

Description

Title: Vacuum pump

Technical field of the invention

5 [0001] The present invention relates to a vacuum pump. The invention relates more particularly to the sealing between the pumping chamber and the lubricant housing(s) of the vacuum pump.

Technical background

10 [0002] Positive-displacement vacuum pumps have one or more pumping stages in series, in which a gas to be pumped circulates between an intake and a delivery. A distinction is made between rough-vacuum pumps with rotary lobes, also known as “Roots” pumps, having two lobes or more, “Claw” pumps, and screw pumps. Vacuum pumps of the “Roots Blower” type are also known, these being used upstream of the rough-vacuum pumps in order to increase the pumping capability under heavy-flow conditions. These vacuum pumps are referred to as “dry” since, in operation, the rotors
15 rotate inside the stator without any mechanical contact with each another or with the stator, this making it possible to not use oil in the pumping stages.

[0003] The rotation of the rotors is synchronized by means of gears. The rotors are guided in rotation by rolling bearings generally situated at each end of the pumping chamber. These gears and bearings are lubricated with oil or grease contained in the
20 lubricant housings which are isolated from the pumping chamber by a sealing means through which the shafts are nevertheless able to rotate. The sealing devices mainly comprise physical barriers to the lubricants, such as rubbing lip seals, ejector discs, gas purges and/or obstacles such as labyrinth seals and baffles.

[0004] However, in operation, the pressures employed in vacuum pumps fluctuate
25 significantly, particularly in applications in which a volume of gas is cyclically brought under vacuum. Although the atmosphere in the lubricant housings is not placed under vacuum but left at atmospheric pressure, it too, to a lesser extent, experiences the pressure variations that occur in the pumping part. This is because the sealing means are not perfectly gastight as they need to allow the shafts to rotate. In addition, the
30 contact of the rubbing lip seals with the rotary parts may become degraded or even lost over the course of time, under the action of their own heating or the wearing of the lips as a result of the movements thereof, these movements themselves being generated by the variation in pressure differentials, making these seals somewhat ineffective. It

then follows that the gases pumped in the pumping chamber may enter the lubricant housings.

[0005] These pumped gases may contain corrosive species, precursors, or else vapours of resins, in the semiconductor, flat panel display, solar and deposition industries. Certain applications, such as HARP (High Aspect Ratio Process) generate large quantities of solid byproducts (powders, pastes, pieces). These byproducts may succeed in gaining access, in large quantities, to the lubricant housings and to the dead volumes of the sealing devices, notably in baffles or labyrinth seals, where they accumulate and/or react. This contamination may lead to premature degradation of the properties of the lubricants or to poor lubrication of the rolling bearings, and this may, over a greater or lesser length of time, lead to premature wearing or even breakage thereof, reducing the lifespan of the vacuum pumps. This phenomenon is accelerated in the case of cyclic pumping applications where the successive emptyings and fillings of the lubricant housings encourage these gas transfers and therefore the contamination of the lubricants.

Summary of the invention

[0006] One of the aims of the present invention is therefore to propose a dry vacuum pump which at least partially overcomes the drawbacks of the prior art.

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

- a lubricant housing,
 - a pumping chamber comprising at least one pumping stage,
 - two rotary shafts configured to drive the rotation of the rotors in the pumping chamber, the shafts being guided in rotation in bearings lubricated by a lubricant contained in the lubricant housing,
 - at least one first and one second annular lip seal, these being arranged in series along each shaft, interposed between the lubricant housing and the pumping chamber, the lips of the annular seals facing in the same direction and in such a way that a pressure in the pumping stage of the pumping chamber adjoining the second annular lip seals that is higher than the pressure in an inter-seals volume situated between the first and second annular lip seals, presses the lips against the shaft,
 - a gas injection duct fluidically connected to the lubricant housing,
 - an over-pressurizing device arranged in the gas injection duct,
- characterized in the vacuum pump further comprises:

- a discharge duct fluidically connecting the lubricant housing to the inter-seals volume, and

- a pressure-gradient control device comprising a non-return valve arranged on the discharge duct so as to allow the purge gas to pass from the lubricant housing towards the inter-seals volume when the variation in pressure between the upstream and downstream sides of the non-return valve is above a predetermined threshold so that the pressure in the lubricant housing is greater than the pressure in the inter-seals volume.

[0008] The purge gas supply flowrate and the lubricant housing over-pressurizing device on the one hand, and the rate at which the gas is discharged as a result of leaks via the first annular lip seals on the housing side and the discharge duct via the pressure-gradient control device on the other hand, make it possible to ensure that the lubricant housing is continuously at an over-pressure with respect to the inter-seals volume, which is to say that the pressure in the lubricant housing is greater than that of the inter-seals volume and that the gas escapes continuously from the inter-seals volume under the lips of the second annular lip seals towards the pumping chamber.

[0009] The pumping chamber thus makes it possible to lower the pressure in the inter-seals volume by aspiration through the leaks of the second annular lip seals. One advantage of this configuration is that the pumping-out of the inter-seals volume is performed by a pumping stage of the pumping chamber, which is to say directly by the vacuum pump itself.

[0010] When the first annular lip seals become worn (on the lubricant-housing side first), the gas begins to pass under the lips of these first annular lip seals to reach the inter-seals volume in addition to continuing to escape via the non-return valve. The proportion of the gas flow that escapes via the non-return valve decreases, but the direction of flow, from the lubricant housing towards the pumping chamber, continues to be maintained because of the pressurization that is maintained in the lubricant housing and this then ensures that there is no ingress of particles, powders or other pumped contaminants into the lubricant housing.

[0011] The more the lips of the first annular seals become worn, the more the flow of purge gas can escape under the lips. The more the flowrate of gas passing under the lips increases, the more the flowrate of gas escaping via the non-return valve

decreases. The flowrate discharged from the inter-seals volume via the discharge duct thus automatically adapts to the degree of wear of the first annular lip seals.

[0012] Another effect that is obtained once the flow of gas under the lips of the first annular lip seals has increased is that this also makes it possible to limit the damage sustained by these first annular lip seals on the housing side.

[0013] The vacuum pump may moreover have one or more of the features that are described below, considered on their own or in combination.

[0014] The first and second annular lip seals are, for example, of the single lip type.

[0015] The opening threshold of the non-return valve is, for example, greater than 40 mbar (4000 Pa), for example comprised between 40 mbar (4000 Pa) and 100 mbar (10 000 Pa), being for example 75 mbar (or 7500 Pa). This threshold allows the non-return valve to open before the gases start to leak through the first annular lip seals when these are new. Thus, when the first annular lip seals on the housing side are new, the majority of the flow of purge gas is discharged via the non-return valve.

[0016] The non-return valve comprises, for example, a spring urging the shutter of the non-return valve into the closed, seated, position.

[0017] The discharge duct may fluidically connect the gas injection duct, between the over-pressurizing device and the lubricant housing, to the inter-seals volume.

[0018] The pressure-gradient control device may comprise a lubricant filter interposed between the non-return valve and the lubricant housing.

[0019] The over-pressurizing device may comprise a restriction and a pressurizing non-return valve which are mounted in series in the gas injection duct.

[0020] The opening threshold of the pressurizing non-return valve is, for example, less than 20 mbar (or 2000 Pa), for example less than or equal to 10 mbar (or 1000 Pa).

The pressurizing non-return valve is, for example, a gravity non-return valve.

[0021] The vacuum pump may comprise a casing in which the gas injection duct and the discharge duct are at least partially housed, the casing accommodating the over-pressurizing device, the non-return valve and the lubricant filter.

Brief description of the figures

[0022] Other advantages and features will become apparent on reading the description of the invention, and also the appended drawings, in which:

[0023] [Fig.1] Figure 1 shows a schematic view of one example of a vacuum pump.

[0024] [Fig. 2] Figure 2 is a view in cross section, from the side, of elements of the vacuum pump of Figure 1 in the region of an inter-seals volume.

[0025] [Fig. 3] Figure 3 shows a view in cross section, from above, of the elements of Figure 2.

5 [0026] [Fig. 4A] Figure 4A shows a partial view, in cross section, of the vacuum pump of Figure 1 in the region of a casing.

[0027] [Fig. 4B] Figure 4B shows a diagram of the casing of Figure 4A and of the elements it contains.

10 [0028] [Fig. 5] Figure 5 shows a graph of pressure (in mbar) as a function of time (in seconds) for the pressure in the lubricant housing of the vacuum pump of Figure 1 (curve P1, in broken line), in the inter-seals volume (curve P2, in fine solid line) and in the pumping chamber (curve P3, in thick solid line).

[0029] In these figures, identical elements bear the same reference numerals.

Detailed description

15 [0030] The following embodiments are examples. Although the description refers to one or more embodiments, this does not necessarily mean that each reference relates to the same embodiment, or that the features apply only to one embodiment. Individual features of various embodiments can also be combined or interchanged to provide other embodiments, without departing from the scope of the invention as defined by the claims.

[0031] An “upstream” element is to be understood as one that comes before another in relation to the direction of circulation of the gas that is to be pumped. By contrast, a “downstream” element is to be understood to mean one that comes after another in relation to the direction of circulation of the gas that is to be pumped.

25 [0032] The invention applies to any type of dry vacuum pump, that is to say comprising one or at least two pumping stages, such as comprising one to ten pumping stages. This vacuum pump may be a rough-vacuum pump comprising a plurality of pumping stages and configured to deliver the pumped gases to atmospheric pressure or a dry vacuum pump of the Roots pump or Roots Blower type, with one to three pumping stages which, in use, is fluidically connected in series with and upstream of a rough-vacuum pump and the delivery pressure of which is that obtained by the rough-vacuum pump.

30 [0033] Figure 1 shows one example of a vacuum pump.

[0034] The vacuum pump 1 comprises at least a lubricant housing 2, a pumping chamber 3 comprising at least one pumping stage T1-T6, two rotary shafts 4 (see Figure 3) which are configured to drive the rotation of the rotors 5 in the pumping chamber 3, and at least one sealing device 6 interposed between the lubricant housing 2 and the pumping chamber 3.

[0035] The vacuum pump 1 may comprise just one or may comprise a plurality of pumping stages T1-T6, such as six, which are mounted in series between the inlet and the outlet of the vacuum pump 1.

[0036] Each pumping stage T1-T6 has a respective inlet and outlet. When the vacuum pump 1 comprises a plurality of pumping stages, the successive pumping stages are fluidically connected in series one after another by respective inter-stage channels fluidically connecting the outlet of the preceding pumping stage to the inlet of the following pumping stage. The pumping flowrates of the pumping stages T1-T6 are either decreasing or equal according to their position between the inlet and the outlet of the vacuum pump, the flowrate generated by the first pumping stage T1 at the lowest pressure corresponding to the highest pumping flowrate.

[0037] The shafts 4 drive the rotation of the rotors 5 in the pumping stages T1-T6 of the pumping chamber 3 in order to drive a gas that is to be pumped from the inlet to the outlet of the vacuum pump 1. The shafts 4 are driven in rotation by at least one motor M of the vacuum pump 1.

[0038] During rotation, the gas drawn in through the inlet is trapped in the volume created by the rotors 5 and the stator, and is then driven by the rotors 5 towards the following stage. The rotors 5 of the vacuum pump 1 have, for example, lobes with identical profiles, for example of the "Roots" pump type (a cross section in the shape of a figure-eight or of a kidney bean), or are of the three-lobed type or "Claw" type, of the screw type or use some other similar positive-displacement vacuum pump principle.

[0039] The shafts 4 are guided in rotation in bearings lubricated by a lubricant contained in the lubricant housing 2. The lubricant, such as oil or grease, is able to lubricate notably the rolling bearings 7 of the bearings and/or the synchronizing gears 8 that synchronize the shafts 4.

[0040] The vacuum pump 1 is referred to as "dry" since, in operation, the rotors 5 rotate inside the stator without any mechanical contact with each another or with the stator, thus making it possible to not use oil in the pumping chamber 3.

[0041] The vacuum pump 1 comprises for example two lubricant housings 2 arranged one at each end of the pumping chamber 3, a sealing device 6 that seals against lubricants being interposed between the lubricant housing 2 and a pumping stage T1, T6 at each shaft passage, on each side of the pumping stages T1, T6.

5 **[0042]** The sealing device 6 comprises at least a first annular lip seal 9 and a second annular lip seal 10 these being arranged in series along each shaft 4. There are therefore at least two first annular lip seals 9 and two second annular lip seals 10 (Figure 3). The first annular lip seals 9 are interposed between the lubricant housing 2 and the second annular lip seals 10. The second annular lip seals 10 are interposed
10 between the first annular lip seals 9 and the pumping chamber 3.

[0043] The first and second annular lip seals 9, 10 are, for example, of the single lip type (just 1 lip). The lips of the annular seals 9, 10 may rub against the rubbing rings mounted on the shafts 4.

[0044] Best visible in Figure 2, the lips of the annular seals 9, 10 face in the same
15 direction and in such a way that a pressure in the pumping stage T1, T6 of the pumping chamber 3 adjoining the second annular lip seals 10 that is greater than the pressure in the inter-seals volume 11 situated between the first and second annular lip seals 9, 10, presses the lips against the shaft 4. Conversely, the lips of the annular seals 9, 10 have a tendency to lift and thus "leak" when the pressure in the inter-seals volume 11 is
20 greater than that of the pumping chamber 3.

[0045] The pumping stages T1, T6 adjoining the first and second lip seals 9, 10 are, in this instance, the first and last pumping stages.

[0046] The sealing device 6 may also comprise a "dynamic" seal, which is to say a seal that does not rub, such as a seal involving sealing rings, a labyrinth seal or a baffle or
25 "wall" of gas. The sealing device 6 may also comprise a deflector disc in the overall shape of a disc mounted on the shaft 4 so that it rotates as one therewith. The sealing device 6 creates a very small amount of conductance around the rotary shaft 4, making it possible to greatly limit the passage of lubricants from the housing 2 to the dry pumping stages and vice versa, while still allowing the shafts 4 to turn.

30 **[0047]** The vacuum pump 1 further comprises a gas injection duct 12 fluidically connected to the lubricant housing 2, an over-pressurizing device 13 arranged in the gas injection duct 12, a discharge duct 14 fluidically connecting the lubricant housing 2 to the inter-seals volume 11, and a pressure-gradient control device 15.

[0048] The purge gas injected is, for example, nitrogen.

[0049] The gas injection duct 12 opens into the internal volume of the lubricant housing 2 in an injection zone topologically situated in such a way as to limit as far as possible any mixing of oil mist with purge gas in order to limit entrainment thereof. The inlet of

5 the gas injection duct 12 is intended to be fluidically connected to a purge-gas supply.

[0050] The over-pressurizing device 13 ensures that a small flow of purge gas can quickly and easily enter the lubricant housing 2. The maximum injection flowrate of purge gas is for example 3.2 slm (or 5.4 Pa.m³/s), for a lubricant housing 2 situated on the side of the last pumping stage T6 of a multistage vacuum pump, or 0.5 slm (or

10 0.8 Pa.m³/s) for the lubricant housing 2 situated on the side of the first pumping stage of a multistage vacuum pump or for a vacuum pump of the Roots Blower type. These small flows also ensure that the ingress of purge gas into the lubricant housing 2 does not agitate the lubricants and does not entrain them towards the pumping chamber 3.

[0051] According to one example of embodiment, the over-pressurizing device 13

15 comprises a restriction 16, which is to say an orifice of low conductance (also referred to as a calibrated orifice or nozzle) and a pressurizing non-return valve 17 which are mounted in series in the gas injection duct 12. The pressurizing non-return valve 17 is interposed between the restriction 16 and the lubricant housing 2.

[0052] The restriction 16 makes it possible to limit the maximum purge gas injection

20 flowrate.

[0053] The pressurizing non-return valve 17 prevents gas from the lubricant housing 2 from being able to enter the gas injection duct 12. Conversely, it is possible to supply the lubricant housing 2 with purge gas by opening the valve 17 when the difference in pressure between the gas injection duct 12 and the lubricant housing 2 is greater than

25 a threshold value for which the pressurizing non-return valve 17 is calibrated, which is to say when the pressure in the lubricant housing 2 is too low.

[0054] The pressurizing non-return valve 17 is calibrated to allow gas to pass in the direction of the lubricant housing 2 when the variation in pressure between the upstream and downstream sides of the valve 17 is greater than a predetermined

30 opening threshold. This opening threshold is low; it is for example of the order of a few mbar, for example less than 20 mbar (or 2000 Pa), for example less than or equal to 10 mbar (or 1000 Pa).

[0055] The pressurizing non-return valve 17 is, for example, a gravity non-return valve, the shutter, for example a ball, a bullet-shaped or other-shaped body, being held on its seat in the closed position under the effect of gravity.

[0056] The restriction 16 and the pressurizing non-return valve 17 thus provide control
5 over the flow of injected gas which is mechanical, simple to implement and inexpensive

[0057] Alternatively, the over-pressurizing device 13 comprises a flow controller or flowmeter (mass flow controller).

[0058] The purge gas supply flowrate in the gas injection duct 12 and the over-pressurizing device 13 on the one hand, and the flowrate at which the purge gas is
10 discharged as a result of leaks via the first annular lip seals 9 and the discharge duct 14 via the pressure-gradient control device 15 on the other hand, make it possible to ensure that the lubricant housing 2 is continuously at an over-pressure with respect to the inter-seals volume 11, which is to say that the pressure in the lubricant housing 2 is greater than that of the inter-seals volume 11. The lubricant housing 2 can thus be
15 pressurized with a gas that is clean.

[0059] The discharge duct 14 fluidically connects for example the gas injection duct 12, between the over-pressurizing device 13 and the lubricant housing 2, to the inter-seals volume 11.

[0060] The pressure-gradient control device 15 comprises a non-return valve 18
20 arranged in the discharge duct 14. The non-return valve 18 is calibrated so as to allow the purge gas to pass from the lubricant housing 2 towards the inter-seals volume 11 when the variation in pressure between the upstream and downstream sides of the non-return valve 18 is above a predetermined opening threshold so that the pressure in the lubricant housing 2 is greater than the pressure in the inter-seals volume 11. The
25 non-return valve 18 also makes it possible to prevent gases from the pumping chamber 3 from entering the lubricant housing 2.

[0061] The opening threshold of the non-return valve 18 is, for example, greater than 40 mbar (4000 Pa), for example comprised between 40 mbar (4000 Pa) and 100 mbar (10 000 Pa), being for example 75 mbar (or 7500 Pa). This threshold allows the non-
30 return valve 18 to open before the gases start to leak through the first annular lip seals 9 when these are new. Thus, when the first annular lip seals 9 on the housing side are new, the majority of the flow of purge gas is discharged via the non-return valve 18.

[0062] To make it easier to achieve the predetermined threshold, the non-return valve 18 comprises for example a spring 19, for example a compression spring, that urges the shutter of the non-return valve 18, which for example is a ball, a bullet-shaped or other-shaped body, into a closed, seated, position.

- 5 [0063] The pressure-gradient control device 15 may comprise a lubricant filter 20 interposed between the non-return valve 18 and the lubricant housing 2 in order to trap any micro-droplets of oil mist that might be progressing from the lubricant housing 2 into the inter-seals volume 11 via the non-return valve 18.

- 10 [0064] The lubricant filter 20, for example a sintered stainless steel filter, is able to separate the oil or other lubricant from the gas so that the housing 2 is not emptied of its lubricant.

- [0065] When the discharge duct 14 is fluidically connected to the gas injection duct 12 between the over-pressurizing device 13 and the lubricant housing 2, the lubricant filter 20 may be arranged on the gas injection duct 12 between the intersection with the
15 discharge duct 14 and the lubricant housing 2.

- [0066] According to one example of embodiment visible in Figures 4A and 4B, the vacuum pump 1 comprises a casing 21 fixed to the stator of the vacuum pump 1 and in which the gas injection duct 12 and the discharge duct 14 are at least partially housed, the casing 21 accommodating the over-pressurizing device 13 (notably the pressurizing
20 non-return valve 17 and the restriction 16), the non-return valve 18 and, where applicable, the spring 19 that urges the non-return valve 18 into the closed position, and/or the lubricant filter 20. The inlet of the gas injection duct 12 may have a coupling 22 external to the casing 21 for fluidically connecting the duct 12 to a purge gas supply source.

- 25 [0067] According to another example, the elements of the casing 21 are arranged in the body of the stator 2 of the vacuum pump 1.

- [0068] In operation, when the annular lip seals 9, 10 are new, the lips are pressed against the shafts 4. In an equilibrium situation, because the pressure is higher in the lubricant housing 2, the gas continuously escapes from the lubricant housing 2 via the
30 non-return valve 18 into the inter-seals volume 11 and from the inter-seals volume 11 under the lips of the second annular lip seals 10 towards the pumping chamber 3.

[0069] The pumping chamber 3 thus makes it possible to lower the pressure in the inter-seals volume 11 by aspiration through the leaks of the second annular lip seals

10. One advantage is that the pumping-out of the inter-seals volume 11 is performed by a pumping stage T1-T6 of the pumping chamber 3, which is to say directly by the vacuum pump 1 itself.

[0070] When the first annular lip seals 9 become worn (on the lubricant-housing 2 side first), the gas begins to pass under the lips of these first annular lip seals 9 to reach the inter-seals volume 11 in addition to continuing to escape via the non-return valve 18. The proportion of the gas flow that escapes via the non-return valve 18 decreases, but the direction of flow, from the lubricant housing 2 towards the pumping chamber 3, continues to be maintained because of the pressurization that is maintained in the lubricant housing 2, and this then ensures that there is no ingress of particles, powders or other pumped contaminants into the lubricant housing 2.

[0071] The more the lips of the first annular seals 9 become worn, the more the flow of purge gas can escape under the lips. The more the flowrate of gas passing under the lips increases, the more the flowrate of gas escaping via the non-return valve 18 decreases. The pressure-gradient control device 15 and the fact that the pressure in the lubricant housing 2 is greater than the pressure in the inter-seals volume 11 therefore allows the flowrate discharged from the inter-seals volume 11 via the discharge duct 14 to be adapted to the degree of wear of the first annular lip seals 9.

[0072] Another effect obtained as a result of the fact that the flow of gas escaping via the non-return valve 18 decreases following the increase in the flow of gas under the lips of the first annular lip seals 9 is that damage to these first annular lip seals 9 is limited.

[0073] The advantages of the present invention may be better understood with reference to the graph of Figure 5 which shows curves of pressure in the lubricant housing (curve P1) on the side of the first pumping stage T6 of a multistage vacuum pump 1, in the inter-seals volume (curve P2), and in the last pumping stage T6 of the pumping chamber (curve P3) at the second annular lip seals 10.

[0074] In an equilibrium situation and, in this instance, when the annular lip seals 9 are new (seal very tightly), the pressure in the lubricant housing, P1, is of the order of 1180 mbar (or 118 000 Pa) and the pressure in the inter-seals volume, P2, is of the order of 1080 mbar (or 108 000 Pa). The 100 mbar (or 10 000 Pa) difference between the two values is the result of the calibration value of the pressurizing non-return valve 17, which is of the order of 75 mbar (7500 Pa) and of the various conductances.

[0075] The pressure in the pumping chamber, P3, is a mean value between the intake and delivery pressures in the pumping stage T6. This mean value is, in this instance, in an equilibrium situation, of the order of 760 mbar (or 76 000 Pa).

5 [0076] The pressure in the lubricant housing, P1, is thus greater than the pressure in the inter-seals volume, P2, which is itself greater than the pressure in the last pumping stage, P3. The gas continuously escapes from the lubricant housing 2 via the non-return valve 18 towards the inter-seals volume 11 and from the inter-seals volume 11 under the lips of the second annular lip seals 10 towards the pumping chamber 3.

10 [0077] Upon opening t1 an isolation valve arranged upstream of the vacuum pump 1 in the direction of flow of the gases pumped in order to evacuate an enclosure (or equivalent) fluidically connected to the inlet of the vacuum pump 1, the sudden ingress of the pumped gases into the vacuum pump 1 leads to a rise in pressure in the last pumping stage (curve P3). The pressure in the pumping stage T6 then almost immediately becomes higher than the pressure in the inter-seals volume P2, and this
15 tends to cause the second lip seals 10 to close. This isolation causes the pressure in the lubricant housing P1 and in the inter-seals volume P2 to rise because the over-pressurizing device 13 continues to inject purge gas into the lubricant housing 2 and, therefore, into the inter-seals volume 11.

20 [0078] Then, once the volume of the enclosure has been evacuated, the pressure in the last pumping stage P3 drops again and falls below the pressure of the inter-seals volume P2 (at the time t2). This then is a return to the situation in which the pressure in the lubricant housing, P1, is greater than the pressure in the inter-seals volume, P2, which is itself greater than the pressure in the last pumping stage, P3. The gas therefore escapes from the lubricant housing 2 via the non-return valve 18 towards the
25 inter-seals volume 11 and from the inter-seals volume 11 under the lips of the second annular lip seals 10 towards the pumping chamber 3, so that the pressures P1 in the lubricant housing and P2 in the inter-seals volume drop again.

30 [0079] The increase in pressure in the lubricant housing 2 and in the inter-seals volume 11 which is brought about by the closure of the second annular seals 10 and by the continuous injection by the over-pressurizing device 13 has made it possible to reduce the length of time (in this instance to 1.5 seconds) for which the pressure in the pumping chamber 3 was greater than in the inter-seals volume 11, and for which

particles or contaminants can be entrained towards the lubricant housing 2 and for which the second annular lip seals 10 on the pumping side become worn.

- [0080]** Although Figure 1 illustrates an over-pressurizing device 13 and a pressure-gradient control device 15 for just one of the two lubricant housings 2, the invention
- 5 may apply to one or the other of the two lubricant housings 2 or to both lubricant housings 2 of the vacuum pump 1.

CLAIMS

[Claim 1] Dry vacuum pump (1) having:

- a lubricant housing (2),
- a pumping chamber (3) comprising at least one pumping stage (T1-T6),
- 5 - two rotary shafts (4) configured to drive the rotation of the rotors (5) in the pumping chamber (3), the shafts (4) being guided in rotation in bearings lubricated by a lubricant contained in the lubricant housing (2),
- at least one first and one second annular lip seal (9, 10) these being arranged in series along each shaft (4), interposed between the lubricant housing (2) and the
- 10 pumping chamber (3), the lips of the annular seals (9, 10) facing in the same direction and in such a way that a pressure in the pumping stage (T1, T6) of the pumping chamber (3) adjoining the second annular lip seals (10) that is higher than the pressure in an inter-seals volume (11) situated between the first and second annular lip seals (9, 10), presses the lips against the shaft (4),
- 15 - a gas injection duct (12) fluidically connected to the lubricant housing (2),
- an over-pressurizing device (13) arranged in the gas injection duct (12), characterized in the vacuum pump (1) further comprises:
- a discharge duct (14) fluidically connecting the lubricant housing (2) to the inter-seals volume (11), and
- 20 - a pressure-gradient control device (15) comprising a non-return valve (18) arranged on the discharge duct (13) so as to allow the purge gas to pass from the lubricant housing (2) towards the inter-seals volume (11) when the variation in pressure between the upstream and downstream sides of the non-return valve (18) is above a predetermined opening threshold so that the pressure in the lubricant housing (2) is
- 25 greater than the pressure in the inter-seals volume (11).

[Claim 2] Vacuum pump (1) according to the preceding claim, characterized in that the first and second annular lip seals (9, 10) are of the single lip type.

- [Claim 3]** Vacuum pump (1) according to one of the preceding claims, characterized in that the non-return valve (18) comprises a spring (19) urging the
- 30 shutter of the non-return valve (18) into the closed, seated, position.

[Claim 4] Vacuum pump (1) according to one of the preceding claims, characterized in that the opening threshold of the non-return valve (18) is greater than 4000 Pa, for example comprised between 4000 Pa and 10 000 Pa.

[Claim 5] Vacuum pump (1) according to one of the preceding claims, characterized in that the discharge duct (14) fluidically connects the gas injection duct (12), between the over-pressurizing device (13) and the lubricant housing (2), to the inter-seals volume (11).

- 5 **[Claim 6]** Vacuum pump (1) according to one of the preceding claims, characterized in that the pressure-gradient control device (15) comprises a lubricant filter (20) interposed between the non-return valve (18) and the lubricant housing (2).

- [Claim 7]** Vacuum pump (1) according to one of the preceding claims, characterized in that the over-pressurizing device (13) comprises a restriction (16) and
10 a pressurizing non-return valve (17) which are mounted in series in the gas injection duct (12).

[Claim 8] Vacuum pump (1) according to the preceding claim, characterized in that the pressurizing non-return valve (17) is a gravity non-return valve.

- [Claim 9]** Vacuum pump (1) according to one of Claims 7 and 8, characterized in
15 that the opening threshold of the pressurizing non-return valve (17) is less than 2000 Pa, for example less than or equal to 1000 Pa.

- [Claim 10]** Vacuum pump (1) according to Claim 6, characterized in that it comprises a casing (21) in which the gas injection duct (12) and the discharge duct (14) are at least partially housed, the casing (21) accommodating the over-pressurizing
20 device (13), the non-return valve (18) and the lubricant filter (20).