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(54) **Vacuum pump**

(57) The present invention concerns a rotary vacuum pump (101) including a plurality of pumping stages obtained through the cooperation between alternate rotor discs (123) and stator discs or rings (115), at least one duct (135, 127) for introducing a gas or a gas mixture into the pump, said duct being interrupted by an electrically controllable valve (133), and an electronic control device (129) programmed to detect at least one operating

parameter of the pump and to modify the configuration of said valve (133) so as to cause an increase or a decrease in the amount of gas passing through said duct (135) based on the detected value of said parameter. The invention further concerns a method of operating said pump, a pumping system including one or more such vacuum pumps and a method of operating said pumping system.

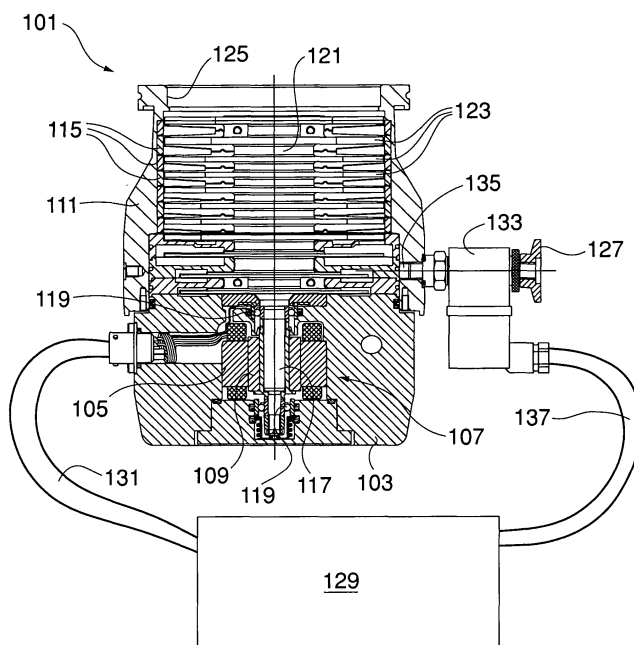


Fig. 1

Description

[0001] The present invention concerns a rotary vacuum pump and a method of operating said vacuum pump. The invention also concerns a pumping system including at least one rotary vacuum pump and a method of operating said pumping system.

[0002] As known, rotary vacuum pumps, and in particular turbomolecular pumps, are machines including a part rotating at very high speed, comprising a rotating shaft to which a set of parallel rotor discs are secured and cooperating with a stationary part, generally a set of stator rings or discs, in order to achieve gas pumping from an inlet port to an outlet port of the pump.

[0003] Depending on the kind of pump, more or less high vacuums can be achieved. For instance, a turbomolecular pump may produce a vacuum of the order of 10^{-7} mbar (10^{-5} Pa) at a nominal shaft rotation speed ranging from 2×10^4 to 9×10^4 revolutions per minute.

[0004] One of the technical problems encountered when developing turbomolecular pumps is how to stop the pump, i.e. its rotating part, during the shut-down phase, while avoiding the risks related with too fast or too slow a deceleration of said rotating part.

[0005] According to the prior art, thanks to the opening of a proper valve, known as vent valve or back-to-air valve, a gas (generally at atmospheric pressure), is introduced into the pump and such gas slows down the rotating part of the pump by friction.

[0006] Now, in case of too fast a deceleration, the gas introduced into the pump not only frictionally slows down the rotor but, due to the parallel-disc geometry of the rotor, the gas also has a lift effect on said rotor, tending to raise it towards the inlet port. Such a lift effect may cause contact between the pump rotor and the stationary pump components, which contact clearly would be destroying for the pump itself. On the long term, moreover, the lift effect entails a rotor deformation, which may lead to stresses and permanent damages to the rotor itself. Lastly, the preload conditions of the bearings supporting the rotating shaft and the rotor of the pump is strongly modified by the aforementioned lift effect, with a consequent decrease in the bearing life.

[0007] In the opposite case, where deceleration is too slow, a considerable increase in the pump vibrations occurs. Indeed, during deceleration, i.e. while passing from a nominal rotation frequency to a null rotation frequency, the pump passes through some frequency ranges that are critical from the structural and vibrational standpoint. Too slow a deceleration excessively lengthens the pump permanence within such frequency ranges, thus leading to said vibration increase, which can negatively affect both the life of the bearings supporting the rotor, and the rotor balancing.

[0008] According to the prior art, the opening of the vent or back-to-air valve is controlled by a control device associated with the vacuum pump, and said valve is kept open for a predetermined time interval, which is deemed

sufficient to stop the pump.

[0009] Vacuum pumps equipped with a programmed electronic control device to control the pump during the shut-down phase and to cause the vent valve opening in such phase are disclosed for instance in U.S. 6,461,113, US 5,443,368 and US 2004/0013531.

[0010] According to the prior art, however, it is impossible to avoid a priori the aforementioned risks and problems, related with too fast or too slow a deceleration.

[0011] Thus, it is an object of the present invention to provide a rotary vacuum pump and a method of operating same, which are free from the above drawbacks.

[0012] As known to the skilled in the art, usually turbomolecular vacuum pumps are not used alone, since they cannot pump a gas from high vacuum levels (10^{-3} to 10^{-8} mbars) up to atmospheric pressure. Generally, said turbomolecular pumps are inserted into pumping systems comprising one or more turbomolecular pumps, operating between the high vacuum and an intermediate pressure, and one or more forepumps, operating between said intermediate pressure and atmospheric pressure.

[0013] It is another object of the present invention to provide a vacuum pumping system comprising one or more rotary pumps, and a method of operating said system, which are free from the above drawbacks.

[0014] The above and other objects are achieved thanks to the pump, the vacuum pumping system and the method of operating said pump and said system, as claimed in the appended claims.

[0015] In the vacuum pump according to the invention, thanks to the possibility of controlling the opening and closing of the vent valve during the shut-down phase, the flow rate of gas within the pump, and consequently the braking effect of said gas onto the pump rotor, can be increased or decreased.

[0016] Advantageously, opening and closing of the vent valve are controlled based on the monitoring of an operating parameter of the vacuum pump, more particularly based on the rate at which its rotation frequency decreases, that is on its deceleration.

[0017] Thus, said deceleration can be kept within a desired range of values.

[0018] In the pumping system according to the invention, thanks to the presence of a vent valve communicating with one or more vacuum pumps of said pumping system, opening and closing of which valve can be controlled during the shut-down phase, it is possible to increase or decrease the flow rate of gas within said pump(s) in order to keep deceleration of said pump(s) within a desired range of values.

[0019] Note that, advantageously, also deceleration of a vacuum pump without vent valve can be controlled in the pumping system according to the invention, since it is sufficient that said vacuum pump is in communication with a duct where a valve of the pumping system, utilisable as a vent valve, is located.

[0020] Advantageously, said vent valve is preferably in communication with the chamber evacuated by the

pumping system according to the invention, so that gas can be simultaneously introduced into all rotary pumps connected to said chamber.

[0021] A preferred embodiment of the pump and the pumping system according to the invention, given by way of non-limiting example, will be described hereinafter with reference to the accompanying drawings, in which:

- Fig. 1 is a cross sectional view of a rotary pump according to the invention;
- Fig. 2 is a flow chart of the control cycle of the vent valve during shut-down of the vacuum pump depicted in fig. 1;
- Fig. 3 is a block diagram schematically illustrating the vacuum pumping system according to the invention.

[0022] Referring to Fig. 1, a turbomolecular rotary pump 101 is schematically shown.

[0023] Said pump 101 comprises a stationary part and a rotating part. The stationary part includes a base 103, onto which there are mounted stator 105 of electric motor 107 (e.g. an asynchronous or a brushless or a d.c. electric motor, etc) used to rotate the rotating part of pump 101, and housing 111 of the same pump. The latter bears a plurality of stator discs 115, smooth or provided with vanes, depending on the pump kind.

[0024] The rotating part of pump 101 comprises a rotating shaft 117, which is supported by rolling bearings 119 and onto which there are mounted rotor 109 of electric motor 107 and pump rotor 121, the latter being equipped with discs 123, smooth or provided with vanes, depending on the pump kind.

[0025] Stationary stator discs 115 and rotating rotor discs 123 cooperate to build successive pumping stages through which a gas can be pumped from an inlet port 125 at lower pressure until an exhaust port (not shown) at higher pressure.

[0026] According to the invention, pump 101 further comprises a vent valve 133 (for instance a pneumatically controlled valve), communicating on the one side with the interior of pump 101 through a first duct 135, and on the other side either with the outer environment or with a tank for a gas (e.g. nitrogen) or a gas mixture, through a second duct 127.

[0027] As shown, said valve 133 is a one-way valve that can take an open or a closed position. In its open position, the valve puts the interior of the pump in communication with the outer environment (or with the gas tank connected to the same valve) through duct 135, thereby allowing the passage of a gas from the outer environment (or from said tank). In its closed position, the valve prevents said gas from entering the pump.

[0028] In the illustrated example, during normal operation of the pump, rotating shaft 117 and rotor 121 are rotated at a nominal shaft rotation speed ranging from 2×10^4 to 9×10^4 revolutions per minute and a vacuum of the order of 10^{-7} mbar (10^{-5} Pa) is achieved at inlet port

125.

[0029] Note that, during normal operation, vent valve 133 remains closed.

[0030] The operating conditions of pump 101 are monitored and adjusted by a control device 129, connected to pump 101 by electric conductors 131 (e.g. an RS-232 cable) and provided with a microprocessor in order to control pump 101 according to programmed control sequences corresponding to the different operating phases of the same pump.

[0031] According to the invention, during the shut-down phase of the pump, where the pump rotor is to be stopped, opening and closing of vent valve 133 are controlled by control device 129, e.g. pneumatically through a duct 137, depending on the deceleration value of rotor 121 detected by the same control device 129.

[0032] To this end, control device 129 includes means for detecting the rotation frequency of rotor 121 of pump 101 and means for computing the variations of said frequency during the shut-down phase.

[0033] Said means for detecting the rotation frequency of rotor 121 may include either rotation speed detectors (e.g. optical readers or encoders) for a direct detection of the rotation frequency of said rotor, or vibration or pressure detectors, allowing an indirect attainment of the rotation frequency through known relations.

[0034] Fig. 2 shows the flow chart of control cycle 201 of vent valve 133 during the shut-down phase of pump 101.

[0035] Said control cycle 201 begins with a stop command (step 203) by which control device 129 cuts off the supply to the vacuum pump motor.

[0036] At the subsequent step (step 205), the control device checks whether the function of detecting the rotation frequency and the rotation frequency variation (SSR = Speed Stop Reading) of the pump is active.

[0037] In the negative (SSR = 0), the control cycle of the vent valve cannot be performed (step 207), and thus the vent valve will be opened for a predetermined time interval (step 208), deemed theoretically sufficient for stopping the pump.

[0038] In the affirmative (SSR $\neq$ 0), the actual control cycle of the vent valve is started, the cycle beginning with the vent valve in closed position (step 209).

[0039] The control device sets an opening time interval T_{open} for the vent valve to a preset value stored in the control device and equal to 1 preset time unit (e.g. equal to 0.1 sec, 0.5 sec, 1 sec, etc) and sets a monitoring time interval T_{period} for the pump rotation frequency to a value that also is preset and stored in the control device and that is equal to a certain multiple of T_{open} , e.g. 5, as in the example of Fig. 2 (step 211).

[0040] Thereafter, the control device checks whether pump rotation frequency F_{rot} exceeds minimum rotation frequency F_{min} , substantially corresponding to the frequency below which the detectors cannot detect the rotation frequency and the pump can be considered as wholly decelerated (step 213).

[0041] If the pump is not yet wholly decelerated ($F_{rot} > F_{min}$), the control device monitors rotation frequency F_{rot} of the pump for a time interval equal to T_{period} and, based on the detected values, it computes pump deceleration SD , i.e. the rate at which said rotation frequency decreases with time (step 215). Said pump deceleration value SD is compared with a preset maximum threshold value SD_{max} stored in the control device (step 217).

[0042] If SD_{max} is exceeded (too fast a deceleration), the system monitors again rotation frequency F_{rot} (steps 213, 215) without opening the vent valve, so as to slow down the pump deceleration.

[0043] If on the contrary SD_{max} is not exceeded, pump deceleration SD is compared with a minimum threshold value SD_{min} that is also preset and stored in the control device (step 219).

[0044] If deceleration SD is higher than threshold SD_{min} , opening time T_{open} of the vent valve is kept at its starting value (step 221), and said valve is opened and kept open for a time interval equal to T_{open} . Thereafter, the valve is closed again (steps 223a to 223c).

[0045] Then, the system monitors again the pump rotation frequency (steps 213, 215).

[0046] Note that, in the control cycles following the first one, if vent valve opening time T_{open} was previously incremented (according to the modalities described below), in case $SD_{min} < SD < SD_{max}$, the value of T_{open} is reset to its starting value (as shown in solid line in the chart in Fig. 2).

[0047] Yet, a variant embodiment of the invention could envisage that T_{open} is kept unchanged at the increased value (as shown in dashed line in the chart in Fig. 2).

[0048] If at step 219 deceleration SD is lower than threshold SD_{min} (too slow a deceleration), the control device increments vent valve opening time T_{open} by one time unit (step 227) after having checked that the new opening time is still shorter than monitoring time T_{period} (step 225).

[0049] Now, the control device opens the vent valve and keeps it open for that incremented opening period T_{open} , and then closes again the valve (steps 229a to 229c), so as to allow gas entering the pump and hence to bring again pump deceleration SD within the preset value range.

[0050] Subsequently, the control device monitors again the pump rotation frequency (steps 213, 215).

[0051] The control cycles are repeated as long as pump rotation frequency F_{rot} exceeds preset minimum frequency F_{min} , by alternating more or less long closing and opening periods of the vent valve so as to keep pump deceleration SD within the preset value range, thereby avoiding too fast or too slow decelerations with the consequent drawbacks.

[0052] When pump rotation frequency F_{rot} becomes lower than minimum frequency F_{min} , the pump can be considered as stopped.

[0053] Under such conditions, depending on the choic-

es set by the user by means of a flag "OPTION", the vent valve can be kept in closed or open condition (steps 233, 235) until the pump is restarted.

[0054] Note that several variants of the embodiment disclosed above are possible without departing from the scope of the invention.

[0055] More particularly, according to a variant embodiment shown in dashed line in Fig. 2, should the vent valve control being insufficient to keep pump deceleration within the desired value range, the pump electric motor could be used as a supplementary means for controlling said deceleration.

[0056] More particularly, it is possible to set a control sequence of control device 129 according to which, if deceleration is too fast ($SD > SD_{max}$) even by keeping the vent valve closed (step 217), said control device supplies the vacuum pump motor for a limited and predetermined time interval $T = T_{motor}$ (step 237). In this manner, the action of the electric motor, which tends to increase the vacuum pump rotation frequency, opposes the deceleration of the same pump, thereby slowing down said deceleration and bringing it again below threshold SD_{max} .

[0057] Conversely, if vacuum pump deceleration is too slow ($SD < SD_{min}$) even with completely open vent valve (step 225), it is possible to use the vacuum pump motor as a brake, by setting a control sequence of control device 129 according to which said control device supplies the vacuum pump motor for a limited and predetermined time interval $T = T_{motor}$ (step 237) and makes the motor rotate in reverse direction at a frequency almost equal to the rotation frequency (step 239). In this manner, the action of the electric motor, which tends to slow down the vacuum pump rotation, adds to the braking effect of the gas introduced through the vent valve, thereby bringing again deceleration of the vacuum pump above threshold SD_{min} .

[0058] Moreover, even if the embodiment shown in Figs. 1 and 2 refers to a vent valve 133 that can take only two positions (completely open/completely closed), use of an adjustable-opening vent valve can be envisaged, so as to achieve a fine control of vacuum pump deceleration. In this case, the control device could act on the opening degree of the vent valve instead of acting on the opening time T_{open} of said valve, or in the alternative, it could act on both said parameters.

[0059] Note that, as it will be apparent for the skilled in the art, the method described above could be implemented by a computer program, running e.g. on a personal computer. In such case, control device 129 could just simply be a personal computer.

[0060] Turning now to Fig. 3, a block diagram of vacuum pumping system 301 according to the invention is shown.

[0061] As disclosed before, turbomolecular pumps like that shown in Fig. 1 are not used alone, since they cannot exhaust gas at atmospheric pressure, and therefore they are associated with corresponding forepumps

[0062] Therefore, the vacuum pumping system according to the invention generally includes one or more turbomolecular pumps 305a, 305b (of the kind shown in Fig. 1), associated with a chamber 303 to be evacuated and operating between the high vacuum and an intermediate pressure, and one or more forepumps 307a, 307b (for instance, mechanical oil pumps), operating between said intermediate pressure and atmospheric pressure.

[0063] Pumping system 301 further includes a control device 309, connected with chamber 303 and vacuum pumps 305a, 305b and 307a, 307b through electrical connectors (e.g. RS-232 cables) and equipped with a microprocessor programmed for monitoring the pressure in said chamber and for controlling said pump according to programmed control sequences corresponding to the different operating phases of the same pumps.

[0064] According to the invention, the vacuum pumping system according to the invention further includes at least one vent valve 311 so arranged that it can selectively establish communication between at least one of turbomolecular pumps 305a, 305b and the outer environment or a tank filled with a suitable gas (e.g. nitrogen).

[0065] Always according to the invention, during pumping system stopping, opening and closing of vent valve 311 are controlled by control device 309 based on the deceleration values of the turbomolecular pump(s) detected by the same control device 309.

[0066] Preferably, vent valve 311 is in communication with vacuum chamber 303, whereby the valve can simultaneously put all turbomolecular pumps 305a, 305b connected with said vacuum chamber in communication with the outer environment (or the gas tank).

[0067] It is clear that in such case the opening and closing criteria for vent valve 311 must simultaneously take the deceleration values of all pumps 305a, 305b into account.

[0068] As an alternative, individual vent valves 313a, 313b can be provided for each of turbomolecular pumps 305a - 305b, as shown by a dashed line in Fig. 3.

[0069] According to that variant, a vent valve is arranged on foreline 315a, 315b between each turbomolecular pump 305a, 305b and each forepump 307a, 307b, and such valve allows putting the turbomolecular pump connected with the respective foreline in communication with the outer environment (or the gas tank). It is evident that said gas, due to the lower pressure, will tend to pass from the foreline to turbomolecular pump 305a, 305b and to enter such pump through the exhaust port.

[0070] Note that, if on the one hand such a variant entails an increase in the number of components of pumping system 301 (as many vent valves as are the turbomolecular pumps, in place of a single valve associated with the vacuum chamber), on the other hand the variant increases the system versatility, since each vent valve 313a, 313b can be independently controlled, based on the deceleration of the only pump 305a, 305b connected thereto.

[0071] Note also that, advantageously, it is possible to

introduce also pumps without vent valves into the pumping system according to the invention and to control deceleration thereof during the shut-down phase, thanks to the provision of valves located in ducts communicating with said pumps and controlled by control device 309 according to the modalities described above.

Claims

1. A rotary vacuum pump (101) including:

- a plurality of pumping stages obtained through the cooperation between alternate rotor discs (123) and stator discs or rings (115);
- an electric motor (107) to rotate said rotor discs;
- at least one duct (135, 127) for introducing a gas or a gas mixture into the pump, said duct being interrupted by an electrically controllable valve (133);

the pump being **characterised in that** it includes an electronic control device (129) programmed to perform the steps of:

- detecting at least one operating parameter of the pump;
- modifying the configuration of said valve (133) so as to cause an increase or a decrease in the amount of gas passing through said duct (135) based on the detected value of said parameter.

2. The rotary vacuum pump (101) as claimed in claim 1, wherein said modification of the configuration of said valve (133) is the opening/closing of said valve.

3. The rotary vacuum pump (101) as claimed in claim 1, wherein said modification of the configuration of said valve (133) is the adjustment of the opening degree of said valve.

4. The rotary vacuum pump (101) as claimed in claim 1, wherein said electronic control device (129) is further programmed to stop the electric supply to the motor of said pump during said detecting and modifying steps.

5. The rotary vacuum pump (101) as claimed in claim 1, wherein said electronic control device is further programmed to stop and restore the electric supply to the motor of said pump during said detecting and modifying steps.

6. The rotary vacuum pump (101) as claimed in claim 1, wherein said operating parameter is the rotation speed of the rotor of said pump.

7. The rotary vacuum pump (101) as claimed in claim

- 1, wherein said operating parameter is the vibration frequency of the rotor of said pump.
8. The rotary vacuum pump (101) as claimed in claim 1, wherein said valve (133) puts said duct (135) in communication with the outer environment. 5
9. The rotary vacuum pump (101) as claimed in claim 1, wherein said valve (133) puts said duct (135) in communication with a tank for a gas or a gas mixture, for instance nitrogen. 10
10. The rotary vacuum pump (101) as claimed in any preceding claim, wherein said vacuum pump is a turbomolecular pump. 15
11. A method of operating a rotary vacuum pump (101) of the type including:
- a plurality of pumping stages obtained through the cooperation between alternate rotor discs (123) and stator rings (115); 20
 - an electric motor (107) to rotate said rotor discs;
 - at least one duct (135, 127) for introducing a gas or a gas mixture into the pump, said duct being interrupted by an electrically controllable valve (133); 25
- said method being **characterised in that** it comprises the steps of: 30
- detecting at least one operating parameter of the pump;
 - modifying the configuration of said valve so as to cause an increase or a decrease in the amount of gas passing through said duct (135) based on the detected value of said parameter. 35
12. The method as claimed in claim 11, wherein said modification of the configuration of said valve (133) is the opening/closing of said valve. 40
13. The method as claimed in claim 11, wherein said modification of the configuration of said valve (133) is the adjustment of the opening degree of said valve. 45
14. The method as claimed in claim 11, further comprising the step of stopping the electric supply to the motor of said pump during said detecting and modifying steps. 50
15. The method as claimed in claim 11, further comprising the steps of stopping or restoring the electric supply to the motor of said pump during said detecting and modifying steps. 55
16. The method as claimed in claim 11, wherein said operating parameter is the rotation speed of the rotor of said pump.
17. The method as claimed in claim 11, wherein said operating parameter is the vibration frequency of the rotor of said pump.
18. A vacuum pumping system (301) equipped with at least one rotary vacuum pump (305a, 305b) of the type including a plurality of pumping stages obtained through the cooperation between alternate rotor discs and stator rings, and an electric motor to rotate said rotor discs, said system further including at least one duct for introducing a gas or a gas mixture into said at least one pump, said duct being interrupted by an electrically controllable valve (311; 313a, 313b), the system being **characterised in that** it includes an electronic control device (309) programmed to:
- detect at least one operating parameter of the pump;
 - modify the configuration of said valve (311; 313a, 313b) so as to cause an increase or a decrease in the amount of gas passing through said duct based on the detected value of said parameter.
19. The pumping system (301) as claimed in claim 18, wherein said modification of the configuration of said valve (133) is the opening/closing of said valve.
20. The pumping system (301) as claimed in claim 16, wherein said modification of the configuration of said valve (133) is the adjustment of the opening degree of said valve.
21. The pumping system (301) as claimed in claim 18, wherein said operating parameter is the rotation speed of the rotor of said at least one pump.
22. The pumping system (301) as claimed in claim 18, wherein said operating parameter is the vibration frequency of the rotor of said at least one pump.
23. The pumping system (301) as claimed in claim 18, wherein said valve (311; 313a, 313b) puts said at least one pump (135) in communication with the outer environment.
24. The pumping system (301) as claimed in claim 18, wherein said valve (311; 313a, 313b) puts said at least one pump in communication with a tank for a gas or a gas mixture, for instance nitrogen.
25. The pumping system (301) as claimed in any of claims 18 to 24, wherein said at least one rotary vacuum pump (305a, 305b) is a turbomolecular pump.

26. The pumping system (301) as claimed in any of claims 18 to 25, further comprising a chamber (303) connected with said at least one pump and arranged to be evacuated by means of said at least one pump, wherein said duct for introducing a gas or a gas mixture into the pump is provided in correspondence with said chamber.
27. The pumping system (301) as claimed in any of claims 18 to 25, further comprising at least one fore-pump (307a, 307b) connected to said at least one rotary vacuum pump (305a, 305b) through a foreline (315a, 315b), said duct for introducing a gas or a gas mixture into the pump being provided in correspondence with said foreline.
28. A method of operating a vacuum pumping system equipped with at least one rotary vacuum pump (305a, 305b) of the type including a plurality of pumping stages obtained through the cooperation between alternate rotor discs and stator rings, and an electric motor to rotate said rotor discs, said system including at least one duct for introducing a gas or a gas mixture into the pump, said duct being interrupted by an electrically controllable valve, said method being **characterised in that** it comprises the steps of:
- detecting at least one operating parameter of said at least one pump;
 - modifying the configuration of said at least one valve so as to cause an increase or a decrease in the amount of gas passing through said at least one duct based on the detected value of said parameter.
29. The method as claimed in claim 28, wherein said modification of the configuration of said valve (133) is the opening/closing of said valve.
30. The method as claimed in claim 28, wherein said modification of the configuration of said valve (133) is the adjustment of the opening degree of said valve.
31. The method as claimed in claim 28, further comprising the step of stopping the electric supply to the motor of said at least one pump during said detecting and modifying steps.
32. The method as claimed in claim 28, further comprising the steps of stopping or restoring the electric supply to the motor of said at least one pump during said detecting and modifying steps.
33. The method as claimed in claim 28, wherein said operating parameter is the rotation speed of the rotor of said at least one pump.
34. The method as claimed in claim 28, wherein said operating parameter is the vibration frequency of the rotor of said at least one pump.
35. A method of operating an electronic control device (129; 309) for controlling one or more rotary vacuum pumps (101; 305a, 305b) including a plurality of pumping stages obtained through the cooperation between alternate rotor discs (123) and stator rings (115), an electric motor (107) to rotate said rotor discs and at least one duct (135, 127) for introducing a gas or a gas mixture into the pump, said duct being interrupted by an electrically controllable valve (133; 311; 313a, 313b), said method being **characterised in that** it comprises the steps of:
- detecting at least one operating parameter of said pump(s);
 - modifying the configuration of said valve(s) so as to cause an increase or a decrease in the amount of gas passing through said duct(s) based on the detected value of said parameter.
36. The method as claimed in claim 35, wherein said modification of the configuration of said valve (133) is the opening/closing of said valve.
37. The method as claimed in claim 35, wherein said modification of the configuration of said valve (133) is the adjustment of the opening degree of said valve.
38. The method as claimed in claim 35, further comprising the step of stopping the electric supply to the motor(s) of said pump(s) during said detecting and modifying steps.
39. The method as claimed in claim 35, further comprising the steps of stopping or restoring the electric supply to the motor(s) of said pump(s) during said detecting and modifying steps.
40. The method as claimed in claim 35, wherein said operating parameter is the rotation speed of the rotor of said pump(s).
41. The method as claimed in claim 35, wherein said operating parameter is the vibration frequency of the rotor of said pump(s).
42. A computer program for operating one or more rotary vacuum pumps (101; 305a, 305b) including a plurality of pumping stages obtained through the cooperation between alternate rotor discs (123) and stator discs or rings (115), an electric motor (107) to rotate said rotor discs, and at least one duct (135, 127) for introducing a gas or a gas mixture into the pump, said duct being interrupted by an electrically controllable valve (133; 311; 313a, 313b), said program be-

ing **characterised in that** it includes the steps of:

- detecting at least one operating parameter of said pump(s);
- modifying the configuration of said valve(s) so as to cause an increase or a decrease in the amount of gas passing through said duct(s) based on the detected value of said parameter.

- 43.** The program as claimed in claim 42, wherein said modification of the configuration of said valve (133) is the opening/closing of said valve. 10
- 44.** The program as claimed in claim 42, wherein said modification of the configuration of said valve (133) is the adjustment of the opening degree of said valve. 15
- 45.** The program as claimed in claim 42, further comprising the step of stopping the electric supply to the motor(s) of said pump(s) during said detecting and modifying steps. 20
- 46.** The program as claimed in claim 42, further comprising the step of stopping or restoring the electric supply to the motor(s) of said pump(s) during said detecting and modifying steps. 25
- 47.** The program as claimed in claim 42, wherein said operating parameter is the rotation speed of the rotor of said pump(s). 30
- 48.** The program as claimed in claim 42, wherein said operating parameter is the vibration frequency of the rotor of said pump(s) 35

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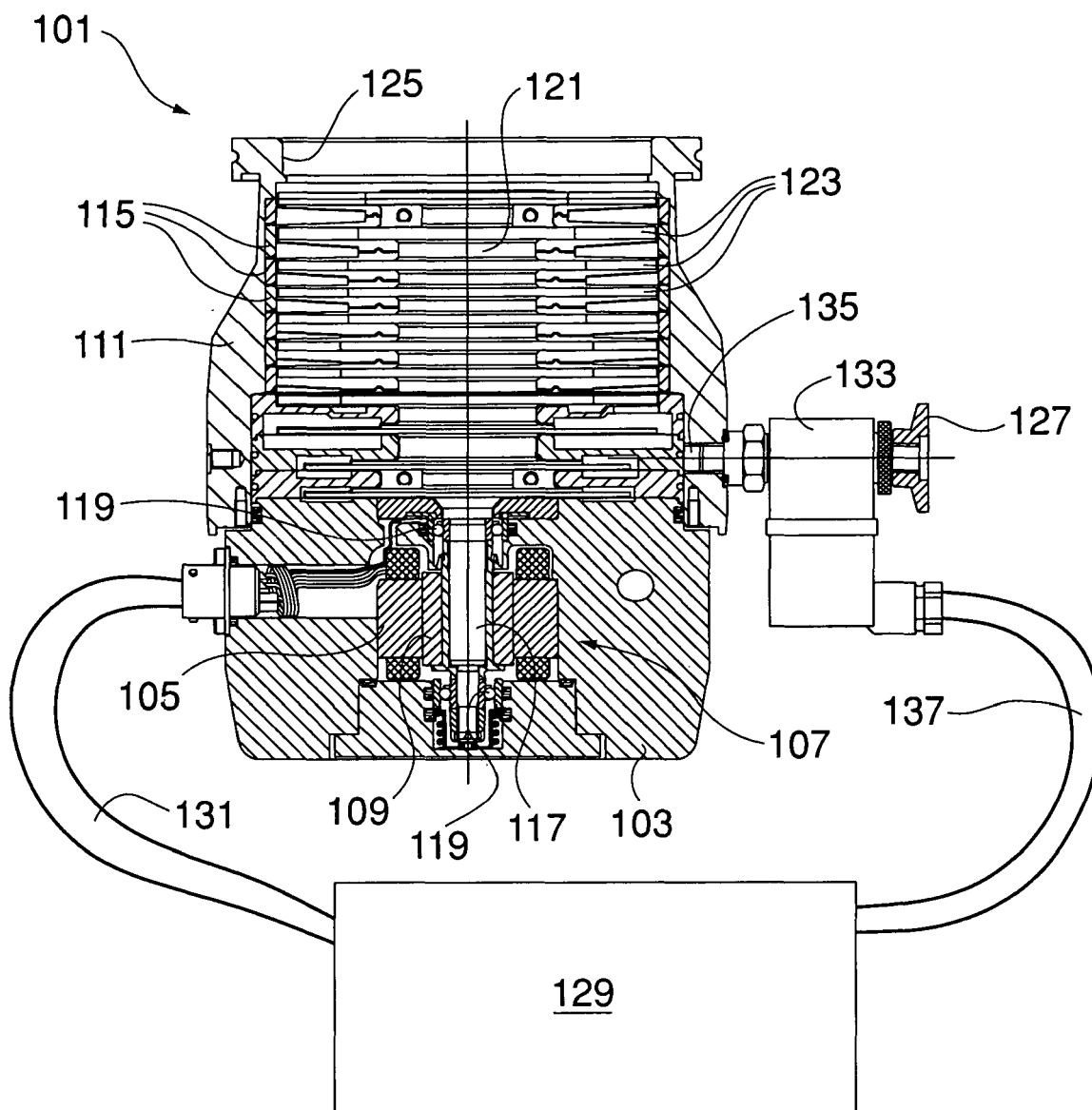


Fig. 1

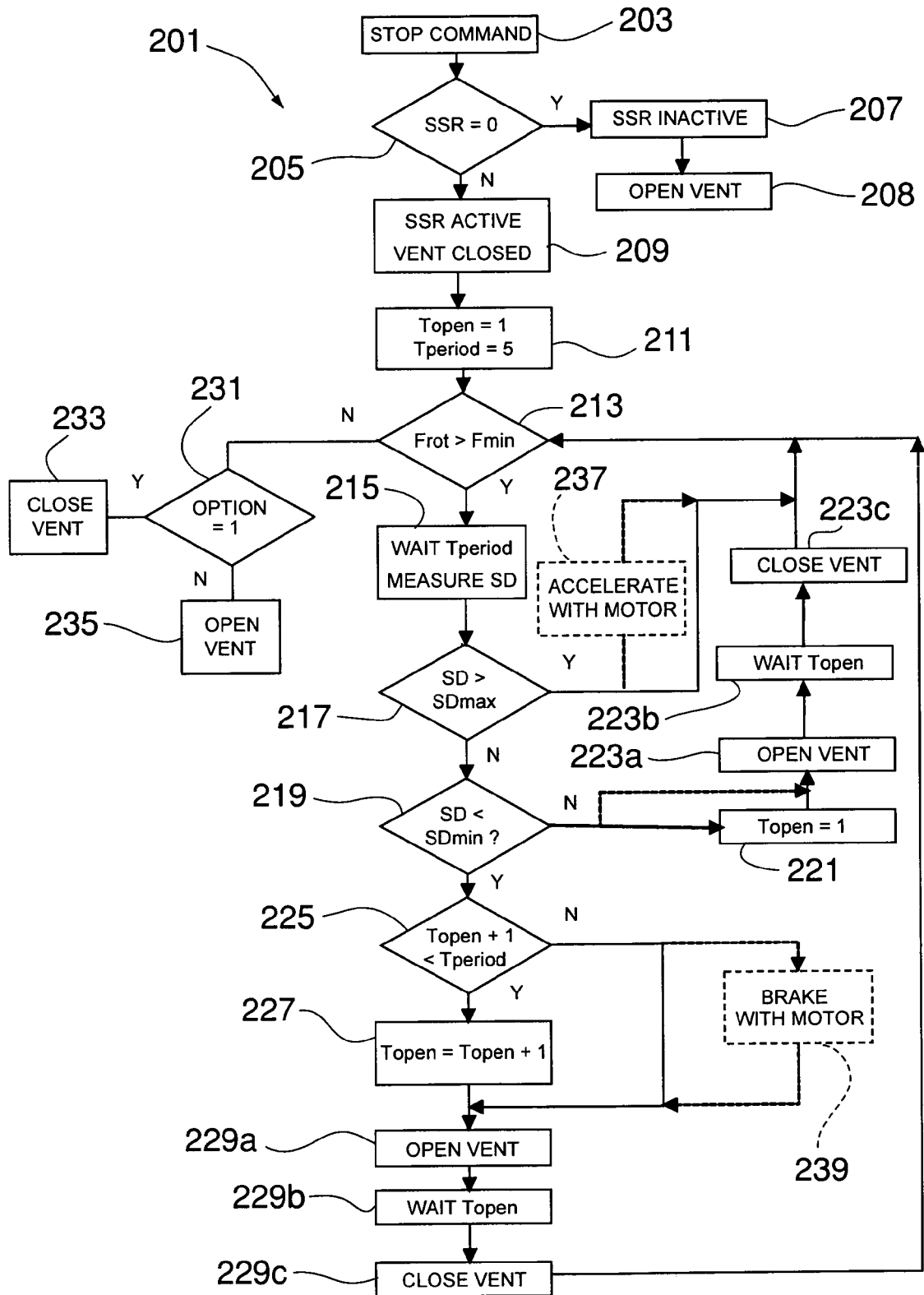


Fig. 2

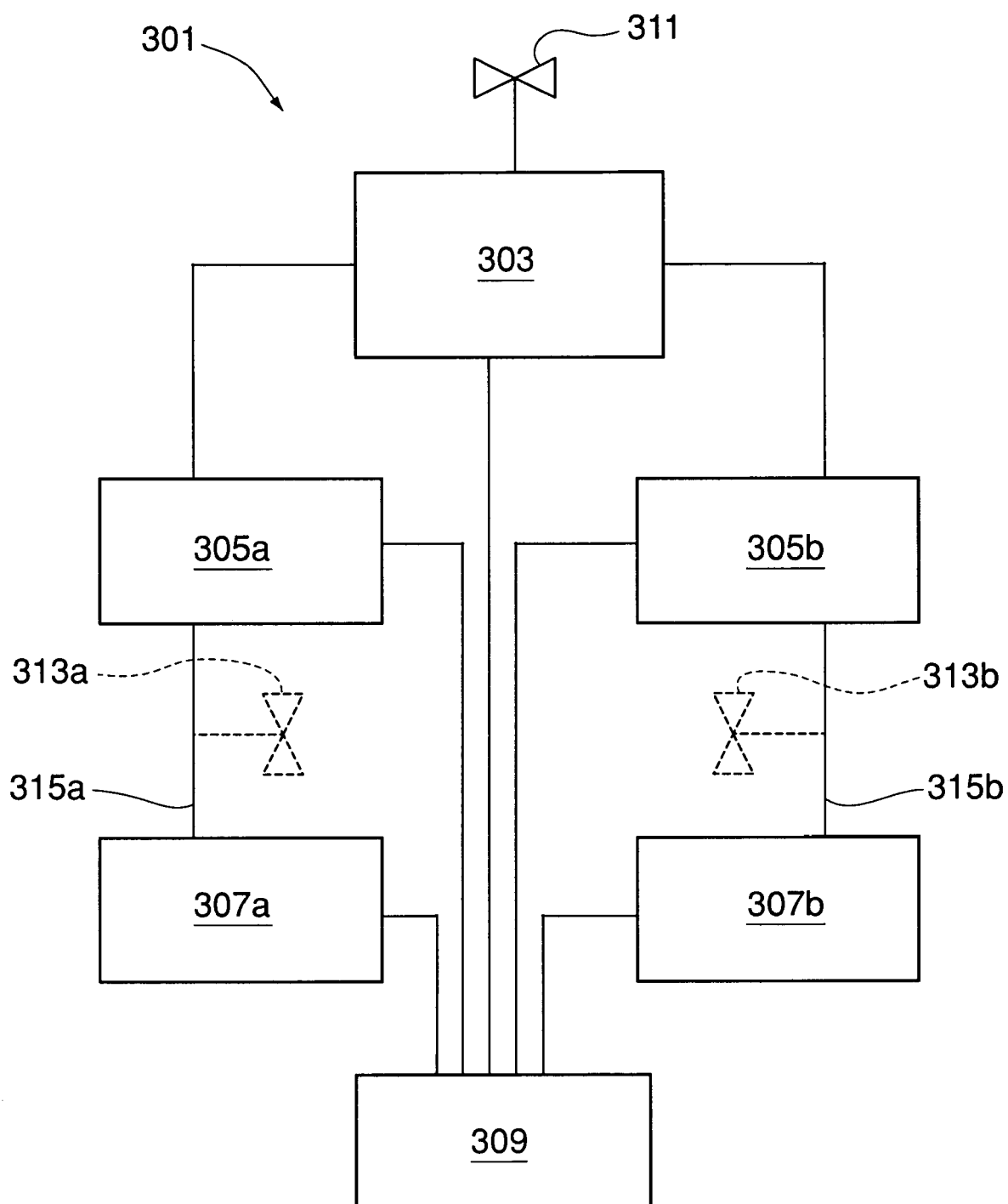


Fig. 3



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 42 5468

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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