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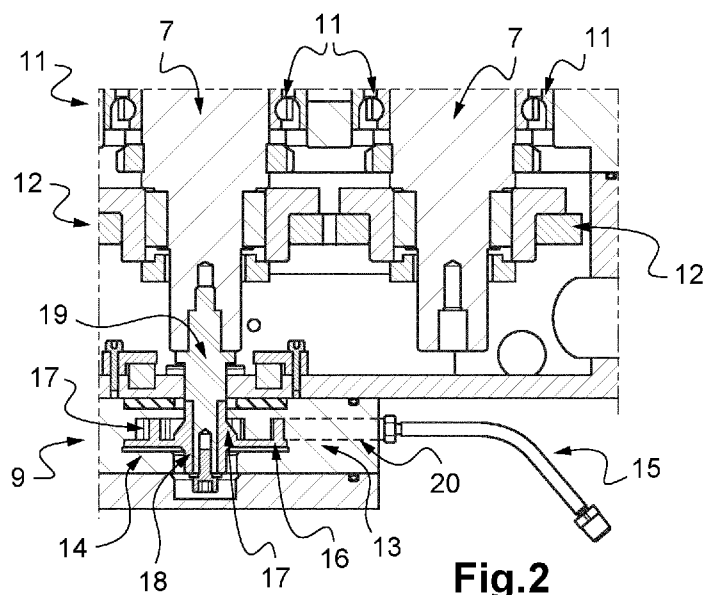


Fig.2

(57) Abstract: Vacuum pump (1) comprising a stator (4) comprising at least one compression chamber (5), two rotors (6) configured to rotate in the compression chamber (5) about a respective axis of rotation (I-I), the axes of rotation (I-I) being vertical, and elements to be lubricated mounted on shafts (7) of the rotors (6), the vacuum pump (1) further comprises an oil pump (9) comprising an oil sump (13) and at least one turbine (14) mounted on one of the shafts (7) of the rotors (6), the turbine (14) being bathed in a liquid lubricant received in a chamber of the oil sump (13), the rotation of the turbine (14) causing some of the lubricant to circulate in a lubricating duct (15) towards the elements to be lubricated and the oil pump (9) is a vane pump, the turbine (14) having a disc (16) and at least one vane (17) projecting from an upper face of the disc (16), the lubricating duct (15) comprising an inlet duct (20) communicating with the chamber of the oil sump (13) receiving the turbine (14) and oriented tangentially or radially to the turbine (14).

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Description

Title of the invention: Vacuum pump

Technical field of the invention

[0001] The present invention relates to a dry vacuum pump such as a pump of the
5 “Roots” or “Claw” or screw type, with the axes of rotation being vertical.

Technical background

[0002] Dry vacuum pumps comprise one or more pumping stages in series through
which a gas that is to be pumped circulates between a suction inlet and a delivery
outlet. Amongst known vacuum pumps, a distinction is made between those which
10 have rotary lobes, also known by the name of “Roots” pumps, pumps known as “Claw”
pumps, and screw pumps. Also known are vacuum pumps of the Roots compressor (or
“Roots Blower”) type which are used upstream of the rough-vacuum pumps in order to
increase the pumping capability under high flow conditions. These vacuum pumps are
referred to as “dry” because, in operation, the rotors rotate inside the stator without any
15 mechanical contact between them or with the stator, which makes it possible not to use
oil in the pumping stages.

[0003] The rotors are supported by bearings lubricated by oil or grease and they are
synchronized by means of likewise lubricated gearings. It is indispensable that no trace
of oil or grease is found in the pumping part for “dry” applications, such as methods for
20 manufacturing semiconductor substrates. A sealing means via which the shafts are still
capable of rotating isolates the region containing lubricants from the dry pumping part.

[0004] In the case of vacuum pumps arranged horizontally, an oil stirrer disc is
generally used to create a misted atmosphere of air and lubricants in the oil sump,
facilitating the lubrication of the bearings. The oil stirrer is fastened to one of the shafts
25 of the pump, a lower end of the stirrer dipping into the liquid oil of the sump. The
rotation of the shaft supporting the oil stirrer forms an oil mist, projecting droplets of
lubricant onto the walls of the sump which then trickle down to the components to be
lubricated.

[0005] In the case of a vertical architecture, it is no longer possible to effectively use oil
stirrer discs. There is therefore sought a means for forcing the oil to circulate in the
30 channels and to rise towards the rolling bearings of a vertical vacuum pump that are to
be lubricated.

Summary of the invention

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[0006] An aim of the present invention is to propose a vacuum pump solving at least one of the disadvantages described above.

[0007] To this end, one subject of the invention is a vacuum pump comprising:

- a stator comprising at least one compression chamber,
- 5 – two rotors configured to rotate in the compression chamber about a respective axis of rotation, the axes of rotation being vertical, and
- elements to be lubricated mounted on shafts of the rotors,

characterized in that the vacuum pump further comprises an oil pump comprising an oil sump and at least one turbine mounted on one of the shafts of the rotors, the turbine
10 being bathed in a liquid lubricant received in a chamber of the oil sump, the rotation of the turbine causing some of the lubricant to circulate in a lubricating duct towards the elements to be lubricated.

[0008] In operation, the motor drives the rotors in rotation in the compression chamber for pumping the gases in the dry pumping part. At the same time, the rotation of the
15 shafts causes the turbine of the oil pump to rotate. The rotation of the turbine accelerates the liquid lubricant which is driven radially by centrifugal force or by rotating mechanical elements of the turbine (vanes or teeth of pinions) into the lubricating duct. The oil pump can then force the lubricant to rise to the level of the elements to be lubricated situated above the oil sump. The oil pump is inexpensive since it uses the
20 same rotational drive means as those of the rotors of the vacuum pump. Moreover, the oil pump has no wear parts and is simple to implement.

[0009] The vacuum pump may further comprise one or more of the features which are described below, taken alone or in combination.

[0010] According to a first example of embodiment, the oil pump is a vane pump, the
25 turbine having a disc and at least one vane projecting from an upper face of the disc.

[0011] The turbine comprises, for example, between two and six curved vanes extending over a circular arc of between 10° and 120°, for example up to the edge of the disc of the turbine.

[0012] According to a second example of embodiment, the oil pump is a centrifugal
30 pump.

[0013] According to one example of embodiment, the turbine of the centrifugal pump comprises a smooth disc.

[0014] According to another example of embodiment, the turbine of the centrifugal pump has a disc extended by a cylindrical wall to form a cylindrical bowl, at least two through-holes being formed in the cylindrical wall of the bowl.

[0015] According to a third example of embodiment, the oil pump is a gear pump,
5 comprising at least one turbine mounted on a shaft of the rotors, formed by a toothed wheel of a synchronizing gearing of the vacuum pump.

[0016] The elements to be lubricated comprise, for example, toothed wheels of a synchronizing gearing that are mounted on a respective shaft of the rotors and/or at least one first pair of bearings mounted at the end of a shaft of the rotors and/or at least
10 one second pair of bearings. The synchronizing gearing and/or the pairs of bearings are situated along the shafts of the rotors, for example above the oil sump.

[0017] The vacuum pump may comprise an oil return channel formed between the elements to be lubricated and the chamber of the oil sump. In operation, the excess lubrication returns into the oil sump via the oil return channel.

[0018] The lubricating duct may comprise an inlet duct communicating with the
15 chamber of the oil sump receiving the turbine and oriented tangentially or radially to the turbine.

[0019] The inlet duct may comprise a flow restriction configured to accelerate the circulation of the lubricant by Venturi effect.

[0020] The inlet duct may be straight and tangent to the disc of the turbine.
20

[0021] According to one example of embodiment, the inlet of the inlet duct is in the form of a volute. The volute winds in a spiral around a disc of the turbine, the diameter of the channel of the volute increasing, for example, on approaching a straight and tangential part of the inlet duct. The volute may extend over a complete circle around
25 the disc, the periphery of the disc forming the inlet of the inlet duct. In the case where the cross section of the volute increases following the direction of circulation of the lubricant, the volute makes it possible to channel the lubricant into the lubricating duct while limiting turbulence. In the case where the cross section of the volute decreases following the direction of circulation of the lubricant, the volute makes it possible to
30 accelerate the circulation of the lubricant in the lubricating duct by Venturi effect.

[0022] There can also be provision that a central through-orifice is formed in the turbine for fastening the turbine at the end of a shaft of the rotors.

[0023] Another subject of the present invention is a vacuum pump comprising:

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- a stator comprising at least one compression chamber,
- two rotors configured to rotate in the stator about a respective axis of rotation, the axes of rotation being vertical,
- elements to be lubricated mounted on shafts of the rotors,
- 5 – a motor configured to drive the shafts of the rotors in rotation,

characterized in that the vacuum pump further comprises an external oil pump comprising its own rotational drive means for circulating some of the lubricant contained in an oil sump of the vacuum pump towards the elements to be lubricated.

[0024] Given that it has its own rotational drive means, the flow rate of liquid lubricant
10 circulated by the external oil pump is independent of the speed of rotation of the vacuum pump. It is then possible to precisely control the desired lubrication flow rate without depending on the frequency of the vacuum pump. It is possible notably to ensure a constant lubrication flow rate even in the case of reduced speed of the vacuum pump.

15 **[0025]** The vacuum pump may further comprise one or more of the features which are described below, taken alone or in combination.

[0026] The external oil pump may be a positive-displacement oil pump, such as a vane pump.

20 **[0027]** In this case, the desired lubrication flow rate can then be controlled without depending on the viscosity of the oil.

[0028] The external oil pump may also be a non-positive-displacement pump, such as a centrifugal pump.

25 **[0029]** In this case, the vacuum pump may comprise a temperature sensor configured to measure the temperature of the liquid lubricant and a control unit connected to the temperature sensor, configured to control the speed of rotation of the rotational drive means of the external oil pump in order to control the lubrication flow rate as a function of the measured temperature.

[0030] Another subject of the present invention is a vacuum pump comprising two vacuum pump units each comprising:

- 30 – a stator comprising at least one compression chamber,
- two rotors configured to rotate in a compression chamber of the stator about a respective axis of rotation,
- elements to be lubricated mounted on shafts of the rotors, and

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- a motor configured to drive the rotors in rotation.

[0031] The axes of rotation of the vacuum pump units are vertical.

[0032] The vacuum pump further comprises an external oil pump comprising its own rotational drive means for circulating some of the lubricant contained in an oil sump of
5 each vacuum pump unit towards the elements to be lubricated. More precisely for example, the external oil pump forces the circulation of the lubricant in a lubricating duct common to the two vacuum pump units towards the elements of each unit that are to be lubricated.

Brief description of the figures

10 [0033] Other advantages and features will become apparent on reading the following description of a particular, but nonlimiting, embodiment of the invention and from the appended drawings, in which:

[0034] [Fig.1] Figure 1 is a schematic representation of a vacuum pump.

[0035] [Fig.2] Figure 2 is a partial view in longitudinal section of the vacuum pump of
15 Figure 1, according to a first embodiment.

[0036] [Fig.3] Figure 3 is a partial view in cross section of an oil pump of the vacuum pump of Figure 2.

[0037] [Fig.4] Figure 4 is a perspective view of the turbine of the oil pump of Figure 3.

[0038] [Fig.5] Figure 5 is a view in cross section of an oil pump according to a first
20 variant embodiment.

[0039] [Fig.6] Figure 6 is a view similar to Figure 5 of an oil pump according to a second variant embodiment.

[0040] [Fig.7] Figure 7 shows a view in longitudinal section of an oil pump of a vacuum pump according to a second embodiment.

25 [0041] [Fig.8] Figure 8 shows a perspective view of a turbine of the oil pump of Figure 7.

[0042] [Fig.9] Figure 9 shows a partial view in cross section of an oil pump according to a variant embodiment.

[0043] [Fig.10] Figure 10 shows a view in longitudinal section of a vacuum pump
30 according to a third embodiment.

[0044] [Fig.11] Figure 11 shows a partial top view of an oil pump of the vacuum pump of Figure 10.

[0045] [Fig.12] Figure 12 shows a perspective view of a turbine of the oil pump of Figure 11.

[0046] [Fig.13] Figure 13 shows a view in cross section of the oil pump of Figure 11.

5 [0047] [Fig.14] Figure 14 is a schematic representation of a vacuum pump according to a variant embodiment.

[0048] [Fig.15] Figure 15 is a schematic representation of a vacuum pump according to another variant embodiment.

[0049] [Fig.16] Figure 16 is a schematic representation of a vacuum pump according to a fourth embodiment.

10 [0050] [Fig.17] Figure 17 shows a view in cross section of the vacuum pump of Figure 16.

[0051] [Fig. 18] Figure 18 shows a view in cross section of an oil pump of the vacuum pump of Figure 17.

[0052] [Fig.19] Figure 19 shows a vacuum pump according to another invention.

15 [0053] [Fig.20] Figure 20 shows a variant embodiment of the vacuum pump of Figure 19.

[0054] The following embodiments are examples. Although the description refers to one or more embodiments, this does not necessarily mean that each reference concerns the same embodiment or that the features apply only to one embodiment.

20 Single features of different embodiments can also be combined or interchanged to provide other embodiments.

[0055] The invention applies to any type of single-stage or multi-stage dry vacuum pump, that is to say comprising one or more stages, such as comprising from one to ten pumping stages. This vacuum pump may be a multi-stage rough-vacuum pump configured to deliver gases pumped at atmospheric pressure or a dry vacuum pump with from one to three pumping stages which, in use, is connected upstream of a rough-vacuum pump and whose delivery pressure is that obtained by the rough-vacuum pump.

25 [0056] In the description, the longitudinal or axial direction is parallel to the axes of rotation of the shafts. The transverse direction is the direction perpendicular to the axial direction of rotation. The vertical direction is the direction parallel to the direction of gravity. The horizontal direction belongs to a plane perpendicular to the vertical.

Detailed description

[0057] Figures 1 to 6 show a first embodiment of the oil pump 9.

[0058] The vacuum pump 1 comprises a dry pumping part 2 and a mechanical drive part 3 (Figure 1).

[0059] The dry pumping part 2 comprises a stator 4 comprising at least one
5 compression chamber 5 and two rotors 6 configured to rotate in the compression chamber 5 of the stator 4 about a respective axis of rotation I-I. The vacuum pump 1 is configured to be installed, that is to say, for example, placed on the ground or on a chassis, with the axes of rotation I-I being vertical. The vertical arrangement of the vacuum pump 1 makes it possible to significantly reduce the footprint.

10 **[0060]** The rotors 6 have matching profiles able to be assembled on the shafts 7 or they can be produced in one piece with the shafts 7 (referred to as one-piece rotors). The rotors 6 are, for example, of "Roots" type with at least two lobes or of "Claw" type or they are of another similar positive-displacement vacuum pump principle. These vacuum pumps are referred to as "dry" because, in operation, the rotors 6 rotate inside
15 the stator 4 without any mechanical contact between them or with the stator 4, which makes it possible not to use oil in the dry pumping part 2.

[0061] The vacuum pump 1 may comprise a plurality of pumping stages arranged in series. Each pumping stage comprises a compression chamber 5 receiving two matching rotors 6, the compression chambers 5 comprising a respective inlet and
20 outlet. During rotation, the gas drawn from the inlet is trapped in the volume generated by the rotors 6 and the stator 4 and then is driven by the rotors 6 towards the following stage. The successive pumping stages are connected in series following one another by respective inter-stage channels connecting the outlet of the preceding pumping stage to the inlet of the following pumping stage.

25 **[0062]** The vacuum pump 1 further comprises a lubricant-tight sealing device (not shown) interposed between the mechanical drive part 3 and the dry pumping part 2. The sealing device allows the rotation of the shafts 7 in the dry pumping part 2 while limiting the transfers of lubricants.

[0063] The mechanical drive part 3 comprises a motor 8 configured to drive the rotors
30 6 in rotation.

[0064] The vacuum pump 1 also comprises elements to be lubricated that are mounted on the shafts 7 of the rotors 6 and an oil pump 9 for forcing the circulation of a liquid lubricant towards these elements to be lubricated.

[0065] The elements to be lubricated comprise, for example, at least one first pair of bearings 10 mounted at the end of a shaft of the rotors 6 and/or at least one second pair of bearings 11. In the first example of embodiment, the motor 8 is interposed between the first pair of bearings 10 and the second pair of bearings 11.

5 **[0066]** The bearings 10, 11 comprise, for example, rolling bearings.

[0067] The elements to be lubricated may also comprise a synchronizing gearing comprising two toothed wheels 12 mounted on a respective shaft 7 of the rotors 6. The toothed wheels 12 are configured to synchronize the rotation of the shafts 7.

[0068] The oil pump 9 comprises an oil sump 13 and at least one turbine 14 mounted
10 on one of the shafts 7 of the rotors 6, equally the driving shaft or the driven shaft, here the driven shaft. The oil sump 13 comprises a chamber configured to contain a reserve of liquid lubricant, which is injected and drained, for example, via an orifice in the oil sump 13 formed in a chamber closure plate and able to be closed off by a plug 21 (see, for example, Figures 16 and 17).

15 **[0069]** The turbine 14 is bathed in the liquid lubricant received in the chamber of the oil sump 13. The rotation of the turbine 14 due to the rotation of the shaft 7 circulates some of the lubricant in the lubricating duct 15 towards the elements to be lubricated, here the first pair of upper bearings 10 (Figure 1).

[0070] An oil return channel 25 may be formed between the elements to be lubricated
20 and the chamber of the oil sump 13. In operation, the excess lubrication returns into the oil sump 13 via the oil return channel 25.

[0071] According to one example of embodiment, the chamber of the oil sump 13 communicates with the synchronizing gearing and the second pair of lower bearings 11.

25 **[0072]** In this first embodiment, the oil pump 9 is a vane pump, the turbine 14 having a disc 16 and at least one vane 17 projecting from an upper face of the disc 16 (Figures 2, 3 and 4). The disc 16 mounted on the vertical shaft 7 therefore extends in a horizontal plane.

[0073] The turbine 14 comprises, for example, between two and six vanes 17, such as
30 three vanes 17. The vanes 17 may be curved. They extend, for example, over a circular arc of between 10° and 120°, such as 120° in the illustration of Figures 3 to 5. The rear edges of the vanes 17 extend, for example, up to the edge of the disc 16 of the turbine 14.

[0074] A central through-orifice 18 may be formed in the turbine 14 for fastening the turbine 14 at the end of a shaft of the rotors 6, for example by screwing onto an adapter 19 inserted into an orifice in the end of a shaft (Figure 2).

5 [0075] The lubricating duct 15 may comprise an inlet duct 20 communicating with the chamber of the oil sump 13 receiving the turbine 14 and oriented tangentially to the turbine 14. As visible in the example of Figure 3, the inlet duct 20 is straight and tangent to the disc 16 of the turbine 14. According to another example that has not been shown, the inlet duct 20 is oriented radially to the turbine 14.

10 [0076] In operation, the motor 8 drives the rotors 6 in rotation in the compression chamber 5 for pumping gases in the dry pumping part 2. At the same time, the rotation of the shafts 7 drives the rotation of the turbine 14 of the oil pump 9. The rotation of the turbine 14 causes the liquid lubricant to rotate in the chamber of the oil sump 13. The liquid lubricant is accelerated and driven radially up to the edges of the disc 16 by the vanes 17 and then into the inlet duct 20. The oil pump 9 can then cause some of the
15 lubricant to circulate from the chamber of the oil sump 13 towards the inlet duct 20 and then into the lubricating duct 15. The lubricant can then rise to the level of the elements to be lubricated situated above the oil sump 13, in particular the second pair of bearings 11, the toothed wheels 12 of the synchronizing gearing and/or the first pair of bearings 10 situated higher than the second pair of bearings 11. The excess lubrication
20 returns into the oil sump 13 via the oil return channel 25. This circulation of the liquid lubricant is illustrated by arrows in Figure 1.

[0077] The oil pump 9 is inexpensive since it uses the same rotational drive means as those of the rotors 6 of the vacuum pump 1. Moreover, the oil pump 9 has no wear parts and is simple to implement.

25 [0078] Figure 5 illustrates a first variant embodiment of the oil pump 9.

[0079] In this example, the oil pump 9 is also a vane pump. It comprises the same turbine 14 as in the first example of embodiment. This example differs from the preceding one through the fact that the inlet of the inlet duct 20 is in the form of a volute
22.

30 [0080] The inlet in the form of a volute 22 winds in a spiral around the disc 16 of the turbine 14, the diameter of the channel of the volute 22 increasing on approaching the straight and tangential part of the inlet duct 20.

[0081] The volute 22 extends, for example, over a complete circle around the disc 16, the periphery of the disc 16 forming the inlet of the inlet duct 20.

[0082] The rear edges of the vanes 17 situated at the edge of the disc 16 of the turbine 14 are situated downstream of the vanes 17 in the direction of expansion of the volute 22 and of rotation of the turbine 14 (see arrow in Figure 5).

[0083] The volute 22 makes it possible to channel the lubricant towards the inlet duct 20 while limiting flow turbulence.

[0084] Figure 6 illustrates a second variant embodiment of the oil pump 9.

[0085] In this example, the oil pump 9 is also a vane pump. The turbine 14 comprises curved vanes 17, for example. This example is differentiated from the preceding one through the fact that the vanes 17 are shorter and further away from the centre than in the first variant embodiment. They extend, for example, over a circular arc of between 10° and 45°. The rear edges of the vanes 17 extend, for example, up to the edge of the disc 16 of the turbine 14.

[0086] Shorter vanes 17 are simpler to produce and therefore less costly, but the lubricant flow rate can be less well controlled and it is lower than for more elongated vanes.

[0087] Figures 7 to 13 show a second embodiment of the oil pump 9.

[0088] In the second embodiment, the oil pump is a centrifugal pump.

[0089] In the example illustrated by Figures 7 to 9, the turbine 14 comprises a smooth disc 16. As in the preceding examples, the disc 16 mounted on the shaft 7 extends in a horizontal plane.

[0090] A central through-orifice 18 may also be formed in the turbine 14 to fasten the turbine 14 at the end of a shaft of the rotors 6, for example by screwing onto an adapter 19 inserted into an orifice in the end of a shaft.

[0091] The lubrication duct 15 may comprise an inlet duct 20 communicating with the chamber of the oil sump 13 receiving the turbine 14 and oriented tangentially to the turbine 14 (Figure 9). According to another example that has not been shown, the inlet duct 20 is oriented radially to the turbine 14.

[0092] According to a first example of embodiment illustrated by Figure 7, the inlet duct 20 is straight and tangent to the disc 16 of the turbine 14.

[0093] In operation, the motor 8 drives the rotors 6 in rotation in the compression chamber 5 for pumping gases in the dry pumping part 2. At the same time, the rotation

of the shafts 7 drives the rotation of the turbine 14 of the oil pump 9. The rotation of the turbine 14 causes the liquid lubricant to rotate in the chamber of the oil sump 13. The liquid lubricant is accelerated and driven radially up to the edges of the disc 16 by the centrifugal force and then into the inlet duct 20. The oil pump 9 can then circulate some of the lubricant from the chamber of the oil sump 13 towards the inlet duct 20 and then the lubricating duct 15. The lubricant rises to the level of the elements to be lubricated situated above the oil sump 13, in particular the second pair of bearings 11, the toothed wheels 12 of the synchronizing gears and/or the first pair of bearings 10 situated above the second pair of bearings 11.

10 **[0094]** The turbine 14 having a smooth disc 16 is simpler to produce and therefore less costly than a turbine with vanes, but the lubricant flow rate may be less well controlled and lower.

[0095] Figure 9 illustrates a variant embodiment of the centrifuge oil pump 9.

15 **[0096]** In this example, the oil pump 9 comprises the same turbine 14 with smooth disc as in the preceding example of embodiment illustrated by Figure 7. This example is differentiated therefrom through the fact that the inlet of the inlet duct 20 is in the form of a volute 22.

20 **[0097]** As described above, the volute 22 winds in a spiral around the disc 16 of the turbine 14, the diameter of the channel of the volute 22 increasing upon approaching the straight and tangential part of the inlet duct 20.

[0098] The volute 22 extends, for example, over a complete circle around the disc 16, the periphery of the disc 16 forming the inlet of the inlet duct 20.

[0099] Figures 10 to 13 show another example of embodiment of the centrifugal oil pump 9.

25 **[0100]** In this embodiment, the turbine 14 has a disc 16 extended by a cylindrical wall 24 to form a cylindrical bowl, at least two through-holes 23 being formed in the cylindrical wall 24 of the bowl (Figures 10 and 12). The disc 16 of the bowl extends in a horizontal plane.

30 **[0101]** There are, for example, between two and ten holes 23, here six, regularly distributed over the periphery of the bowl (Figures 12 and 13).

[0102] A central through-orifice 18 may also be formed in the turbine 14 for fastening the turbine 14 at the end of a shaft of the rotors 6, for example by screwing onto an adapter 19 inserted into an orifice in the end of a shaft (Figure 10).

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[0103] The lubricating duct 15 may comprise an inlet duct 20 communicating with the chamber of the oil sump 13 receiving the turbine 14 and oriented tangentially to the turbine 14. The inlet duct 20 is, for example, straight and tangent to the disc 16 of the turbine 14 (Figure 11). According to another example that has not been shown, the
5 inlet duct 20 is oriented radially to the turbine 14.

[0104] In operation, the motor 8 drives the rotors 6 in rotation in the compression chamber 5 for pumping gases in the dry pumping part 2. At the same time, the rotation of the shafts 7 drives the rotation of the turbine 14 of the oil pump 9. The rotation of the turbine 14 causes the liquid lubricant to rotate in the chamber of the oil sump 13. The
10 liquid lubricant is accelerated and driven radially up to the edges of the bowl by the centrifugal force and then into the inlet duct 20, via the holes 23. The oil pump 9 can then drive some of the lubricant from the chamber of the oil sump 13 towards the inlet duct 20 and then the lubricating duct 15. The lubricant rises to the level of the elements to be lubricated situated above the oil sump 13, in particular the second pair of
15 bearings 11, the toothed wheels 12 of the synchronizing gearings and/or the first pair of bearings 10 situated above the second pair of bearings 11.

[0105] Figure 13 illustrates a variant embodiment of the oil pump 9.

[0106] In this example, the oil pump 9 comprises the same turbine 14 with the cylindrical bowl as in the preceding example of embodiment. This example is
20 differentiated from the preceding one through the fact that the inlet of the inlet duct 20 is in the form of a volute 22.

[0107] As described above, the volute 22 winds in a spiral around the disc 16 of the turbine 14, the diameter of the channel of the volute 22 increasing upon approaching the straight and tangential part of the inlet duct 20.

25 [0108] The volute 22 extends, for example, over a complete circle around the disc 16, the periphery of the disc 16 forming the inlet of the inlet duct 20.

[0109] In all the embodiments described above, the arrangement of the oil sump 13, of the motor 8 and of the oil pump 9 may vary in the vacuum pump 1 without departing from the present invention, as can be seen, for example, in Figures 14 and 15.

30 [0110] In the example of Figure 14, the oil sump 13 is arranged at the end of a shaft, the motor 8 being interposed between the oil sump 13 on the one hand, and the synchronizing gearing and the second pair of bearings 11 on the other hand.

[0111] Moreover, an oil filter 25 may be arranged in the lubricating duct 15 and/or in the oil return channel 25. This feature notably can apply to all the embodiments and variant embodiments.

[0112] According to another variant, independent of the position of the oil sump 13, and visible in Figure 14 notably, the turbine 14 is mounted on the driving shaft 7.

[0113] Figure 15 shows another variant embodiment of the vacuum pump 1 in which the motor 8 is arranged at the end of a shaft and the oil sump 13 is interposed between the motor 8 on the one hand and the synchronizing gearing and the second pair of bearings 11 on the other hand.

[0114] Figures 16 to 18 show a third embodiment of the oil pump 9.

[0115] In this embodiment, the oil pump 9 comprises a turbine 14 mounted on a shaft 7 of the rotors 6, the turbine 14 being formed by a toothed wheel 12 of the synchronizing gearing. The toothed wheels 12 extend in a horizontal plane.

[0116] In this example also, the lubricating duct 15 comprises an inlet duct 20 communicating with the chamber of the oil sump 13 receiving the turbine 14. The inlet duct 20 is oriented tangentially or radially to the turbine 14. It may comprise a flow restriction 27 configured to accelerate the circulation of the lubricant in the lubricating duct 15 by Venturi effect (Figure 18).

[0117] The oil pump 9 with gearings uses the rotation of the toothed wheels 12 of the synchronizing gearing and the profile of the toothed wheels 12 to accelerate and circulate the liquid lubricant in the lubricating duct 15.

[0118] The chamber of the oil sump 13 may also directly communicate with the second pair of lower bearings 11.

[0119] In the example shown in Figures 16 and 17, the motor 8 is interposed between the dry pumping part 2 on the one hand and the second bearing 11 and the synchronizing gearing 12 on the other hand (Figure 16).

[0120] In operation, the motor 8 drives the rotors 6 in rotation in the compression chamber 5 for pumping gases in the dry pumping part 2. At the same time, the rotation of the shafts 7 drives the rotation of the turbine 14 of the oil pump 9. The teeth of the toothed wheels 12 and therefore of the turbine 14 accelerate and drive some of the lubricant from the chamber of the oil sump 13 towards the lubricating duct 15. The lubricant rises to the level of the elements to be lubricated that are situated above the

oil sump 13, in particular the second pair of bearings 11 and/or the first pair of bearings 10 situated above the second pair of bearings 11.

[0121] In this embodiment, the synchronizing gearing already present is used for synchronizing the shafts 7 as rotational drive means of the oil pump 9 for the forced
5 circulation of the liquid lubricant.

[0122] Although, in Figures 16 to 18, a single toothed wheel 12 is used as turbine 14 of the oil pump 9, it is quite conceivable to make the system symmetrical by making provision that the oil pump 9 comprises two turbines 14 mounted on a respective shaft 7 of the rotors 6, each formed by a toothed wheel 12 of the synchronizing gearing.

10 [0123] Figures 19 and 20 show a vacuum pump 1 produced according to another invention.

[0124] The vacuum pump 1 comprises a dry pumping part 2 and a mechanical drive part 3.

[0125] The dry pumping part 2 comprises a stator 4 comprising at least one
15 compression chamber 5 and two rotors 6 configured to rotate in the compression chamber 5 of the stator 4 about a respective axis of rotation I-I. The vacuum pump 1 is configured to be installed, that is to say, for example, placed on the ground or on a chassis, with the axes of rotation I-I being vertical. The vertical arrangement of the vacuum pump 1 makes it possible to significantly reduce the footprint.

20 [0126] The rotors 6 have matching profiles able to be assembled on the shafts 7 or they may be produced in one piece with the shafts 7 (referred to as one-piece rotors). The rotors 6 are, for example, of "Roots" type with at least two lobes or of "Claw" type or they are of another similar positive-displacement vacuum pump principle. These vacuum pumps are referred to as "dry" because, in operation, the rotors 6 rotate inside
25 the stator 4 without any mechanical contact between them or with the stator 4, which makes it possible not to use oil in the dry pumping part 2.

[0127] The vacuum pump 1 may comprise a plurality of pumping stages arranged in series. Each pumping stage comprises a compression chamber 5 receiving two matching rotors 6, the compression chambers 5 comprising a respective inlet and
30 outlet. During rotation, the gas drawn from the inlet is trapped in the volume generated by the rotors 6 and the stator 4 and then is driven by the rotors 6 towards the following stage. The successive pumping stages are connected in series following one another

by respective inter-stage channels connecting the outlet of the preceding pumping stage to the inlet of the following pumping stage.

[0128] The vacuum pump 1 further comprises a lubricant-tight sealing device (not shown) interposed between the mechanical drive part 3 and the dry pumping part 2.

- 5 The sealing device allows the rotation of the shafts 7 in the dry pumping part 2 while limiting the transfers of lubricants.

[0129] The vacuum pump 1 also comprises elements to be lubricated that are mounted on the shafts 7 of the rotors 6 and an external oil pump 30 for forcing circulation of a liquid lubricant towards these elements to be lubricated.

- 10 **[0130]** The elements to be lubricated comprise, for example, at least one first pair of bearings 10 mounted at the end of a shaft of the rotors 6 and/or at least one second pair of bearings 11, for example interposed between a motor 8 and the dry pumping part 2. Alternatively, the motor 8 can be interposed between the dry pumping part 2 and the second pair of bearings 11.

- 15 **[0131]** The bearings 10, 11 comprise, for example, rolling bearings.

[0132] The elements to be lubricated may also comprise a synchronizing gearing comprising two toothed wheels 12 mounted on a respective shaft 7 of the rotors 6. The toothed wheels 12 are configured to synchronize the rotation of the shafts 7.

- 20 **[0133]** The vacuum pump 1 also comprises, for example, an oil sump 31 containing a reserve of liquid lubricant, communicating, for example, with the synchronizing gearing, the second pair of bearings 11 and possibly also the motor 8.

[0134] A lubricating duct 15 connects, for example, the liquid lubricant reserve of the oil sump 31 to the external oil pump 30 and to the elements to be lubricated, here the first pair of bearings 10 situated at the end of a shaft (Figure 19).

- 25 **[0135]** An oil return channel 25 may be formed between the elements to be lubricated and the chamber of the oil sump 31. In operation, the excess lubrication returns into the oil sump 31 via the oil return channel 25.

[0136] An oil filter 26 may be arranged in the lubricating duct 15 and/or in the oil return channel 25.

- 30 **[0137]** The external oil pump 30 comprises its own rotational drive means. What is meant by its own means is that the rotational drive means of the external oil pump 30 are independent of the drive motor 8 of the rotors 6 of the dry pumping part 2 of the vacuum pump 1.

[0138] The external oil pump 30 may be a positive-displacement oil pump, such as a vane pump. The rotational drive means are then configured to drive the rotation of an eccentric vane rotor of the external oil pump 30 in order to circulate some of the lubricant in the lubricating duct 15.

5 [0139] In operation, the external oil pump 30 circulates some of the liquid lubricant from the oil sump 31 towards the elements to be lubricated, here the first pair of bearings 10. The circulation of the liquid lubricant is illustrated by arrows in Figure 19.

[0140] According to another example of embodiment, the external oil pump is a non-positive-displacement oil pump, such as a centrifugal pump. The rotational drive means
10 are then configured to rotate a centrifugal disc of the external oil pump 30 in order to circulate the lubricant in the lubricating duct 15.

[0141] In this case, the vacuum pump 1 may further comprise a temperature sensor configured to measure the temperature of the liquid lubricant and a control unit connected to the temperature sensor, configured to control the speed of rotation of the
15 rotational drive means of the external oil pump 30 in order to control the lubrication flow rate as a function of the measured temperature.

[0142] Given that it has its own rotational drive means, the liquid lubricant flow rate circulated by the external oil pump 30 is independent of the speed of rotation of the vacuum pump 1. It is then possible to precisely control the desired lubrication flow rate
20 without depending on the frequency of the vacuum pump 1. It is notably possible to ensure a constant lubrication flow rate even in the case of reduced speed of the vacuum pump 1, for example in idle mode. This solution also makes it possible to simplify the use of the oil filter 26 in order to ensure an increased service life of the mechanical elements.

25 [0143] Figure 20 shows a variant embodiment in which the external oil pump 30 is common to two vacuum pump 1 units.

[0144] The vacuum pump 1 comprises two vacuum pump units 32 each comprising a stator 4 comprising at least one compression chamber 5, two rotors 6 configured to rotate in a compression chamber of the stator 4 about a respective axis of rotation I-I,
30 elements to be lubricated that are mounted on shafts 7 of the rotors 6 and a motor 8 configured to drive the rotors 6 in rotation.

[0145] The axes of rotation I-I of the vacuum pump units 32 are vertical.

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[0146] The vacuum pump 1 further comprises an external oil pump 30 comprising its own rotational drive means for circulating some of the lubricant contained in an oil sump 31 of each vacuum pump unit 32 towards the elements to be lubricated. More precisely, for example, the external oil pump 30 forces the circulation of the lubricant in
5 a lubricating duct 15 common to the two vacuum pump units 32 towards the elements of each unit 32 that are to be lubricated, here the first pair of upper bearings 10.

CLAIMS

[Claim 1] Vacuum pump (1) comprising:

- a stator (4) comprising at least one compression chamber (5),
- two rotors (6) configured to rotate in the compression chamber (5) about a
5 respective axis of rotation (I-I), the axes of rotation (I-I) being vertical, and
- elements to be lubricated mounted on shafts (7) of the rotors (6),
- the vacuum pump (1) further comprising an oil pump (9) comprising an oil
10 sump (13) and at least one turbine (14) mounted on one of the shafts (7) of
 the rotors (6), the turbine (14) being bathed in a liquid lubricant received in a
 chamber of the oil sump (13), the rotation of the turbine (14) causing some
 of the lubricant to circulate in a lubricating duct (15) towards the elements to
 be lubricated,

characterized in that the oil pump (9) is a vane pump, the turbine (14) having a
disc (16) and at least one vane (17) projecting from an upper face of the disc (16), the
15 lubricating duct (15) comprising an inlet duct (20) communicating with the chamber of
 the oil sump (13) receiving the turbine (14) and oriented tangentially or radially to the
 turbine (14).

[Claim 2] Vacuum pump (1) according to Claim 1, characterized in that the turbine
(14) comprises between two and six curved vanes (17) extending over a circular arc of
20 between 10° and 120° up to the edge of the disc (16) of the turbine (14).

[Claim 3] Vacuum pump (1) according to either of the preceding claims,
characterized in that the elements to be lubricated comprise toothed wheels (12) of a
synchronizing gearing that are mounted on a respective shaft (7) of the rotors (6).

[Claim 4] Vacuum pump (1) according to one of the preceding claims,
25 characterized in that the elements to be lubricated comprise at least one first pair of
 bearings (10) mounted at the end of a shaft of the rotors (6) and/or at least one second
 pair of bearings (11), situated along the shafts (7) of the rotors (6), above the oil sump
 (13).

[Claim 5] Vacuum pump (1) according to one of the preceding claims,
30 characterized in that the inlet duct (20) comprises a flow restriction (27) configured to
 accelerate the circulation of the lubricant by Venturi effect.

[Claim 6] Vacuum pump (1) according to one of the preceding claims,
characterized in that an inlet (22) of the inlet duct (20) is in the form of a volute.

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[Claim 7] Vacuum pump (1) according to one of the preceding claims, characterized in that it comprises an oil return channel (25) formed between the elements to be lubricated and the chamber of the oil sump (13).

[Claim 8] Vacuum pump (1) according to one of the preceding claims,
5 characterized in that a central through-orifice (18) is formed in the turbine (14) for fastening the turbine (14) at the end of a shaft of the rotors (6).

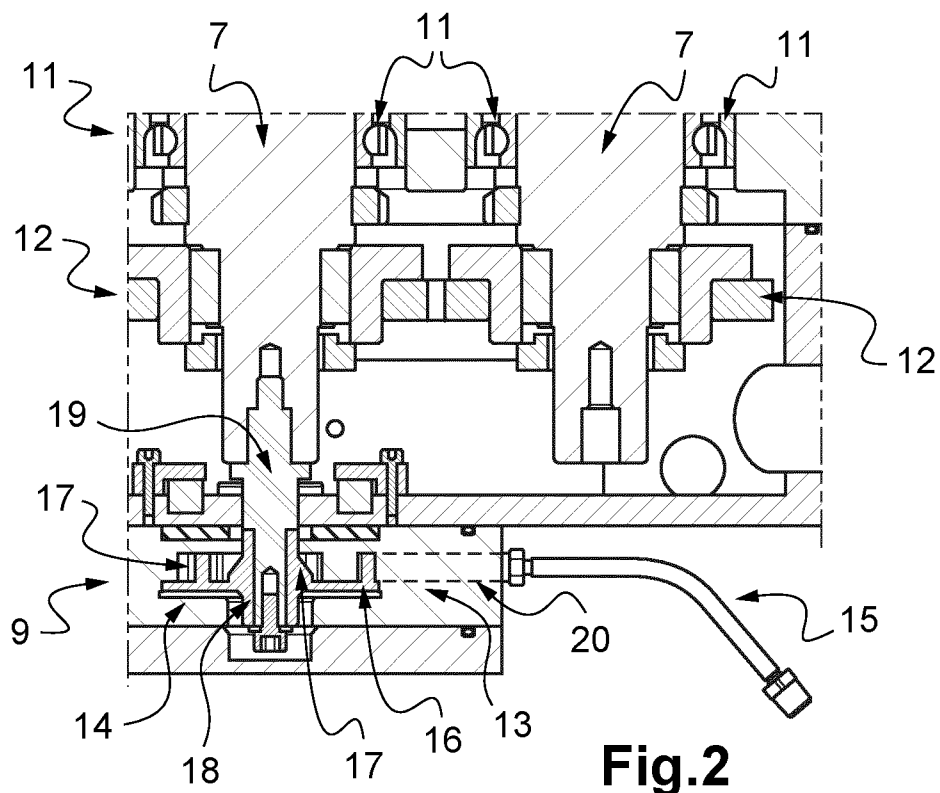
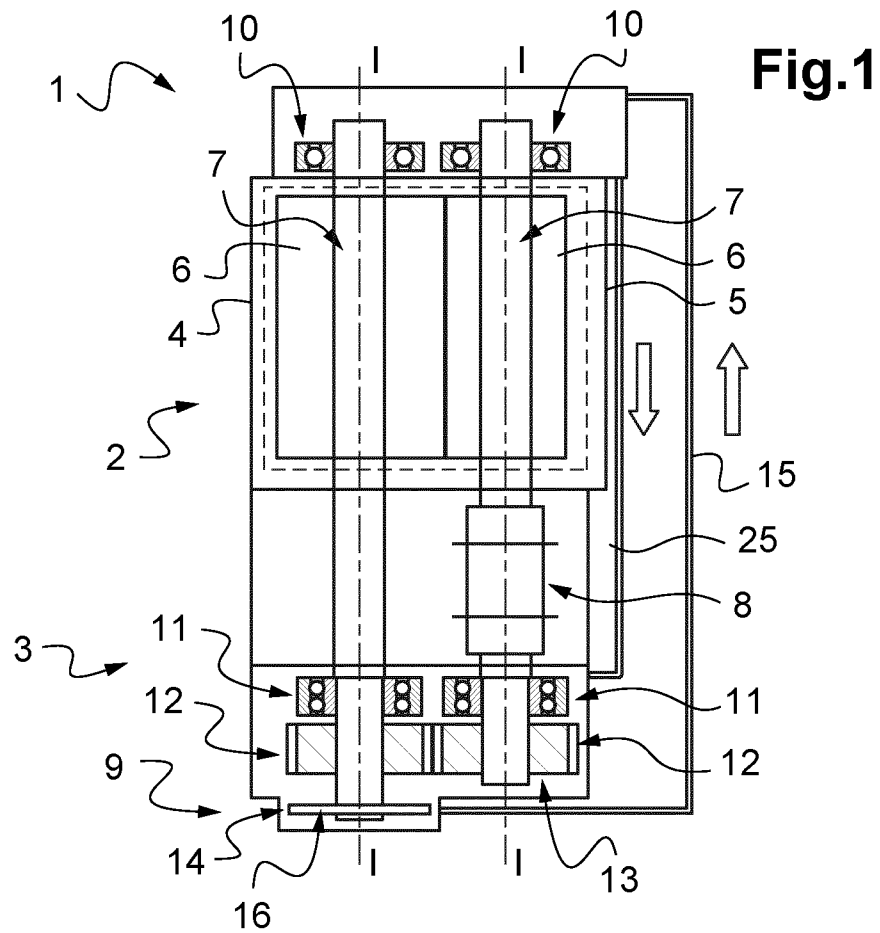


Fig.3

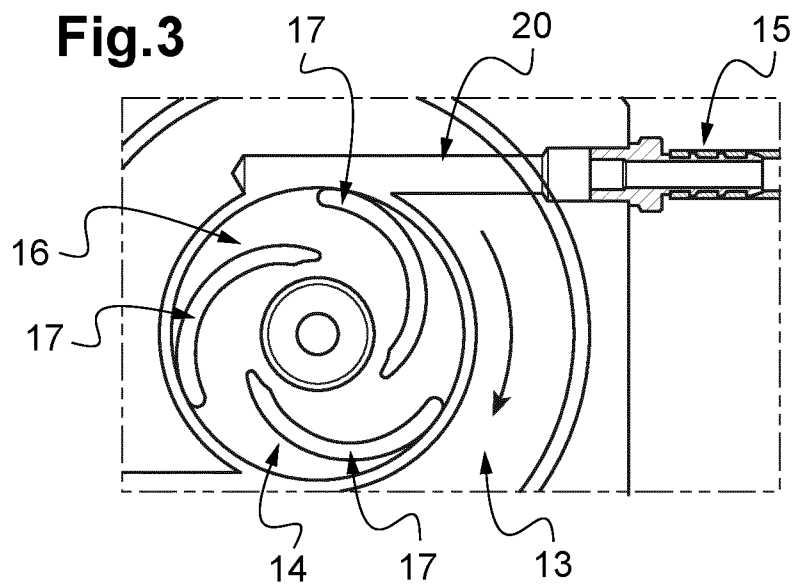


Fig.4

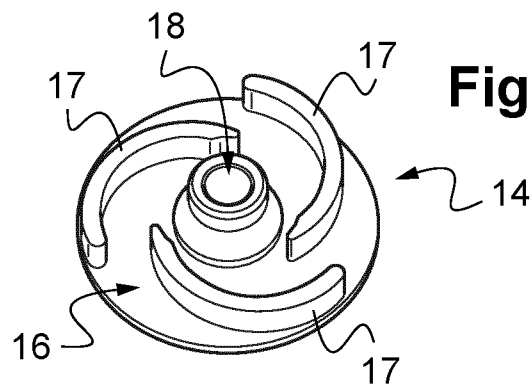
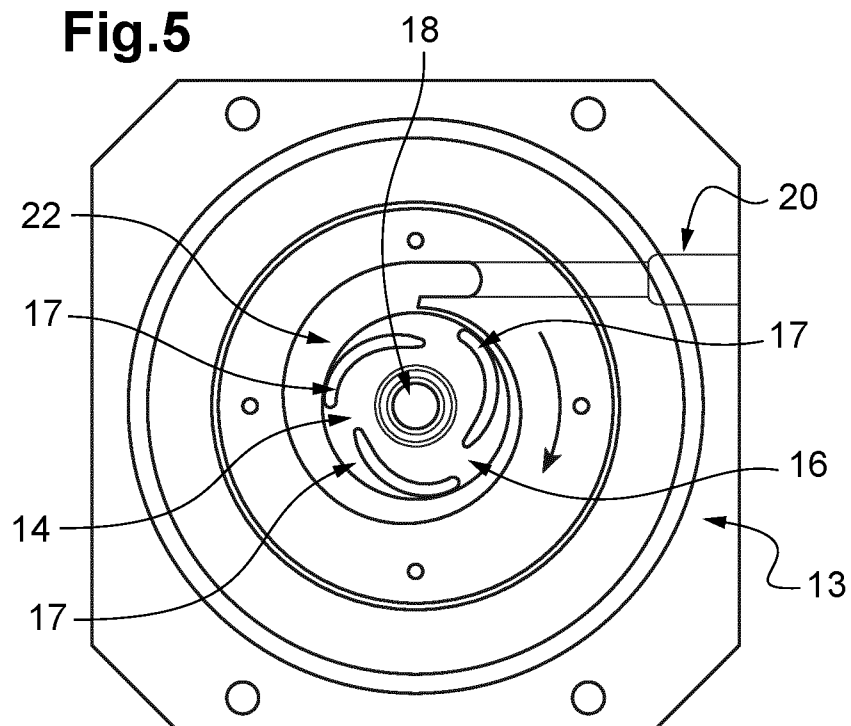


Fig.5



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Fig.6

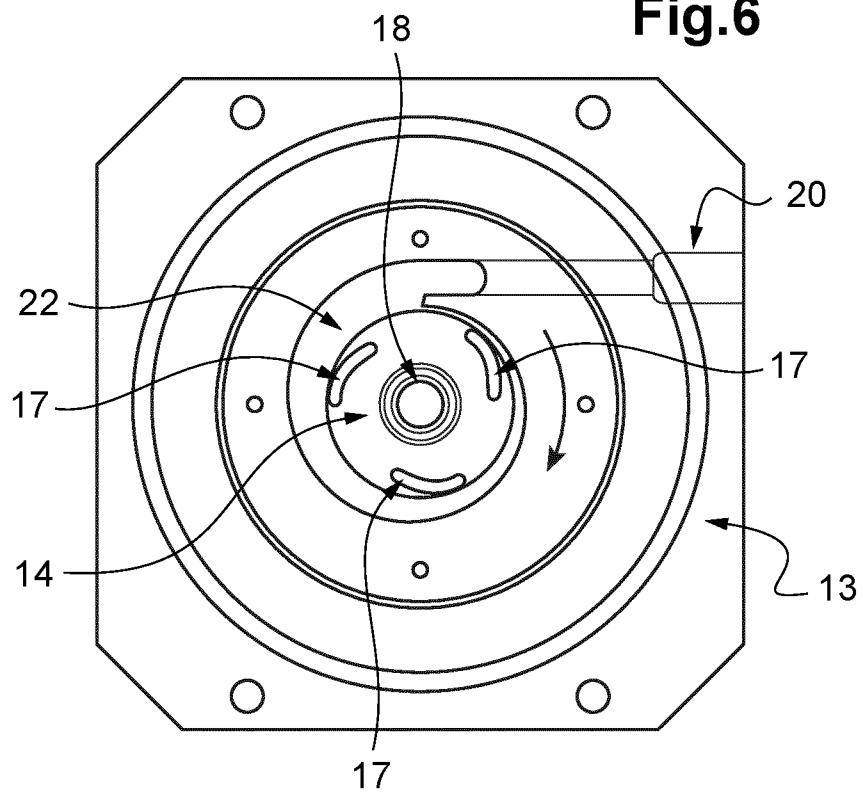


Fig.7

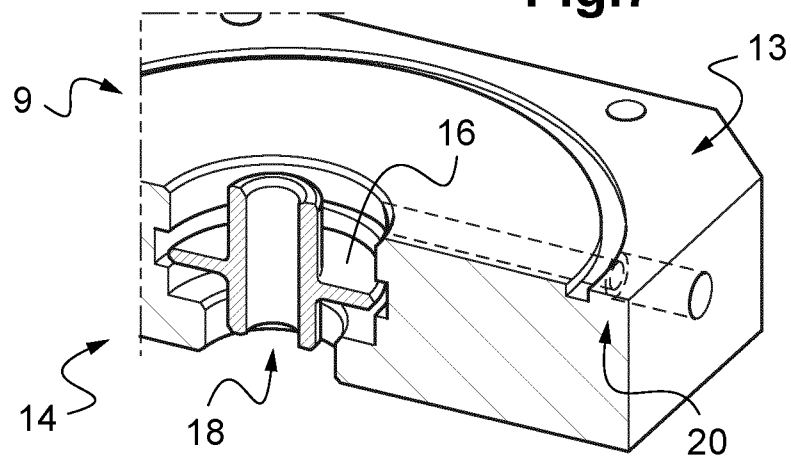
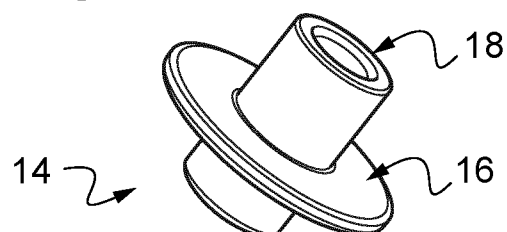
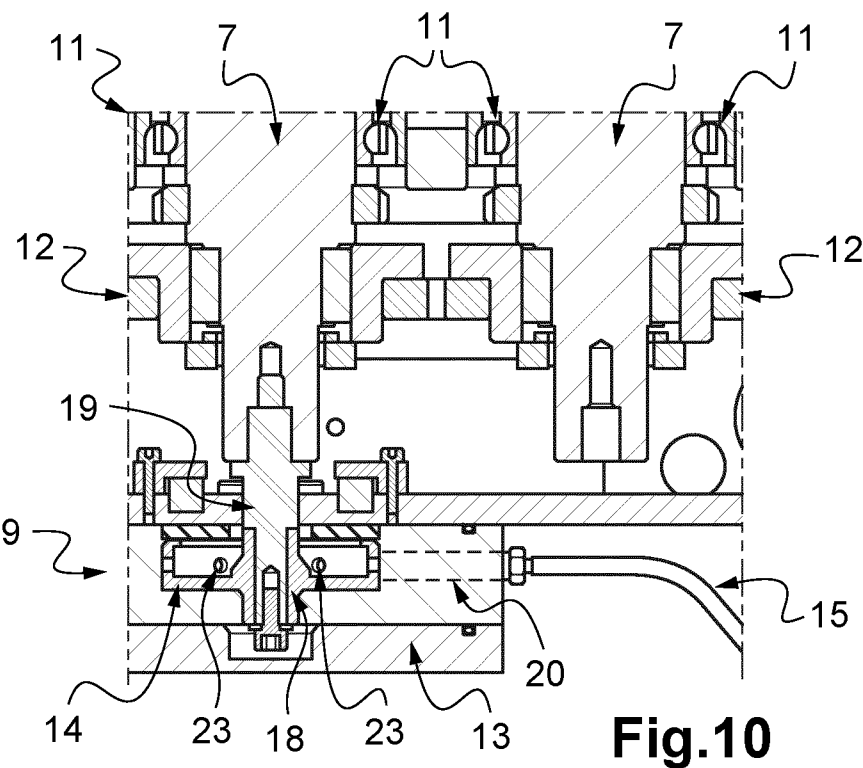
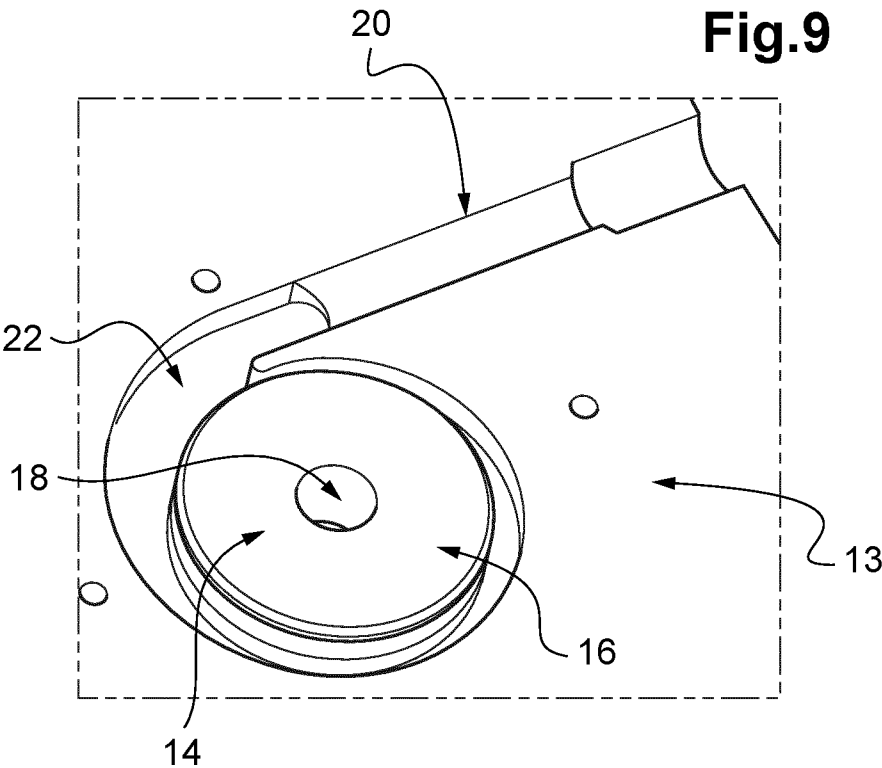
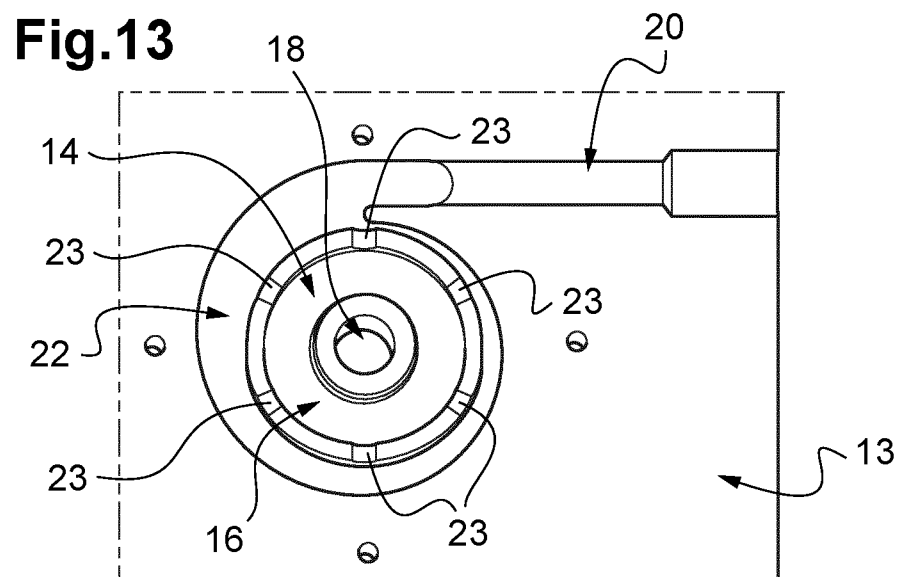
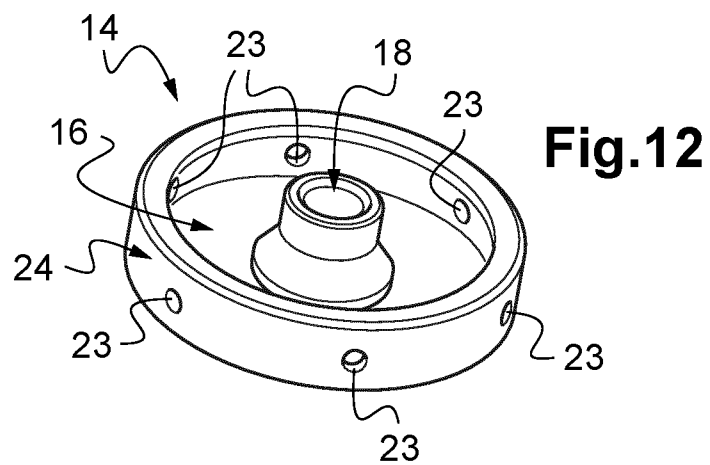
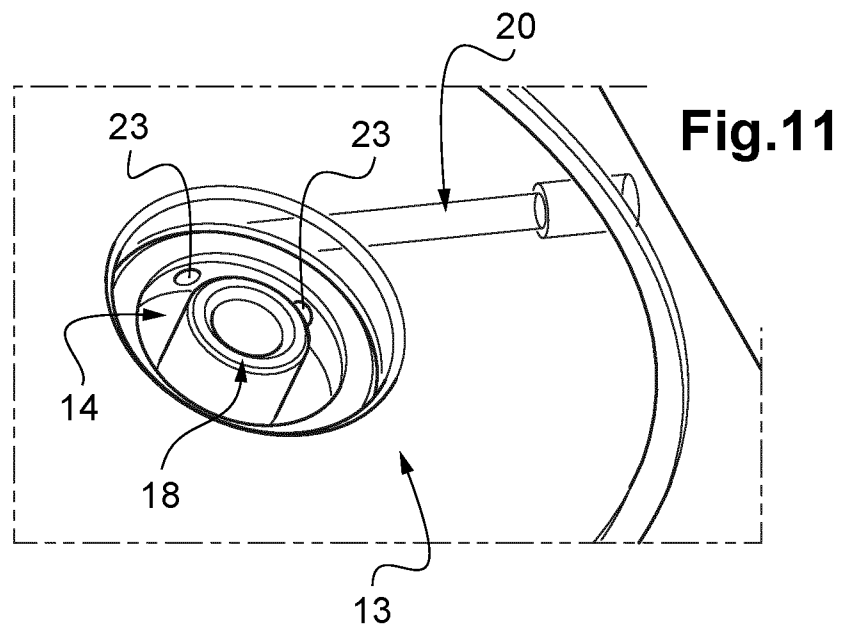


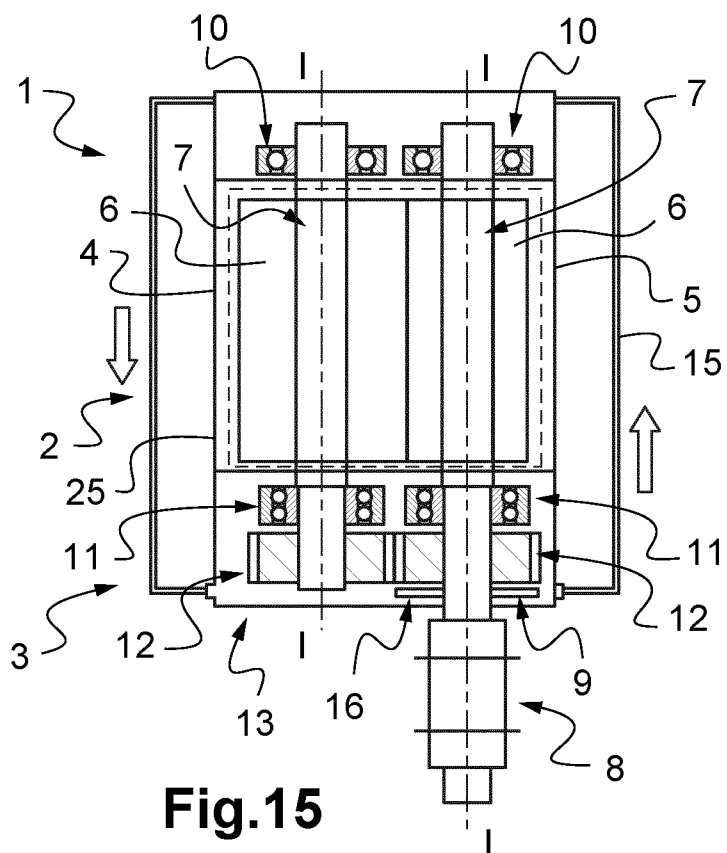
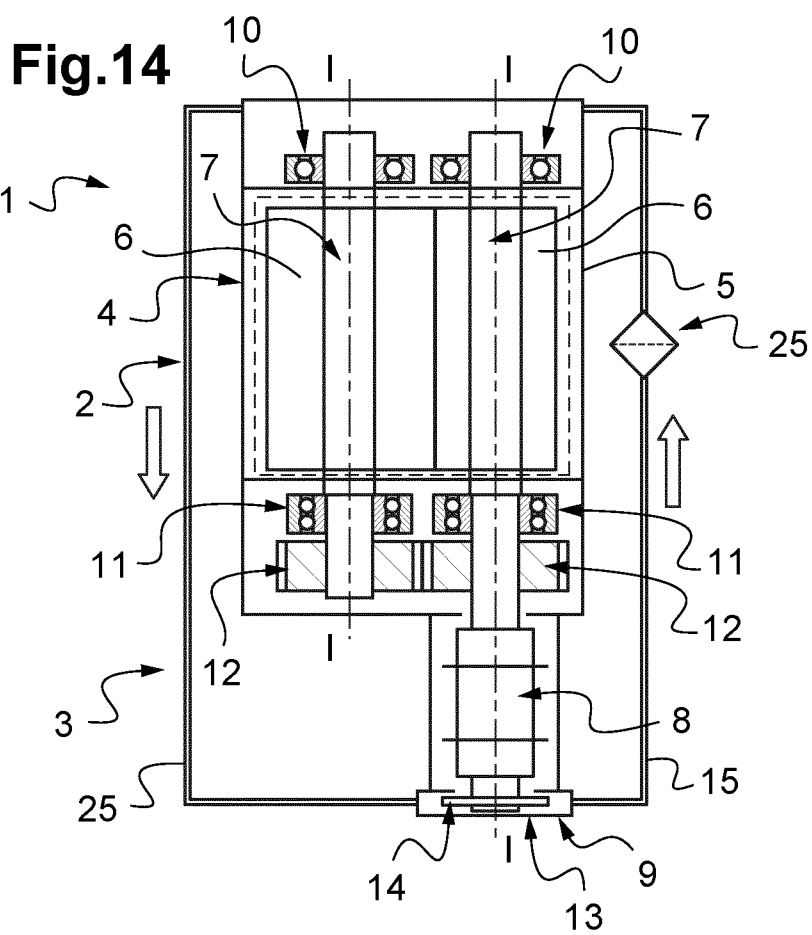
Fig.8

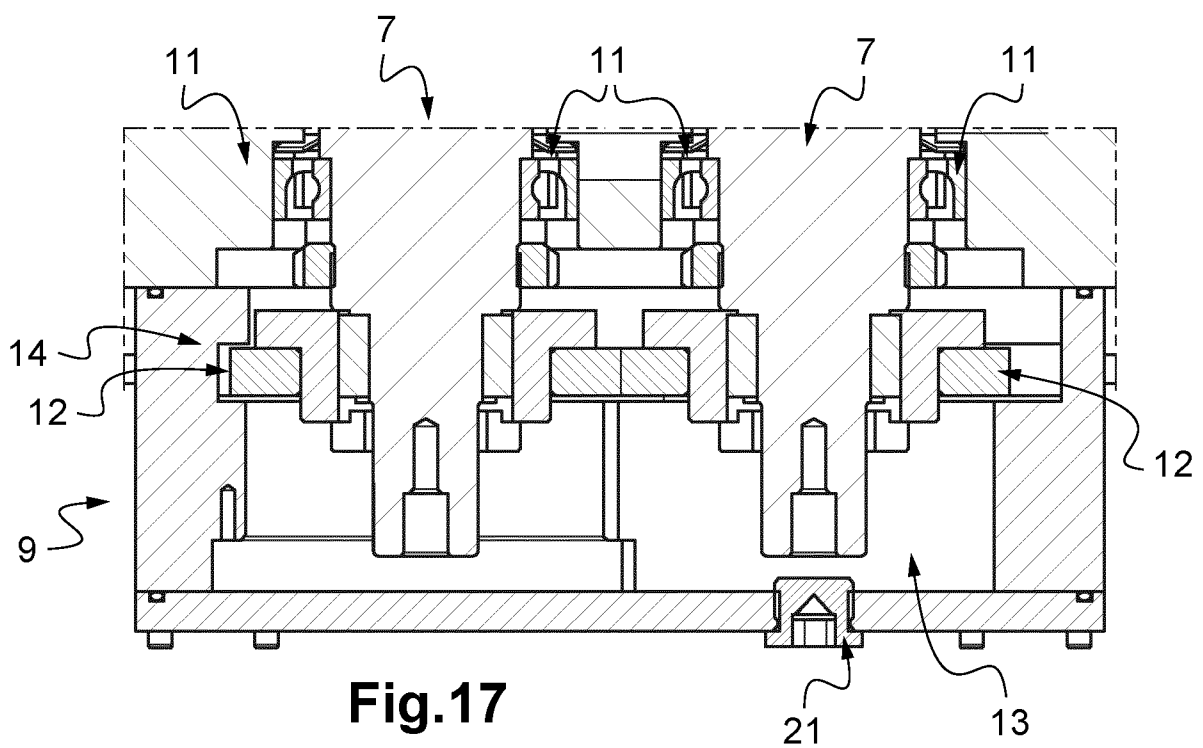
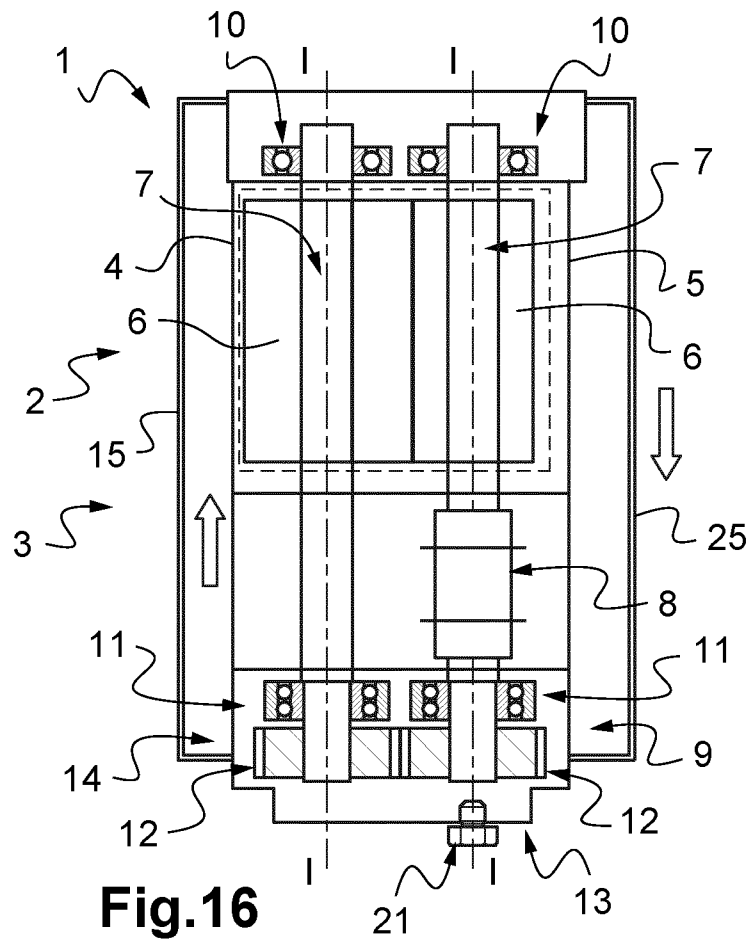


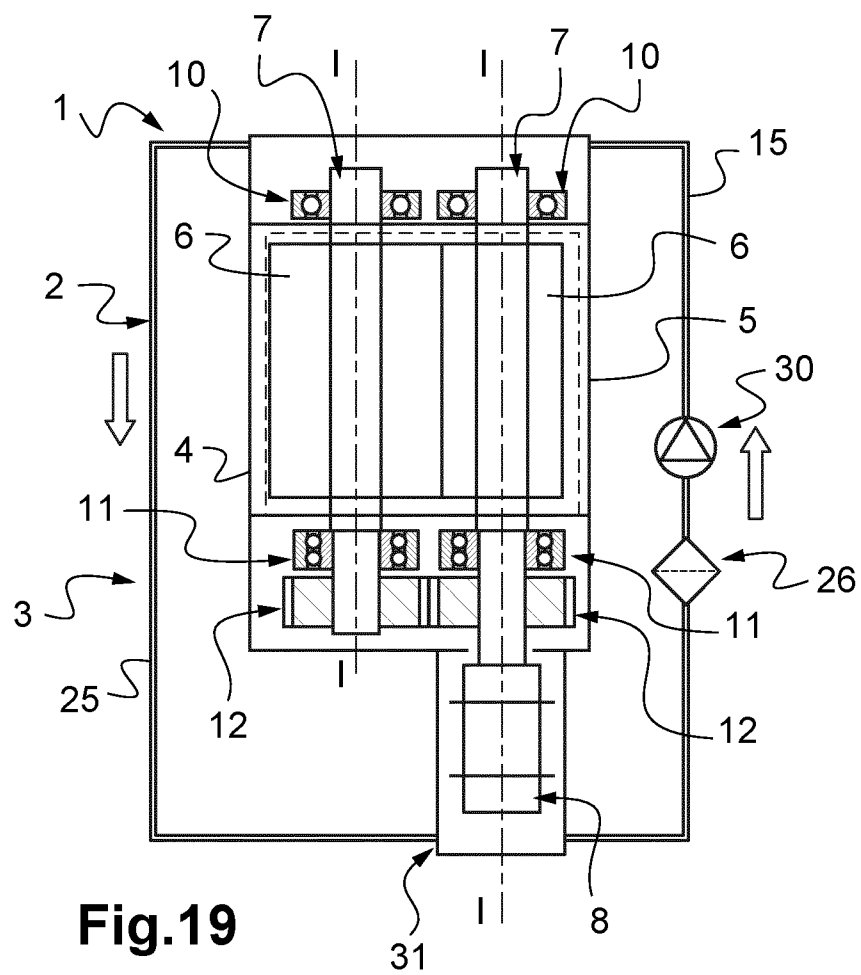
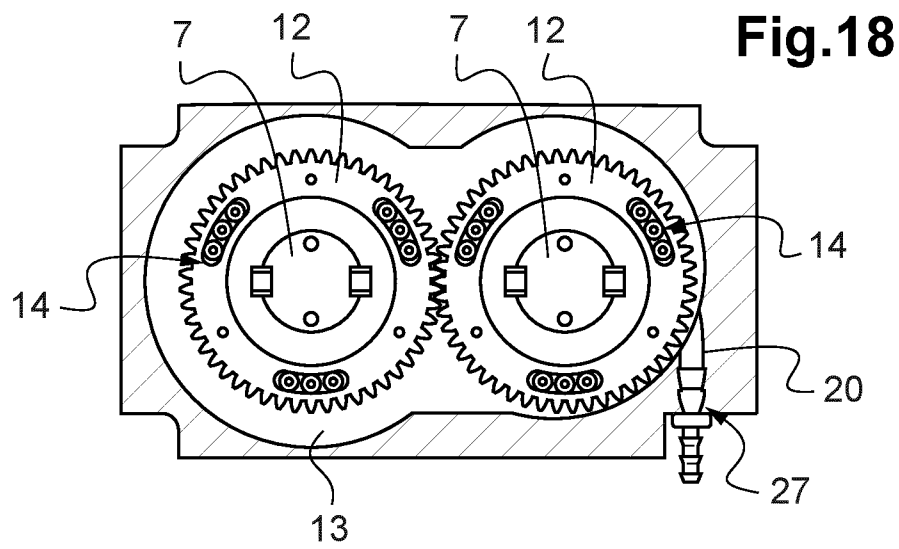


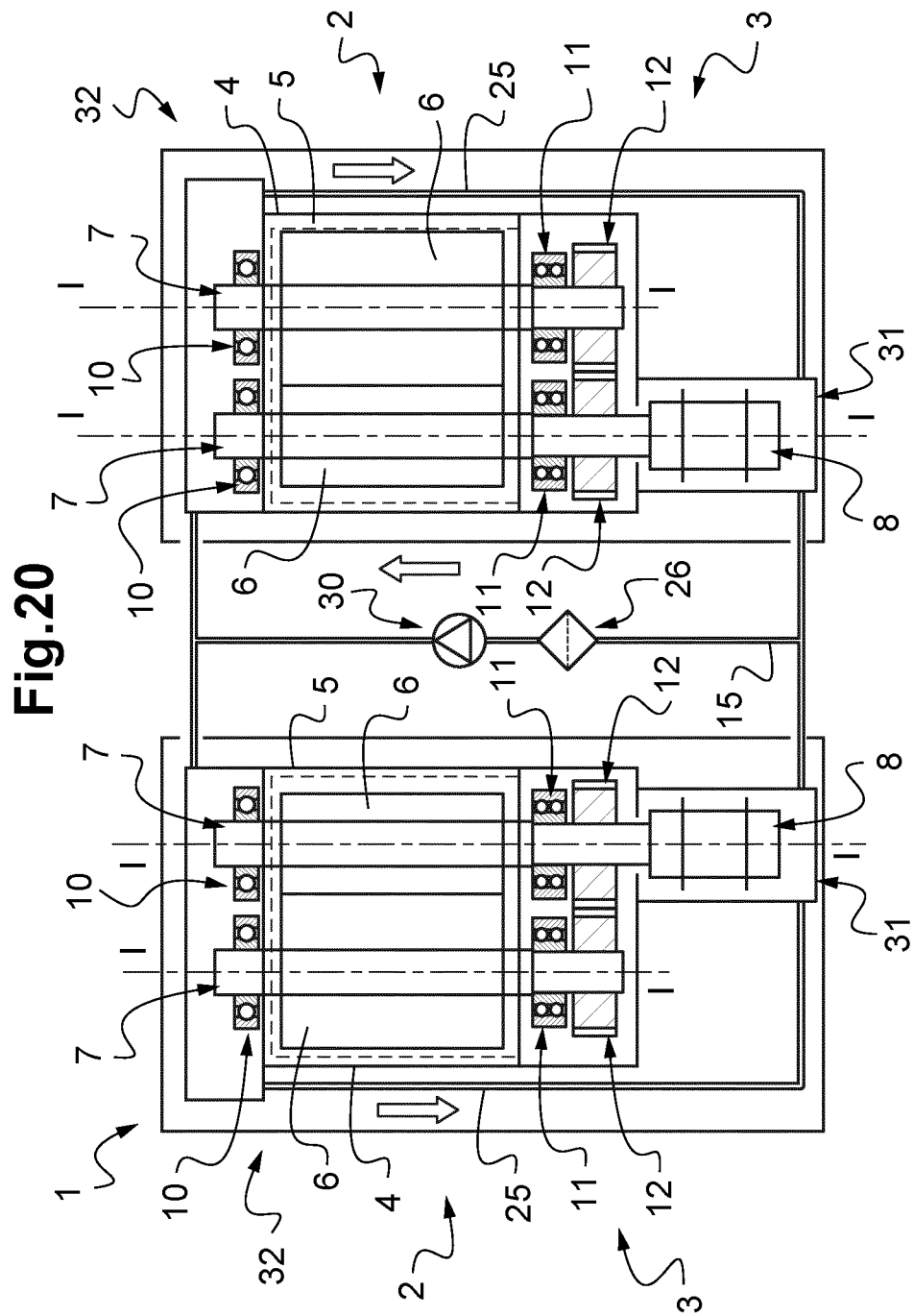
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/067942

A. CLASSIFICATION OF SUBJECT MATTER

INV. F04C25/02 F04C29/02
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04C F04B F04D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2011/049362 A2 (KODIVAC LTD [KR]; LEE HON [KR]) 28 April 2011 (2011-04-28) paragraphs [0001], [0040]; figures 1,2 -----	1-8
A	US 2016/222967 A1 (IGNATIEV KIRILL M [US] ET AL) 4 August 2016 (2016-08-04) paragraphs [0054], [0058], [0060]; figures 1,2 -----	1-8
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A	US 2011/150690 A1 (TANG YUEH-JU [TW] ET AL) 23 June 2011 (2011-06-23) paragraph [0036] - paragraph [0037]; figures 4,5 ----- -/-	1-8

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

4 October 2022

Date of mailing of the international search report

18/10/2022

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2022/067942

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 3 086 012 A1 (PFEIFFER VACUUM [FR]) 20 March 2020 (2020-03-20) page 7, line 20 - page 8, line 17; claim 1; figures 2-4 -----	1-8

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