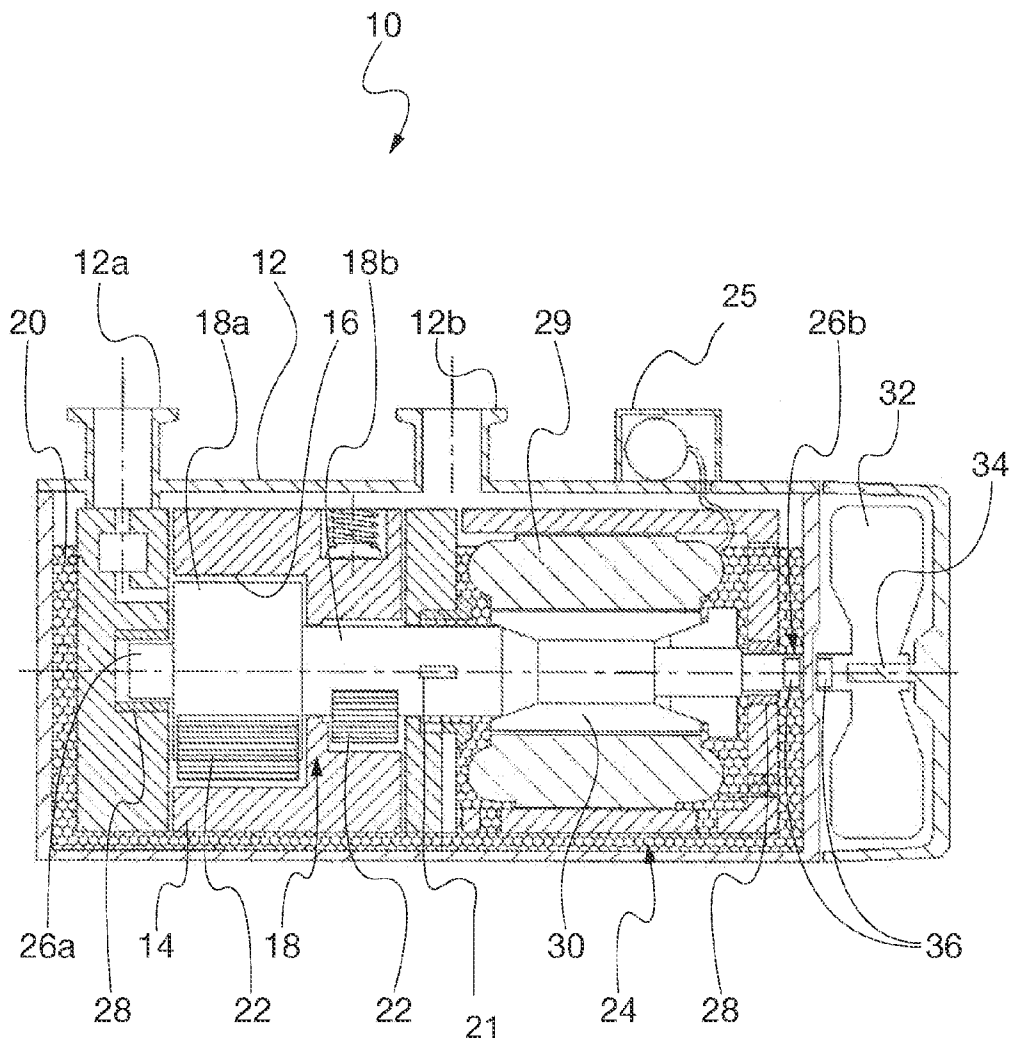




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(19) **United States**(12) **Patent Application Publication**
Carboneri et al.(10) **Pub. No.: US 2014/0363319 A1**(43) **Pub. Date: Dec. 11, 2014**(54) **ROTARY VANE VACUUM PUMP**(71) Applicant: **Agilent Technologies, Inc.**, Loveland,
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(2013.01); **F04C 29/02** (2013.01)USPC **417/372**(57) **ABSTRACT**

A rotary vane vacuum pump includes a pump casing having a gas inlet port and a gas outlet port, a stator provided within the pump casing and defining a cylindrical stator chamber and a cylindrical rotor eccentrically arranged in the stator chamber and equipped with radially movable radial vanes, the vanes cooperating with the inner wall of the stator chamber for pumping a gas from the gas inlet port to the gas outlet port, the pump casing being filled with such an amount of oil that the stator is immersed in an oil bath acting as cooling and lubricating fluid, wherein a motor for driving the pump is further provided, the motor being arranged in a motor casing that is in fluid communication with the pump casing, whereby the motor is immersed in the oil bath.



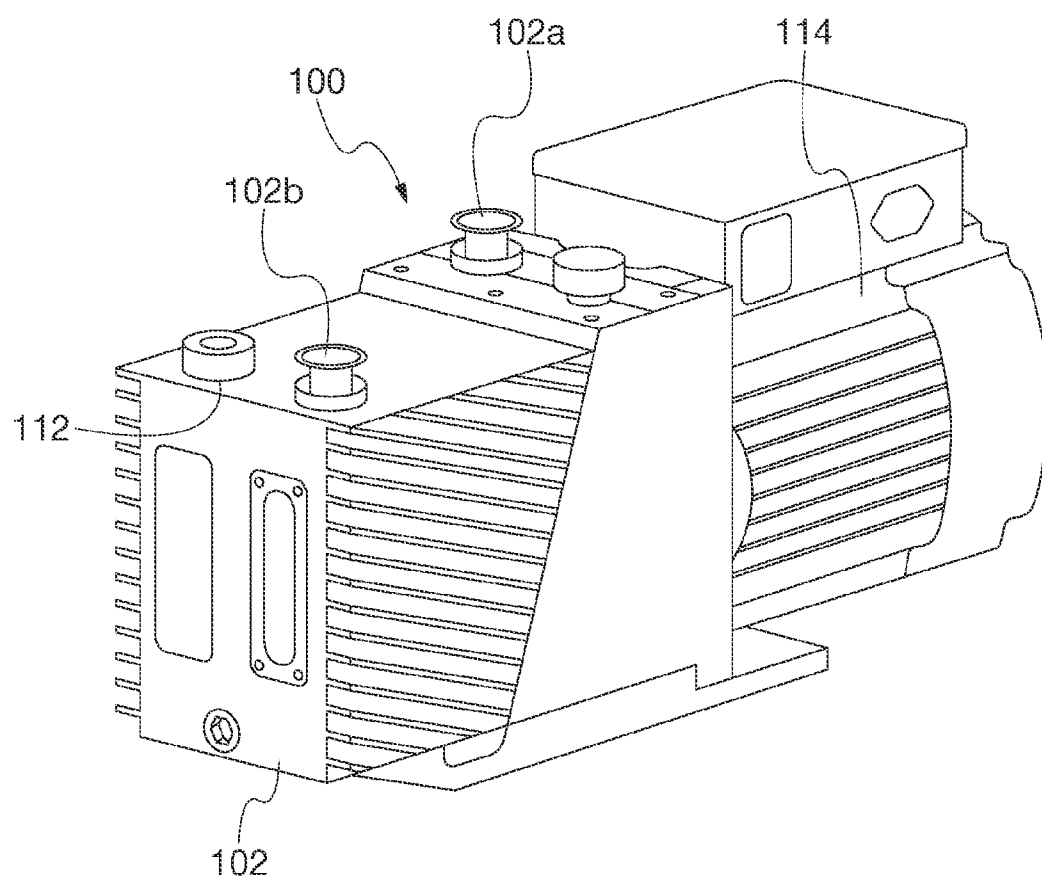


Fig. 1

(PRIOR ART)

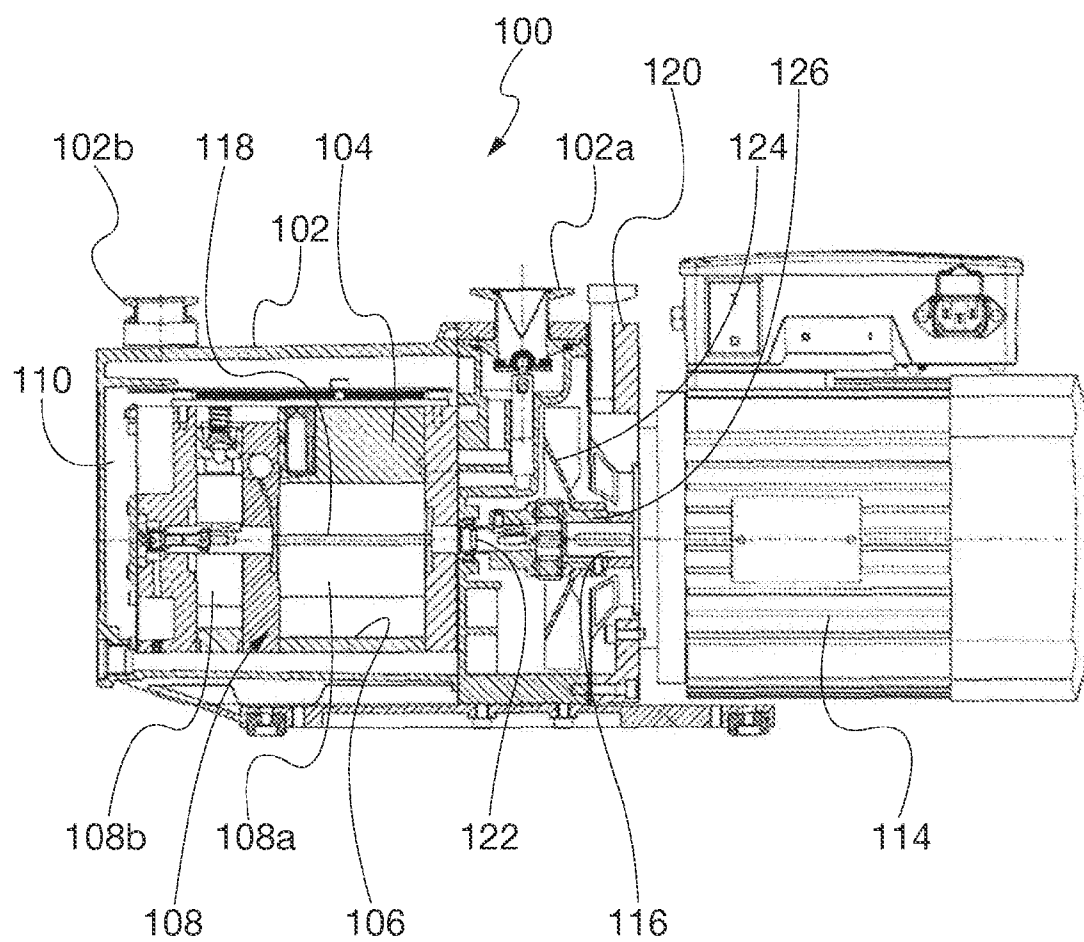


Fig. 2

(PRIOR ART)

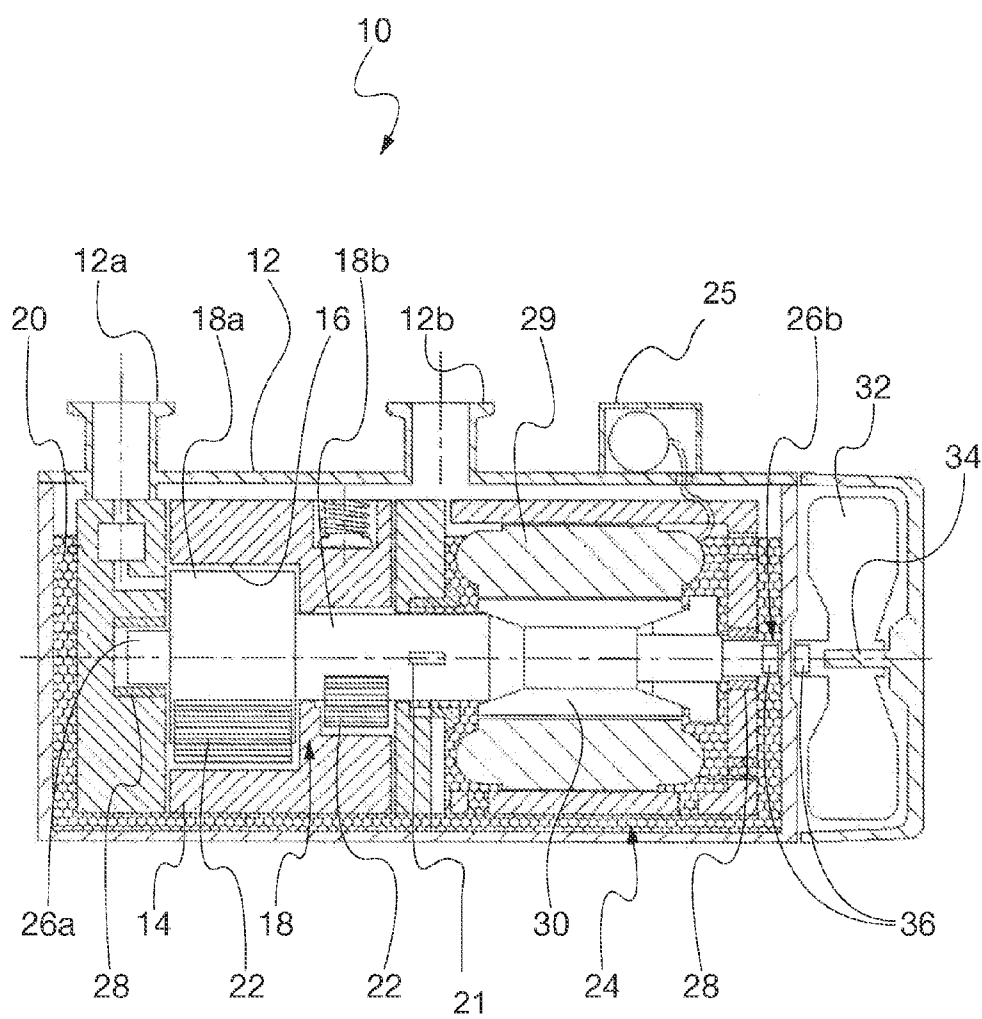


Fig. 3

ROTARY VANE VACUUM PUMP

TECHNICAL FIELD

[0001] The present invention relates to a rotary vane vacuum pump.

BACKGROUND

[0002] Rotary vane vacuum pumps are mechanical pumps, more particularly positive displacement pumps, which are generally used to obtain low vacuum conditions, in a pressure range from atmospheric pressure to about 10^{-1} Pa.

[0003] According to prior art, rotary vane vacuum pumps generally include a casing having a gas inlet port or suction port and a gas outlet port or exhaust port and housing a stator defining a cylindrical chamber; a cylindrical rotor is eccentrically arranged inside the stator chamber, which rotor is equipped with spring-loaded radial vanes cooperating with the wall of the stator chamber for pumping a gas from the gas inlet port to the gas outlet port. The pump casing is filled with oil so that the stator is immersed in an oil bath, which has the function of cooling down and lubricating the pump and isolate it from the outside environment.

[0004] Pumps of such kind are known for instance from U.S. Pat. No. 6,019,585 "Oil-Sealed Vane-Type Rotary Vacuum Pump With Oil Feed" and GB Patent Application No. 2151091A "Electric Drive for Oil Sealed Sliding Vane Rotary Vacuum Pump".

[0005] According to prior art, a driving motor, namely an electric motor, is operatively connected to the pump through a shaft connection in order to drive in rotation the rotation shaft of the pump rotor.

[0006] More in detail, the electric motor is arranged outside the pump casing and it is connected to the pump casing through an interface flange, an oil dynamic seal being provided on the vacuum pump casing at the interface flange for preventing oil from leaking from the oil bath to the outside environment.

[0007] However, such a known solution is not free from drawbacks, since it is difficult to guarantee a complete tightness at the oil dynamic seal in any operative conditions of the vacuum pump, including failure conditions.

[0008] In this respect, it should be noted that the oil dynamic seal is subjected to wear, which increases the risk of loss of tightness of the seal itself.

[0009] Moreover, the electric motor is generally cantilevered on the pump casing, which can lead to an uneven mass distribution, leading in turn to high mechanical stresses at the shaft connection between the electric motor and the vacuum pump.

[0010] Therefore, there is a need for obviating the above-identified drawbacks, by providing a rotary vane vacuum pump that allows to completely avoid oil leakages in any operative conditions of the vacuum pump.

[0011] There is also a need for providing a rotary vane vacuum pump in which mechanical stresses at the shaft connection between the vacuum pump and the electric motor driving the pump can be significantly reduced.

[0012] There is also a need for providing a rotary vane pump having a simple, inexpensive and sound structure, with a reduced number of rotating parts and with reduced noise.

SUMMARY

[0013] To address the foregoing problems, in whole or in part, and/or other problems that may have been observed by persons skilled in the art, the present disclosure provides methods, processes, systems, apparatus, instruments, and/or devices, as described by way of example in implementations set forth below.

[0014] According to a first aspect of the invention, a rotary vane vacuum pump comprises a pump casing having a gas inlet or suction port and a gas outlet or exhaust port, a stator provided within the pump casing and defining a cylindrical stator chamber, and a cylindrical rotor eccentrically arranged in the stator chamber, rotatable about a pump rotor shaft and equipped with radially movable radial vanes cooperating with the wall of the stator chamber for pumping a gas from the gas inlet port to the gas outlet port, the pump casing being filled with such an amount of oil that the stator is immersed in an oil bath acting as cooling and lubricating fluid, wherein a motor for driving the pump is further provided, the motor being arranged inside a motor casing that is in fluid communication with the pump casing, whereby the motor is immersed in the oil bath.

[0015] In some embodiments, the motor casing and the pump casing are made as a single common casing housing both the vacuum pump and its motor.

[0016] As the motor is immersed in the oil bath, no seal is needed any longer between the pump and its motor.

[0017] With respect to prior solutions, where complicated sealing systems are required in order to prevent oil from leaking from the oil bath, in the vacuum pump according to an embodiment of the invention providing tight casings for the vacuum pump and the motor or a single tight casing for both the vacuum pump and the motor is sufficient for guaranteeing that any oil leakage is prevented.

[0018] Moreover, contrary to prior solutions, wherein the motor is generally cooled by an air flow, in the present solution the oil may act as coolant fluid both for the vacuum pump and for the motor, which may lead to a more uniform temperature distribution.

[0019] Advantageously, by placing the motor inside the pump casing, a more compact arrangement can be obtained, which allows for less demanding space requirements for installing the vacuum pump.

[0020] According to a second aspect of the invention, a rotary vane vacuum pump comprises a pump casing having an inlet or suction port and an outlet or exhaust port, a stator provided within the casing and defining a cylindrical stator chamber, and a cylindrical rotor eccentrically arranged in the stator chamber, rotatable about a pump rotor shaft and equipped with radially movable radial vanes cooperating with the wall of the stator chamber for pumping a gas from the pump inlet port to the pump outlet port, the casing being filled with such an amount of oil that the stator is immersed in an oil bath acting as cooling and lubricating fluid, wherein a motor for driving the pump is further provided, the motor comprising a stator and a rotor rotatable about a motor rotor shaft, the motor rotor shaft and the pump rotor shaft being made as a single, monolithic pump shaft having supports, such as sleeves or bearings, arranged at both its opposite ends.

[0021] It is evident that such an arrangement can be easily carried out when both the pump and its motor are arranged in a common space, i.e. two communicating casings or, alternatively, a single common casing.

[0022] As the pump shaft is supported at its opposite ends and no part is cantilevered thereon, a better and more uniform weight distribution than in prior solutions can be obtained, thus significantly reducing the mechanical stresses acting on the pump shaft itself

[0023] According to some embodiments, the motor rotor and the pump rotor are made as a single, monolithic piece together with the pump shaft, which leads to a significant reduction of the number of rotating parts in the vacuum pump and makes the manufacturing of the vacuum pump easier and less expensive and its operation more reliable.

[0024] Other devices, apparatus, systems, methods, features and advantages of the invention will be or will become apparent to one with skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be included within this description, be within the scope of the invention, and be protected by the accompanying claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The invention can be better understood by referring to the following figures. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. In the figures, like reference numerals designate corresponding parts throughout the different views.

[0026] FIG. 1 is a perspective schematic view of a rotary vane vacuum pump according to prior art;

[0027] FIG. 2 is a schematic cross-sectional view of the vacuum pump shown in FIG. 1;

[0028] FIG. 3 is a schematic cross-sectional of a rotary vane vacuum pump according to an embodiment of the present invention.

DETAILED DESCRIPTION

[0029] Referring to FIGS. 1 and 2, a rotary vane vacuum pump 100 according to prior art is schematically shown.

[0030] Vacuum pump 100 comprises an external casing 102 in which a gas inlet port 102a and a gas outlet port 102b are defined. An internal casing or stator 104 defining a cylindrical chamber 106 is tightly arranged inside external casing 102. Chamber 106 houses a cylindrical rotor 108 having an axis parallel to the axis of chamber 106, but eccentrically arranged relative to the chamber axis.

[0031] Depending on different applications and pumping requirements, rotor 108 can be a single-stage rotor or a dual-stage rotor, such as in the example shown in FIGS. 1 and 2. In that case, rotor 108 comprises a first rotor stage 108a at lower pressure and a second rotor stage 108b at higher pressure. According to a well-known arrangement, each rotor stage 108a and 108b is equipped with one or more radially movable radial vanes that are mounted onto rotor 108 and kept against the wall of chamber 106, for instance by means of centrifugal forces, springs or pressure of a fluid supplied from the rotor axis in the radial direction.

[0032] In most common designs of rotary vane vacuum pumps having a dual-stage rotor, the second rotor stage is cantilevered.

[0033] External casing 102 is filled with such an amount of oil (oil plug 112 can be seen in FIG. 1) that stator 104 is immersed in an oil bath 110 acting as cooling and lubricating fluid. In a known manner, pump 100 is indeed manufactured so that a certain amount of oil can penetrate into stator cham-

ber 106 and form a thin film ensuring tightness between the rotor vanes and the wall of chamber 106.

[0034] A motor, and more particularly an electric motor 114 is arranged externally to casing 102 and cantilevered thereon, this motor 114 driving in rotation rotor 108 of pump 100.

[0035] More in detail, shaft 116 of the rotor of motor 114 is connected to shaft 118 of rotor 108 of pump 100 for driving the latter in rotation about its axis.

[0036] Motor 114 is connected to pump 100 through a connecting flange 120 and an oil dynamic seal 122 is provided on the pump casing 102 at the shaft connection between motor rotor shaft 116 and pump rotor shaft 118 in order to prevent oil from leaking from casing 102.

[0037] In FIG. 2 a mechanical cooling fan 124 for cooling pump 100 is also shown, cooling fan 124 being also mounted on motor shaft 116 by means of a sleeve 126.

[0038] The drawbacks of the arrangement shown in FIGS. 1 and 2 are evident.

[0039] First of all, connecting flange 120 has a complicated structure and oil dynamic seal 122 is not capable of guaranteeing a perfect tightness of oil bath in any operative conditions.

[0040] Moreover, oil dynamic seal 122 is subjected to wear, which increases the risk of loss of tightness thereof

[0041] Furthermore, both second rotor stage 108b of pump rotor and motor 114 are cantilevered on the pump rotor shaft, which causes relevant mechanical stresses to arise on this shaft, especially if the weight distribution on this shaft is not uniform and symmetrical.

[0042] Moreover, several rotating parts are provided on pump shaft and connected thereon, which makes the structure of the pump complex and its operation subjected to a high risk of failures.

[0043] Turning now to FIG. 3 a rotary vane vacuum pump 10 according to an embodiment of the invention is schematically illustrated.

[0044] Vacuum pump 10 comprises a pump casing in which a gas inlet port 12a and a gas outlet port 12b are defined. A stator 14, defining a cylindrical chamber 16, is arranged inside pump casing 12. Chamber 16 houses a cylindrical rotor 18, having an axis parallel to the axis of chamber 16, but eccentrically arranged relative to the chamber axis, rotor 18 being rotatable about a pump rotor shaft.

[0045] In the exemplary embodiment shown in FIG. 3, rotor 18 comprises a first rotor stage 18a at lower pressure and a second rotor stage 18b at higher, each rotor stage 18a and 18b being equipped, in a known manner, with one or more radially movable radial vanes 22 that are mounted onto rotor 18 and kept against the wall of chamber 16, for instance by means of centrifugal forces, springs or pressure of fluid supplied from the rotor axis in the radial direction. Radial vanes 22 of rotor stages 18a, 18b cooperate with the inner wall of stator chamber 16 for pumping a gas from the gas inlet port 12a to the gas outlet port 12b.

[0046] External casing 12 is filled with such an amount of oil that stator 14 is immersed in an oil bath 20 acting as cooling and lubricating fluid: in a known manner, a certain amount of oil can penetrate from oil bath 20 into stator chamber 16 and form a thin film ensuring tightness between the rotor vanes 22 and the inner wall of chamber 16.

[0047] In this respect, an oil pump 21 can be optionally provided for forced oil circulation.

[0048] Pump 10 is equipped with a motor 24 for driving in rotation rotor 18 of pump 10. Motor 24 preferably is an electric motor, and most preferably an asynchronous electric motor.

[0049] In this respect, as shown in FIG. 3 motor 24 can be connected to a box 25 containing electric components for driving and controlling the motor operation.

[0050] According to an embodiment, motor 24 is located inside a motor casing that is in fluid communication with pump casing, whereby motor 24 is immersed in oil bath 20.

[0051] More precisely, in the embodiment shown in FIG. 3, pump casing and motor casing are made as a single, common casing 12 housing both pump 10 and motor 24.

[0052] Accordingly, no complicated connection or sealing system is required any longer between the pump and its motor. Moreover, the resulting overall structure is more compact than rotary vane vacuum pumps of known type, which turns out to be very advantageous in many applications where there is little room available for accommodating the vacuum pump.

[0053] In a known manner, motor 24 includes a stationary stator 29 and a rotor 30 rotatable about a motor rotor shaft. As both pump 10 and pump motor 24 are arranged inside the same casing 12, the pump rotor shaft and the motor rotor shaft can be manufactured as a single, monolithic piece, i.e. a single, monolithic pump shaft 26, which can be supported at both its opposite ends 26a, 26b by supports 28, such as sleeves or bearings.

[0054] Thanks to this arrangement a smoother and more uniform weight distribution along pump shaft 26 can be obtained, thus significantly reducing the mechanical stresses acting on the pump shaft itself.

[0055] According to an embodiment, the pump rotor 18 and the motor rotor 30 can be manufactured as a single monolithic piece together with pump shaft 26, so that no connection is required between such rotors and the shaft and the number of rotating parts of the rotary vane vacuum pump is significantly reduced.

[0056] Since motor 24 is immersed in oil bath 20, the oil acts as a coolant fluid both for pump 10 and for motor 24. This may advantageously lead to a more uniform temperature distribution between pump 10 and its motor 24.

[0057] In turn, oil bath 20 can be cooled by any conventional cooling techniques, including water cooling and air cooling.

[0058] For instance, in the exemplary illustrated embodiment, oil is cooled by air cooling using a fan. More particularly, in order to completely eliminate any mechanical connection on pump shaft 26, a magnetic fan 32 is used for cooling the oil bath, as shown in FIG. 3.

[0059] Magnetic fan 32 is not mounted on pump shaft 26; on the contrary, it has its own fan shaft 34, which is coaxially arranged with pump shaft 26. By simply using a pair of cooperating magnets 36, the first of these magnets being provided on pump shaft 26 and the second one being provided on fan 32, fan 32 can be driven in rotation without the need for any mechanical connection with pump shaft 26.

[0060] It is evident from the above description that the rotary vane vacuum pump according to the invention has a simple and compact structure and that oil leakages from oil bath can be efficiently prevented without the need for any complicated sealing system. Moreover, thanks to the arrangement of the invention, the number of rotating mechanical parts can be significantly reduced and a more uniform weight

distribution on the pump shaft can be obtained, thus decreasing the mechanical stresses acting on this shaft and, consequently, reducing the risk of failures.

[0061] It is also evident that the above exemplary embodiment has been given for a better understanding of the invention and not for limiting the scope of protection of the invention itself and that, starting from the above disclosure, many variants and modifications that fall within the scope of protection of the invention will be evident to those skilled in the art.

[0062] It will be understood that various aspects or details of the invention may be changed without departing from the scope of the invention. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation—the invention being defined by the claims.

What is claimed is:

1. A rotary vane vacuum pump, comprising:

a pump casing in which a gas inlet port and a gas outlet port are defined;

a stator arranged inside the pump casing and defining a stator chamber of cylindrical shape;

a cylindrical rotor housed inside the stator chamber and having an axis parallel to the axis of the stator chamber, but eccentrically arranged relative to the chamber axis, which rotor is rotatable about a pump rotor shaft and is equipped with one or more radially movable radial vanes that cooperate with the inner wall of the stator chamber for pumping a gas from the gas inlet port to the gas outlet port;

wherein the pump casing is filled with such an amount of oil that the stator is immersed in an oil bath; and

wherein the pump is equipped with a motor for driving in rotation the pump rotor, the motor being arranged inside a motor casing that is in fluid communication with the pump casing.

2. The rotary vane vacuum pump as claimed in claim 1, wherein the pump casing and the motor casing are made as a single, common casing housing both the vacuum pump and the motor.

3. The rotary vane vacuum pump as claimed in claim 1, wherein the motor is an electric motor.

4. The rotary vane vacuum pump as claimed in claim 3, wherein the motor is an asynchronous electric motor.

5. The rotary vacuum pump as claimed in claim 1, wherein the oil of the oil bath acts as coolant fluid both for the vacuum pump and for the motor.

6. The rotary vane vacuum pump as claimed in claim 1, wherein the motor includes a stator and a rotor rotatable about a motor rotor shaft and wherein the pump rotor shaft and the motor rotor shaft are made as a single, monolithic pump shaft.

7. The rotary vane vacuum pump as claimed in claim 6, wherein the pump shaft is supported by supports arranged at both its opposite ends.

8. The rotary vane vacuum pump as claimed in claim 6, wherein the pump rotor and the motor rotor are made as a single, monolithic piece together with the pump shaft.

9. The rotary vane vacuum pump as claimed in claim 6, wherein the pump is further equipped with a cooling fan.

10. The rotary vane vacuum pump as claimed in claim 9, wherein the cooling fan is rotatable about a fan shaft that is arranged coaxially with the pump shaft.

11. The rotary vane vacuum pump as claimed in claim 10, wherein a pair of cooperating magnets are provided for driv-

ing in rotation the cooling fan, a first magnet of the pair of magnets being arranged in the pump shaft and the second magnet of the pair of magnets being arranged on the fan.

12. The rotary vane vacuum pump as claimed in claim 1, wherein the rotor comprises a first rotor stage at lower pressure and a second rotor stage at higher pressure, each of the rotor stages being rotatable about the pump rotor shaft and being equipped with one or more radially movable radial vanes that cooperate with the inner wall of the stator chamber for pumping a gas.

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