

## Description

### Title of the invention: Dry vacuum pump

- [1] The present invention relates to a dry vacuum pump.
- [2] The vacuum pumps of dry type comprise one or more pumping stages in series in which  
5 a gas to be pumped circulates. Known vacuum pumps that can be distinguished are those with rotary lobes also known as "Roots" or those with beaks, also known as "claws". These vacuum pumps are said to be "dry" because, in operation, the rotors rotate inside a stator with no mechanical contact between them or with the stator, which allows oil not to be used in the pumping stages.
- 10 [3] As an example, the document US6,572,351B2 discloses a vacuum pump structure having a stator in the form of half-shells jointed on a longitudinal joining surface which is generally parallel to the axes of the rotors. The vacuum pump comprises a one-piece seal having two end annular parts and two side rails connecting the end annular parts and which are at right angles thereto. The two end annular parts are parallel to one  
15 another and each is inserted between an end piece and the half-shells. The side rails are inserted between the half-shells. This one-piece seal ensures both the seal between the half-shells and the seal between the half-shells and the added end pieces to insulate the compression stages from the outside atmosphere.
- [4] However, in some pumping applications, such as in the pumping methods used in the  
20 semiconductor, "flat panel display" and photovoltaic industries and in the coating methods, the gases used can be corrosive, notably the gases employed during the phases of cleaning of the process chambers. Such is the case notably with the gases  $\text{NF}_3$ ,  $\text{ClF}_3$ ,  $\text{F}_2$ ,  $\text{Cl}_2$ . These corrosive gases can damage the seals situated between the half-shells.
- 25 [5] In addition to the performance losses of the pumping device, the degradation of this seal can lead to safety problems. On the one hand, the oxygen or water vapour from the surrounding air can enter into the pumping chambers and react with the conveyed gases, which can notably risk causing the pumped gases to ignite or explode. Also, toxic gases can leak from the pumping chambers of the vacuum pump to the atmosphere, notably  
30 the high-pressure pumping stages, which presents a risk for the safety of personnel.
- [6] To avoid that, the vacuum pumps have a sliced architecture, in which the stators are composed by the axial assembly of several stator elements, including an annular seal compressed radially between the stator elements, twinned with a Teflon® (or PTFE) seal received in the same annular seal groove. The Teflon® seal takes the form of a  
35 strip of parallelepipedal section which is crushed between the stator elements to produce

the seal. The twinning of the annular seal with a Teflon ® barrier makes it possible to secure the seal at a relatively economic cost.

- [7] However, this embodiment, which is very suitable for pumps with a sliced architecture, cannot simply be applied to the pumps having a half-shell architecture in which the seal is produced by the one-piece seal described above. Indeed, it is not easy to produce three-dimensional seals in Teflon ®, and a Teflon ® barrier produced in multiple parts joined by crushing would not be a satisfactory solution because the seal between the different parts could not be guaranteed without ingress of gas because of the small surfaces in contact and the non-elastic properties of the Teflon ®.
- [8] Moreover, in the case where the end part comprises a nose axially joining with the half-shells, nor is the mounting of a Teflon ® barrier which is neither elastic nor toroidal, around the axial nose, an easy operation. Also, the assembly in the axial direction of the half-shells with the noses of the added end pieces does not allow for an effective compression of the Teflon ® barrier.
- [9] One aim of the present invention is to at least partially resolve one of the abovementioned drawbacks.
- [10] To this end, the subject of the invention is a dry vacuum pump comprising:
- a stator comprising at least one first and one second complementary half-shells and one first end piece and one second end piece, the half-shells and the end pieces being joined to one another by axial assembly to form at least one pumping chamber of a pumping stage,
  - two rotor shafts configured to rotate synchronously in reverse directions in the at least one pumping stage,
- characterized in that the vacuum pump further comprises:
- an elastic outer seal and at least one elastic inner seal respectively comprising:
    - one first and one second end annular parts that are parallel to one another and inserted between a respective end piece and the half-shells, and
    - two side rails connecting the end annular parts and which are at right angles thereto, the side rails being inserted between the half-shells, the at least one inner seal being arranged inside the outer seal so that the at least one inner seal and the outer seal form at least two successive sealing barriers for the gases.
- [11] The at least one inner seal is smaller than the outer seal to be able to be arranged inside, in a “nested” arrangement. It is thus possible to double, even triple, the seals. This multiplying of the sealing barriers makes it possible to ensure a good seal both from the outside to the inside and vice versa, and allows for the use of different materials for

each seal capable of offering corrosive gas and/or heat resistance performance levels that decrease with distance from the pumping chambers.

[12] The vacuum pump can also comprise one or more of the features which are described hereinbelow, taken alone or in combination.

5 [13] The outer seal can be in one piece.

[14] The at least one inner seal can be in one piece.

[15] According to another exemplary embodiment, the outer seal and/or the inner seal are joined end-to-end, that is to say formed by placing multiple elastic seal parts end-to-end.

10 [16] The at least one inner seal can be formed from a material that is more resistant to corrosion, abrasion and/or high temperatures than the material of the outer seal.

[17] The outer seal can be made of a fluorinated elastomer material.

[18] The at least one inner seal can be made of a perfluoroelastomer material.

15 [19] According to an exemplary embodiment, the half-shells and the end pieces are joined to one another by axial assembly of a first and a second axial nose and a first and a second axial void that are complementary, one being borne by the half-shells, the others by the end pieces, the first and second end annular parts being inserted between a respective axial nose and a complementary axial void.

20 [20] A first and at least one second peripheral annular grooves can be formed in at least one axial nose and/or in at least one axial void to receive the first and second end annular parts of the outer seal and of the at least one inner seal.

[21] According to another exemplary embodiment, the half-shells and the end pieces are joined to one another without the presence of the complementary axial noses and voids. The end pieces and/or the half-shells for example have annular grooves formed in the planes of the end pieces and the planes of the facing edges of the half-shells.

25 [22] At least two longitudinal grooves can be formed in one and/or the other of the half-shells in a joining surface on either side of the pumping chambers, to receive the side rails of the outer seal and of the inner seal.

30 [23] At least one injection duct can be formed in a half-shell of the stator and emerge through at least one injection orifice in an interstitial space situated between the at least one inner seal and the outer seal, the vacuum pump comprising a gas feed device configured to inject a neutral gas into the injection duct. This circulation of gas creates a third sealing barrier for the gases and a thermal barrier. This sealing barrier notably makes it possible to preserve the outer seal, particularly if it has a material that is less resistant to corrosion, abrasion and/or high temperatures.

35 [24] The injection duct can emerge in the zone of the interstitial space situated in a joining surface of the half-shells, between two side rails.

- [25] The gas feed device can be configured to heat the neutral gas.
- [26] The gas feed device can be configured to inject the neutral gas with overpressure.
- [27] At least one suction duct can be formed in a half-shell of the stator and emerge in an interstitial space situated between the at least one inner seal and the outer seal, through  
5 at least one suction orifice, the suction duct connecting the interstitial space with a pumping chamber or an inter-stage channel of the vacuum pump.
- [28] The suction duct can emerge in the zone of the interstitial space situated in a joining surface of the half-shells, between two side rails.
- [29] The vacuum pump can comprise a pressure sensor configured to measure the  
10 pressure in an interstitial space situated between the at least one inner seal and the outer seal. The measurement of a pressure variation above a threshold may reveal the presence of a leak and therefore of a sealing fault.
- [30] The vacuum pump can comprise a gas sensor configured to determine the presence of at least one corrosive gaseous species such as Cl or Cl<sub>2</sub>, O<sub>2</sub>, F or F<sub>2</sub>, H or H<sub>2</sub>, HBr, HF,  
15 HCl, ClF<sub>3</sub>, NF<sub>3</sub>, SiF<sub>4</sub> in an interstitial space situated between the at least one inner seal and the outer seal. The gas sensor is, for example, of electrochemical type such as with two or three electrodes. The presence of one of these gaseous species in the interstitial space may reveal the presence of a leak and therefore of a sealing fault in the inner seal.
- [31] The gas or pressure sensor is, for example, an MEMS ("microelectromechanical  
20 systems") sensor.
- [32] The vacuum pump comprises, for example, a control unit, such as a controller or microcontroller, linked to the gas sensor and configured to trigger maintenance if a threshold of concentration of the at least one corrosive gaseous species is exceeded and/or the control unit is linked to the pressure sensor and is configured to trigger  
25 maintenance if a pressure variation threshold is exceeded.
- [33] The half-shells of the stator can form at least two pumping stages mounted in series between a suction and a discharge of the vacuum pump.
- [34] The stator can comprise at least two pairs of complementary half-shells, the elastic outer and inner seals respectively comprising at least one interposed annular part  
30 inserted between two pairs of half-shells.
- [35] The stator can further comprise at least one one-piece pumping stage mounted in series of the at least one pumping stage formed in the at least first and second half-shells.
- [36] Drawings

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

[38] **[Fig.1]** Figure 1 is an exploded schematic view of elements of a dry vacuum pump according to a first exemplary embodiment.

[39] **[Fig.2]** Figure 2 is a perspective view of an example of rotor shaft of the vacuum pump of Figure 1.

[40] **[Fig.3]** Figure 3 is a perspective view of a half-shell assembled with an outer seal, an inner seal and an end piece of the vacuum pump of Figure 1.

[41] **[Fig.4]** Figure 4 is a plan view of elements of Figure 3.

[42] **[Fig.5]** Figure 5 is a longitudinal cross-sectional view of the half-shell of Figure 4 seen from the side, and an enlarged view of a detail of the half-shell.

[43] **[Fig.6]** Figure 6 is a view in cross section BB of the half-shell of Figure 4 seen from the front, and an enlarged view of a detail of the half-shell.

[44] **[Fig.7]** Figure 7 is an exploded schematic view of elements of a dry vacuum pump according to a second exemplary embodiment.

[45] In these figures, the elements that are identical or similar bear the same reference numbers.

[46] The figures have been simplified in the interests of clarity. Only the elements that are necessary to an understanding of the invention are represented.

[47] 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 a single embodiment. Simple features of different embodiments can also be combined or swapped to provide other embodiments.

[48] A primary vacuum pump defines a volumetric vacuum pump, which is configured to, using two rotor shafts, suck, transfer, then discharge the gas to be pumped at atmospheric pressure. The rotor shafts are driven in rotation by a motor of the primary vacuum pump. A primary vacuum pump can be started up from atmospheric pressure.

[49] A Roots-type vacuum pump or Roots compressor (also called "Roots Blower") defines a volumetric vacuum pump configured to, using rotors of Roots type, suck, transfer then discharge the gas to be pumped. The Roots-type vacuum pump is mounted upstream of and in series with a primary vacuum pump. The rotors are borne by two shafts driven in rotation by a motor of the Roots-type vacuum pump. The Roots vacuum pump comprises from one to three pumping stages.

[50] "Upstream" is understood to mean an element which is placed before another with respect to the direction of circulation of the gas to be pumped. By contrast, "downstream" is understood to mean an element placed after another with respect to the direction of circulation of the gas to be pumped.

5 [51] The axial direction is defined as the longitudinal direction of the pump in which the axes of the rotor shafts extend.

[52] The dry vacuum pump 1 of Figure 1 comprises a stator 2 forming at least one pumping stage, such as at least two pumping stages 3a-3f mounted in series between a suction 4 and a discharge 5, such as between two and ten pumping stages (six in the  
10 illustrative example). The vacuum pump 1 can be a primary vacuum pump (Figure 1) or a Roots-type vacuum pump.

[53] The vacuum pump 1 further comprises two rotor shafts 6 (Figure 2) configured to turn synchronously in reverse directions in the at least one pumping stage 3a-3f such that the rotors drive a gas to be pumped between the suction 4 and the discharge 5. The rotor  
15 shafts 6 can be in one piece or produced by the assembly of various added elements.

[54] The rotors have, for example, lobes of identical profiles, for example of "Roots" type (Figure 2) or of "claw" type or of another similar volumetric vacuum pump principle. The shafts bearing the rotors are driven by a motor (not represented) situated, for example, at an end of the vacuum pump 1, for example on the discharge 5 side.

20 [55] Each pumping stage 3a-3f of the stator 2 is formed by a pumping chamber receiving two conjugate rotors, the pumping chambers comprising respective inlets and outlets. During rotation, the gas sucked from the inlet is held captive in the volume generated by the rotors and the stator 2, then is driven by the rotors to the next stage.

[56] The successive pumping stages 3a-3f are connected in series one after the other by  
25 respective inter-stage channels (not represented) connecting the outlet of the preceding pumping stage 3a-3e to the inlet of the next pumping stage 3b-3f. The inlet of the first pumping stage 3a connects with the suction 4 of the vacuum pump 1. The outlet of the last pumping stage 3f connects with the discharge 5. The axial dimensions of the rotors and of the pumping chambers are, for example, equal or they decrease with the pumping  
30 stages, the pumping stage 3a situated on the side of the suction 4 receiving the rotors 6 of greatest axial dimension.

[57] These vacuum pumps are said to be "dry" because, in operation, the rotors turn inside the stator 2 with no mechanical contact between them or with the stator 2, which allows oil not to be used in the pumping stages 3a-3f.

35 [58] The stator 2 comprises at least one first and one second complementary half-shells 7, 8 and a first end piece and a second end piece 9, 10. The half-shell architecture makes it

possible to reduce the assembly time by virtue of the lesser number of interfaces to be aligned. This architecture also makes it possible to reduce the risks of aggregated alignment defects. The cost of the vacuum pump 1 can therefore be reduced and assembly simplified.

5 [59] The half-shells 7, 8 are joined to one another by a joining surface 11 to form at least one pumping chamber of the at least one pumping stage 3a-3f. The at least one compression chamber, and the transfer channels if appropriate, are formed partly in the first half-shell 7 and partly in the second half-shell 8.

[60] The joining surface 11 is, for example, a flat joining surface, passing for example  
10 through a median plane of the dry vacuum pump 1. The flat joining surface 11 contains, for example, the axes of the rotor shafts 6. This flat joining surface 11 can be strictly flat or can for example have complementary relief forms or grooves for side rails of seals between the half-shells as will be seen later.

[61] A first end of the half-shells 7, 8 is closed by a first end piece 9 and a second end of  
15 the half-shells 7, 8 is closed by a second end piece 10. Orifices are of course formed in the transverse walls 15 of the half-shells 7, 8 separating the pumping chambers if appropriate, and the end pieces 9, 10 for the passage of the rotor shafts 6.

[62] The half-shells 7, 8 and the end pieces 9, 10 are joined to one another by axial  
20 assembly, for example by the axial assembly of complementary first and second axial noses 12 and first and second axial voids 13, one being borne by the half-shells 7, 8, the others being borne by the end pieces 9, 10.

[63] In the example illustrated in Figures 1 to 6, the first and second axial noses 12 are formed in a respective end piece 9, 10.

[64] The axial nose 12 protrudes in the axial direction. It has, for example, an oblong  
25 transverse form which corresponds substantially to the form of the cross sections of the pumping chambers of the pumping stages 3a-3f in which the complementary axial voids 13 are formed. The axial nose 12 has, for example, a solid form. The axial voids 13 are formed, for example, in the pumping chamber of the first pumping stage 3a and in the pumping chamber of the last pumping stage 3f.

30 [65] The vacuum pump 1 further comprises an outer seal 16 and at least one inner seal 17. These seals 16, 17 are three-dimensional and can be of a single piece, that is to say in one piece.

[66] According to another exemplary embodiment, the outer seal 16 and/or the inner seal  
35 17 are joined end-to-end, that is to say formed by the end-to-end placement of several elastic parts of seals 16, 17.

[67] They are elastic, notably because they comprise elastomer materials. They are, for example, obtained by press or injection moulding. The outer and inner seals 16, 17 have, for example, a substantially circular cross section in the non-compressed state.

[68] The outer seal 16 and the inner seal 17 respectively comprise a first and a second  
5 end annular parts 161, 162, 171, 172 that are parallel to one another, and two side rails 163, 173 connecting the end annular parts 161, 162, 171, 172 and which are at right angles thereto.

[69] The end annular parts 161, 171, 162, 172 have conventional loop forms. They are inserted between an end piece 9, 10 and the respective half-shells 7, 8, such as between  
10 a respective complementary axial nose 12 and axial void 13. For example, the first end annular parts 161, 171 are inserted between the axial nose 12 and the first end piece 9 and the axial void 13 of the pumping chamber of the last pumping stage 3f, at a first axial end of the half-shells 7, 8. The second end annular parts 162, 172 are inserted between the axial nose 12 of the second end piece 10 and the axial void 13 of the pumping  
15 chamber of the first pumping stage 3a, at a second axial end of the half-shells 7, 8.

[70] This circular form and the elastic property of the end annular parts 161, 171, 162, 172 allow them to be mounted/removed easily on a respective axial nose 12.

[71] The side rails 163, 173 of the outer seal 16 and of the at least one inner seal 17 are inserted between the half-shells 7, 8, on the joining surface 11. There are thus two side  
20 rails 163, 173 extending parallel to one another in the axial direction, on either side of the pumping chambers.

[72] The at least one inner seal 17 is arranged inside the outer seal 16 so that the at least one inner seal 17 and the outer seal 16 form at least two successive sealing barriers for the gases. The at least one inner seal 17 is smaller than the outer seal 16 to be able to  
25 be arranged inside, in a "nested" arrangement.

[73] The seals can thus be doubled. This multiplication of the sealing barriers makes it possible to ensure a good seal both from the outside to the inside and vice versa and allows for the use of different materials potentially offering corrosive gas and/or thermal resistance performance levels that decrease with distance from the pumping chambers.

[74] Indeed, provision can be made for the at least one inner seal 17 to be formed by a material that is more resistant, notably to corrosion, to abrasion and/or to high  
30 temperatures, than the material of the outer seal 16. The material of the outer seal 16 can thus be more economical than the material of the inner seal 17 while being acceptable in safety terms. The outer seal 16 is, for example, made of a fluorinated elastomer material (FKM) and the at least one inner seal 17 is, for example, made of  
35 perfluoroelastomer material (FFKM).

- [75] It is also possible to triple, or multiply even more, the seals, the vacuum pump 1 then comprising at least two inner seals 17, at least one first inner seal being arranged inside at least one second inner seal. Also, the at least one first inner seal 17 can be formed from a material that is more resistant, notably to corrosion, to abrasion and/or to high temperatures, than the material of the at least one second inner seal 17.
- [76] A first peripheral annular groove 18a and at least one second peripheral annular groove 18b can be formed in at least one axial nose 12 (Figure 5) and/or in at least one axial void 13 to receive the first end annular parts 161, 171 of the outer seal 16 and of the at least one inner seal 17.
- [77] A first peripheral annular groove 18a and at least one second peripheral annular groove 18b can be formed in at least one axial nose 12 (Figure 5) and/or in at least one axial void 13 to receive the second end annular parts 162, 172 of the outer seal 16 and of the at least one inner seal 17.
- [78] The axial nose 12 formed in the end pieces 9, 10 has the advantage that the peripheral annular grooves 18a, 18b are of a single piece, without connections between the half-shells and therefore without additional seals. It is also easier to produce peripheral annular grooves 18a, 18b in the axial noses 12. The mounting/dismantling of the end annular parts 161, 162, 171, 172 in the peripheral annular grooves 18a, 18b and the production thereof is therefore simpler for peripheral annular grooves formed in axial noses 12 formed in the end pieces 9, 10. There are thus, for example, two peripheral annular grooves 18a, 18b offset axially in the axial nose 12 of each of the two end pieces 9, 10.
- [79] At least two longitudinal grooves 19a, 19b can be formed in one and/or the other of the half-shells 7, 8 in the joining surface 11, on either side of the pumping chambers, to receive the side rails 163, 173 of outer seal 16 and of the inner seal 17 (Figure 6).
- [80] There are, for example, four longitudinal grooves 19a, 19b receiving four side rails 163, 173 of an inner seal 17 and of an outer seal 16, two longitudinal grooves 19a, 19b being formed on either side of the pumping chambers.
- [81] Each outer and inner seal 16, 17 can thus be received in its respective peripheral annular grooves 18a, 18b and respective longitudinal grooves 19a, 19b. Furthermore, it is preferable to form a single groove on one side of the stator 2 with a flat surface facing it, rather than a groove on each side. That simplifies the mounting/dismantling and machining. A good seal can thus be obtained by radial compression of the end annular parts 161, 171, 162, 172 and of the side rails 163, 173.
- [82] The interstitial space 22 situated between the outer seal 16 and the at least one inner seal 17 defines a tightly closed volume.

[83] According to an exemplary embodiment, at least one injection duct 20 is formed in a half-shell 8 of the stator 2 and emerges through at least one injection orifice 21 into the interstitial space 22 (Figure 6). As can be seen better in Figures 3 and 4, the induction duct 20 emerges, for example, in the zone of the interstitial space 22 situated in the joining surface 11, between the two side rails 163, 173. There are, for example, at least two injection ducts 20 formed in a half-shell 8 and emerging in said zone, on each side of the pumping chamber of the penultimate pumping stage 3e.

[84] The vacuum pump 1 further comprises a gas feed device 23 configured to inject a neutral gas into the injection duct 20 (Figure 6). A neutral gas can then be injected into the interstitial space 22 and circulate longitudinally between the side rails 163, 173 and around the axial noses 12, between the end annular parts 161, 171, 162, 172. This circulation of gas creates a third sealing barrier for the gases and a thermal barrier. This sealing barrier notably allows the outer seal 16 to be preserved, particularly if it has a material less resistant to corrosion, to abrasion and/or to high temperatures.

[85] The gas feed device 23 can be configured to inject the neutral gas with overpressure, that is to say a pressure greater than atmospheric pressure.

[86] The gas feed device 23 can also be configured to heat the neutral gas. It comprises, for example, a coil in thermal contact with the stator 2, configured to heat the neutral gas circulating in the coil by heat exchange with the stator 2. The stator 2 is heated by the compression of the gases and/or by its own temperature control device.

[87] At least one suction duct (not visible) emerging in the interstitial space 22 through at least one suction orifice 24, can be formed in a half-shell 7, 8 of the stator 2. The suction duct connects, for example, the interstitial space 22 with a pumping chamber or an inter-stage channel of the vacuum pump 1, such as the first pumping stage 3a. The transfer channels are, for example, formed on the sides of the pumping chambers, in the half-shells.

[88] The pumping function of the vacuum pump 1 can thus be used either alone to create a vacuum in the interstitial space 22, or with complementary injection of a neutral gas to cause the neutral gas to circulate in the interstitial space 22. The interstitial space 22, in vacuum pressure mode or in gas circulation mode, can also make it possible to produce a third sealing barrier for the gases.

[89] The suction duct emerges, for example, in the zone of the interstitial space 22 situated in the joining surface 11, between the two side rails 163, 173. There are, for example, at least two suction ducts formed in a half-shell 8 and emerging in said zone, on each side of the pumping chamber of the first pumping stage 3a.

- [90] The vacuum pump 1 can further comprise a pressure sensor 25 configured to measure the pressure in the interstitial space 22. The pressure sensor 25 is, for example, connected to the injection duct 20 (Figure 6). The measurement of a pressure variation above a threshold can reveal the presence of a leak and therefore of a sealing defect.
- 5 This information can be used by a control unit 26 of the vacuum pump 1, linked to the pressure sensor 25 and configured to signal the need to trigger maintenance if the pressure variation threshold is exceeded.
- [91] The vacuum pump 1 can further comprise a gas sensor 27 configured to determine the presence of at least one corrosive gaseous species in an interstitial space 22
- 10 situated between the at least one inner seal 17 and the outer seal 16. The gas sensor 27 is, for example, connected to the injection duct 20 (Figure 6).
- [92] The gas sensor 27 is, for example, configured to determine the presence of at least one corrosive gaseous species from among Cl or Cl<sub>2</sub>, O<sub>2</sub>, F or F<sub>2</sub>, H or H<sub>2</sub>, HBr, HF, HCl, ClF<sub>3</sub>, NF<sub>3</sub>, SiF<sub>4</sub>. The gas sensor 27 is, for example, of electrochemical type such as with
- 15 two or three electrodes.
- [93] The presence of one of these gaseous species in the interstitial space 22 can reveal the presence of a leak and therefore of a sealing defect in the inner seal 17. This information can be used by the control unit 26 then linked to the gas sensor 27 and configured to signal the need to trigger maintenance if a threshold of concentration of the
- 20 at least one corrosive gaseous species is exceeded.
- [94] The gas sensor 27 or pressure sensor 25 is, for example, an MEMS ("Microelectromechanical systems") sensor.
- [95] By detecting a pressure fault or the presence of a predetermined gaseous species in the dead volume delimited by the two seals 16, 17, it is possible to detect a sealing
- 25 failure without risks for the safety of personnel or equipment, while allowing a maintenance operator to intervene.
- [96] Figure 7 shows a second exemplary embodiment of the vacuum pump 1.
- [97] In this example, the stator 2 comprises at least two pairs of complementary half-shells 7, 8, 70, 80, 700, 800 (three in the illustrative example).
- 30 [98] For example, two half-shells 7, 8 form two pumping stages 3a, 3b, two half-shells 70, 80 form two other pumping stages 3c, 3d and two half-shells 700, 800 form two other pumping stages 3e, 3f, the pumping stages 3a-3f being mounted in series between the suction 4 and the discharge 5 of the vacuum pump 1.
- [99] The elastic outer 16 and inner 17 seals respectively comprise at least one interposed
- 35 annular part 164, 174, 165, 175 inserted between two pairs of half-shells 7, 8. The interposed annular parts 164, 174, 165, 175 are parallel to the end annular parts 161,

171, 162, 172 and connected to the two side rails 163, 173 and are at right angles thereto.

[100] Like the end annular parts 161, 171, 162, 172, the interposed annular parts 164, 174, 165, 175 have conventional loop forms and can be inserted between a respective  
5 complementary axial nose 12 and axial void 13. For example, the first interposed annular parts 164, 174 are inserted between the two pairs of half-shells 7, 8, 70, 80, and the two interposed annular parts 165, 175 are inserted between the two pairs of half-shells 70, 80, 700, 800. An axial nose 12 is, for example, borne by a pair of half-shells 70, 80 at a first end and an axial void 13 is, for example, formed in a pumping chamber of the pair of  
10 half-shells 70, 80, at a second end.

[101] Moreover, and although not represented in the figures, the vacuum pump 1 can also comprise at least one one-piece pumping stage, mounted in series, upstream or downstream, of the at least one pumping stage 3a-3f formed in the at least first and second half-shells 7, 8.

15 [102] Also, according to another exemplary embodiment, the half-shells 7, 8 and the end pieces 9, 10 can be joined to one another without the presence of the complementary axial noses and voids. The end pieces 9, 10 and/or the half-shells 7, 8 have, for example, annular grooves formed in the planes of the end pieces and the planes of the facing edges of the half-shells 7, 8.

## Claims

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

- a stator (2) comprising at least one first and one second complementary half-shells (7, 8) and one first end piece and one second end piece (9, 10), the half-shells (7, 8) and the end pieces (9, 10) being joined together by axial assembly to form at least one pumping chamber of a pumping stage (3a-3f),
  - two rotor shafts (6) configured to turn synchronously in reverse directions in the at least one pumping stage,
- characterized in that the vacuum pump (1) further comprises:
- an elastic outer seal (16) and at least one elastic inner seal (17) respectively comprising:
    - one first and one second end annular parts (161, 171, 162, 172) parallel to one another and inserted between a respective end piece (9, 10) and the half-shells (7, 8), and
    - two side rails (163, 173) connecting the end annular parts (161, 171, 162, 172) and which are at right angles thereto, the side rails (163, 173) being inserted between the half-shells (7, 8), the at least one inner seal (17) being arranged inside the outer seal (16) so that the at least one inner seal (17) and the outer seal (16) form at least two successive sealing barriers for the gases, wherein the at least one inner seal (17) is formed from a material that is more resistant to corrosion, to abrasion and/or to high temperatures than the material of the outer seal (16).

[Claim 2] Vacuum pump (1) according to the preceding claim, characterized in that the outer seal (16) is in one piece.

[Claim 3] Vacuum pump (1) according to one of the preceding claims, characterized in that the at least one inner seal (17) is in one piece.

[Claim 4] Vacuum pump (1) according to one of the preceding claims, characterized in that the outer seal (16) is made of a fluorinated elastomer material and the at least one inner seal (17) is made of a perfluoroelastomer material.

[Claim 5] Vacuum pump (1) according to one of the preceding claims, characterized in that the half-shells (7, 8) and the end pieces (9, 10) are joined to one another by axial assembly of a first and second axial nose (12) and a first and second axial void (13) that are complementary, one being borne by the half-shells (7, 8), the others by the end pieces (9, 10), the first and second end annular parts (161, 171, 162, 172) being inserted between a respective complementary axial nose (12) and axial void (13).

[Claim 6] Vacuum pump (1) according to the preceding claim, characterized in that:

- a first and at least one second peripheral annular grooves (18a, 18b) are formed in at least one axial nose (12) and/or in at least axial void (13) to receive the first and second end annular parts (161, 171, 162, 172) of the outer seal (16) and of the at least one inner seal (17),
- at least two longitudinal grooves (19a, 19b) are formed in one and/or the other of the half-shells (7, 8) in a joining surface (11) on either side of the pumping chambers, to receive the side rails (163, 173) of the outer seal (16) and of the inner seal (17).

[Claim 7] Vacuum pump (1) according to one of the preceding claims, characterized in that at least one injection duct (20) is formed in a half-shell (7, 8) of the stator (2) and emerges through at least one injection orifice (21) in an interstitial space (22) situated between the at least one inner seal (17) and the outer seal (16), the vacuum pump (1) comprising a gas feed device (23) configured to inject a neutral gas into the injection duct (20).

[Claim 8] Vacuum pump (1) according to the preceding claim, characterized in that the injection duct (20) emerges in the zone of the interstitial space (22) situated in a joining surface (11) of the half-shells (7, 8), between two side rails (163, 173).

[Claim 9] Vacuum pump (1) according to one of Claims 7 and 8, characterized in that the gas feed device (23) is configured to heat the neutral gas.

[Claim 10] Vacuum pump (1) according to one of Claims 7 to 9, characterized in that the gas feed device (23) is configured to inject the neutral gas with overpressure.

[Claim 11] Vacuum pump (1) according to one of Claims 1 to 9, characterized in that at least one suction duct is formed in a half-shell (7, 8) of the stator (2) and emerges in an interstitial space (22) situated between the at least one inner seal (17) and the outer seal (16), through at least one suction orifice (24), the suction duct (24) connecting the interstitial space (22) with a pumping chamber or an interstage channel of the vacuum pump (1).

[Claim 12] Vacuum pump (1) according to the preceding claim, characterized in that the suction duct (24) emerges in the zone of the interstitial space (22) situated in a joining surface (11) of the half-shells (7, 8), between two side rails (163, 173).

[Claim 13] Vacuum pump (1) according to one of the preceding claims, characterized in that it comprises a pressure sensor (25) configured to measure the pressure in an interstitial space (22) situated between the at least one inner seal (17) and the outer seal (16).

[Claim 14] Vacuum pump (1) according to one of the preceding claims, characterized in that it comprises a gas sensor (27) configured to determine the presence of at least

one corrosive gaseous species in an interstitial space (22) situated between the at least one inner seal (17) and the outer seal (16).

[Claim 15] Vacuum pump (1) according to one of the preceding claims, characterized in that the half-shells (7, 8) of the stator (2) form at least two pumping stages (3a-3f) mounted in series between a suction (4) and a discharge (5) of the vacuum pump (1).

[Claim 16] Vacuum pump (1) according to one of the preceding claims, characterized in that the stator (2) comprises at least two pairs of complementary half-shells (7, 8, 70, 80, 700, 800), the elastic outer (16) and inner (17) seals respectively comprising at least one interposed annular part (164, 165, 174, 175) inserted between two pairs of half-shells (7, 8, 70, 80, 700, 800).

[Claim 17] Vacuum pump (1) according to one of the preceding claims, characterized in that the stator (2) further comprises at least one one-piece pumping stage mounted in series of the at least one pumping stage (3a-3f) formed in the at least first and second half-shells (7, 8).