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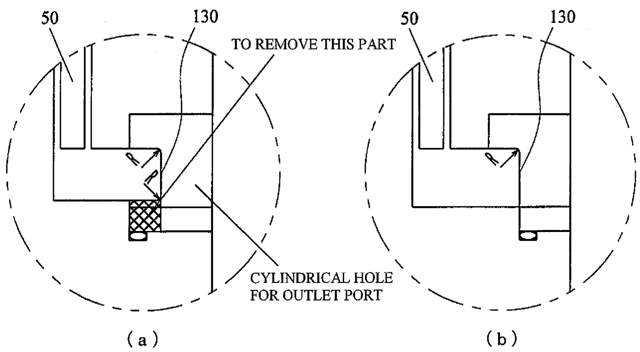
(54) **VACUUM PUMP AND MEMBER USED FOR VACUUM PUMP**

(57) To provide a vacuum pump in which possibilities of decreased exhaust performance and gas leakage at the time of breakage of a rotor are lessened, in the case where a rotating part closes the inside opening portion of an exhaust outlet portion to decrease the height dimension of the vacuum pump, and further a connector lead wire is installed easily.

An inside opening edge portion of a gas discharge passage for combining the downstream space of the rotor with the exhaust outlet portion is caused to take a shape such that the opening edge portion has no blind portion when a gas exhaust passage forming member is viewed from at least either of an upper side or an oblique upper side, or from at least either of an lower side or an oblique lower side. Furthermore, the inner corner portion of this opening edge portion is formed into a rounded shape to reduce stress concentration. Also, a base is provided with a groove for combining a lead wire installing hole with a hole in the central part, and further the corners of these parts are formed into a rounded shape.

Fig.3



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Description

[0001] The present invention relates to a vacuum pump such as a turbomolecular pump performing gas evacuation from a vacuum container such as a process chamber used in a semiconductor fabrication apparatus. More particularly, the present invention relates to a technique for improving the evacuation performance that decreases depending on the arrangement positions of an outlet port and a connector, and for reducing the size of a vacuum pump.

[0002] A multiple-stage blade pump in which a rotary blade section and a cylindrical threaded section are combined is widely used as a large-flow-rate pump such as a turbomolecular pump.

[0003] FIG. 9 illustrates an example of such a multiple-stage blade pump. This multiple-stage blade pump 200 is constituted by a tubular casing 20 having, formed in the upper portion thereof, an inlet port 10 for sucking in the gas from a chamber that is not shown in the figure, a plurality of rotary blades 32 that are provided at a rotating body 30 inside the casing 20, fixed blades 40 provided alternately with the rotary blades 32, a thread groove spacer 45 and a rotary blade cylindrical portion 50 constituting a spiral groove portion 80 where evacuation is performed by drag action, a disk-shaped base 70 covering the lower portion of the casing 20, an outlet port 90 for evacuating the gas evacuated from the upstream side where the inlet port is located to the outside on the downstream side, a connector 100 that is electrically connected to an externally located controller for controlling the pump, and a rear lid 110 that covers the bottom portion.

[0004] The rotating body 30 is contactless supported and position controlled by magnetic levitation implemented by radial bearings 34, 36 and a thrust bearing 38. The rotating body 30 is rotatably driven at a high speed by a drive motor 60. When the rotating body 30 rotates at a high speed, the rotary blades 32 provided at the rotating body 30 simultaneously rotate at a high speed such that these rotary blades 32 interact with the alternately disposed stator blades 40, whereby evacuation is performed.

[0005] Turbomolecular pumps generally have a back pressure dependence, that is, the pump performance is affected by the pressure on the back pressure side (outlet port side). Accordingly, in a multiple-stage blade pump, a low pressure is maintained on the inlet port side and the back pressure is increased, thereby improving the pump performance, by enlarging the diameter of the spiral groove portion 80 and increasing the axial length of the spiral groove portion 80.

[0006] However, multiple-stage blade pumps should be designed with consideration for restrictive conditions relating to the installation thereof. In particular, where the length of the spiral groove portion 80 is increased, the axial length of the pump itself is also increased causing problems in installation.

[0007] Japanese Patent Application Publication No. 2008-163857 discloses a technique for preventing the reduction of the opening area of outlet port inside the pump and the degradation of exhaust performance caused by the extension of the spiral groove portion. Thus, when the rotary section of the pump blocks a opening portion of the outlet port inside the pump, the exhaust performance is degraded because the reduction of the opening decreases the conductance and prevents the flow of gas into the outlet port.

[0008] Accordingly, with the aforementioned technique, a U-shaped groove for which the radial direction from the inner side serves as a depth direction is provided with respect to a cylindrical hole connecting the spiral groove portion with the outlet port provided in the base or thread groove spacer. The reduction in the opening area of outlet port is thereby prevented. As a result, the exhaust performance of the pump is improved.

[0009] However, where a U-shaped groove is provided from the inside with respect to the cylindrical hole leading to the outlet port according to the technique described in Japanese Patent Application Publication No. 2008-163857, special cutting tools and settings are required during turning and the machining is difficult. Further, even if the machining is successful, significant time and efforts are required therefor and the production cost rises.

[0010] Further, where the housing is manufactured by casting, since the concave groove exists on the inner side, the cast housing is difficult to remove from the mold, the mold structure becomes complex, and the casting cost rises significantly.

[0011] In addition, where the spiral rotor is broken during rotation, the broken pieces thereof collide with the spiral stator and a force acts on the spiral stator or on the housing via the spiral stator. In this case, stress concentration occurs in the corners of the formed groove, thereby creating weak points in terms of the pump strength and reducing the strength of the pump itself.

[0012] Further, in a dry etching apparatus, which is one of semiconductor fabrication apparatuses, where the pressure of process gas that has taken part in a reaction inside the chamber increases, the increase in temperature over the normal temperature results in a phase transition from a gaseous state to a solid state. For this property, when a multiple-stage blade pump is used for evacuating a dry etching apparatus, the solidified reaction products of the process gas are deposited on the spiral groove portion where the gas pressure rises, thereby degrading the exhaust performance of the pump. For this reason, the reaction products that have deposited on the interior portions of the pump should be removed periodically. However, a cleaning agent or a removal tool is difficult to insert into the U-shaped groove and therefore the removal operation becomes difficult.

[0013] Furthermore, when the reaction products are removed, it is necessary to confirm visually that all of the reaction products have been removed. Since the process gas in the dry etching apparatus is typically highly corrosive, it is also necessary to verify visually after the removal whether corrosion is present on the gas flow channel surface of the housing or spiral stator and whether the surface film such as a plated film provided for corrosion protection has peeled off from the surface, and where such defects are present, they should be repaired. Where portions of the gas flow channel surface cannot be visually inspected, the residues of corrosion products or corrosion can remain unnoticed on such portions and the vacuum pump is restarted in the unrepaired state. Another problem is that when the corrosion advances, the strength of the spiral stator or housing decreases and the abovementioned rotor fracture occurs, the spiral stator and housing can be fractured and the gas can leak therethrough. With the U-shaped groove, such as that of the conventional technique, the portion that cannot be visually inspected can be reduced in size by decreasing the groove depth. However, the problem arising in this case is that because the groove is shallow, a sufficient opening area cannot be ensured.

[0014] Another problem is associated with a connector. A turbomolecular pump has a connector serving to connect the pump to a controller for power supply to the motor or magnetic bearings or input/output of signals. The pump structure is such that the hole for passing the connector wiring is completely isolated from the exhaust flow channel. Such a structure is used because if the exhaust flow channel and the hole are connected and gas flows to the connector, the exhaust performance is degraded or the connector is corroded. In some cases, it can result in accidents and cause significant problems for the pump.

[0015] Further, when the height position of the lower end of the spiral groove portion is below the height position of the hole for connector wiring, the opening area of the hole for connector wiring should be reduced and the operation of passing the wiring from the motor or magnetic bearings to the connector becomes complex. Accordingly, the problem associated with the connector is similar to that relating to the outlet port. Namely, the increase in the spiral groove portion length requires the vacuum pump height to be increased.

[0016] Such a problem relating to the connector is not taken into account in the above-described conventional technique.

[0017] It is the first object of the present invention to provide a vacuum pump in which the decrease in exhaust performance occurring when the spiral groove portion is extended or positioned further below inside the pump with the object of reducing the size of the vacuum pump can be prevented.

[0018] It is the second object of the present invention to provide a vacuum pump in which the operability of connector wiring that decreases when the spiral groove portion is extended or positioned further below inside the pump with the object of reducing the size of the vacuum pump can be improved.

[0019] The invention described in claim 1 provides a vacuum pump which includes an inlet port, a motor, a rotating body rotatably driven by the motor, a stator located facing the rotating body, and an outlet port for exhausting a gas that has been sucked in through the inlet port, and a gas exhaust passage combining a downstream space of the rotating body with the outlet port is formed in a flow channel of the gas, and the rotating body extends into an inner circumferential side in a radial direction of the rotating body, of the gas exhaust passage, wherein no blind portion exists at an opening edge portion of the gas exhaust passage, of the downstream space side when a gas exhaust passage forming member that forms the gas exhaust passage is viewed from at least either of an upper side or an oblique upper side, or from at least either of a lower side or an oblique lower side.

[0020] The invention described in claim 2 provides the vacuum pump according to claim 1, wherein the gas exhaust passage forming member is the stator.

[0021] The invention described in claim 3 provides the vacuum pump according to claim 1, further including a casing that covers an outer circumferential side of the rotating body and/or the stator, wherein the gas exhaust passage forming member is the casing.

[0022] The invention described in claim 4 provides the vacuum pump according to claim 1, further including a housing or a base member that supports the stator, wherein the gas exhaust passage forming member is the housing or the base member.

[0023] The invention described in claim 5 provides the vacuum pump according to claim 1, further including an outlet port member that forms the outlet port and extends inward the vacuum pump, wherein the gas exhaust passage forming member is the outlet port member.

[0024] The invention described in claim 6 provides the vacuum pump according to any one of claims 1 to 5, wherein an inner corner portion of the opening edge portion has a rounded inner corner shape that reduces stress concentration.

[0025] The invention described in claim 7 provides a vacuum pump which includes an inlet port, a motor, a rotating body rotatably driven by the motor, a stator located facing the rotating body, and an outlet port for exhausting a gas that has been sucked in through the inlet port, and a gas exhaust passage combining a downstream space of the rotating body with the outlet port is formed in a flow channel of the gas, and the rotating body extends into an inner circumferential side in a radial direction of the rotating body, of the gas exhaust passage, wherein an inner corner portion of an opening edge portion of the gas exhaust passage, of the downstream space side has a rounded inner corner shape that reduces stress concentration.

[0026] The effect of reducing stress concentration can be obtained even when the rounding size of the rounded inner corner portion is 0.1 mm. Even greater effect can be obtained when the rounding size is further increased.

[0027] The invention described in claim 8 provides the vacuum pump according to any one of claims 1 to 7, further including a connector for connecting a controller that controls the rotation of the rotating body, wherein the housing or the base member has a nearly coaxial hole that is nearly coaxial with a rotation center axis of the rotating body, a conductor wire insertion hole into which a conductor wire that connects the connector and the motor is inserted, and a groove that combines the nearly coaxial hole with the conductor wire insertion hole.

[0028] The controller may be directly connected to the connector or may be connected by a cable.

[0029] The invention described in claim 9 provides a vacuum pump which includes an inlet port, a motor, a rotating body rotatably driven by the motor, a stator located facing the rotating body, a housing or a base member supporting the stator, and a connector for connecting a controller that controls the rotation of the rotating body, wherein the housing or the base member has a nearly coaxial hole that is nearly coaxial with a rotation center axis of the rotating body, a conductor wire insertion hole into which a conductor wire that connects the connector and the motor is inserted, and a groove that combines the nearly coaxial hole with the conductor wire insertion hole.

[0030] The invention described in claim 10 provides the vacuum pump according to claim 8 or 9, wherein an edge of at least one from the nearly coaxial hole, the conductor wire insertion hole, and the groove has a rounded outer corner shape such that damage of the conductor wire caused by contact with the edge is reduced.

[0031] The invention described in claim 11 provides the vacuum pump according to any one of claims 8 to 10, wherein an outer circumferential end of the groove in the radial direction of the rotating body is positioned further toward the outer circumferential side than an inner circumferential end of the conductor wire insertion hole.

[0032] The invention described in claim 12 provides a member for use in a vacuum pump which includes an inlet port, a motor, a rotating body rotatably driven by the motor, a stator located facing the rotating body, and an outlet port for exhausting a gas that has been sucked in through the inlet port, and a gas exhaust passage combining a downstream space of the rotating body with the outlet port is formed in a flow channel of the gas, wherein no blind portion exists at an opening edge portion of the gas exhaust passage, of the downstream space side when the member is viewed from at least either of an upper side or an oblique upper side, or from at least either of a lower side or an oblique lower side.

[0033] Examples of the aforementioned member include the stator, casing, housing, base member, and outlet port member extending inward of the vacuum pump, which constitute the vacuum pump.

[0034] In accordance with the present invention, the decrease in exhaust performance of the vacuum pump occurring when the spiral groove portion of the pump is extended or positioned further below inside the pump can be prevented.

[0035] Further, in accordance with the present invention, the degradation of wiring operability that decreases when the spiral groove portion is extended or positioned further below inside the pump can be reduced.

FIG. 1 is a vertical sectional view illustrating a multiple-stage blade pump in which an outlet port is provided in a thread groove spacer according to the first embodiment;
FIG. 2 is vertical sectional view illustrating a multiple-stage blade pump in which an outlet port is provided in a base according to the first embodiment;
FIG. 3 illustrates the first embodiment relating to the case in which the outlet port is provided in the thread groove spacer;
FIG. 4 illustrates the first embodiment relating to the case in which the outlet port is provided in the base;
FIG. 5 relates to an example in which a cylindrical hole is formed as a gas evacuation passage in the thread groove spacer and illustrates the blind portions;
FIG. 6 illustrates how the thread groove spacer is viewed directly from a lower side and an oblique lower side;
FIG. 7 illustrates how the base is viewed directly from an upper side and an oblique upper side;
FIG. 8 illustrates the second embodiment; and
FIG. 9 is a vertical sectional view illustrating an example of the conventional multiple-stage blade pump.

[0036] The preferred embodiment of the vacuum pump in accordance with the present invention will be explained below in greater detail with reference to FIGS. 1 to 8.

[0037] FIGS. 1 and 2 are vertical sectional views illustrating the configuration of the multiple-stage blade pump using the present invention.

[0038] FIG. 1 illustrates an example where an outlet port is provided in a thread groove spacer 45 serving as a stator. FIG. 2 illustrates an example where an outlet port is provided in a base 70 serving as a base member. In the explanation of FIGS. 1 to 8, the members identical to those in FIG. 9 that illustrates the conventional example will be assigned with same reference numerals.

[0039] The first embodiment relates to a technique for improving the exhaust performance of a vacuum pump that has decreased because a rotary blade cylindrical portion 50 serving as a rotating body or a thread groove spacer 45 covers the opening of a cylindrical hole 45a or 70a serving as a gas exhaust passage combining an outlet port 90 with a downstream space S of the rotary blade cylindrical portion 50 on the space S side.

[0040] In this embodiment, a thread groove spacer 45 serving as a gas exhaust passage forming member in the configuration shown in FIG. 1 and the base 70 serving as a gas exhaust passage forming member in the configuration shown in FIG. 2 form the cylindrical hole 45a or 70a as shown in FIGS. 3B and 4B. The opening edge portion 130 of the cylindrical hole 45a on the space S side in the thread groove spacer 45 is formed such that no blind portion exists at the opening edge portion 130 when the thread groove spacer 45 is viewed from at least either of the lower side or the oblique lower side.

[0041] The opening edge portion 130 of the cylindrical hole 70a on the space S side in the base 70 is formed such that no blind portion exists at the opening edge portion 130 when the base 70 is viewed from at least either of the upper side or the oblique upper side.

[0042] FIG. 5 is an explanatory drawing illustrating the blind portions in the case where the cylindrical hole 45a is formed as the gas exhaust passage in the thread groove spacer 45. In FIG. 5, because the cross-hatched portion exists, blind portions exist at the opening edge portion 130 when the thread groove spacer 45 is viewed from at least either of the lower side or the oblique lower side. By contrast, in the present embodiment, in the cylindrical hole 45a formed by the thread groove spacer 45, the opening edge portion 130 is formed such that no blind portion exists at the opening edge portion 130 when the thread groove spacer 45 is viewed from at least either of the lower side or the oblique lower side. When the thread groove spacer 45 is viewed from at least either of the lower side or the oblique lower side, the field of view such as the cross-hatched portion in FIG. 5 is not blocked. Therefore, the entire opening edge portion 130 can be seen. In accordance with the present invention, no blind portion exists in such a state.

[0043] Meanwhile, in the cylindrical hole 70a formed by the base 70, the opening edge portion 130 is formed such that no blind portion exists at the opening edge portion 130 when the base 70 is viewed from at least either of the upper side or the oblique upper side. When the base 70 is viewed from at least either of the upper side or the oblique upper side, the field of view such as the cross-hatched portion in FIG. 5 is not blocked. Therefore, the entire opening edge portion 130 can be seen.

[0044] The definition of the "upper side", "oblique upper side", "lower side", and "oblique lower side" will be explained below. FIG. 6 shows the thread groove spacer 45 and FIG. 7 shows the base 70. As shown in FIGS. 6 and 7, when these components are assembled in the multiple-stage blade pump, the inlet port is on the upper side and the pump bottom is on the lower side. Thus, the C side of the center line C-C' is taken as the upper side and the C' side is taken as the lower side. Further, the C side of a straight line forming an angle α less than 90 degrees with the center line C-C' is taken as the oblique upper side and the C' side meeting such a requirement is taken as the oblique lower side. The absence of an blind portion at the opening edge portion 130 when the thread groove spacer 45 is viewed from at least either of the lower side or the oblique lower side means that any portion of the opening edge portion 130 is included in at least either of the visible portion of the opening edge portion 130 when it is viewed from the lower side or the visible portion of the opening edge portion 130 when it is viewed from the oblique lower side. The absence of a blind portion at the opening edge portion 130 when the base 70 is viewed from at least either of the upper side or the oblique upper side means that any portion of the opening edge portion 130 is included in at least either of the visible portion of the opening edge portion 130 when it is viewed from the upper side or the visible portion of the opening edge portion 130 when it is viewed from the oblique upper side.

[0045] The outer side of the outlet port 90 is connected by a pipe to an auxiliary pump having the usual suction power.

[0046] In the above-described related art, a U-shaped groove is formed in the opening edge portion 130 of the cylindrical hole combining the outlet port 90 with the downstream space S of the rotary blade cylindrical portion 50, the groove being formed on the space S side of the cylindrical hole. FIGS. 3A and 4A illustrate an example in which the conventional U-shaped groove is formed. With the conventional technique, the inner corner portion of the opening edge portion 130 does not have the rounded inner corner shape such as shown in these figures.

[0047] Cylindrical shapes and cavities thereof are usually machined by turning, and when a groove is bored in the direction perpendicular to the center axial line of the cylinder in the inner wall of the cavity portion, the cutting cannot be performed to the necessary depth or the cutting process becomes complex and the production cost rises due to the restrictions such as a machinable range of the cutting tool (bite). However, with the shape of the opening edge portion 130 of the present embodiment, cutting may be performed so as to bore a hole that becomes coaxial with the cylindrical outer circumferential surface in the center axial line direction of the cylinder and therefore the machining in the turning process is facilitated.

[0048] Furthermore, when the thread groove spacer 45 or base 70 is cast, since no concave groove exists on the inner wall of the hollow portion, the mold structure does not become complex and the cast article can be easily removed from the mold, thereby making it possible to reduce the casting cost.

[0049] Further, with the present embodiment, the operation of removing the deposited reaction products, verifying the presence of corrosion on the thread groove spacer 45 or base 70, and repairing the corrosion are not complex. Therefore, the residual amount of reaction products and leak caused by poor repair of corrosion can be reduced.

[0050] Further, since the cross-hatched portions shown in FIGS. 3A and 4A do not exist, the rotary blade cylindrical portion 50 can be moved further down or the vacuum pump height can be further reduced.

[0051] As a variation example of the first embodiment, a structure is considered in which the inner corner portion of the opening edge portion 130 of the cylindrical hole 45a on the space S side is rounded as shown in FIG. 3B, and stress concentration is reduced. In a vacuum pump, in particular a turbomolecular pump, the rotary blade 32 and the rotary blade cylindrical portion 50 rotate at a high speed during operation and a large centrifugal force acts thereupon. Where the material strength decreases due to corrosion or temperature increase caused by friction with the gas or the like, the resistance to the centrifugal force decreases and the pump is fractured. Where the rotary blade cylindrical portion 50 is fractured in high-speed rotation, the rotary blade cylindrical portion is often split into 3 to 4 sections and these split cylindrical sections collide with the thread groove spacer 45. As a result a force is applied to the thread groove spacer 45 and to the base 70 via the thread groove spacer 45. The rotary blade 32 and rotary blade cylindrical portion 50 usually rotate as a speed equal to or higher than 10,000 rpm, and where they are fractured the rotation energy thereof is released. Therefore, the force acting upon the thread groove spacer 45 or base 70 becomes very strong. When such a force is received, large stresses are generated in the thread groove spacer 45 and base 70. In the case of the conventional U-shaped groove, stress concentration occurs in the inner corner portions of the groove and cracks can initiate from the stress concentration zones. The cracks can cause fracture and destruction of the thread groove spacer 45 or base 70 that can result in the gas leaking to the outside of the pump. This gas leak adversely affects the environment. When the inner corner portion of the opening edge portion 130 of the cylindrical hole 45a or 70a on the spacer S side is machined to a rounded shape, as in the present embodiment, the stress concentration can be reduced. As a result, the strength of the pump itself can be increased and the probability of gas leak can be reduced. Further, in the present embodiment, only one inner corner portion exists, by contrast with the conventional U-shaped groove having two inner corner portions and the number of stress concentration zones is small. Therefore, the probability of gas leak can be further reduced.

[0052] The inner corner portions of the conventional U-shaped groove may be also rounded as shown in FIGS. 3A and 4A.

[0053] The second embodiment in which the problems associated with the connector are resolved will be explained below.

[0054] FIG. 8 is the view of the base 70 taken from the rear lid 110. As shown in the figure, a structure is obtained in which when the connector wiring hole 120 serving as a conductor wire insertion hole is drilled in the base 70 from the outer circumferential side, the drilling is performed to the outer circumferential side in the radial direction of the rotary blade cylindrical portion 50 and a groove 102 is provided from the bottom surface of the base 70 so as to combine the connector wiring hole 120 with the hole 101 that is nearly coaxial with the rotation center axial line of the rotary blade cylindrical portion 50.

[0055] In the present embodiment, as shown in FIG. 8, the connector wiring hole 120 is drilled as far as the outer circumferential side of the rotary blade cylindrical portion 50, rather than linearly to the hole 101 in order to avoid interference of the connector wiring hole 120 with the rotary blade cylindrical portion 50 or with the space S for the gas flow channel located therebelow. Where the connector wiring hole 120 interferes and is combined with the space S for the gas flow channel, the gas flows into the connector wiring hole 120 and the connector is corroded.

[0056] Further, as shown in FIG. 8, the outer corners formed in the connector wiring hole 120 and groove 102 can have the rounded outer corner shape. In such a case, a structure can be obtained in which the connector 100 and the conductor wire connected to the motor or magnetic bearings are unlikely to be damaged.

[0057] Further, the end o of the groove 102 on the outer circumferential side of the pump is located on the outside of the end i of the connector wiring hole 120 on the inner circumferential side of the pump. This is done so because by increasing the distance "L" between the two ends "o" and "I" it is possible to ensure a larger pass-through area from the groove 102 to the connector 100.

[0058] According to this embodiment, where the depth of the groove 102 is reduced within a range in which the minimum pass-through area necessary for the wiring of the conductor wire can be ensured, the rotary blade cylindrical portion 50 or the space S for the gas flow channel located therebelow can be disposed at a lower level. Since the wiring of the conductor wire to the connector 100 is also performed by the groove of the shape obtained by cutting the wall below the inner circumferential portion of the connector wiring hole 120, the wiring connection is facilitated. Consequently, the production time of the pump can be reduced.

[0059] As a result, the rotary blade cylindrical portion 50 and the space S for the gas flow channel located therebelow can be enlarged in length to reach the lower level or disposed at the lower level without interfering with the connector wiring hole 120. In addition, the connector 100 can be provided at a height greater than that in the conventional pump. As a result, the vacuum pump can be reduced in height.

[0060] Further, with the above-described embodiment, the machined shape of the base 70 can be simplified and the production cost thereof can be reduced, without changing significantly the structure of the conventional pump.

10	Inlet port
20	Casing
30	Rotating body
32	Rotary blade
34,	36 Radial bearings
38	Thrust bearing
40	Fixed blade
45	Thread groove spacer
45a	Cylindrical hole
50	Rotary blade cylindrical portion
60	Drive motor

70	Base
70a	Cylindrical hole
80	Spiral groove portion
90	Outlet port
100	Connector
110	Rear lid
120	Connector wiring hole
130	Opening edge portion

Claims

1. A vacuum pump comprising:

an inlet port;
a motor;
a rotating body rotatably driven by the motor;
a stator located facing the rotating body;
an outlet port for exhausting a gas that has been sucked in through the inlet port; and
a gas exhaust passage combining a downstream space of the rotating body with the outlet port and being formed in a flow channel of the gas,
and the rotating body extending into an inner circumferential side in a radial direction of the rotating body, of the gas exhaust passage,
wherein no blind portion exists at an opening edge portion of the gas exhaust passage, of the downstream space side when a gas exhaust passage forming member that forms the gas exhaust passage is viewed from at least either of an upper side or an oblique upper side, or from at least either of a lower side or an oblique lower side.

2. The vacuum pump according to claim 1, wherein the gas exhaust passage forming member is the stator.

3. The vacuum pump according to claim 1, further comprising a casing that covers an outer circumferential side of the rotating body and/or the stator, wherein the gas exhaust passage forming member is the casing.

4. The vacuum pump according to claim 1, further comprising a housing or a base member that supports the stator, wherein
the gas exhaust passage forming member is the housing or the base member.

5. The vacuum pump according to claim 1, further comprising an outlet port member that forms the outlet port and extends inward the vacuum pump, wherein the gas exhaust passage forming member is the outlet port member.

6. The vacuum pump according to any one of claims 1 to 5, wherein an inner corner portion of the opening edge portion has a rounded inner corner shape that reduces stress concentration.

7. A vacuum pump comprising:

an inlet port;
a motor;
a rotating body rotatably driven by the motor;
a stator located facing the rotating body; and
an outlet port for exhausting a gas that has been sucked in through the inlet port;
and a gas exhaust passage combining a downstream space of the rotating body with the outlet port is formed in a flow channel of the gas,
and the rotating body extends into an inner circumferential side in a radial direction of the rotating body, of the gas exhaust passage,
wherein an inner corner portion of an opening edge portion of the gas exhaust passage, of the downstream space side has a rounded inner corner shape that reduces stress concentration.

8. The vacuum pump according to any one of claims 1 to 7, further comprising a connector for connecting a controller that controls the rotation of the rotating body, wherein
the housing or the base member has a nearly coaxial hole that is nearly coaxial with a rotation center axis of the rotating body, a conductor wire insertion hole into which a conductor wire that connects the connector and the motor is inserted, and a groove that combines the nearly coaxial hole with the conductor wire insertion hole.

9. A vacuum pump comprising:

an inlet port;
a motor;
a rotating body rotatably driven by the motor;
a stator located facing the rotating body;
a housing or a base member supporting the stator; and
a connector for connecting a controller that controls the rotation of the rotating body;
wherein the housing or the base member has a nearly coaxial hole that is nearly coaxial with a rotation center axis of the rotating body, a conductor wire insertion hole into which a conductor wire that connects the connector and the motor is inserted, and a groove that combines the nearly coaxial hole with the conductor wire insertion hole.

10. The vacuum pump according to claim 8 or 9, wherein an edge of at least one from the nearly coaxial hole, the conductor wire insertion hole, and the groove has a rounded outer corner shape such that damage of the conductor wire caused by contact with the edge is reduced.

11. The vacuum pump according to any one of claims 8 to 10, wherein
an outer circumferential end of the groove in the radial direction of the rotating body is positioned further toward the outer circumferential side than an inner circumferential end of the conductor wire insertion hole.

12. A member for use in a vacuum pump comprising:

an inlet port;
a motor;
a rotating body rotatably driven by the motor;
a stator located facing the rotating body; and
an outlet port for exhausting a gas that has been sucked in through the inlet port;
and a gas exhaust passage combining a downstream space of the rotating body with the outlet port and being formed in a flow channel of the gas,
wherein no blind portion exists at an opening edge portion of the gas exhaust passage, of the downstream space side when the member is viewed from at least either of an upper side or an oblique upper side, or from at least either of a lower side or an oblique lower side.

Fig.1

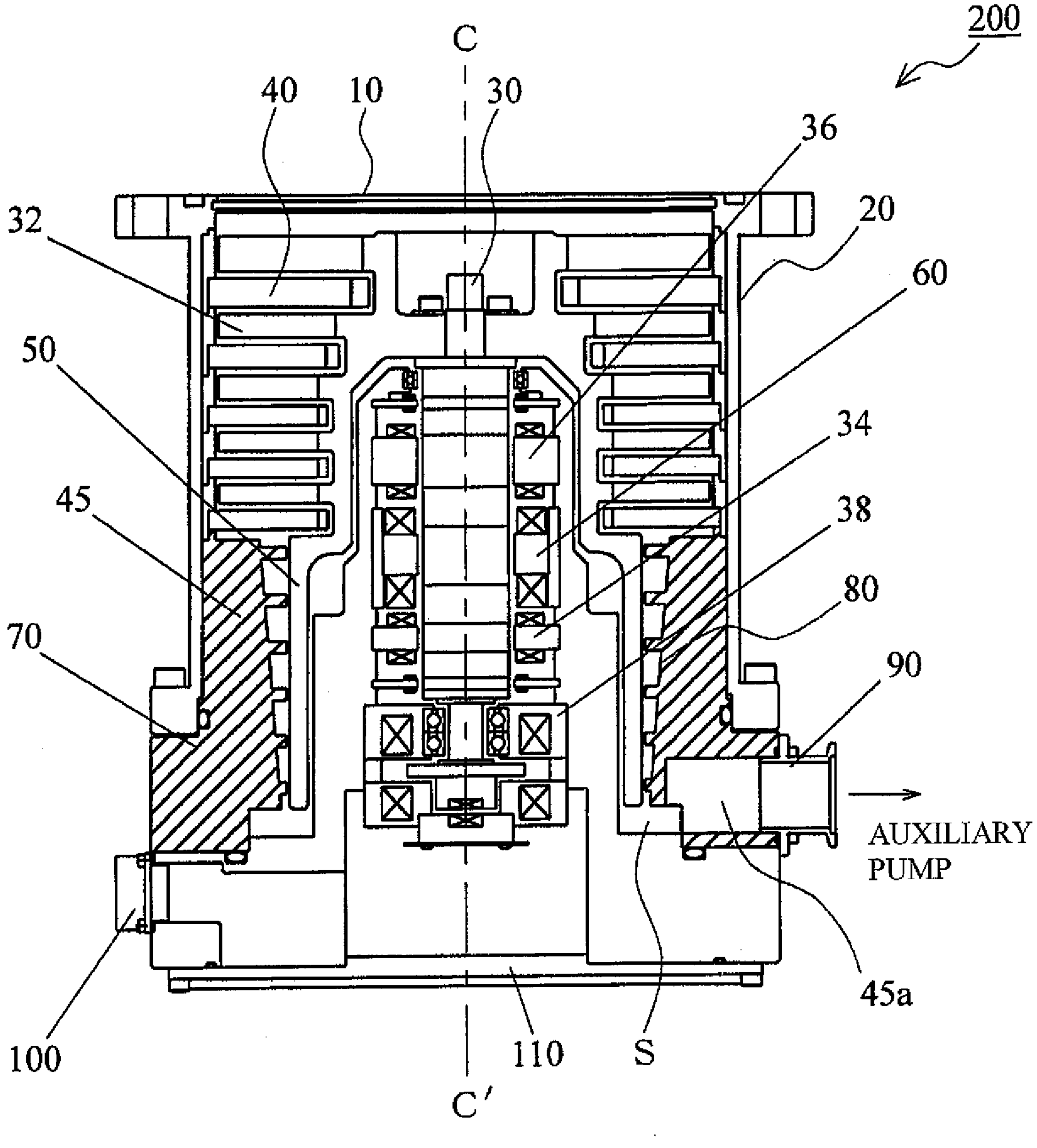

200
C
40
10
30
36
20
32
60
50
34
45
38
80
70
90
AUXILIARY
PUMP
45a
100
110
S
C′

Fig.2

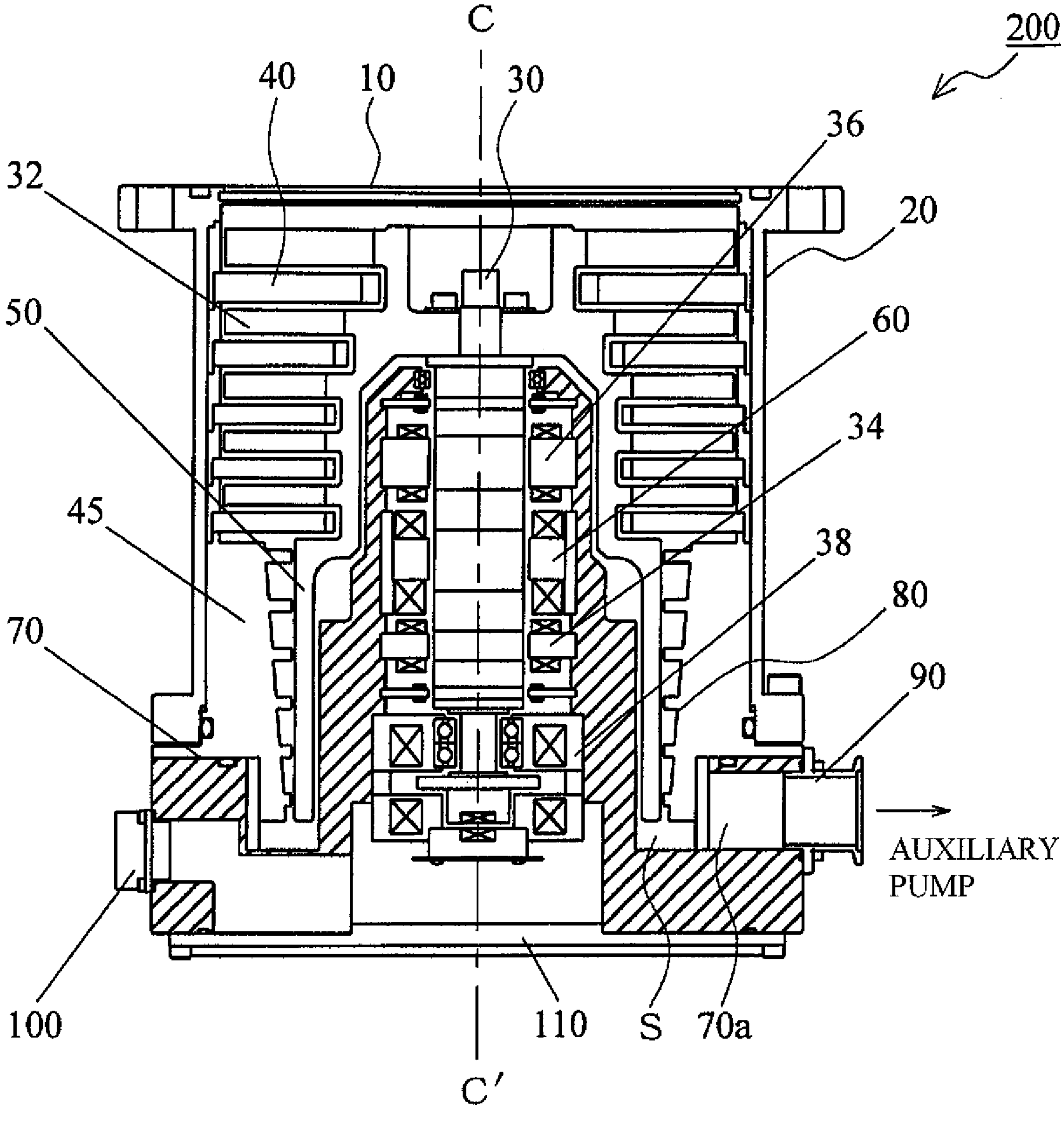

C
200
40
10
30
36
32
20
50
60
34
45
38
80
70
90
AUXILIARY
PUMP
100
110
S
70a
C′

Fig.3

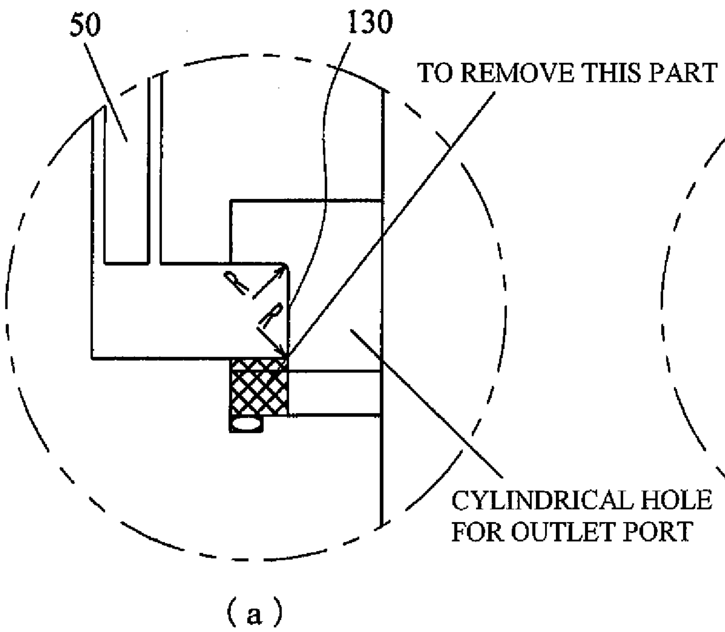

50
130
TO REMOVE THIS PART
R
R
CYLINDRICAL HOLE
FOR OUTLET PORT
(a)
50
130
R
(b)

Fig.4

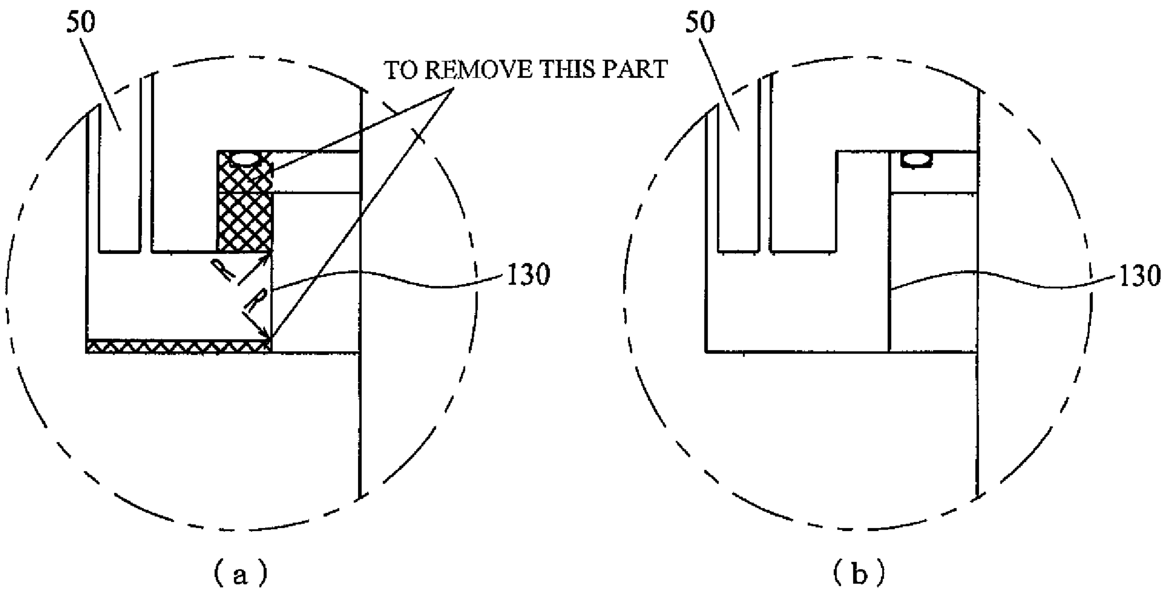

50
TO REMOVE THIS PART
R
R
130
(a)
50
130
(b)

Fig.5

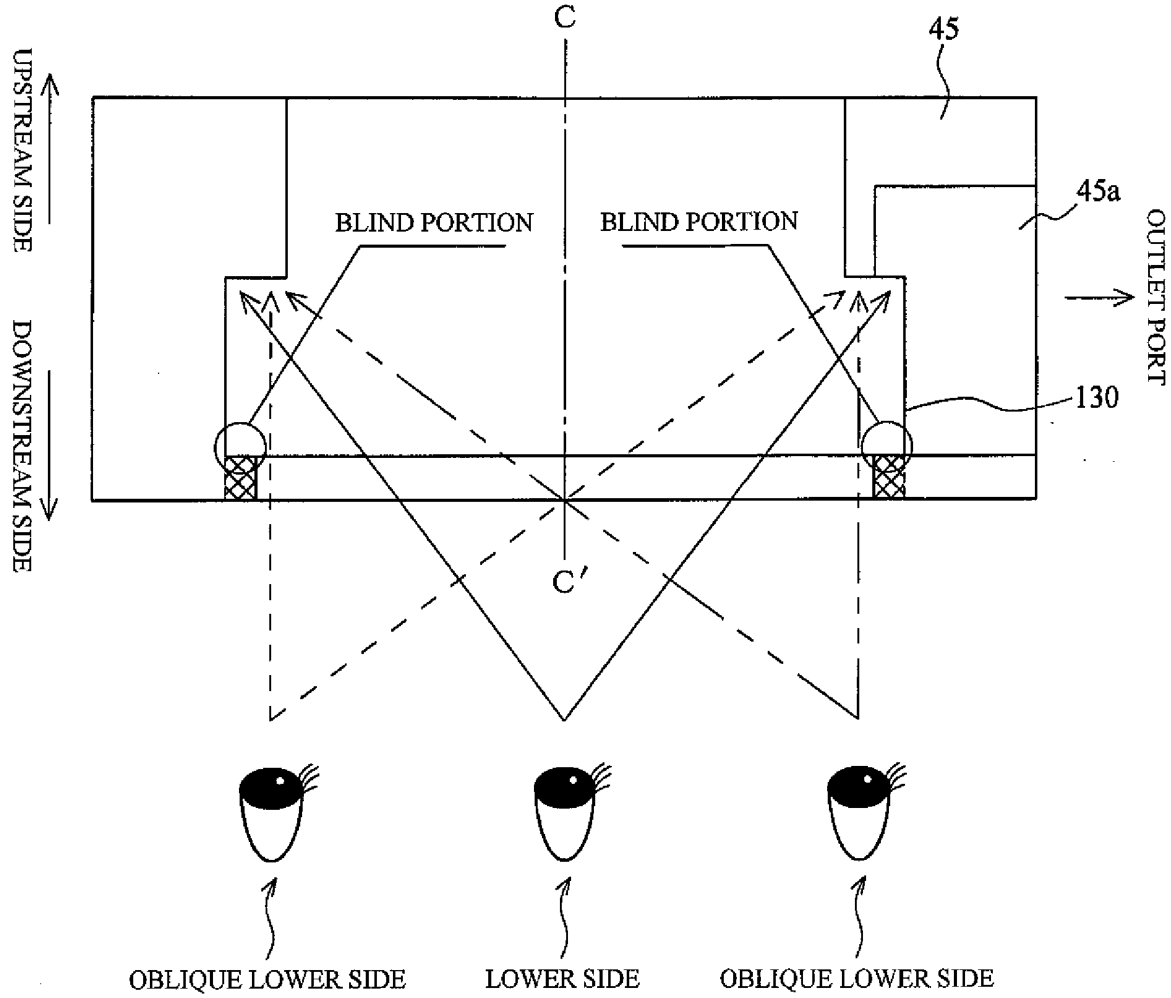

C
45
45a
UPSTREAM SIDE
DOWNSTREAM SIDE
BLIND PORTION
BLIND PORTION
OUTLET PORT
130
C′
OBLIQUE LOWER SIDE
LOWER SIDE
OBLIQUE LOWER SIDE

Fig.6

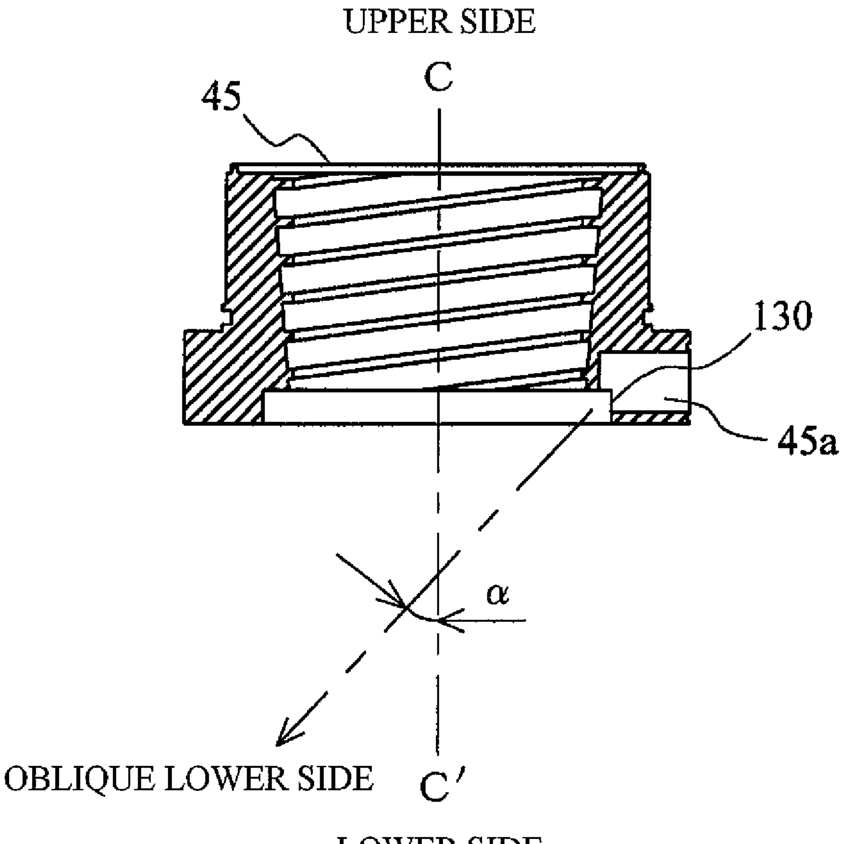


Fig.7

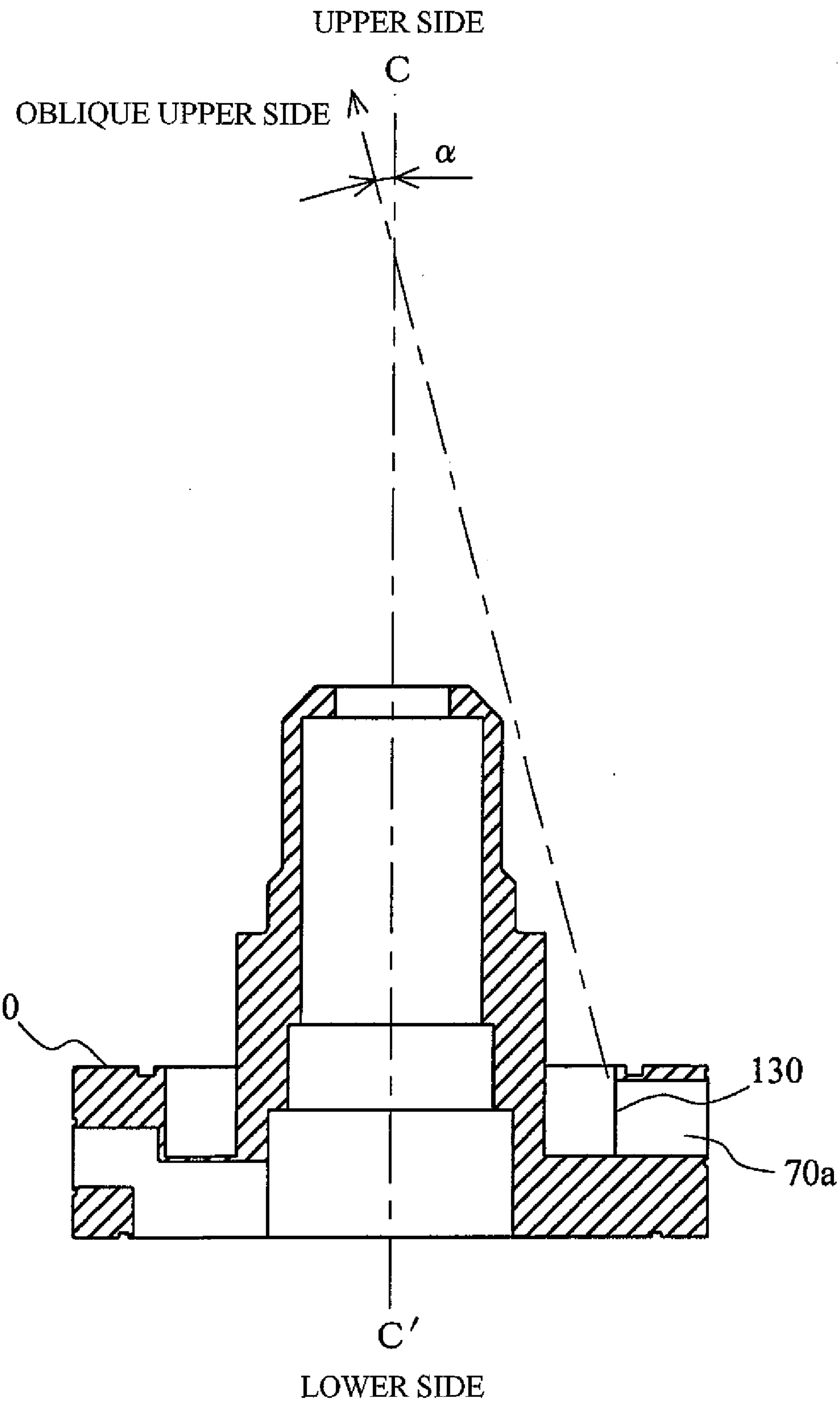


Fig.8

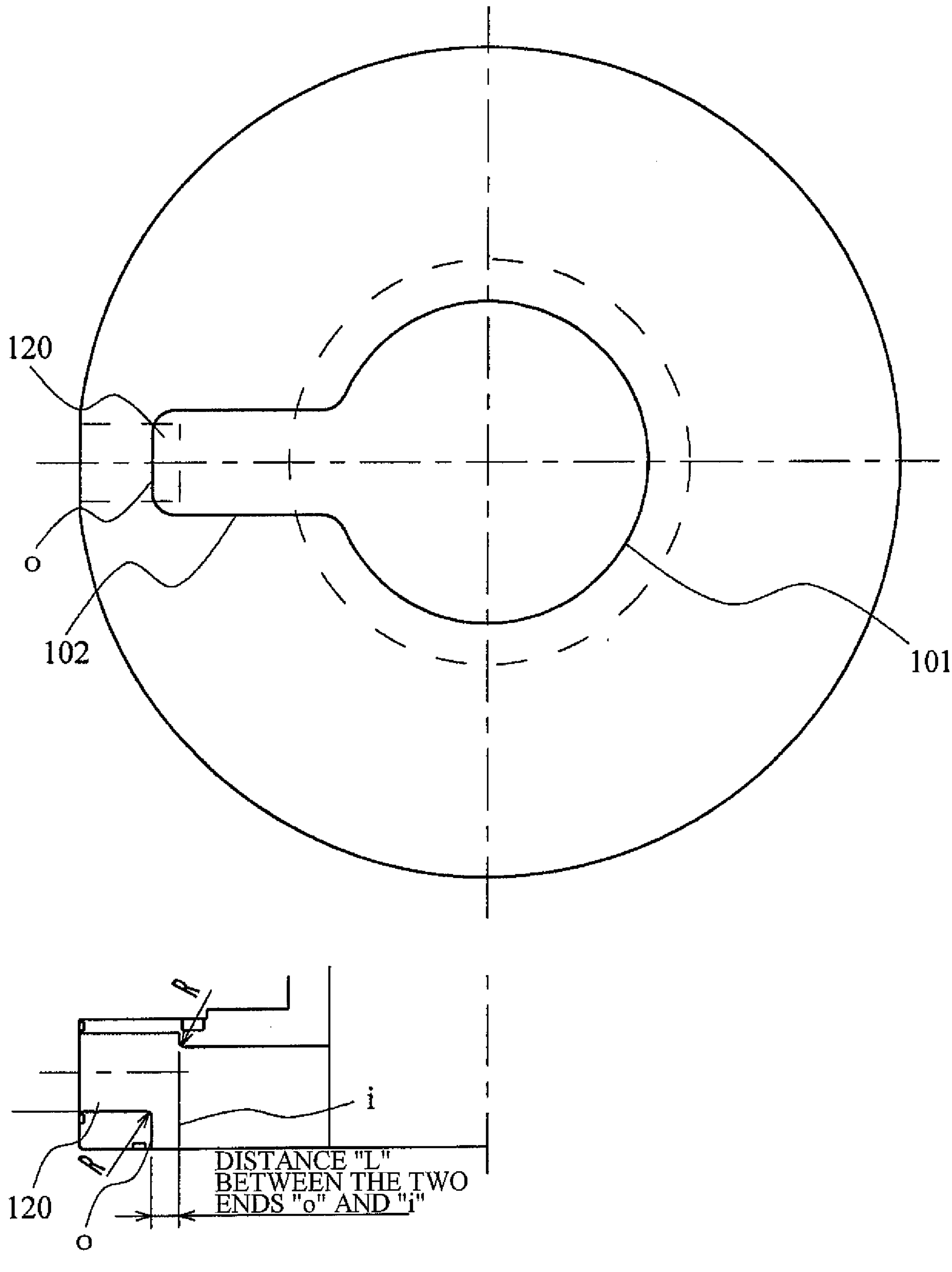
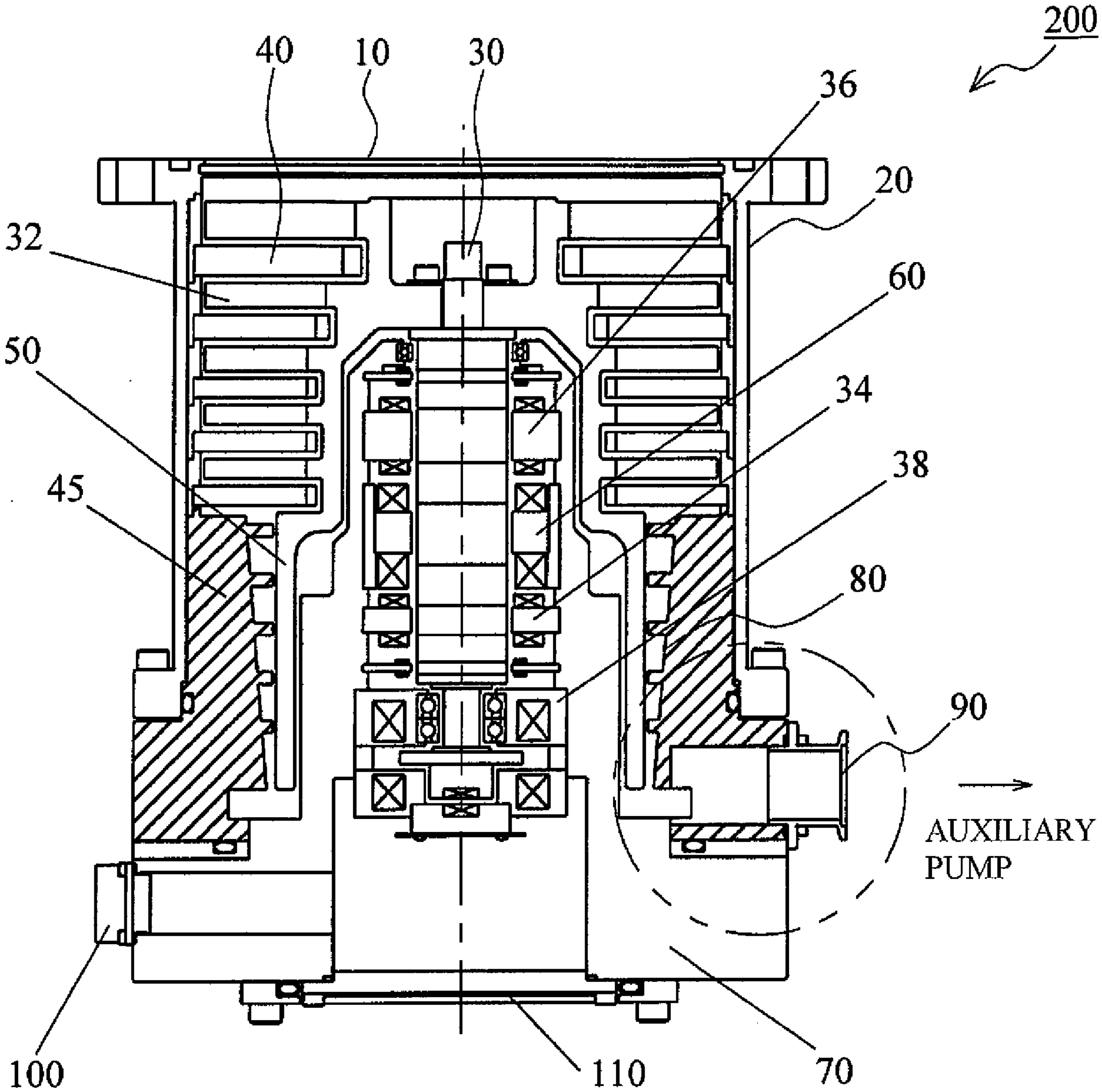


Fig.9


200
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30
36
20
32
60
50
34
45
38
80
90
AUXILIARY
PUMP
100
110
70

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/059186

A. CLASSIFICATION OF SUBJECT MATTER
F04D19/04(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)
F04D19/04

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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2003-278691 A (BOC Edwards Technologies, Ltd.), 02 October 2003 (02.10.2003), fig. 7 (Family: none)	1-2,6-7,12
X	JP 5-272478 A (Matsushita Electric Industrial Co., Ltd.), 19 October 1993 (19.10.1993), fig. 11 & US 5478210 A	1-2,6-7,12

☐ 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
11 August, 2010 (11.08.10)	24 August, 2010 (24.08.10)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/059186

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.:
Claims 1, 2, 6, 7 and 12.

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.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/059186

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

Document 1 discloses the constitutions of "a vacuum pump comprising an air inlet opening, a motor, a rotary body to be rotationally driven by said motor, a stator arranged to face said rotary body, and an air outlet opening for discharging the gas sucked through said air inlet opening, wherein the passage of said gas has a gas discharge passage formed therein for providing the communication between the space downstream of said rotary body and said air outlet opening, and wherein said rotary body extends in said gas discharge passage on the radially inner circumference side of said rotary body, characterized in that the opening edge of said gas discharge passage on the side of said downstream space lacks the invisible section which is invisible when the gas discharge passage forming member forming said gas discharge passage is seen either from at least the upper side or the obliquely upper side or from at least the lower side or the obliquely lower side", "a vacuum pump wherein said gas discharge passage forming member is said stator", and "a member for use in a vacuum pump including an air inlet opening, a motor, a rotary body to be rotationally driven by said motor, a stator arranged to face said rotary body, and an air outlet opening for discharging the gas sucked through said air inlet opening, wherein the passage of said gas has a gas discharge passage formed therein for providing the communication between the space downstream of said rotary body and said air outlet opening, characterized in that the opening edge of said gas discharge passage on the side of said downstream space lacks the invisible section which is invisible when said member is seen either from at least the upper side or the obliquely upper side or from at least the lower side or the obliquely lower side".

Hence, the invention of claims 1, 2 and 12 is not admitted to involve any novelty to and any special technical feature over the invention disclosed in Document 1.
Moreover, the invention of claims 6 and 7 is not admitted to involve any special technical feature, since it is just such an addition of the well-known technique that a corner portion is formed into an R-shape to reduce a stress concentration.

Therefore, it is admitted that the dependent claims of claim 1 and the independent claims contain the five inventions which are related in the following individual special technical features, as indicated in the following, if the special technical features are decided.

Here, the inventions of claims 1, 2, 6, 7 and 12 having no special technical feature are grouped into Invention 1. On the other hand, the inventions of claims 8-11 cannot be grouped into Inventions 1-4, since they are hardly related, in techniques and problems, to the inventions of claims 1-7.

(continued to next extra sheet)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/059186

(Invention 1) Invention of claims 1, 2, 6, 7 and 12

Claims 1, 2, 6, 7 and 12 do not involve any special technical feature.

(Invention 2) Invention of claims 3 and 6 and with the following special technical feature

A vacuum pump "comprising a casing covering the outer circumference of said rotor and/or said stator, wherein said gas discharge passage forming member is said casing".

(Invention 3) Invention of claims 4 and 6 and with the following special technical feature

A vacuum pump "comprising a housing or base member for supporting said stator, wherein said gas discharge passage forming member is said housing or said base member".

(Invention 4) Invention of claims 5 and 6 and with the following special technical feature

A vacuum pump "comprising a discharge port member forming said discharge port and extending into said vacuum pump, wherein said gas discharge passage forming member is said discharge port member."

(Invention 5) Invention of claims 8-11 and with the following special technical feature

A vacuum pump "comprising a connector, to which a controller for controlling the rotation of said rotor is connected, wherein said housing or said base member has a substantially coaxial hole made substantially coaxial with the rotation center axis of said rotor, a conductor inserting hole, into which a conductor for connecting said connector and said motor is inserted, and a groove for providing the communication between said substantially coaxial hole and said conductor inserting hole".

Here, the invention of claim 8 is dependent on claims 1-7, and claims 1-7 are directed to an invention relating to a gas discharge passage whereas claim 8 is an invention relating to a connector section. Thus, claim 8 is an addition of a technical feature of low technical relationship is added to the invention which has been decided immediately before on the presence/absence of the special technical feature. Moreover, claim 8 is hardly related to the specific problem which is grasped from said technical feature and which is to be solved by the invention, that is, the problem to visualize the deposit which accumulates in the gas discharge passage, so that the invention of claim 8 cannot be grouped into inventions 1-4.

Moreover, the invention which can be grouped into a plurality of the aforementioned invention groups is made to belong to the first group.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008163857 A **[0007] [0009]**