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(54) FLUID MACHINE CONNECTED TO A DRIVE SOURCE VIA A MAGNETIC COUPLING

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(57) **ABSTRACT**

The present invention aims to propose a fluid machine in which a magnetic coupling includes an outer rotor **32** to the cylinder-bottom part of which a drive shaft of the drive component is connected, outer rotor side magnets **33** placed on an inner periphery of the outer rotor, an inner rotor **23** fitted to a drive shaft of the fluid machine, inside the outer rotor, inner rotor side magnets **21** placed on an outer periphery of the inner rotor, whereby attraction workings and repulsion workings between the outer rotor side magnets and the inner rotor side magnets transmit torques of the drive component to the fluid machine, and a sealing assembly **20** a partition part of which is placed between the inner rotor **23** and the outer rotor **32** and surrounds a drive shaft of the fluid machine so as to secure gas-tightness, the shaft including the inner rotor **23** and the inner rotor side magnets **21**; further an air ventilation device for ventilating a space inside the outer rotor by means of inducing and/or discharging ambient air is provided into the outer rotor **32** of the magnetic coupling so as to cool the sealing assembly **20** and the outer rotor side magnets **33**.

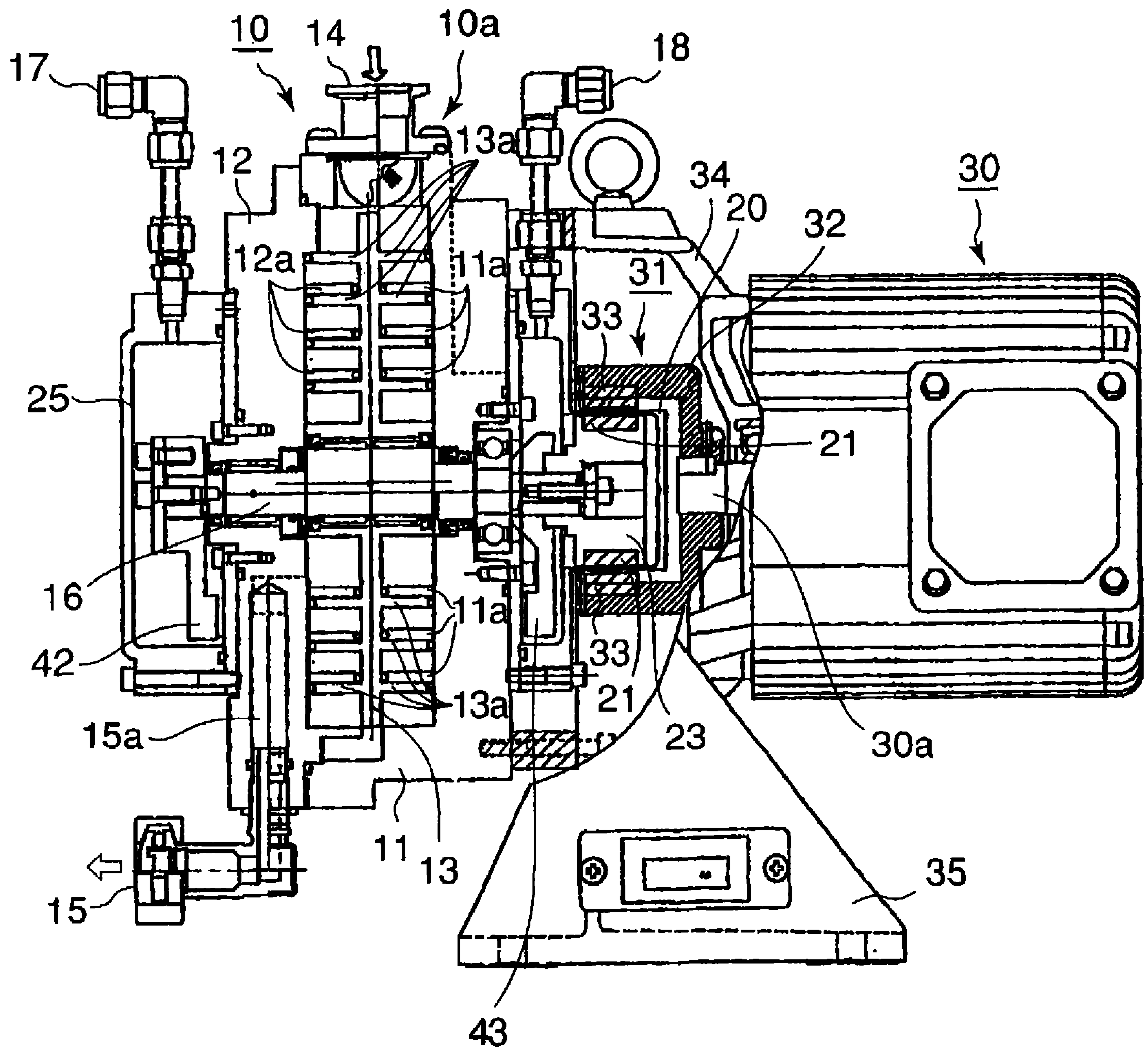

Fig. 1

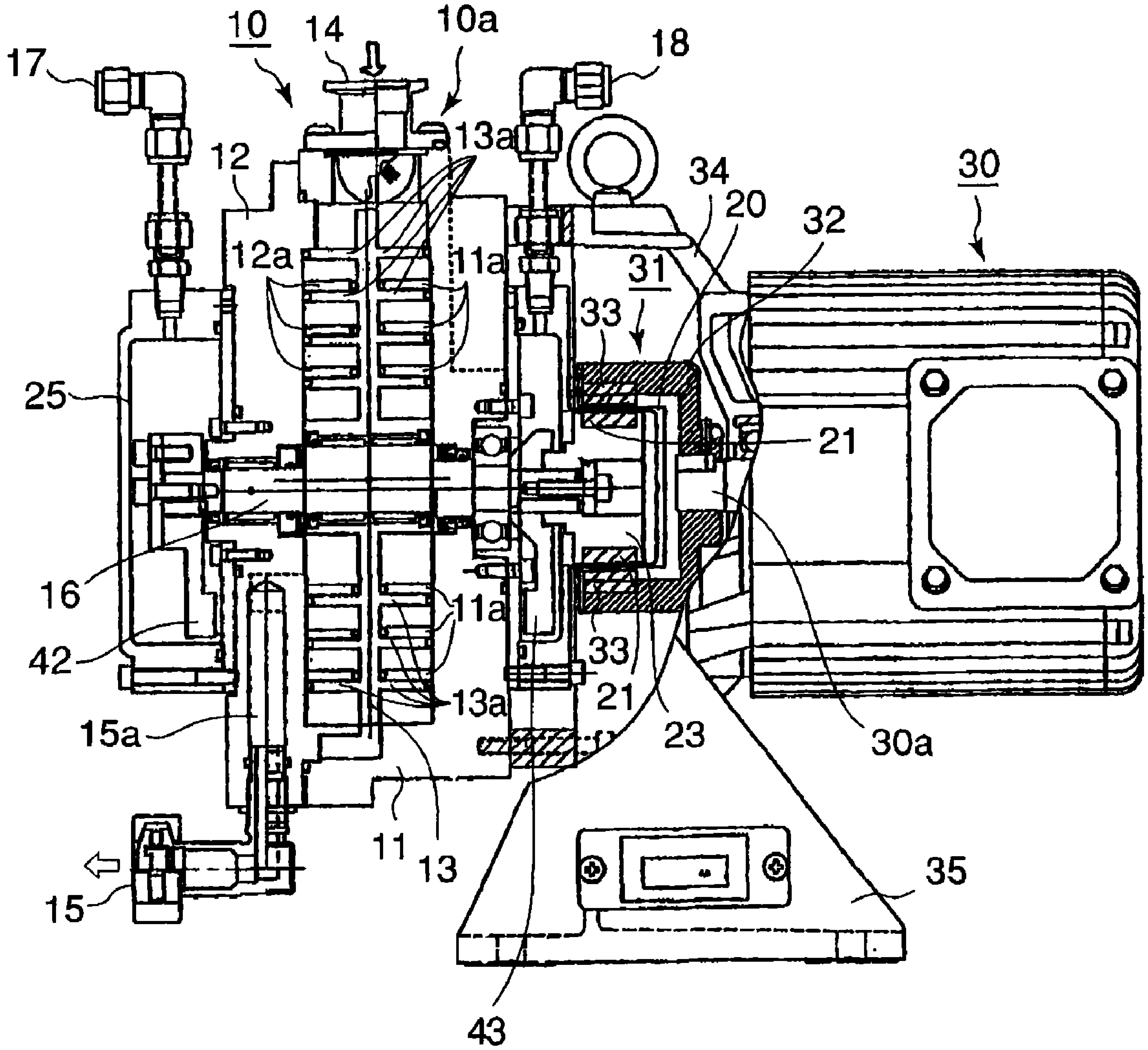
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Fig. 2

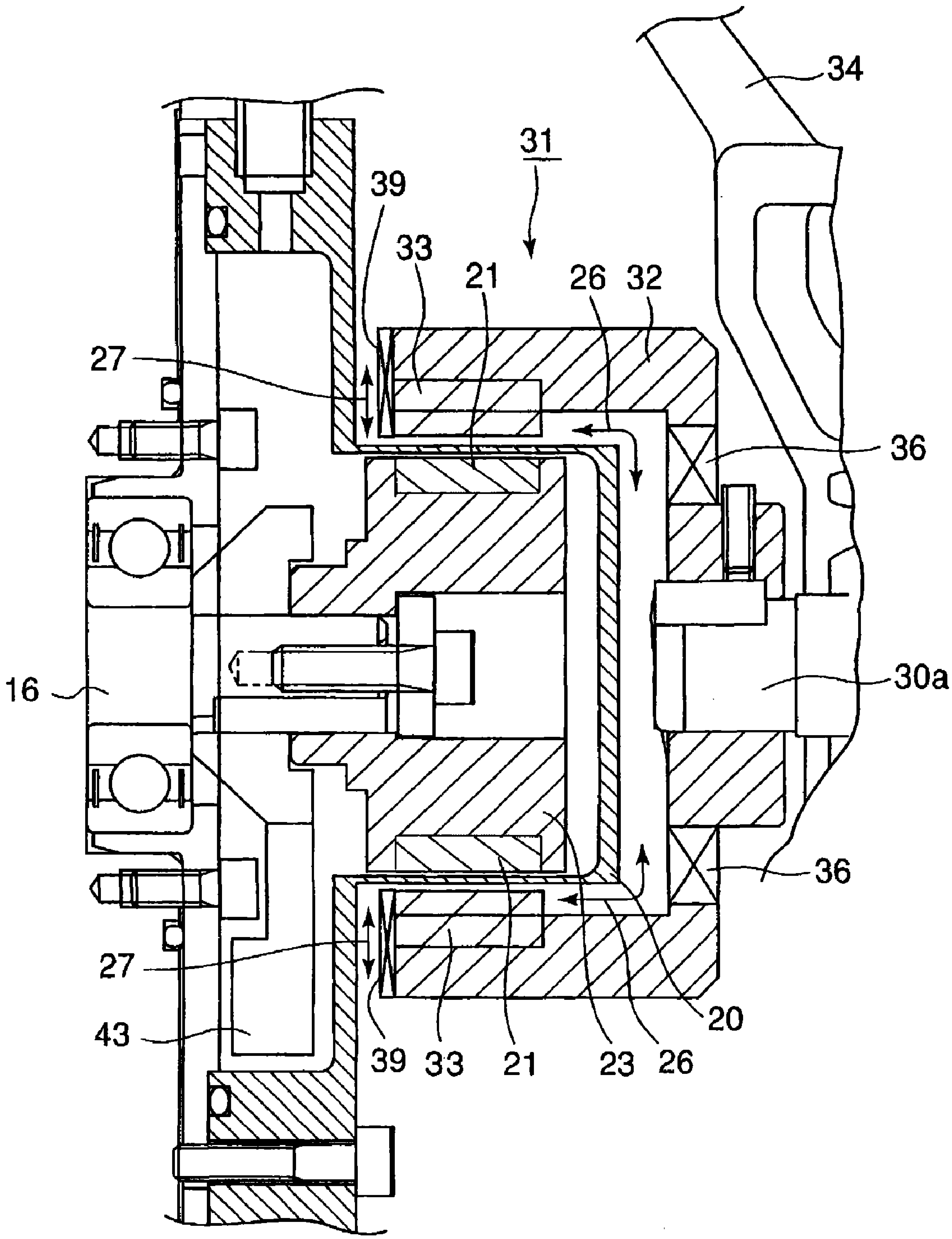


Fig. 3A

Sectional View of line A-A'

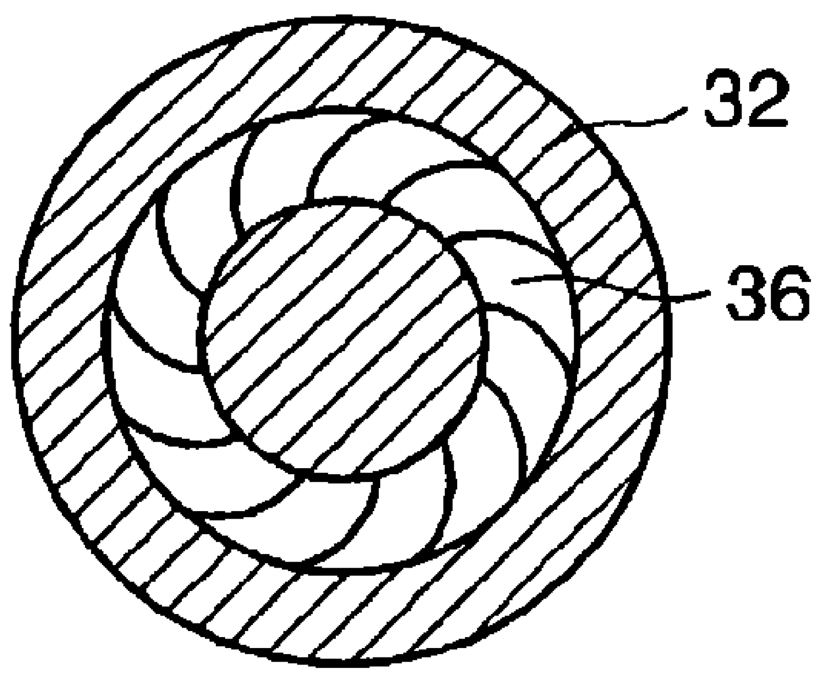


Fig. 3C

Sectional View of line C-C'

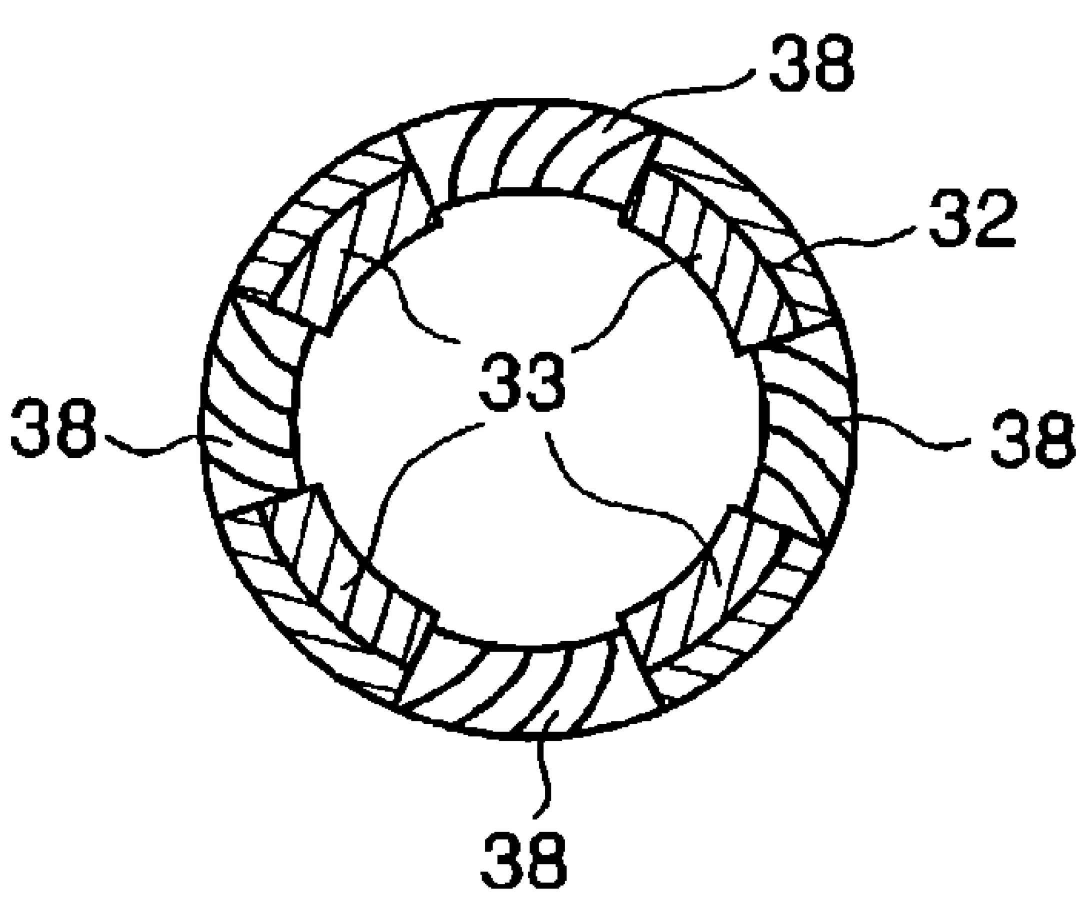


Fig. 3D

Sectional View of line D-D'

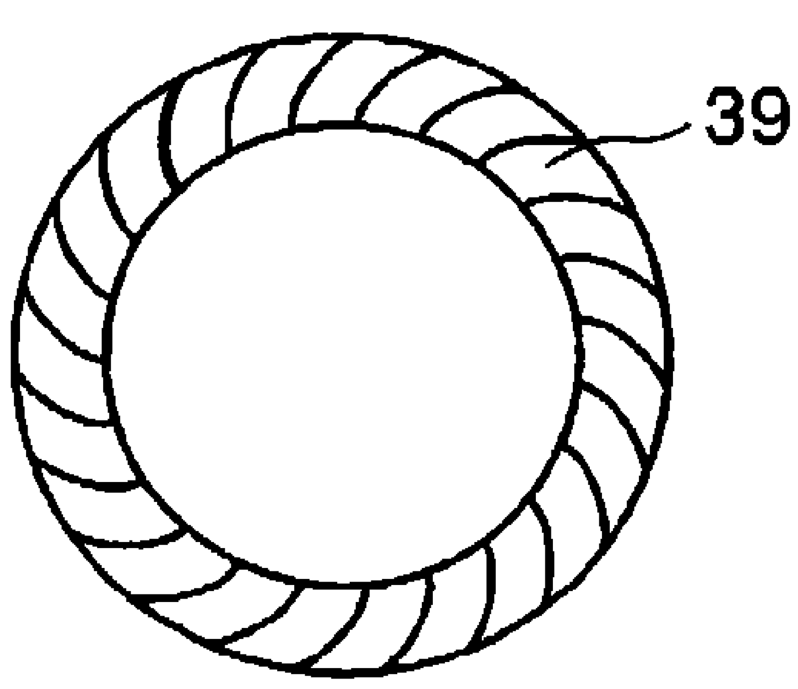


Fig. 3B

Sectional View of line B-B'

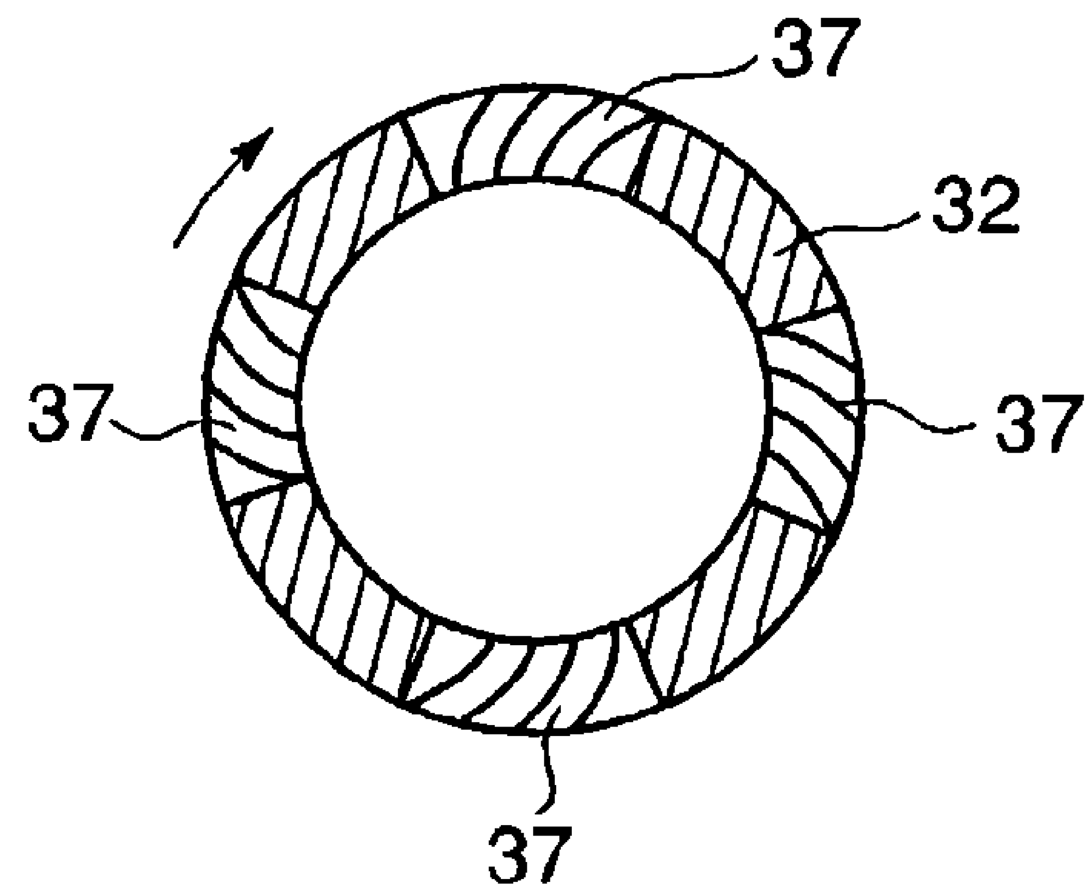


Fig. 3E

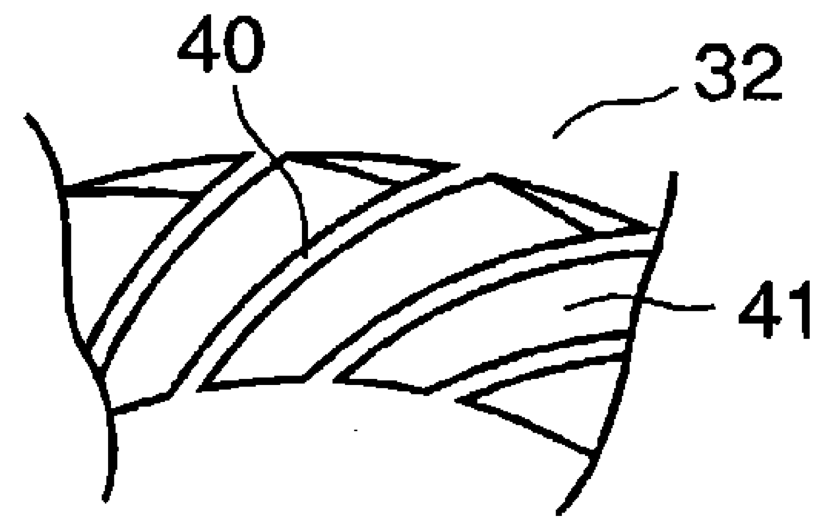


Fig. 3F

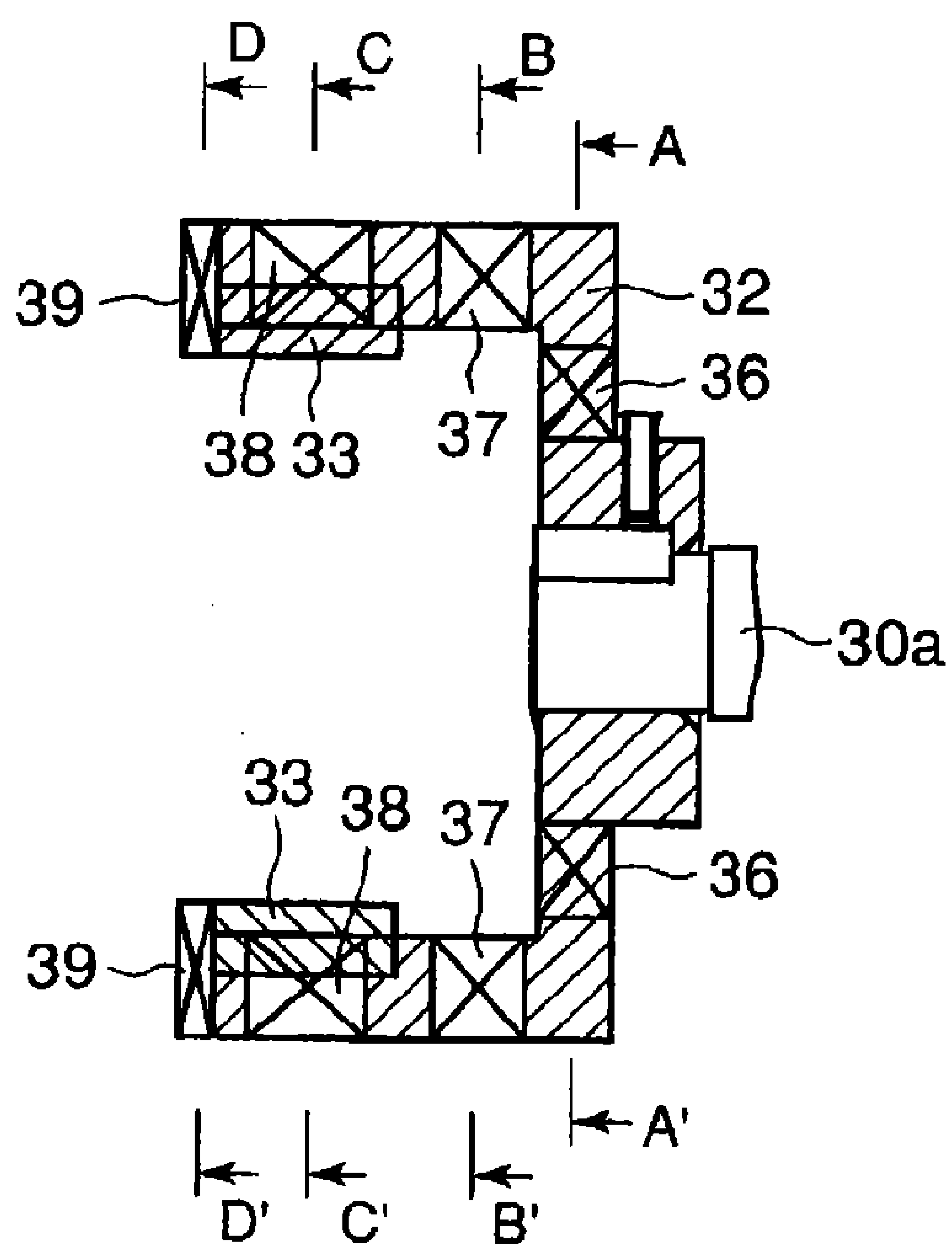
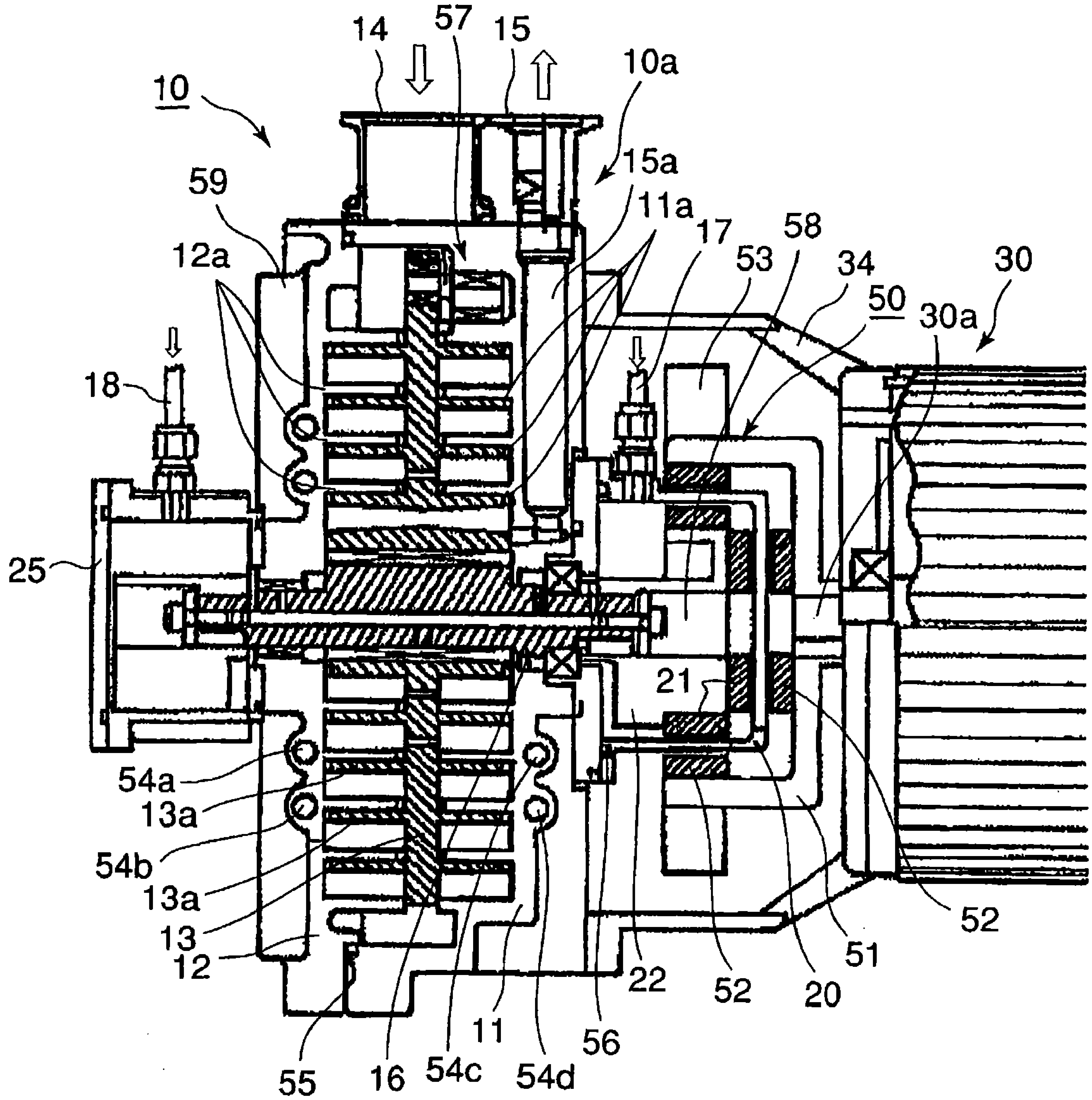


Fig. 4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54c
11
54d
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Fig. 5A

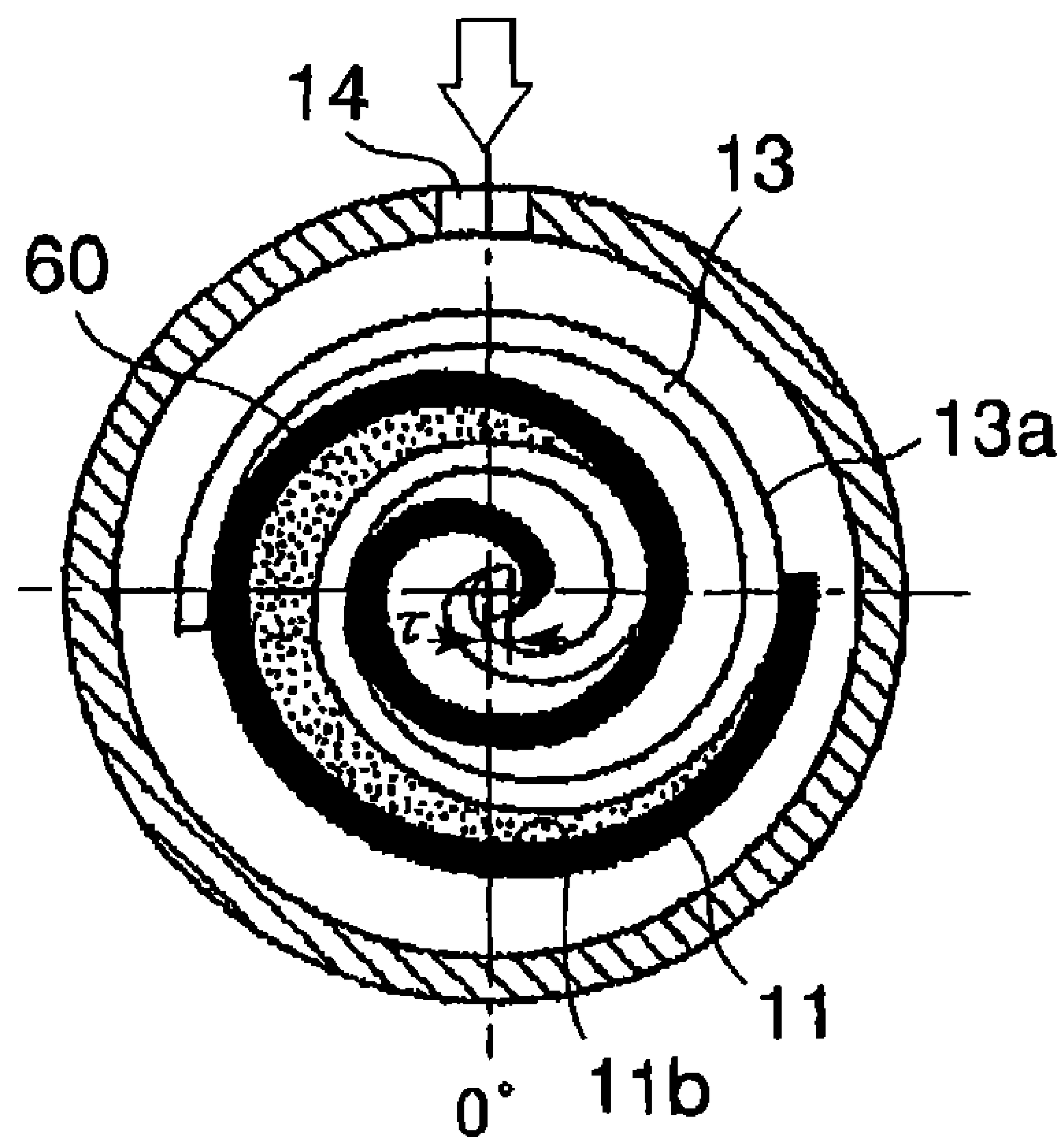


Fig. 5B

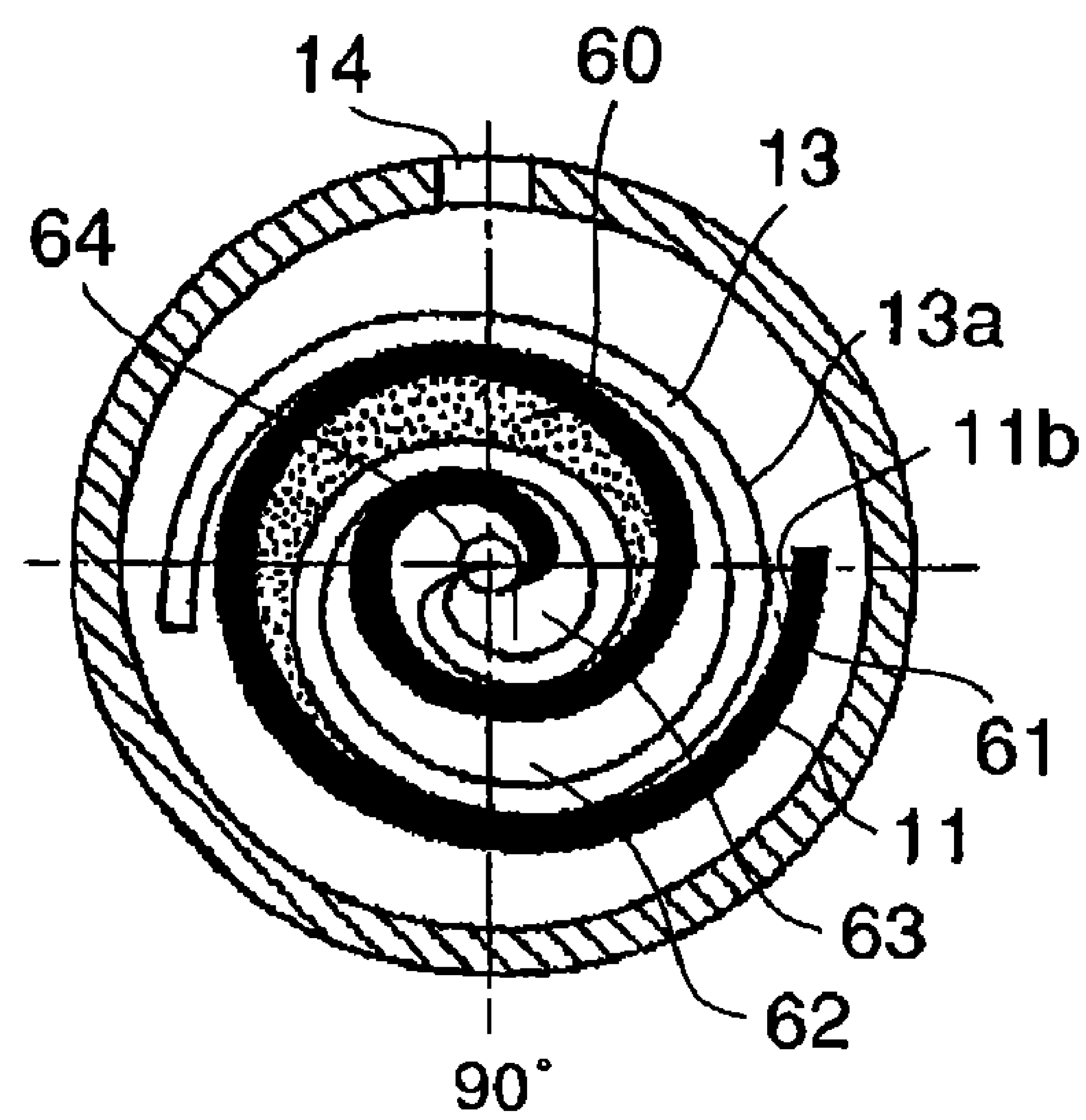


Fig. 5C

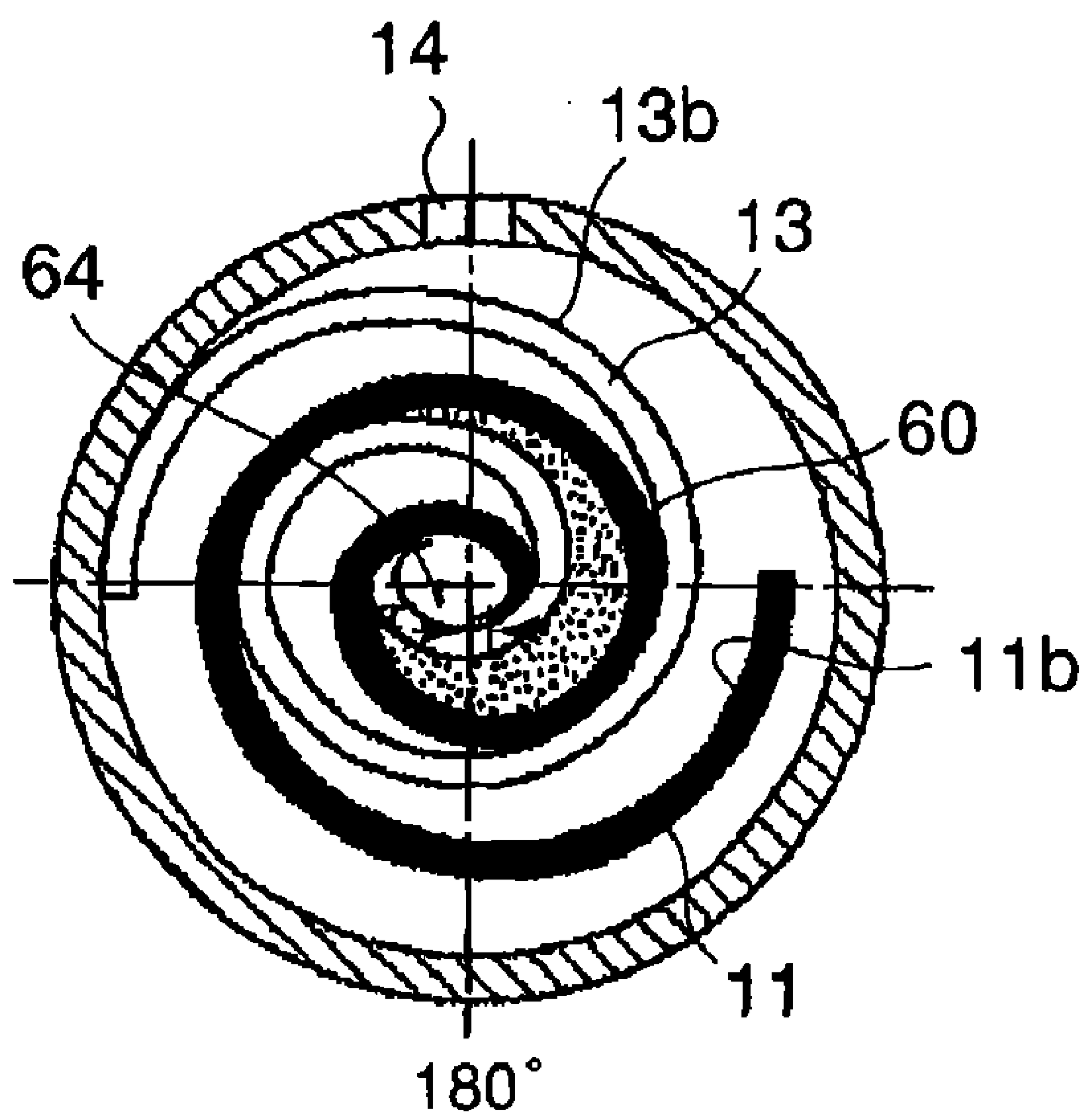
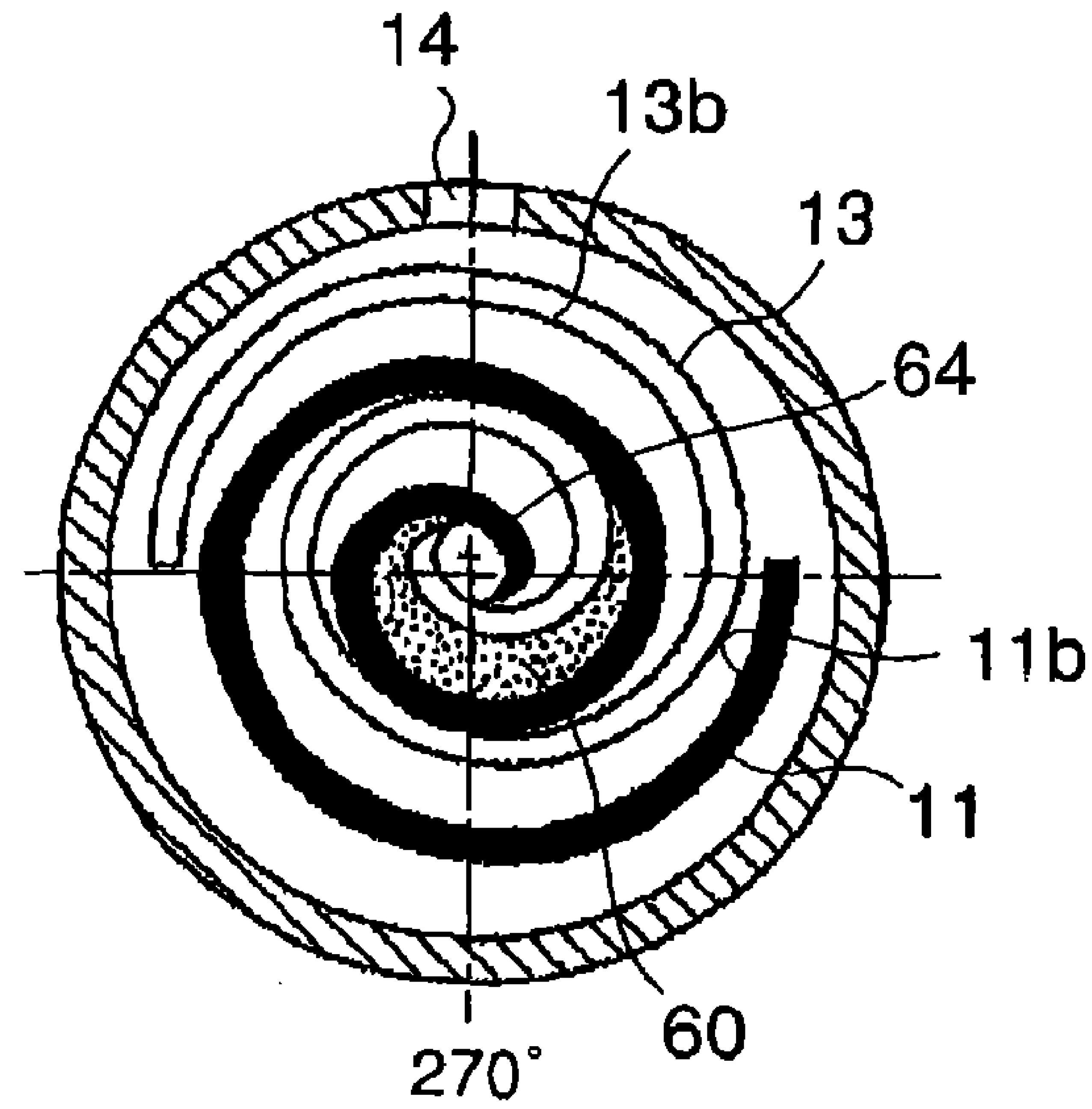


Fig. 5D



FLUID MACHINE CONNECTED TO A DRIVE SOURCE VIA A MAGNETIC COUPLING

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from Japanese Patent Application No. 2006-355474 filed on Dec. 28, 2006, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a fluid machine connected to a drive source via a magnetic coupling, especially to the machine of a gas/liquid leak-proof structure (a closed type structure) except that there are inlet/outlet ports, including pumps and compressors, the machine being provided with non-contact bearings so as to be oil-supply free and driven by the drive source via the magnetic coupling that is a power transmission mechanism for dispensing with a mechanical connection to the drive source, so that toxic gases and/or nuclear industry-related gases and liquids can be treated.

[0003] Machines such as compressors and vacuum pumps for vacuum containers used in nuclear plants are required to be highly durable and reliable, specifically radioactivity-proof and/or wear-proof in order to prevent machine-component deterioration and environmental pollution due to radiations in the plant operation. Moreover, in an operation of a machine as a component of the mentioned plant, it is necessary not only to prevent a radioactive environmental pollution from being formed by other machines as the plant components or a component connected to the machine but also to form a border area that isolates the machine from outside environment so as not to be affected by the outside environment. Thus, in connection with the mentioned points, the machine isolation from the outside as well as the machine cooling has to be designed; in addition, in order to secure high degree vacuum, are required preventive measures, for long continuous operation, against potential difficulties caused by lubrication structure, sealing structure, bearing structure, and the like.

[0004] The situation is similar to the above, in case of the fluid machines such as compressors and pumps that treat with such a toxic gas that may cause problems if the gas leaks outside. For instance, in a conventional technology as shown in a patent reference 1 (JP: 1999-44297) by the applicant of the present invention, the machine is made as a machine of a closed-type except that there are inlet/outlet ports, by using an air bearing of non-contact-type so as to dispense with lubricant-supply, as well as a magnetic coupling without mechanical connection to the drive source.

[0005] In the patent reference, as an example of the fluid machine, is shown a double lapped dry scroll vacuum pump, namely, a pump comprising of an orbiting scroll having a circular-plate and spiral scroll laps set-up on both side-surfaces of the plate in a direction of the axis of the pump shaft, and stationary scrolls which are engaged in the same-spiral-shaped scroll laps of the orbiting scroll in a vertical direction toward the plate.

[0006] The fluid machine structure shown in the patent reference is now explained with FIGS. **4** and **5**. First, FIG. **5** illustrates a working principle of the vacuum pumps with the spiral scroll laps. The stationary scroll **11** has a spiral wall-shape vane (lap). The stationary scroll **11** is fitted into the mentioned orbiting scroll, by making the spiral lap shape of the orbiting scroll **13** substantially the same as that of the orbiting scroll, and placing the spiral lap of the orbiting scroll **13** point-symmetrically to that of the stationary scroll **11** in FIGS. **5**(*a*) to **5**(*d*), so that the orbiting scroll revolves, with a parallel translation movement around the pump axis, by means of a crank mechanism. A crescent shaped closed space **60** (a compression space) is formed between a lap inside surface **11***b* of the stationary scroll **11** and a lap outside surface **13***b* of the orbiting scroll **13**, and the relative movement of the scrolls **11** and **13** changes the volume of the compression space, thus the suction side will be made vacuum.

[0007] In FIG. **5**(*a*), when a lap outside surface **13***b* of the orbiting scroll **13** and a lap inside surface **11***b* of the stationary scroll **11** form a sealed space to finish an inhaling process, an inhaled gas through an inlet port **14** is shut into a compression chamber **60** shown as a dotted region in FIG. **5***a*. Further, when a crank angle of a crank mechanism (not shown) proceeds by 90 degrees as shown in FIG. **5**(*b*), the lap outside surface **13***b* of the orbiting scroll **13** begin to separate from the lap inside surface **11***b* of the stationary scroll **11** around a tail part thereof, to form an open gap space **61** in FIG. **5***b*, from which a gas is sucked. Further, at an intermediate compression space **62**, a compression process is continued, and at a central compression space **63** a compression process is finished so as to start a discharge process through an outlet port **64**.

[0008] With a further advanced crank angle by 90 degrees as shown in FIG. **5***c*, in response to an orbiting rotation of the orbiting scroll **13** without revolution, the aforementioned dotted region **60** moves toward a further central location, reducing its volume gradually, then a compressed gas of the chamber is discharged through the outlet port **64**.

[0009] FIG. **4** shows a cross-sectional outline structure of a double-lapped dry scroll vacuum pump, in which an orbiting scroll **13** having a pair of spiral scroll laps installed-upright on both sides of a circular plate of the orbiting scroll in a pump axis direction is engaged in stationary scrolls **11** and **12**. As shown in FIG. **4**, the vacuum pump comprises a pump body **10** and a drive component **30**, the pump body **10** comprising a scroll compressor body **10***a*, and sealing assemblies **20** and **25**. The sealing assemblies **20**, **25** are gas-tightly attached respectively to the stationary scrolls **11**, **12** that supports both end-part of a drive shaft **16**. The pump body **10** further comprises compressed gas inlets **17** and **18** through which gases of a pressure higher than the compressor outlet pressure are led to the sealing assemblies **20** and **25** respectively, and a magnetic coupling **50** that transmits rotary torque from a drive component **30** to the drive shaft **16** without mechanical contact. Thus, the vacuum pump is isolated from the drive component **30** through the magnetic coupling **50** that is a drive torque transmission means, and there is no leak, toward an ambient side, of a pollutant inhaled from the suction side.

[0010] The magnetic coupling **50** is constructed to have an outer rotor (a coupling element) **51** that is of cylindrical shape and has a bottom part connected to the drive shaft **30***a*, drive magnets **52** installed inside the outer rotor **51**, and rotary wings **53** for inhaling ambient air through vents **34** provided in circumference of the outer rotor as well as for cooling the outer rotor **51** and the drive magnets **52**. The vacuum pump side of the magnetic coupling **50** includes an inner rotor **58** attached to the drive shaft **16** in the pump body, driven magnets **21** installed around the inner rotor, and the sealing assembly **20** that surrounds the inner rotor **58** so as to secure a sealed-up space **22**.

[0011] A partition part of the sealing assembly **20** is of cylindrical shape with bottom, and placed inside the outer rotor **51** in close proximity to the drive magnets **52**. The driven magnets **21** attached around the inner rotor **58** move in close vicinity of the partition part of the sealing assembly **20**. The driven magnets **21** are arranged so as to effectively repel and attract the drive magnets **52**. Thus, in response to the revolution of the outer rotor **51**, the inner rotor **58** revolves.

[0012] The stationary scroll **11** of the scroll compressor body **10***a* comprises a circular plate located vertically to the pump axis and a stationary scroll lap **11***a* of spiral wall shape, the lap **11***a* being set-up on a first side surface of the circular plate, in the pump axis direction. The circular, lid-shaped plate serves as a part of a housing for the scroll compressor body **10***a* and the first side surface of the plate serves as a sliding surface for the orbiting scroll lap. On the other hand, the stationary scroll **12** comprises a circular plate located vertically to the pump axis, and a stationary scroll lap **12***a* of spiral wall shape, the lap **12***a* being set-up on a first side surface of the circular plate, in the pump axis direction. The circular, lid-shaped plate serves as a part of a housing for the scroll compressor body **10***a* and the first side surface of the plate serves as a sliding surface for the orbiting scroll lap. Further, an orbiting scroll **13** comprises a circular plate located vertically to the pump axis, being mounted on the drive shaft **16** that are supported by both side bearings thereof so that the plate is rotated around an axis of the shaft by a crank mechanism, side surfaces of the plate that serves as sliding surfaces for the stationary scroll laps, and orbiting scroll laps **13***a* of spiral wall shape, the laps **13***a* being set-up on side surfaces of the circular plate.

[0013] In the orbiting scroll **13**, the orbiting scroll laps **13***a* of the spiral wall shape set-up, in the pump axis direction, on both side surfaces of a circular disk plate part of the orbiting scroll **13** are engaged into the stationary scroll laps **11***a* and **12***a* of spiral wall shape. Further, tip parts of the spiral stationary scroll laps come in contact with both sliding surfaces of the circular disk plate part of the orbiting scroll **13**, the tip parts of the stationary scroll being sliding on both the side surfaces of the circular disk plate part. On the other hand, in the stationary scrolls **11** and **12**, tip parts of the orbiting scroll laps **13***a* of the spiral wall shape come in contact with both the first surfaces of the stationary scrolls **11** and **12**. The circular disk plate part of the orbiting scroll **13** is mounted on the drive shaft **16** with an off-centering distance between the shaft axis and the circular disk plate axis. With the aid of a rotation prevention device **57**, the orbiting scroll **13** revolves round the drive shaft axis without the rotation on the orbiting scroll axis. As mentioned already, the stationary scrolls **11** and/or **12** and the orbiting scroll **13** form a plurality of crescent-moon-shaped compression-spaces, where gas inhale process through an inlet port **14**, compression process, and discharge process are performed simultaneously and continuously, thus gas flow through an outlet passage **15***a* to an outlet **15** is smoothly performed, so as to function as a vacuum pump.

[0014] As pointed-out already, both the stationary scrolls **11** and **12** include a circular plate part or a circular disk plate part that serves as a part of a housing for the scroll compressor body **10***a*; both the scrolls **11** and **12** are gas-tightly built-up through a sealing element **55**, and incorporate the orbiting scroll **13**; on the other hand, through a sealing element **56**, the stationary scroll **11** and a sealing assembly **20** are gas-tightly built-up; thus, the stationary scrolls **11** and **12** form a closed space therein, and serve as a casing of a gas-tight structure.

[0015] In addition, a compressed inert gas, namely compressed N_2 (nitrogen) here, is blown, through the compressed gas inlets **17** and **18**, into the closed space formed by the orbiting scroll **13**, and the stationary scrolls **11** and **12**; thereby, the pressure of the inert gas is higher than that of the final discharge gas discharged through the outlet **15**, namely, the compressor outlet pressure which is obtained by means of the compression of closed spaces formed by the orbiting scroll **13**, and the stationary scrolls **11** and **12**; thus, the gas compressed in the closed spaces does not flow back through the compressed gas inlets **17** and **18**.

[0016] Another point is that the drive shaft **16** in the pump body is supported by an oil-less bearing (not shown) made of self-lubricating metals to which the gas led through the compressed gas inlets **17** and **18** serves as a lubrication medium, In this way, there can be expected no oil-leakage thanks to oil-less lubrication, no diffusion of lubricant mist into the discharge gas outside, durability improvement of bearings, waste reduction on machine-maintenance; consequently, it becomes possible to operate the pump for a long period without a rest.

[0017] The stationary scroll **12** is provided with cooling fins **59** on a frame part including the circular, lid-shaped plate of the stationary scroll **12** so as to enable natural cooling by an ambient air. Further, in the stationary scrolls **11** and **12** including a circular plate part or a circular disk plate part that serves as a part of a housing for the scroll compressor body **10***a*, are arranged circular cooling-water jackets **54***a*, **54***b*, **54***c*, and **54***d*, and cooling-water flows by a cooling-water circulating means (not shown) comprising of radiators (not shown), and cooling-water circulating pumps (not shown). Thus, the forced cooling of the stationary scrolls **11** and **12** from the back sides thereof is accomplished.

[0018] As mentioned above, the compressed inert gas, the pressure of which is higher than that of the final discharge gas discharged through the outlet port **15**, is led through the compressed gas inlets **17** and **18**, toward each end side of drive shaft bearings, and the inert gas is discharged through the outlet port **15**. As a result, the gas compressed in the closed spaces does not flow back through the compressed gas inlets **17** and **18**. Moreover, the vacuum pump is gas-tightly isolated from outside (except that there are connection parts such as the inlet port **14**, the outlet port **15**, the compression gas inlet **17** and **18**). Further, the pump needs no sealing elements as to the magnetic coupling **50** that is a drive torque transmission means without mechanical contact. Thus, even when radioactive pollution materials is inhaled through the inlet port from the atomic energy plant side, the pollutant cannot leak through the pump toward an ambient side.

[0019] Thus, the vacuum pump as a fluid machine as described in the patent reference can be given a gas-tight isolation due to non-mechanical-contact property of the magnetic coupling **50** that is a drive torque transmission means, the pump leaking outside no pollutant from a suction side. Further, since the pump is provided with an oil-less bearing made of self-lubricating metals or a gas bearing, it is possible to continue the pump operation for a long period without a stop. Furthermore, since the pump is provided with the cooling fins **59** on the circular, lid-shaped plate-frame part of the stationary scroll **12**, as well as provided with circular cooling-water jackets **54***a*, **54***b*, **54***c*, and **54***d* for forced cooling in the frame part, sufficient prevention measures are taken against a possible heat hazard derived from gas compressed in a space between the stationary scrolls **11**, **12** and the orbiting scroll **13**.

[0020] However, the gas sucked through the inlet port **14** is compressed in the space between the stationary scrolls and the orbiting scroll engaged therein, producing remarkable heat. Accordingly, a part of the heat is conducted to the magnetic coupling **50**, and in an operation of the pump for a period to some extent, a heat also comes to the magnetic coupling **50** from the drive component **30**. Nevertheless, measures for cooling the magnetic coupling **50** are only rotary wings **53** fitted on an outer surface of the outer rotor **51**. There is no specific measure for cooling the drive magnets **52** placed inside the outer rotor **51**, and for cooling the sealing assembly **20**.

[0021] On one hand, it is important, from a viewpoint of the torque transmission from the drive component to the inner rotor, to keep a certain range of a clearance between the drive magnets **52** and the sealing assembly **20** and of a clearance between the sealing assembly **20** and the driven magnets **21** fitted on the outer surface of the inner rotor **58**. If temperatures of the sealing assembly **20** and/or the drive magnets **52** increase, spacing between the sealing assembly **20** and the drive magnets **52** is changed. It may happen at worst that both components **20** and **52** touch each other to damage the magnetic coupling **50**. On the other hand, the spaces between the sealing assembly **20** and the drive magnets **52** may expand such that magnetic flux densities reaching the driven magnets are weakened, an ordinary torque transmission being spoiled.

[0022] From a viewpoint of the rotary wings **53** fitted on an outer surface of the outer rotor **51**, the wings are apt to be of large size, requiring a large space for the wings to rotate; bringing a large design of the magnetic coupling **50** and the whole fluid machine all the more.

SUMMARY OF THE INVENTION

[0023] In light of the conventional situation as described so far, the present invention relates to fluid machines such as compressors and pumps that treat with such a toxic gas as may cause problems if the gas leaks outside, and the object of the present invention is to provide a gas-tightly sealed type fluid machine connected to a drive component via a magnetic coupling, in which an efficient cooling for the magnetic coupling is performed without enlarging the space for the magnetic coupling to be built-in.

[0024] To solve the problem, the present invention proposes a fluid machine connected to the drive component via a magnetic coupling, having a drive component, and a fluid machine composed of a pump unit including compressors, being connected to the drive component via a magnetic coupling; said magnetic coupling including, an outer rotor to the cylinder-bottom part of which a drive shaft of the drive component is connected, outer rotor side magnets placed on an inner periphery of the outer rotor, an inner rotor fitted to a drive shaft of the fluid machine, inside the outer rotor, and inner rotor side magnets placed on an outer periphery of the inner rotor, whereby attraction workings and repulsion workings between the outer rotor side magnets and the inner rotor side magnets transmit torques of the drive component to the fluid machine; in which the fluid machine is provided with a pair of sealing assemblies that encloses both end parts of a drive shaft of the fluid machine so as to bring the fluid machine a gas-tightly sealed condition except that there are a gas inlet port, a gas outlet port, and compression gas inlets, and further an air ventilation device for ventilating a space inside the outer rotor by means of inducing and/or discharging ambient air is provided in the outer rotor of the magnetic coupling so as to cool the sealing assembly of the magnetic coupling side, and the outer rotor side magnets.

[0025] By providing, into the outer rotor of the magnetic coupling, an air ventilation device for ventilating a space inside the outer rotor by means of inducing and/or discharging ambient air, potential damages of the magnetic coupling due to insufficient cooling as mentioned above can be evaded. Namely, even when the heat generated according to gas compression in the fluid machine or the heat derived from the drive component is conducted to the magnetic coupling, the sealing assembly of the magnetic coupling side and the outer rotor side magnets are cooled down by the induced and/or discharged ambient air. As a result, it becomes possible to evade possible reduction of the clearances between the outer rotor side magnets and the sealing assembly of the magnetic coupling side to evade possible mechanical contact therebetween. On the other hand, it becomes also possible to evade torque transmission failure due to weakened magnetic flux densities reaching the driven magnets, in case when the clearances are widened.

[0026] Moreover, since the air ventilation device is fitted on the outer rotor itself, neither upsizing of the coupling nor useless large space is required. As a result, the device can realize a compact design of the fluid machine.

[0027] Since blades are fitted therein with an inclination to a rotational direction of the outer rotor so as to form ventilation slits around surface walls of the outer rotor, the air ventilation device can be quite simply realized.

[0028] A preferable embodiment of the present invention is to install the air ventilation device in a drive component side cylinder-bottom part of the outer rotor, in a cylinder-periphery part of the outer rotor, in a cylinder-periphery part of the outer rotor between the outer rotor side magnets attached on inner periphery of the outer rotor, in a fluid machine side cylinder-periphery end-part of the outer rotor, or in a plural locations among said lacations.

[0029] Further, as the air ventilation devices (blade/slits) are placed at the fluid machine side and the drive component side across an band area of the cylinder-periphery part of the outer rotor where the outer rotor side magnets are located inside the outer rotor, and each air inducing and/or air discharging momentum at each blade/slit can be adjustably designed, so that a ventilation air does not stagnate inside the outer rotor. Thus, the sealing assembly of the magnetic coupling side and the outer rotor side magnets can be effectively cooled.

[0030] As described so far, with such a simple structure as an air ventilation device is installed in an outer rotor of a magnetic coupling, the present invention prevents a fluid machine connected to the drive component via a magnetic coupling from being damaged by mechanical contacts between a sealing assembly of the magnetic coupling side and outer rotor side magnets, the contacts being derived from reductions of clearances between the outer rotor side magnets and the sealing assembly of the magnetic coupling side, and the clearance reduction is attributable to a heat generated according to gas compression in the fluid machine and conducted to the magnetic coupling, or a heat derived from the drive component and conducted to the magnetic coupling. Contrary to the above, there may be a case wherein excessive clearances are designed in advance so as to avoid the contacts such as described above. In such a case, the clearances are too sufficient until the magnetic coupling is uselessly heated-up; as a result, is brought sparse magnetic flux reaching the driven magnets from the driven magnets as well as is brought torque transmission failure. The present invention prevents a fluid machine connected to the drive component via a magnetic coupling also from being attacked by this torque transmission failure.

[0031] Moreover, since the air ventilation device is fitted on the outer rotor itself, an introduction of the device requires neither upsizing of the magnetic coupling nor useless large space around the outer rotor. As a result, the device can realize a compact design of the fluid machine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] The invention will now be described in greater detail with reference to the preferred embodiments of the invention and the accompanying drawings, wherein:

[0033] FIG. **1** shows, in a sectional view, an outline structure of a double-lapped dry scroll vacuum pump as an example of a fluid machine connected to a drive component via a magnetic coupling according to the present invention;

[0034] FIG. **2** shows an enlarged sectional view of a magnetic coupling in FIG. **1**;

[0035] FIGS. **3**A, **3**B, **3**C, **3**D, **3**E, and **3**F are sectional views of a structure of blades and slits as an air ventilation device installed in an outer rotor of the magnetic coupling according to the invention and locations as to the device;

[0036] FIG. **4** shows an outline structure of a conventional double-lapped dry scroll vacuum pump in a sectional view; and

[0037] FIGS. **5***a*, **5***b*, **5***c*, and **5***d* illustrate transitions from a state that suction process is finished to compression process, as well as from compression process to discharge process, in a scroll compression body of a scroll vacuum pump.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0038] Hereafter, the present invention will be described in detail with reference to the embodiments shown in the figures. However, the dimensions, materials, shape, the relative placement and so on of a component mentioned in these embodiments shall not be construed as limiting the scope of the invention thereto, unless especially specific mention is placed.

[0039] FIG. **1** shows, in a sectional view, an outline structure of a double-lapped dry scroll vacuum pump as an example of a fluid machine connected to a drive component via a magnetic coupling according to the present invention. FIG. **2** shows an enlarged sectional view of a magnetic coupling **31** in FIG. **1**; FIG. **3** shows, in a sectional view, a structure of slits (blades) as an air ventilation device installed in an outer rotor **32** of the magnetic coupling according to the invention. In order to explain a fluid machine of the present invention, an emphasis is placed on an example of a double-lapped dry scroll vacuum pump as aforementioned with FIG. **4** according to the patent reference. However, the present invention can be obviously applied to other general fluid machines such as compressors, pumps and so on, so long as the fluid machines are connected to a drive source via a magnetic coupling. In the following explanation, the same numerals are basically used for indicating related components/items as shown in FIG. **4**. Further, here and there in the following explanation, there may be some explanation overlaps with the description up to now as to FIG. **4** for understanding the present invention easily.

[0040] At first, a simple outline of the present invention is given. According to the present invention, in a fluid machine represented with a vacuum pump as already explained with FIG. **4**, blades are installed in a coupling element **51** (**32** in FIG. **1**) so as to introduce ventilation slits and to ventilate a space inside the coupling element **51**. (Hereafter, the coupling element **51** (**32**) will be referred to as an outer rotor **51**(**32**).) As illustrated in FIGS. **2** and **3**, the blades are fitted with an inclination to a rotational direction of the outer rotor, to induce an ambient air into the space and discharge the induced air outside the space in response to a rotation movement of the outer rotor, resulting in that a sealing assembly **20** of the vacuum pump and drive magnets (outer rotor side magnets) **52** (**33** in FIG. **1**) of a magnetic coupling are cooled.

[0041] In the air ventilation device, the blades are fitted into the outer rotor **51** (**32** in FIG. **1**) with an inclination to a rotational direction of the outer rotor **51** (**32** in FIG. **1**) so that the blades induce an ambient air into the space inside the outer rotor **51** (**32** in FIG. **1**) as well as discharge the induced air outside the outer rotor **51** (**32** in FIG. **1**); the blades and/or slits as the air ventilation device are installed in a drive component (**30**) side cylinder-bottom part of the outer rotor **51**, in a cylinder-periphery part of the outer rotor **51**, between outer rotor side magnets **52** (**33** in FIG. **1**) attached on inner periphery of the outer rotor **51**, in a vacuum pump side cylinder-periphery end-part of the outer rotor **51**, or in a plurality of the above locations.

[0042] The blade/slits (air ventilation device) are preferably placed at both sides of the vacuum pump side (the fluid machine side) and the drive component **30** side across an band area of the cylinder-periphery part of the outer rotor where the outer rotor side magnets **52** (**33** in FIG. **1**) are located inside the outer rotor, and each air inducing and/or air discharging momentum at each blade/slit can be adjustably designed, so that a ventilation air does not stagnate inside the outer rotor. Thus, the sealing assembly **20** of the magnetic coupling side and the outer rotor side magnets **52** (**33** in FIG. **1**) can be effectively cooled.

[0043] Thus far, is described the outline of a fluid machine connected to a drive component via a magnetic coupling according to the invention. Hereafter, with reference to FIGS. **1** and **2**, is explained a double-lapped dry scroll vacuum pump as an example of a fluid machine connected to a drive component via a magnetic coupling according to the invention. Like the vacuum pump explained with FIGS. **4** and **5**, the vacuum pump shown in FIG. **1** comprises an orbiting scroll **13**, having a circular plate and spiral scroll laps set-up on both side-surfaces of the plate protruding in a direction of an axis of pump shaft, and stationary scrolls **11** and **12**, such that the scroll laps are engaged in the same-spiral-shaped scroll laps of the stationary scrolls.

[0044] In FIG. **1**, a vacuum pump is composed of a pump body **10**, a drive component **30**, and a support member **35** for supporting the pump body **10** and the drive component **30**. The pump body **10** includes a scroll compressor body **10***a*, a pair of sealing assemblies (enclosures) **20** and **25** that are gas-tightly attached respectively to stationary scrolls **11** and **12** that support each end-part of a drive shaft **16** rotating an orbiting scroll so that a protrude of each end-part is enclosed by the sealing assembly **20**, **25** respectively. The pump body

10 further includes compressed gas inlets **17** and **18** through which gases with pressure higher than the compressor outlet pressure (lap compression gas pressure) are led into the sealing assemblies **20** and **25** respectively, and a magnetic coupling **31** that transmits rotary torque from the drive component **30** to the drive shaft **16** without mechanical contact.

[0045] Thus, the vacuum pump is isolated from the drive component **30** by means of the magnetic coupling **31** that is a drive torque transmission means, and there is no leak of a pollutant inhaled from the suction side, toward an ambient side.

[0046] The magnetic coupling **31** of the drive component **30** side is composed of a cylindrical-shaped outer rotor **32** having a bottom part connected to the drive shaft **30***a*, and drive magnets (outer rotor side magnets) **33** installed inside the outer rotor **32**. The magnetic coupling **31** of the vacuum pump side is provided with a inner rotor **23** connected to a drive shaft **16** in the pump body, driven magnets (inner rotor side magnets) **21** installed around the inner rotor, and a sealing assembly **20** that surrounds the inner rotor **23** so as to secure a sealed-up space **22**. (Hereafter, the pump-side coupling element **23** will be referred to as an inner rotor **23**.)

[0047] A partition of the sealing assembly **20** is of cylindrical shape, and placed inside the cylindrical-shaped outer rotor **32** in close proximity to the drive magnets **33**. The inner rotor **23** is composed such that the driven magnets **21** attached around the inner rotor **23** move, in close vicinity of the partition of the sealing assembly **20**, so as to effectively repel and attract the drive magnets (outer rotor side magnets) **33** arranged inside the outer rotor **32**. Thus, the inner **23** is rotated in response to the rotation of the outer rotor **32**.

[0048] The stationary scroll **11** of the scroll compressor body **10***a* is composed of a circular plate located vertically to the pump axis, and a stationary scroll lap **11***a* of spiral wall shape set-up on a first side surface of the circular plate in the pump axis direction. The circular, lid-shaped plate serves as apart of a housing for the scroll compressor body **10***a* and a first side surface of the plate serves as a sliding surface for the orbiting scroll lap.

[0049] On the other hand, the stationary scroll **12** is composed of a circular plate located vertically to the pump axis, and a stationary scroll lap **12***a* of spiral wall shape set-up on a first side surface of the circular plate in the pump axis direction. The circular, lid-shaped plate serves as a part of a housing for the scroll compressor body **10***a* and a first side surface of the plate serves as a sliding surface for the orbiting scroll lap.

[0050] The orbiting scroll has a circular plate to the pump axis, which is vertically installed to the pump axis on the drive shaft **16** supported by both side bearings, to be rotated around the shaft, and orbiting scroll laps **13***a* of spiral wall shape set-up on side surfaces of the circular plate.

[0051] In the orbiting scroll **13**, the orbiting scroll laps **13***a* of the spiral wall shape set-up on both side surfaces thereof in the axial direction are engaged into the stationary scroll laps **11***a* and **12***a* of spiral wall shape. Further, tip parts of the spiral stationary scroll laps come in contact with both side surfaces of the circular disk plate part of the orbiting scroll **13**, to slide on both the side surfaces of the circular disk plate part. On the other hand, in the stationary scrolls **11** and **12**, tip parts of the orbiting scroll laps **13***a* of the spiral wall shape come in contact with both the first side surfaces of the stationary scroll **11** and **12**. The circular disk plate part of the orbiting scroll **13** is mounted on the drive shaft **16** with an off-centering distance between the shaft axis and the circular disk plate axis. With the aid of a rotation prevention device (not indicated in FIG. **1**), the orbiting scroll **13** revolves round the drive shaft axis without the rotation on the orbiting scroll axis. As mentioned already, the stationary scrolls **11** and/or **12** and the orbiting scroll **13** form a plurality of crescent-moon-shaped compression spaces (compression-rooms), where inhale process through an inlet port **14**, compression process, and discharge process are performed simultaneously and continuously, so that gas flows through an outlet passage **15***a* to an outlet **15** smoothly, functioning as a vacuum pump.

[0052] In addition, a compressed inert gas, namely compressed N_2 (nitrogen) here, is blown, through the compressed gas inlets **17** and **18**, into the closed space formed by the orbiting scroll **13** and the stationary scrolls **11** and **12** to be compressed in the space. Since the pressure of the inert gas is higher than that of the final discharge gas discharged through the outlet **15**, namely, the compressor outlet pressure after compressed in the closed spaces, the gas compressed in the closed spaces does not flow back through the compressed gas inlets **17** and **18**.

[0053] Another point is that the drive shaft **16** in the pump body is supported by an oil-less bearing (not shown) made of self-lubricating metals or a gas bearing (not shown) where the gas led through the compressed gas inlets **17** and **18** serves as a lubrication medium. Since there can be expected no oil-leakage thanks to oil-less lubrication, no diffusion of lubricant mist into the discharge gas outside, durability improvement of bearings, waste reduction on machine-maintenance, as described above, it becomes possible to operate the pump for a long period without a rest. Further, the drive shaft is provided with balance-weights **42** and **43** so as to mitigate an imbalance (so-called crank unbalance) of the crank mechanism.

[0054] The stationary scroll **12** is provided with cooling fins (not shown in FIG. **1**) on a frame part including the circular, lid-shaped plate of the stationary scroll **12** so as to enable natural cooling by an ambient air. In the stationary scrolls **11** and **12** including a circular plate part or a circular disk plate part that serves as a part of a housing for the scroll compressor body **10***a*, circular cooling-water jackets (not shown in FIG. **1**) are arranged, and cooling-water flows by a cooling-water circulating means (not shown) comprising of radiators (not shown), and cooling-water circulating pumps (not shown). Thus, the forced cooling of the stationary scrolls **11** and **12** from the back sides thereof is accomplished.

[0055] As mentioned above, the compressed inert gas, the pressure of which is higher than that of the final discharge gas discharged through the outlet port **15**, is led through the compressed gas inlets **17** and **18**, toward each end side of drive shaft bearings, to be discharged through the outlet port **15**. As a result, the gas compressed in the closed spaces does not flow back through the compressed gas inlets **17** and **18**. Moreover, the vacuum pump is gas-tightly isolated from outside (except that there are connection parts such as the inlet port **14**, the outlet port **15**, the compression gas inlet **17** and **18**). Further, the pump needs no sealing elements as to the magnetic coupling **31** that is a drive torque transmission means without mechanical contact. Thus, even when radioactive pollution material is sucked through the inlet port from the atomic energy plant side, the pollutant cannot leak through the pump toward an ambient side. In this connection, the patent reference describes a further detail about a double-lapped dry scroll vacuum pump as an example of a fluid machine connected to a drive component via a magnetic coupling.

[0056] FIG. **2** shows an enlarged sectional view of magnetic coupling **31** in FIG. **1** of the present invention. The magnetic coupling **31** is provided with at least one air ventilation device that is installed in an outer rotor **32** composing a member of the magnetic coupling **31**. The air ventilation device is arranged, for instance, at a part indicated as reference numeral **36** in a drive component side cylinder-bottom part of the outer rotor **32**, and/or at apart indicated as reference numeral **39** in a vacuum pump side cylinder-periphery end-part of the outer rotor **32**, so as to form air streams as illustrated with arrows in FIG. **2**. Here, the reference numeral **20** indicates an sealing assembly (an enclosure), **21** indicates inner rotor side magnets, **23** is an inner rotor, **30***a* is a drive shaft of a drive component **30**, **33** indicates outer rotor side magnets, and **34** indicates a vent.

[0057] Besides the above-mentioned parts **36** and **39** pointed-out beforehand, the air ventilation device may be provided in a cylinder-periphery part of the outer rotor **32**, in a cylinder-periphery part of the outer rotor between outer rotor side magnets **33** (in FIG. **1**) attached on inner periphery of the outer rotor **32**, or the like. The blade/slits (air ventilation device) are preferably placed at both of the vacuum pump side (the fluid machine side) and the drive component **30** side across an band area of the cylinder-periphery part of the outer rotor where the outer rotor side magnets **33** (in FIG. **1**) are located, and further each air inducing and/or air discharging momentum at each blade/slit is preferably adjusted, so that aventilation air does not stagnate inside the outer rotor. The magnetic coupling is effectively cooled especially by airflows in the pump axis direction through a gap space between the outer rotor side magnets and the inner rotor side magnets. Here, a part of the ventilation devices play role of upstream passages while the remaining devices play role of downstream passages, thereby passage resistance of the downstream passages is preferably smaller than that of the upstream passages or inducing momentum of the upstream passages is preferably larger than that of the down stream passages.

[0058] FIGS. **3**A, **3**B, **3**C, **3**D, **3**E, and **3**F illustrate the structure and installation locations as to the air ventilation device. FIG. **3**F shows, in a sectional view, the locations where the air ventilation devices are installed in the outer rotor **32**. Reference numerals **30***a* and **33** indicate a drive shaft of a drive component **30**, and drive magnets (outer rotor side magnets) **33** respectively. The numerals **36** indicates an air ventilation device installed in a drive component side cylinder-bottom part of the outer rotor **32**, as shown in FIG. **3**A which is a cross-sectional view of line A-A', the numerals **37** indicates an air ventilation device installed in a cylinder-periphery part of the outer rotor **32**, as shown in FIG. **3**B which is a cross-sectional view of line B-B', the numerals **38** indicates an air ventilation device installed in a cylinder-periphery part of the outer rotor between outer rotor side magnets **33** attached on inner periphery of the outer rotor **32**, as shown in FIG. **3**C which is a cross-sectional view of line C-C', and the numerals **39** indicates an air ventilation device installed in a vacuum pump side cylinder-periphery end-part of the outer rotor **32**, as shown in FIG. **3**D which is a cross-sectional view of B-B'.

[0059] As illustrated in FIG. **3**E, an air ventilation device installed in each location is composed, for example, to be a plurality of blades fitted into the outer rotor **32** with an inclination to a rotational direction of the outer rotor **32**, as illustrated in FIG. **3**E. Through the slits formed between the blades **40**, an ambient air is induced into the space inside the outer rotor **32** as well as the induced air is discharged outside the outer rotor **32**.

[0060] As indicated in FIG. **3**A, the air ventilation device **36** installed in the cylinder-bottom part of the outer rotor **30** at the drive component **30** side may be a circular shape centering around the drive shaft **30***a* of the drive component **30**. As a matter of course, there may be solid hub (rib) parts in an annular space of blades and slits from a viewpoint of practical strength design. In FIG. **3**B, the air ventilation device **37** is located in a cylinder-periphery part of the outer rotor **32**. The location area may be any part of the cylinder-periphery part of the outer rotor **32** except the places where the drive magnets occupy, for instance, a band area of the cylinder-periphery part of the outer rotor where the outer rotor side magnets **33** are located inside the outer rotor **32**.

[0061] In the air ventilation device **38** shown in FIG. **3**C, blades are placed in a cylinder-periphery part of the outer rotor, between outer rotor side magnets **33**, across an band area of the cylinder-periphery part of the outer rotor where the outer rotor side magnets **33** are located inside the outer rotor **32**. In FIG. **3**C, the areas in which the drive magnets **33** are arranged protrude inside toward the coupling axis than the areas of the blades/slits **38**. However, the protrusion is not a prerequisite, of course, the inner diameters of both areas, namely, the magnet areas and the blade/slit areas may be the same.

[0062] The air ventilation device **39** shown in FIG. **3**D is installed in a vacuum pump side cylinder-periphery end-part of the outer rotor **32**. With the slits directed so as to induce an ambient air inside, the sealing assembly **20** can be effectively cooled as an airflow blows immediately toward the partition part of the sealing assembly **20**.

[0063] Further, as mentioned before, with the air ventilation devices **36**, **37**, **38**, and **39** that are placed at both of the vacuum pump side (the fluid machine side) and the drive component **30** side across an band area of the cylinder-periphery part of the outer rotor where the outer rotor side magnets **33** are located. With larger differences as to air inducing/discharging amounts between upstream sides and downstream sides, the sealing assembly **20** can be effectively cooled without airflow stagnation (as a whole) inside the outer rotor **32**.

[0064] For obtaining the above effect, for instance, the slit area of the upstream sides may be reduced than that of the downstream sides, an ambient air may be induced inside the outer rotor **32** through the ventilation device **36** and the induced air is discharged outside the outer rotor **32** through the ventilation devices **38** and **39**, an ambient air may be induced through the ventilation device **36** and the induced air is discharged through the ventilation devices **36** and **37**, or the numbers of the ventilation devices on discharge side may be reduced than that on induction side.

[0065] As described so far, in a fluid machine connected to the drive component via a magnetic coupling according to the present invention, the air ventilation devices **36**, **37**, **38**, and **39** for inducing an ambient air are installed in an outer rotor **32** of a magnetic coupling **31** so as to cool the sealing assembly (an enclosing partition) **20** and the outer rotor side magnets (drive magnets) **33**. By the structure, the enclosing partition **20** and the drive magnets **33** are cooled by the induced ambient air, in a case where a gas/fluid compression process in the fluid machine generates a heat or when a heat derived from the drive component **30** is conducted to the magnetic coupling. As a result, it becomes possible to evade possible reduction of the clearances between the outer rotor side magnets **33** and the sealing assembly **20**, that is, it becomes possible to evade possible mechanical contact therebetween. Further, torque transmission failure due to weakened magnetic flux densities reaching the driven magnets (inner rotor side magnets) **22** can be evaded, in a case when the clearances between the outer rotor side magnets **33** and the sealing assembly **20** are widened.

[0066] Moreover, since the air ventilation device is fitted on the outer rotor itself **32**, upsizing of the magnetic coupling **31** or useless large space attended by the conventional rotary wings around the outer rotor is not required. As a result, the device can realize a compact design and production as to both the magnetic coupling and the fluid machine.

[0067] The present invention can realize a fluid machine connected to a drive source via a magnetic coupling, having high durability and reliability, since the magnetic coupling is effectively cooled, granting that heats are conducted to the magnetic coupling from the fluid machine or from the drive source.

What is claimed is:

1. A fluid machine connected to the drive component via a magnetic coupling, comprising of,

a drive component, and

a fluid machine composed of a pump unit including compressors, being connected to the drive component via a magnetic coupling;

said magnetic coupling comprising,

an outer rotor to the cylinder-bottom part of which a drive shaft of the drive component is connected,

outer rotor side magnets placed on an inner periphery of the outer rotor,

an inner rotor fitted to a drive shaft of the fluid machine, inside the outer rotor, and

inner rotor side magnets placed on an outer periphery of the inner rotor, whereby attraction workings and repulsion workings between the outer rotor side magnets and the inner rotor side magnets transmit torques of the drive component to the fluid machine;

the fluid machine being provided with a pair of sealing assemblies that encloses both end parts of a drive shaft of the fluid machine so as to bring the fluid machine a gas-tightly sealed condition except that there are a gas inlet port, a gas outlet port, and compression gas inlets;

wherein an air ventilation device for ventilating a space inside the outer rotor by means of inducing and/or discharging ambient air is provided in the outer rotor of the magnetic coupling so as to cool the sealing assembly of the magnetic coupling side, and the outer rotor side magnets.

2. A fluid machine connected to the drive component via a magnetic coupling of claim **1**, wherein the air ventilation device composed of blades and/or slits, the blades being fitted into a periphery part of the outer rotor with an inclination to a rotational direction of the outer rotor and the slits for ventilation being formed space from a blade to a blade.

3. A fluid machine connected to the drive component via a magnetic coupling of claim **1**, wherein the air ventilation devices are installed in a drive component side cylinder-bottom part of the outer rotor, in a cylinder-periphery part of the outer rotor, in a cylinder-periphery part of the outer rotor between the outer rotor side magnets attached on inner periphery of the outer rotor, in a fluid machine side cylinder-periphery end-part of the outer rotor, or in the plural locations among said locations.

4. A fluid machine connected to the drive component via a magnetic coupling of claim **1**, wherein the air ventilation devices are provided at both of the fluid machine side and the drive component side across an band area of the cylinder-periphery part of the outer rotor where the outer rotor side magnets are located, a part of the ventilation devices playing role of upstream passages and the remaining devices playing role of downstream passages, whereby passage resistance of the downstream passages is smaller than that of the upstream passages or whereby inducing momentum of the upstream passages is larger than that of the down stream passages.

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