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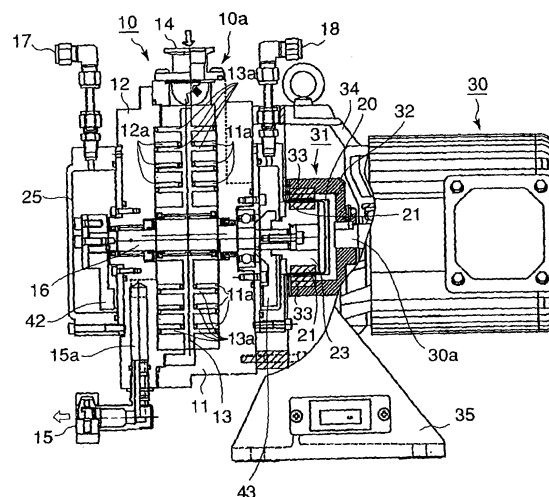
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(54) **A fluid machine connected to a drive source via a magnetic coupling**

(57) 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**



## Description

### BACKGROUND OF THE INVENTION

#### Field of the Invention

**[0001]** 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.

**[0002]** 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.

**[0003]** 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.

**[0004]** 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.

**[0005]** 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 11b of the stationary scroll 11 and a lap outside surface 13b 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.

**[0006]** In Fig. 5(a), when a lap outside surface 13b of the orbiting scroll 13 and a lap inside surface 11b 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. 5a. 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 13b of the orbiting scroll 13 begin to separate from the lap inside surface 11b of the stationary scroll 11 around a tail part thereof, to form an open gap space 61 in Fig. 5b, 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.

**[0007]** With a further advanced crank angle by 90 degrees as shown in Fig. 5c, 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.

**[0008]** 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 10a, 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 mag-

netic 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.

[0009] 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 30a, 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.

[0010] 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.

[0011] The stationary scroll 11 of the scroll compressor body 10a comprises a circular plate located vertically to the pump axis and a stationary scroll lap 11a of spiral wall shape, the lap 11a 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 10a 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 12a of spiral wall shape, the lap 12a 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 10a 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 13a of spiral wall shape, the laps 13a being set-up on side surfaces of the circular plate.

[0012] In the orbiting scroll 13, the orbiting scroll laps 13a 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 11a and 12a 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 13a 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 15a to an outlet 15 is smoothly performed, so as to function as a vacuum pump.

[0013] 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 10a; 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.

[0014] In addition, a compressed inert gas, namely compressed N<sub>2</sub> (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.

[0015] 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.

[0016] 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 10a, are arranged circular cooling-water jackets 54a, 54b, 54c, and 54d, 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.

**[0017]** 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.

**[0018]** 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 54a, 54b, 54c, and 54d 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.

**[0019]** 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.

**[0020]** 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.

**[0021]** 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

**[0022]** 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.

**[0023]** 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.

**[0024]** 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 dis-

charging 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.

**[0025]** 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.

**[0026]** 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.

**[0027]** 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 locations.

**[0028]** 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.

**[0029]** 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.

**[0030]** 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 DRAEINGS

**[0031]** The invention will now be described in greater detail with reference to the preferred embodiments of the invention and the accompanying drawings, wherein:

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 in Fig. 1;

Figs. 3A, 3B, 3C, 3D, 3E, and 3F 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;

Fig. 4 shows an outline structure of a conventional double-lapped dry scroll vacuum pump in a sectional view; and

Figs. 5a, 5b, 5c, and 5d 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

**[0032]** 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.

**[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 com-

ponent 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.

**[0034]** 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.

**[0035]** 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.

**[0036]** 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.

**[0037]** 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.

**[0038]** 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 10a, 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.

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.

**[0039]** 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 30a, 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 an 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.)

**[0040]** 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.

**[0041]** The stationary scroll 11 of the scroll compressor body 10a is composed of a circular plate located vertically to the pump axis, and a stationary scroll lap 11a 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 10a and a first side surface of the plate serves as a sliding surface for the orbiting scroll lap.

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 12a 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 10a and a first side surface of the plate serves as a sliding surface for the orbiting scroll lap.

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 13a of spiral wall shape set-up on side surfaces of the circular plate.

**[0042]** In the orbiting scroll 13, the orbiting scroll laps 13a of the spiral wall shape set-up on both side surfaces thereof in the axial direction are engaged into the stationary scroll laps 11a and 12a 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 13a 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 15a to an outlet 15 smoothly, functioning as a vacuum pump.

**[0043]** 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.

**[0044]** 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.

**[0045]** 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 10a, 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.

**[0046]** 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.

**[0047]** 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 a part 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, 30a is a drive shaft of a drive component 30, 33 indicates outer rotor side magnets, and 34 indicates a vent.

**[0048]** 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 a ventilation 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.

**[0049]** Figs. 3A, 3B, 3C, 3D, 3E, and 3F illustrate the structure and installation locations as to the air ventilation device. Fig. 3F shows, in a sectional view, the locations where the air ventilation devices are installed in the outer rotor 32. Reference numerals 30a 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. 3A 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. 3B 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. 3C 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. 3D which is a cross-sectional view of B-B'.

**[0050]** As illustrated in Fig. 3E, 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. 3E. Through the slits formed be-

tween 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.

**[0051]** As indicated in Fig. 3A, 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 30a 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. 3B, 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.

**[0052]** In the air ventilation device 38 shown in Fig. 3C, 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. 3C, 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.

The air ventilation device 39 shown in Fig. 3D 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.

**[0053]** 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.

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.

**[0054]** 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 device-

es 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.

**[0055]** 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.

**[0056]** 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.

## Claims

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 or 2, 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 any one of claims 1 - 3, 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 downstream passages.

Fig. 1

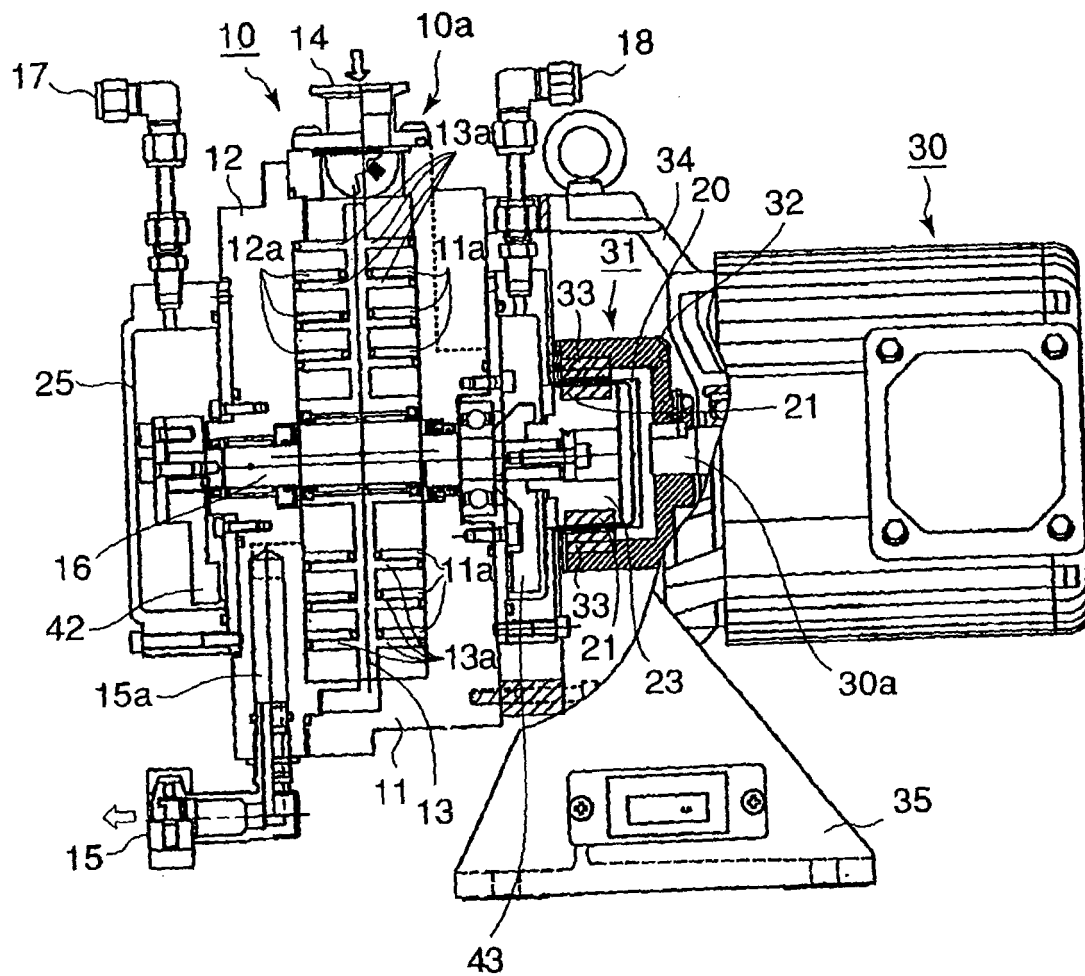
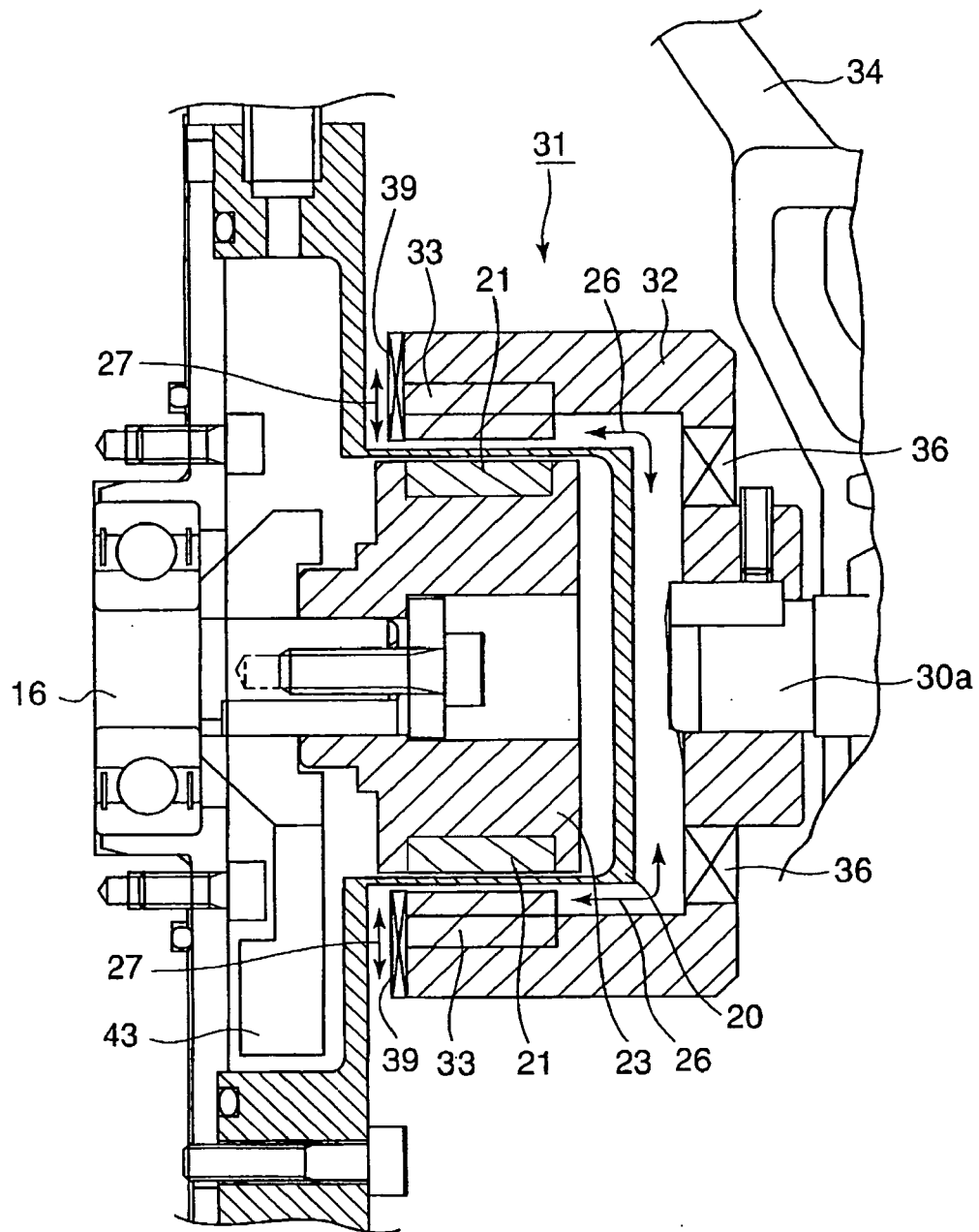
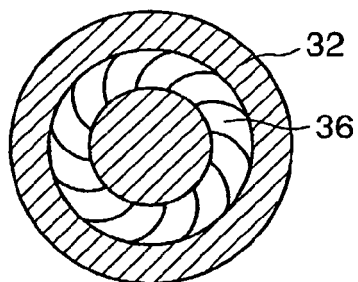


Fig. 2



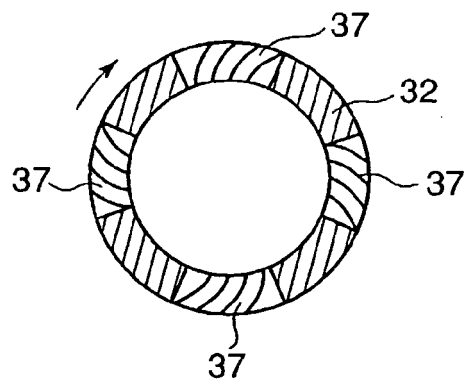
**Fig. 3A**

Sectional View of line A-A'



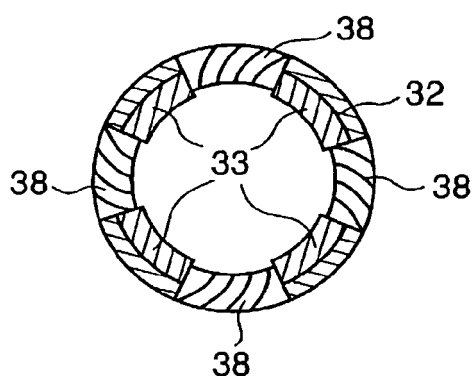
**Fig. 3B**

Sectional View of line B-B'

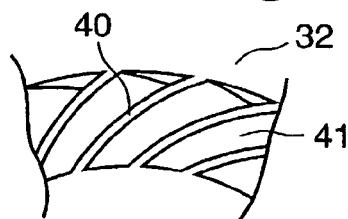


**Fig. 3C**

Sectional View of line C-C'

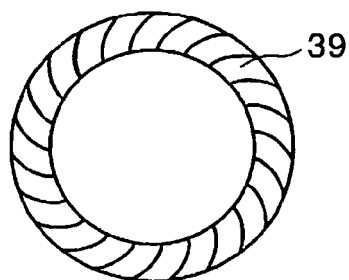


**Fig. 3E**



**Fig. 3D**

Sectional View of line D-D'



**Fig. 3F**

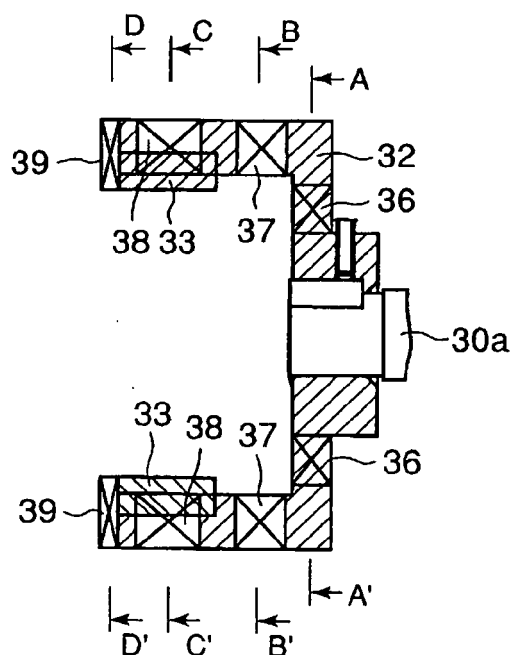


Fig. 4

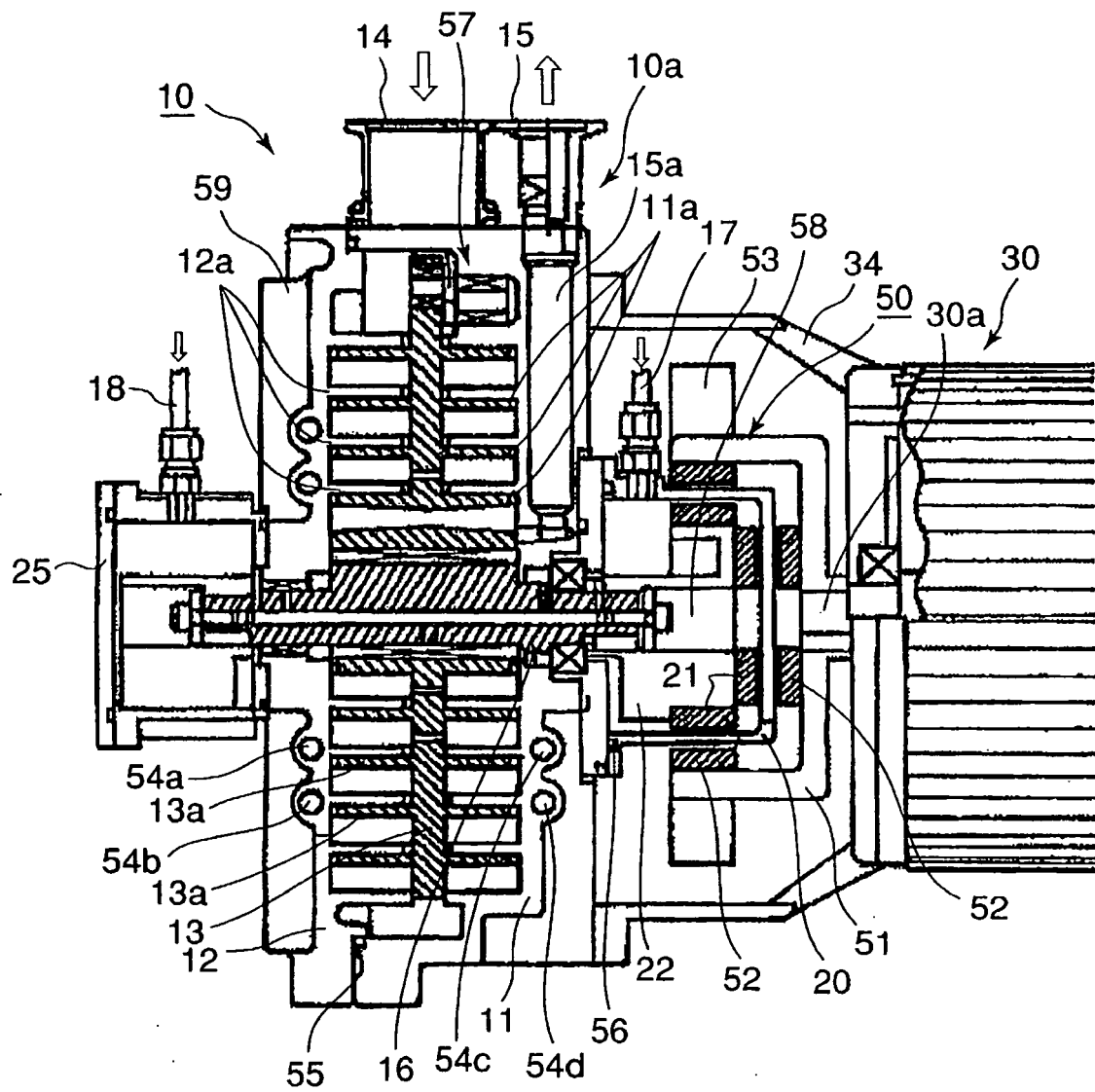


Fig. 5A

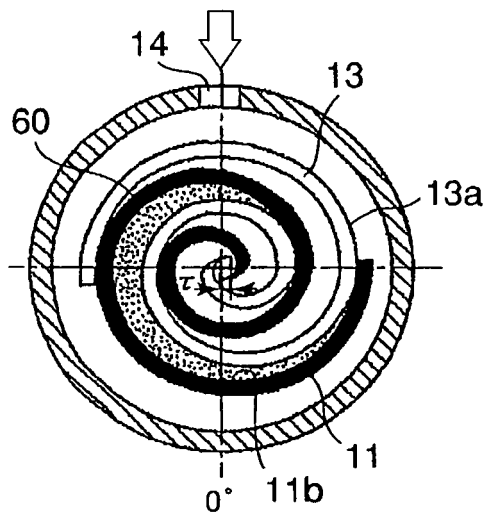


Fig. 5B

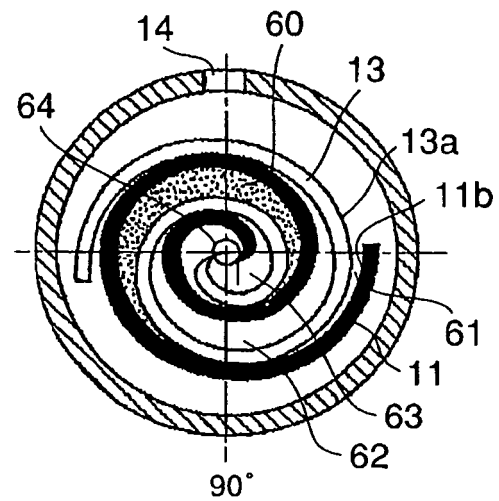


Fig. 5C

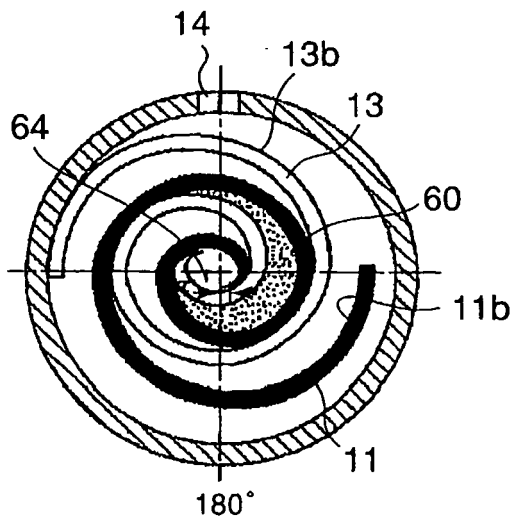
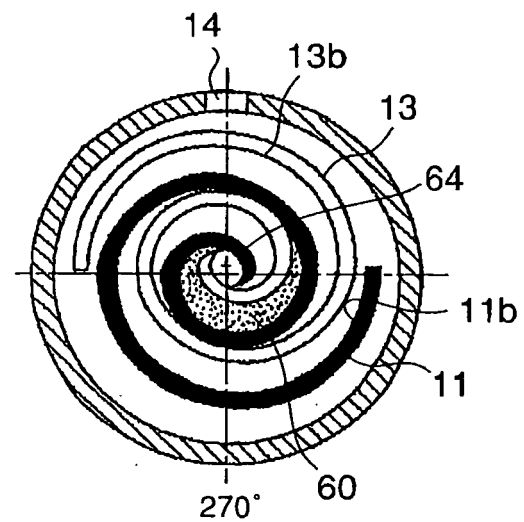


Fig. 5D



**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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