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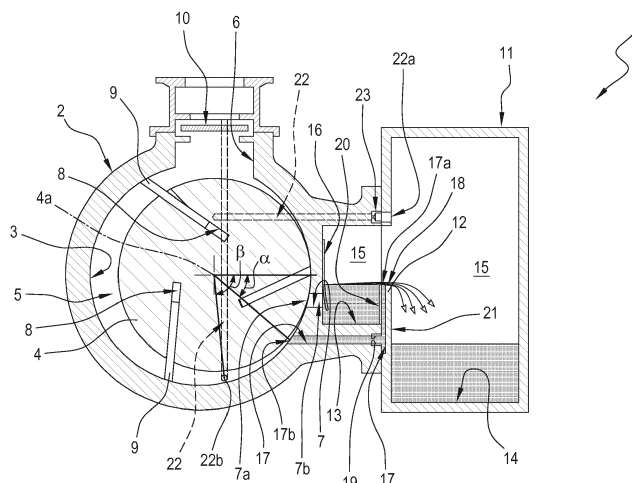
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(54) **LUBRICATED VACUUM PUMP**

(57) Described is a lubricated vacuum pump comprising a stator body (2) having a compartment (3) for housing a rotor (4) positioned eccentrically inside the compartment (3) to define a suction chamber (5) having a supply duct (6) and one or more discharge ducts (7); a suction valve (10), positioned along the supply duct (6), configured for passing from an open position to a closed position and vice versa, adjusting the passage of a gaseous fluid in the suction chamber (5); a chamber for containing lubricating liquid (11), in fluid communication with the one or more discharge ducts (7), which has a dividing wall (12) which delimits a compartment (13) for contain-

ing the lubricating liquid, into which lead the one or more discharge ducts (7); a discharge valve (16), configured to pass from an open position to a closed position and vice versa, which adjusts the passage of a dispersion of lubricating fluid in the gaseous fluid from a respective discharge duct (7) to the compartment (13) for containing the lubricating fluid; the pump (1) has at least one duct (17) for connecting the chamber for containing lubricating liquid (11) with the suction chamber (5); the connecting duct (17) extends at least partly in the dividing wall (12) of the chamber for containing lubricating liquid (11) and leads inside the suction chamber (5).

FIG. 1



Description

[0001] This invention relates to a lubricated vacuum pump.

[0002] More specifically, the lubricated vacuum pump according to the invention addresses the technical field of lubricated vacuum pumps of a rotary type, such as, for example, pumps with blades. Considering a lubricated vacuum pump with blades, it comprises a stator body having a compartment for housing a rotor.

[0003] The rotor has a plurality of seats for housing respective blades, which are slidable in the respective housing seat, which, during the rotation of the rotor move to a position furthest away from the centre of rotation of the rotor, pressing against the walls of the housing compartment.

[0004] The rotor in the housing compartment is positioned in an eccentric fashion, thereby defining a suction chamber in the form of a quarter of a circle, at the ends of which are located the suction channel and the discharge channel of the chamber.

[0005] Upstream of the suction channel there is a suction valve whose opening and closing is determined by the pressure difference between the air volume upstream of the channel and the suction chamber.

[0006] In the case of switching off or failure of the pump, the closing of the suction valve is very important, since, closing the suction channel maintains the degree of vacuum of the volume of air upstream of the same and prevents the oil, drawn by the low pressure, from filling the suction chamber.

[0007] In a lubricated pump, the discharge channel of the suction chamber leads to a chamber for containing lubricating oil.

[0008] Downstream of the discharge channel there is a discharge valve, the opening and closing of which determines the passage, from the suction chamber to the containment chamber, of a dispersion of oil in air.

[0009] Patent document GB1556643 describes a vacuum pump with blades of the lubricated type in which use is made of a discharge valve of the type with segments which, during normal operation of the pump, is completely immersed by the oil which flows from the suction chamber inside the containment chamber, through the discharge duct.

[0010] In the case of switching off or failure of the pump, the flow rate of oil entering the containment chamber decreases and the containment chamber empties of the oil contained therein.

[0011] The level of oil in the containment chamber decreases until the orifice of the segment of the discharge valve is in communication with the air which, through the orifice, flows into the suction chamber.

[0012] In this way, the pressure of the suction chamber is greater than the pressure upstream of the suction valve, causing its closure.

[0013] An alternative embodiment for controlling the closing of the suction valve is found in patent document

US2013/0251578 which comprises making a plurality of compensation channels, each of which is formed by recesses covered by a respective segment of the closing valve in such a way as to define a air inlet channel in communication with the discharge duct.

[0014] In the case of switching off or failure of the pump, the air is sucked through the compensation channels inside the suction chamber, in such a way as to generate a compensation of the pressure and to bring the suction chamber to atmospheric pressure resulting in the closure of the suction valve.

[0015] In this context, the need is felt of providing an alternative solution in a lubricated vacuum pump for controlling the closure of the suction valve in the case of switching off or failure of the pump.

[0016] In this context, one aspect of this invention is that of providing a lubricated vacuum pump comprising a stator body having a compartment for housing a rotor positioned eccentrically in the compartment to define a suction chamber.

[0017] The pump has a duct for supplying a gaseous fluid and one or more ducts for discharging a dispersion of a lubricating fluid in the gaseous fluid.

[0018] A suction valve, positioned along the supply duct is configured for passing from an open position to a closed position and vice versa, adjusting the passage of the gaseous fluid in the suction chamber.

[0019] The pump comprises a chamber for containing lubricating liquid, in fluid communication with the one or more discharging ducts, which has a dividing wall which delimits a compartment for containing the lubricating liquid, into which lead the one or more discharging ducts, and a tank for collecting the excess lubricating liquid contained in the containment compartment.

[0020] The compartment for containing the lubricating fluid being in fluid communication with the suction chamber by means of the one or more discharging ducts.

[0021] At least one discharge valve, configured to pass from an open position to a closed position and vice versa, adjusts the passage of the dispersion of lubricating fluid in the gaseous fluid from a respective discharging duct to the compartment for containing the lubricating fluid.

[0022] The pump comprises at least one duct for connecting the chamber for containing the lubricating fluid with the suction chamber. The connecting duct extends at least partly in the dividing wall of the chamber for containing the lubricating liquid and leads inside the suction chamber. Further features and advantages of this invention are more apparent in the detailed description below, with reference to a preferred, non-limiting, embodiment of lubricated vacuum pump as illustrated in the accompanying drawings, in which:

- Figure 1 illustrates a schematic cross section view of a lubricated vacuum pump according to the invention during a normal operating condition;
- Figure 2 illustrates the pump of Figure 1 during a switched OFF or failed condition.

[0023] The numeral 1 indicates a lubricated vacuum pump according to the invention.

[0024] The pump 1 comprises a stator body 2 comprising a compartment 3 for housing a rotor 4 positioned eccentrically in the compartment 3 to define a suction chamber 5.

[0025] The pump 1 has a supply duct 6 and one or more discharge ducts 7.

[0026] The rotor 4, in the embodiment illustrated, has a plurality of seats 8 for housing respective blades 9, each slidable in the respective housing seat 8.

[0027] During the operation of the pump, the rotor 4 rotates about its axis of rotation 4a, and the blades 9 move to a position furthest away from the axis 4a of rotation of the rotor 4, pressing against the walls of the compartment 3 of the stator body 2.

[0028] The pump 1 comprises a suction valve 10 positioned along the supply duct 6.

[0029] The suction valve 10 is configured for passing from an open position to a closed position and vice versa, adjusting the passage of a gaseous fluid in the suction chamber 5.

[0030] The gaseous fluid is a compressible fluid, such as, for example, air or other gases.

[0031] During normal operation of the pump 1, the suction valve 10 is open to ensure flow of the gaseous fluid into the suction chamber 5 of the pump 1. In the event of a switching off or fault of the pump 1, the suction valve 10 passes from the open condition to the closed condition of the supply duct 6.

[0032] The suction valve 10 may be a spring type plate valve or a pneumatic or electric valve.

[0033] The pump 1 illustrated has a plurality of discharge ducts 7, with reference to a direction of extension of the pump parallel to the axis of rotation 4a of the rotor 4.

[0034] The pump 1 comprises a chamber for containing lubricating liquid 11, in fluid communication with the one or more discharge ducts 7.

[0035] The chamber for containing lubricating liquid 11 has a dividing wall 12 which delimits a compartment 13 for containing the lubricating liquid, into which lead the one or more discharging ducts 7, and a tank 14 for collecting the excess lubricating liquid contained in the containment compartment 13.

[0036] The term lubricating liquid means a lubricating substance, such as, for example, oil, of a mineral and/or silicone and/or synthetic origin.

[0037] The chamber for containing lubricating liquid 11 has an air zone 15 defined by the volume of air above the surface of the liquid lubricant contained therein.

[0038] The dividing wall 12 has a top surface 18.

[0039] The top surface 18 is a surface facing towards the volume of air of the chamber for containing lubricating liquid 11.

[0040] The dividing wall 12 has a first and a second side surface 20 and 21 respectively delimiting the containment compartment 13 and the tank 14 for collecting the excess lubricating fluid contained in the containment

compartment 13.

[0041] The first side surface 20 of the dividing wall 12 defines one of the side walls of the containment compartment 13.

[0042] The second side surface 21 of the dividing wall 12 defines one of the side walls of the collecting tank 14.

[0043] The top surface 18 is contiguous with the first and second side surface 20 and 21 of the dividing wall 12.

[0044] The pump 1 comprises a discharge valve 16, configured to pass from an open position to a closed position and vice versa, to adjust the passage of a dispersion of lubricating fluid in the gaseous fluid from a respective discharge duct 7 to the compartment 13 for containing the lubricating fluid. Each discharge duct 7 has a respective inlet opening 7a, in fluid communication with the suction chamber 5, and a respective outlet opening 7b, in fluid communication with the containment compartment 13 of the lubricating fluid.

[0045] The discharge valve 16 is located facing the respective outlet mouth 7b. According to the preferred variant embodiment, the discharge valve 16 is a flexible valve of a laminar type.

[0046] According to the invention, the pump 1 has at least one duct 17 for connecting the chamber for containing the lubricating fluid 11 with the suction chamber 5.

[0047] The connecting duct 17 extends at least partly in the dividing wall 12 of the chamber for containing the lubricating liquid 11 and leads inside the suction chamber 5.

[0048] The connecting duct 17 extends at least partly in the dividing wall 12 of the chamber for containing the lubricating fluid 11 and at least partly in the stator body 2 of the pump 1.

[0049] More specifically, the connecting duct 17 has a first opening 17a in fluid communication with chamber for containing lubricating liquid 11 and a second opening 17b in fluid communication with the suction chamber 5. The first opening 17a is positioned at the top surface 18 of the dividing wall 12.

[0050] The second opening 17b is positioned inside the suction chamber 5 in the vicinity of the discharge duct 7.

[0051] More specifically, defining as alpha "α" an angle defined by a first joining of the centre of the rotor 4 with the point of maximum vicinity of the stator body 2 with the rotor 4 and a second joining of the centre of the rotor 4 with the second opening 17b of the discharge duct 7, the value of the angle alpha is between 20° and 60°, included. According to an embodiment, the pump 1 can have a plurality of connecting conduits 17, with reference to a direction of extension of the pump 1 parallel to the axis of rotation 4a of the rotor 4, each having a respective first opening 17a, positioned at the top surface 18 of the dividing wall 12, and a respective second opening 17b, leading inside the suction chamber 5.

[0052] Means 19 for adjusting the fluid flow rate are positioned along the respective connecting duct 17.

[0053] The adjusting means 19 according to preferred

variant embodiment are in the form of a nozzle.

[0054] Under normal operating conditions of the pump 1, by means of the rotation of the rotor 4, a dispersion of lubricating fluid in the gaseous fluid is expelled from the suction chamber 5 through the discharge duct 7.

[0055] The overpressure between the inlet opening 7a of the discharge channels 7 and the containment compartment 13 of the lubricating fluid keeps the discharge valve 16 open.

[0056] In this operating condition, the containment compartment 13 fills completely with lubricating liquid and the excess flows into the collection tank 14 thereby defining a film of lubricating fluid on the top surface 18 of the dividing wall 12 of the containment compartment 13 and of the tank 14 for collecting the excess lubricating liquid.

[0057] The discharge valve 16 operates in a bath of lubricating liquid in the containment compartment 13.

[0058] Under normal operating conditions of the pump 1, the connecting duct 17 is filled with the lubricant which derives from the inside of the suction chamber 5 and by at least part of the excess of the containment compartment 13.

[0059] In any case, under steady-state conditions, the connecting duct 17, filled with lubricating fluid, has the first inlet opening 17a occluded by the film of lubricating liquid present on the top surface of the dividing wall 12, as shown in Figure 1.

[0060] This condition continues since, with each rotation of the rotor 4 about its axis 4a, a dispersion of lubricating fluid in the gaseous fluid is continually expelled in the containment compartment 13 and the excess of lubricating liquid which flows from the compartment 13 into the collection tank 14 guarantees the presence of the lubricating liquid film on the top surface of the dividing wall 12.

[0061] In this way, the lubricating liquid prevents the entry of air in the suction chamber 5.

[0062] In the case of a switching off or malfunction of the pump 1, the flow of the dispersion of lubricating fluid in the gaseous fluid from the suction chamber 5 in the containment compartment 13 decreases until stopping in relation to the rotation of the rotor 4 about the relative axis 4a.

[0063] In this condition, the discharge valve 16 passes from the open position to the closed position of the discharge opening 7b of the discharge duct 7.

[0064] The film of lubricating liquid present on the top surface 18 finishes, since the flow of the dispersion of lubricating liquid in the gaseous fluid in the containment compartment 13 stops. The lubricating liquid contained in the connecting duct 17 is drawn inside the suction compartment 5, thus emptying the channel 17.

[0065] Since the first opening 17a of the connecting duct 17 is in communication with the air zone 15 the chamber for containing the lubricating fluid 11, as it no longer occluded by the film of lubricating liquid, the air can flow inside the connection duct 17 in the suction

chamber 5, through the second opening 17b, as illustrated in Figure 2.

[0066] The overpressure created in the suction chamber 5, defined by the air introduced by the connecting conduit, allows the suction valve 10 to be changed from the open position to the closed position.

[0067] Advantageously, the presence of the means 19 for adjusting the flow rate inside the connection duct 17 make it possible to adjust the flow rate of liquid lubricant and air which are introduced into the suction chamber 5 through the channel 17.

[0068] In order to limit the noise of the pump 1 according to the invention, it comprises at least one channel for conveying 22 air having a first opening 22a for inlet of the air in fluid communication with the chamber for containing lubricating liquid 11 in an air zone 15 and a second opening 22b for outlet of the air leading into the suction chamber 5.

[0069] The air conveying channel 22 extends at least partly in the stator body 2. The second opening 22b for outlet of the air from the air conveying channel 22 is positioned in the vicinity of the discharge duct 7.

[0070] More specifically, defining as beta " β " an angle defined by a first joining f the centre of the rotor 4 with the point of maximum vicinity of the stator body 2 with the rotor 4 and a second joining of the centre of the rotor 4 with the second opening 22b for outlet of the from the air conveying channel 22, the value of the angle beta is between 20° and 90°, included. Means 23 for adjusting the flow of air are positioned along the respective channel for conveying air 22, preferably being positioned close to the first opening 22a for inlet of the air.

[0071] Preferably, the adjusting means 23 are in the form of a nozzle. Advantageously, the adjusting means 23 guarantee a constant and predictable air flow rate.

Claims

1. A lubricated vacuum pump comprising a stator body (2) having a compartment (3) for housing a rotor (4) positioned eccentrically inside the compartment (2) to define a suction chamber (5); the pump (1) has a duct (6) for supplying a gaseous fluid and one or more ducts (7) for discharging a dispersion of a lubricating fluid in the gaseous fluid; a suction valve (10), positioned along the supply duct (6) is configured for passing from an open position to a closed position and vice versa, adjusting the passage of the gaseous fluid in the suction chamber (5); the pump (1) comprises a chamber for containing lubricating liquid (11), in fluid communication with the one or more discharging ducts (7), which has a dividing wall (12) which delimits a compartment (13) for containing the lubricating liquid, into which lead the one or more discharging ducts (7), and a tank (14) for collecting the excess lubricating liquid con-

tained in the containment compartment (13);
the compartment (13) for containing the lubricating fluid being in fluid communication with the suction chamber (5) by means of the one or more discharging ducts (7);

at least one discharge valve (16), configured to pass from an open position to a closed position and vice versa, adjusts the passage of the dispersion of lubricating fluid in the gaseous fluid from a respective discharging duct (7) to the compartment (13) for containing the lubricating fluid;

the pump being **characterised in that** it comprises:

at least one duct (17) for connecting the chamber for containing the lubricating liquid (11) with the suction chamber (5); the connecting duct (17) extending at least partly in the dividing wall (12) of the chamber for containing the lubricating liquid (11) and leading inside the suction chamber (5).

2. The pump according to independent claim 1, **characterised in that** the connecting duct (17) extends at least partly in the dividing wall (12) of the chamber for containing the lubricating fluid (11) and at least partly in the stator body (2) of the pump (1).
3. The pump according to independent claim 1 or 2, **characterised in that** the connecting duct (17) has a respective first opening (17a), in fluid communication with the chamber for containing the lubricating liquid (11), leading from the dividing wall (12).
4. The pump according to claim 3, **characterised in that** the dividing wall (12) has a first and a second side surface (20, 21), respectively delimiting the containment compartment (13) and the tank (14) for collecting the excess lubricating liquid, and a top surface (18) adjacent to the first and second side surface (20, 21) of the dividing wall (12); the first opening (17a) of the connecting duct (17) is positioned at the top surface (18) of the dividing wall (12).
5. The pump according to any one of the preceding claims, **characterised in that** the connecting duct (17) has a respective second opening (17b) in fluid communication with the suction chamber (5).
6. The pump according to claim 5, **characterised in that** the second opening (17b) is positioned close to a respective discharge duct (7); more specifically, a first joining of the centre of the rotor (4) with the point of maximum vicinity of the stator body (2) with the rotor (4) and a second joining of the centre of the rotor (4) with the second opening (17b) of the discharge duct (7), forms an angle alpha (α) whose value is between 20° and 60°,

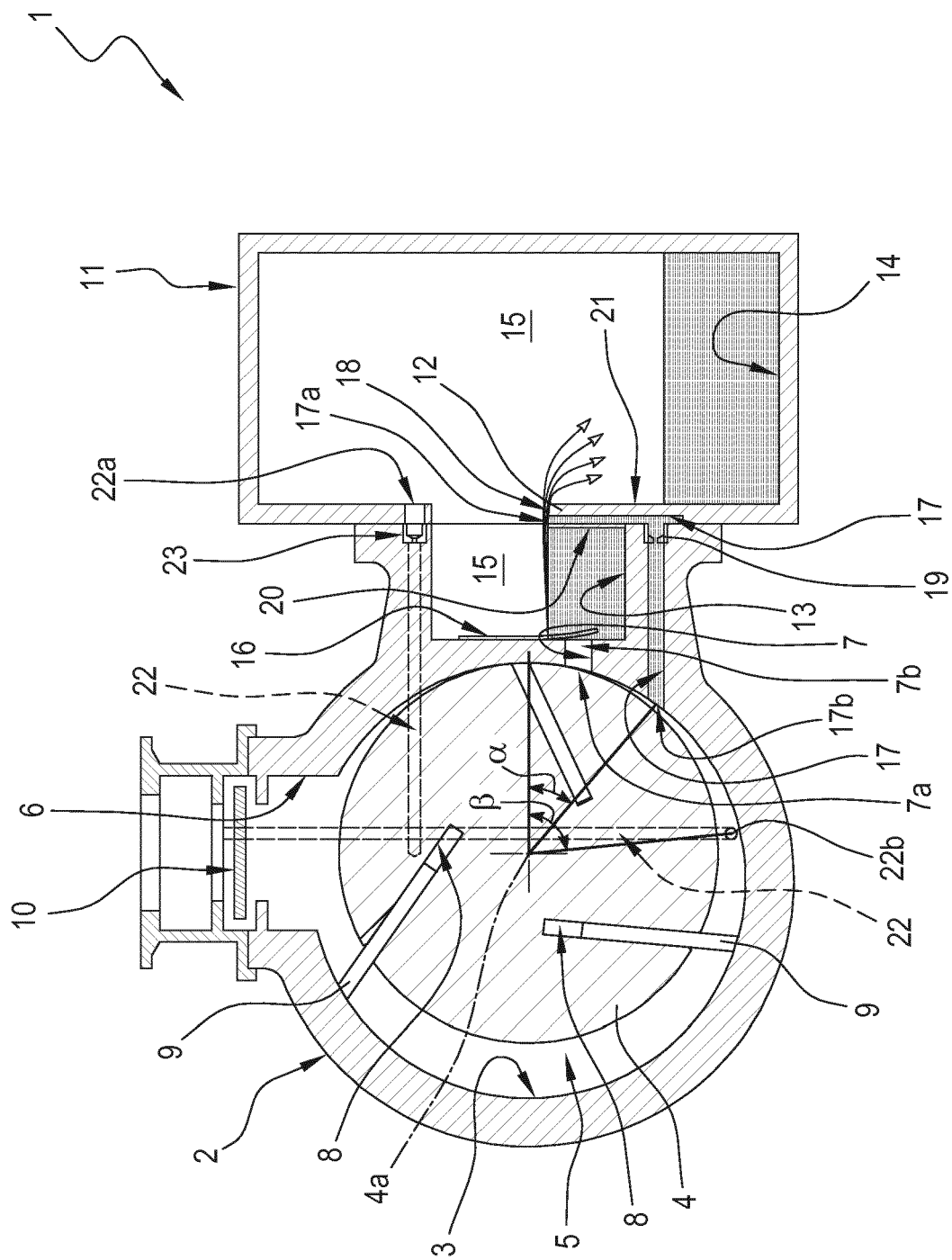
7. The pump according to any one of the preceding claims, **characterised in that** it comprises means (19) for adjusting the flow of fluid positioned along the respective connecting duct (17).

8. The pump according to any one of the preceding claims, **characterised in that** it comprises at least one channel for conveying air (22) having a first opening (22a) for inlet of the air in fluid communication with the chamber for containing lubricating liquid (11) in an air zone (15) and a second opening (22b) for outlet of the air leading into the suction chamber (5).

9. The pump according to claim 8, **characterised in that** it comprises means (23) for adjusting the flow of air positioned along the respective channel for conveying air (22), preferably being positioned close to the first opening (22a) for inlet of the air.

10. The pump according to claim 8 or 9, **characterised in that** an air conveying channel (22) extends at least partly in the stator body (2).

11. The pump according to any one of claims 8 to 10, **characterised in that** the second opening (22b) for outlet of the air of the air conveying channel (22) is positioned close to a respective discharge duct (7); a first joining of the centre of the rotor (4) with the point of maximum vicinity of the stator body (2) with the rotor (4) and a second joining of the centre of the rotor (4) with the second opening (22b) for outlet of the air from the air conveying channel (22), defines an angle beta (β) whose value is between 20° and 90°, included.

1. FIG.

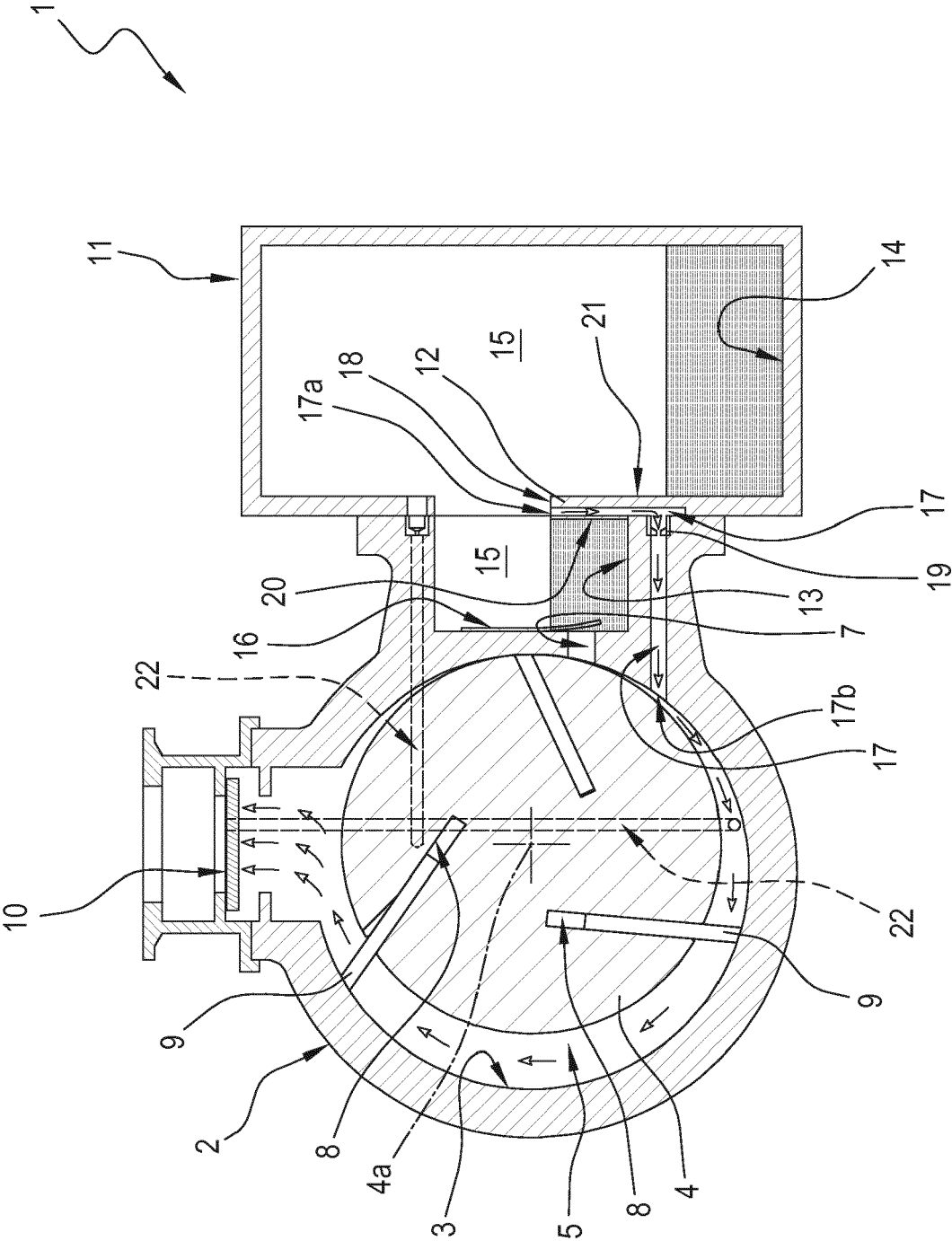


FIG. 2



EUROPEAN SEARCH REPORT

Application Number
EP 18 19 9571

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A	* the whole document *	4	
	* figure 1 *		
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			TECHNICAL FIELDS SEARCHED (IPC)
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Place of search Munich		Date of completion of the search 22 February 2019	Examiner Sbresny, Heiko
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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