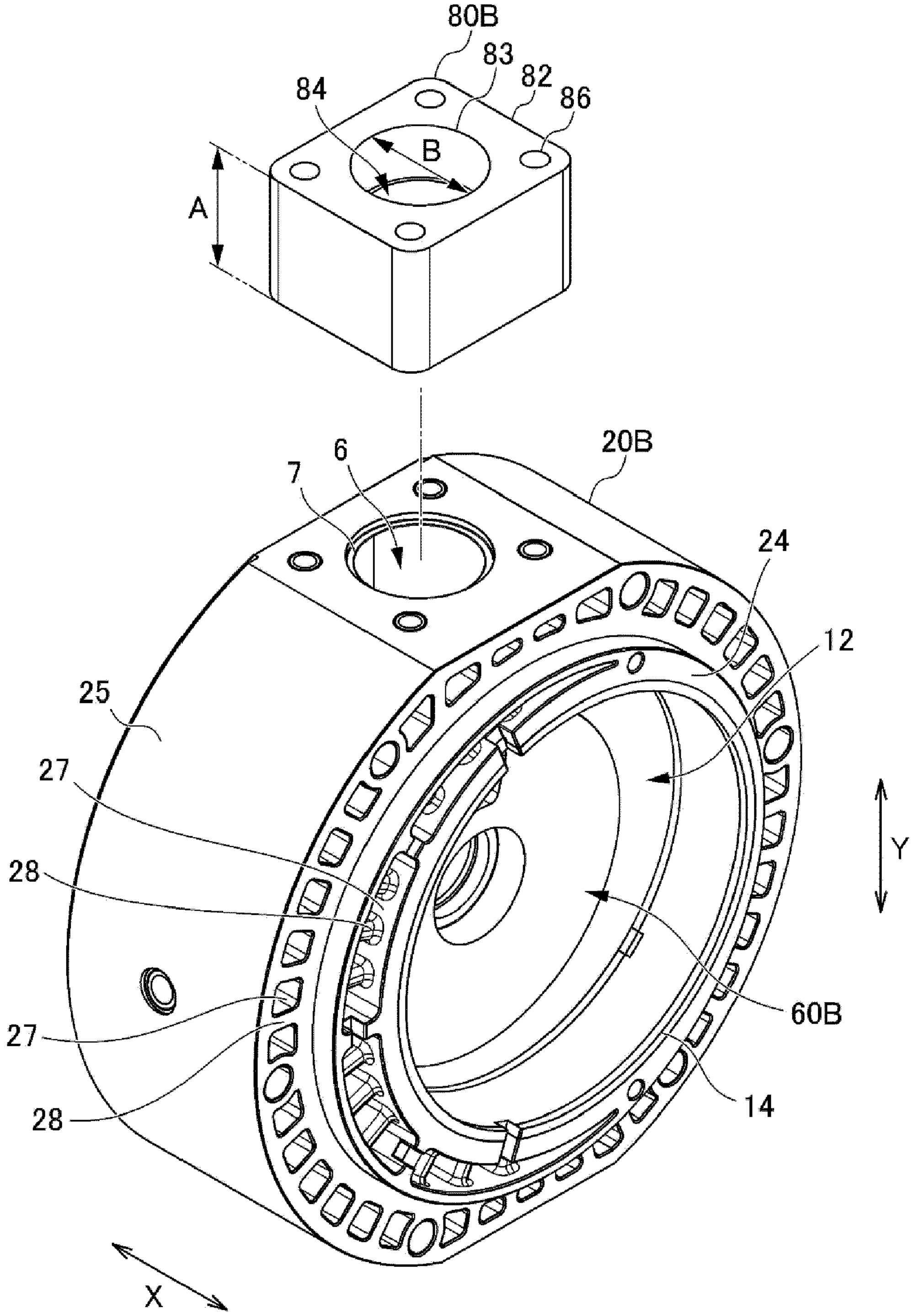


FIG. 4

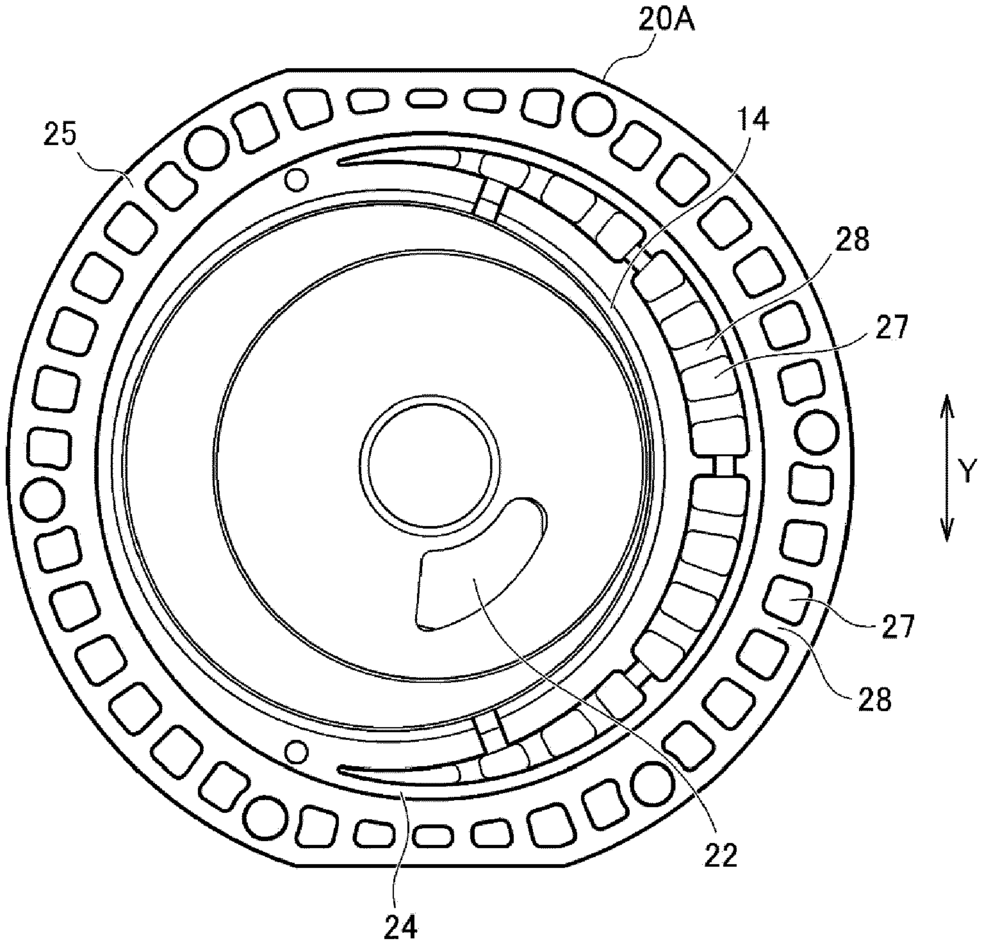
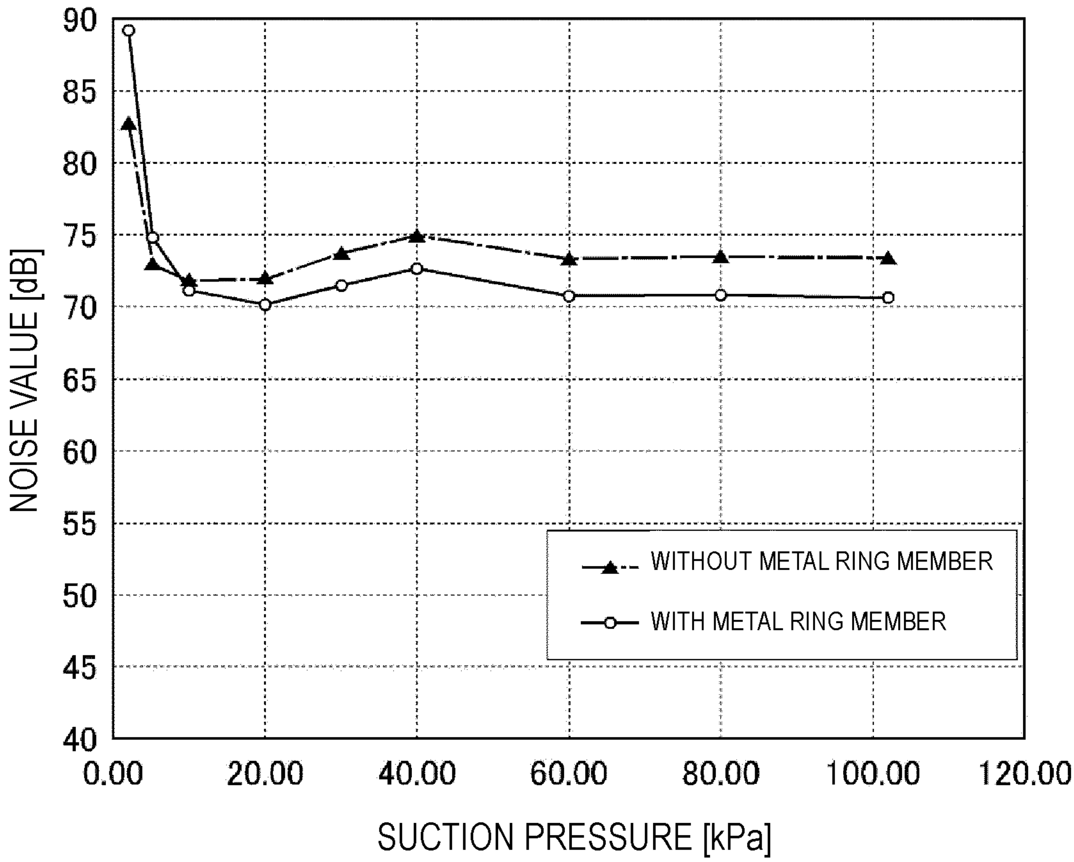


FIG. 5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65
60
55
50
45
40
0.00
20.00
40.00
60.00
80.00
100.00
120.00
NOISE VALUE [dB]
SUCTION PRESSURE [kPa]
WITHOUT METAL RING MEMBER
WITH METAL RING MEMBER

FIG. 6

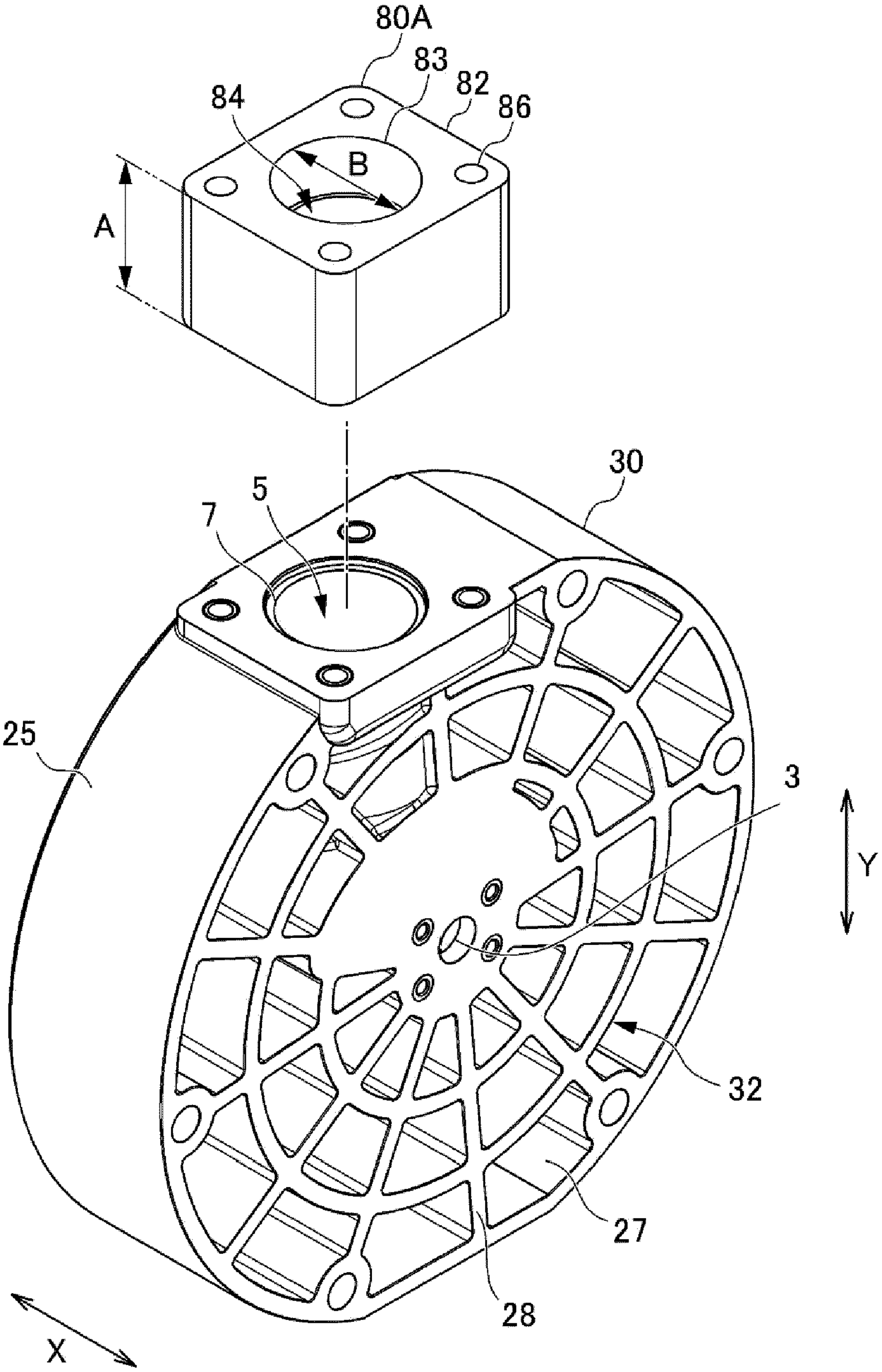


FIG. 7

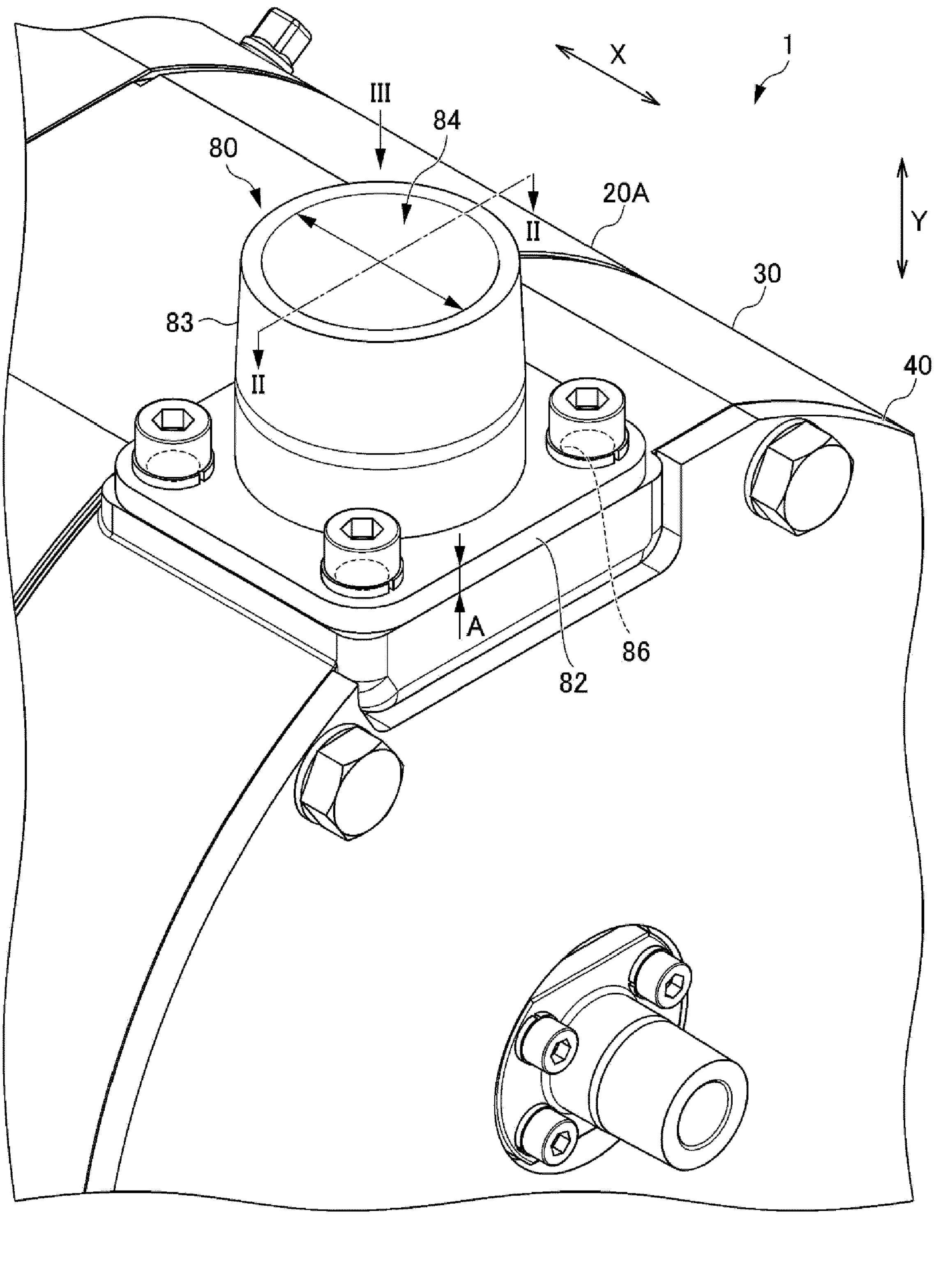


FIG. 8

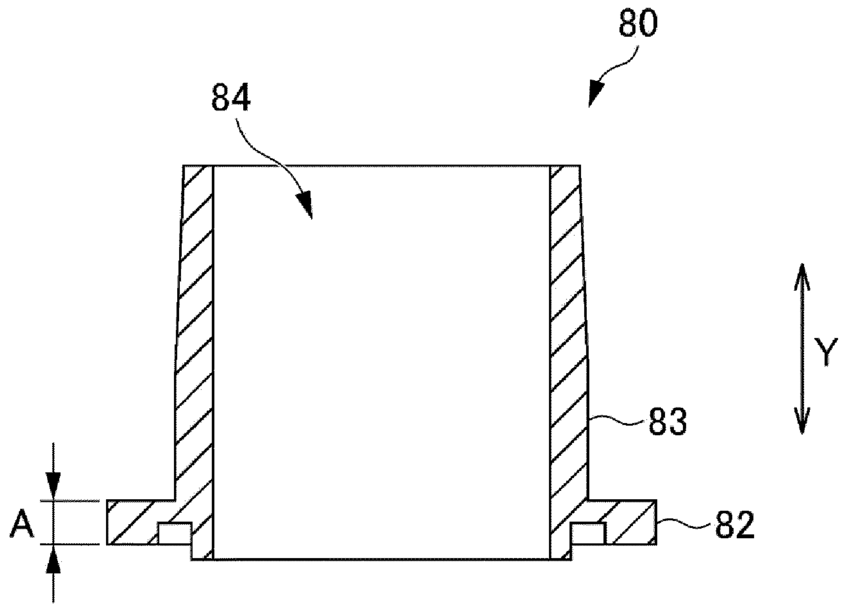
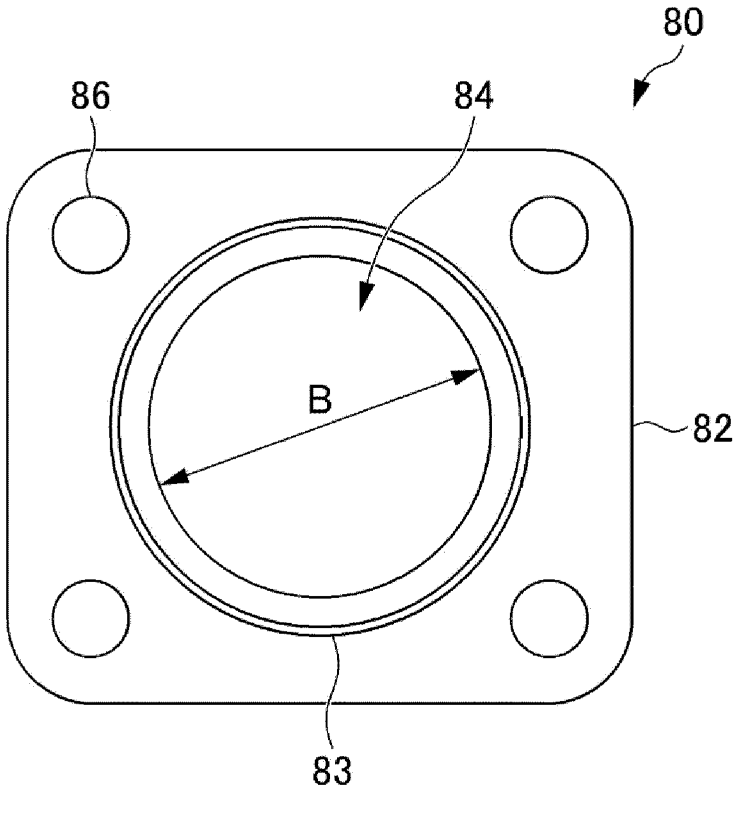


FIG. 9



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EUROPEAN SEARCH REPORT

Application Number
EP 24 15 7074

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	8 July 2024	Descoubes, Pierre

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