(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 260 733 A1**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 87201531.8

(51) Int. Cl.⁴: F 04 D 19/04

(22) Date of filing: 12.08.87

(30) Priority: 12.08.86 NL 8602052

(43) Date of publication of application: 23.03.88 Bulletin 88/12

(84) Designated Contracting States: CH DE FR GB LI NL

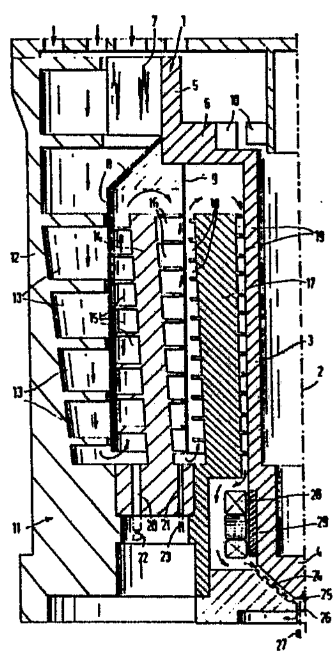
(71) Applicant: ULTRA-CENTRIFUGE NEDERLAND N.V., Planthofsweg 77, NL-7601 PJ Almelo (NL)

(72) Inventor: Moonen Johannes,Jacobus,Emmanuel, Wiegerslaan 8, NL-7606 HV Almelo (NL)

(74) Representative: Smulders, Theodorus A.H.J. et al, Vereenigde Octrooibureaux Nieuwe Parklaan 107, NL-2587 BP 's-Gravenhage (NL)

(54) **High-vacuum pump.**

(57) A high-vacuum pump comprising a rotor (1) arranged for high-speed rotation around a longitudinal shaft, the rotor and the stator being each built up, through part of their length, of one or more coaxial sleeves or pipes (8, 9, 12, 14, 17) of different diameters and having one free end, the systems of rotor pipes and stator sleeves being mutually oppositely directed and fittingly disposed one within the other, so that a pipe of the system of rotor pipes is disposed between two pipes or between one pipe and the wall of the system of stator sleeves, and at least one of each pair of closely-spaced opposing surfaces of stator pipe or wall and rotor pipe or wall being provided with a helical or spiral-shaped groove (13, 15, 16, 18, 19).



EP 0 260 733 A1

Title: High-vacuum pump

The invention relates to a high-vacuum pump comprising a rotor arranged for high-speed rotation around a longitudinal axis , and a stator disposed coaxially with said rotor, said rotor and said stator having opposing surfaces spaced a short distance apart, at least a portion of one of which surfaces is provided with a vertical or spiral-shaped groove.

A pump of this kind is known from Netherlands patent application 8105614. In this prior pump, the inner wall of the stator casing is provided with a spiral-shaped groove. The rotor is dimensioned so that there is a relatively narrow gap between the outer wall of the rotor and the inner wall of the stator casing.

One problem encountered with the prior pump is that the volume of the pump should be large, if at least a reasonable performance of the pump is required. Furthermore, the pumping speed is not very high, and the compression ratio, that is to say, the ratio between the pre-vacuum pressure and the high-vacuum pressure (measured at the same moment) is relatively low. To realize a good pumping speed and compression ratio, a high rotary speed of the rotor should be maintained. Owing to the size of the rotor, this leads to a very high velocity of the outer surface of the rotor, and hence to substantial mechanical stresses. Furthermore, both during starting-up and during nominal operation, a relatively low pre-pressure is required, which means that starting is only possible after the pressure in the entire system has, in one way or another, already been decreased to a given low value.

It is an object of the invention to improve the prior high-vacuum pump so that the problems outlined above occur no longer, or at any rate to a considerably lesser extent.

The object contemplated is achieved,according to the invention, with a pump in which the rotor and the stator are each built up, through part of their length, of one of more coaxial sleeves or pipes of different diameter and having one free end, the systems of rotor pipes and stator sleeves being mutually oppositely directed and fittingly disposed one within the other, so that a pipe of the system of rotor pipes is disposed between two pipes or between a pipe and the wall of the system of stator sleeves, and at least one of each pair of closely-spaced opposing surfaces of stator pipe or wall and rotor pipe or wall is provided with a helical or spiral-shaped groove.

As rotor and stator each comprise at least one coaxial sleeve in addition to the rotor or stator proper, the pump according to the invention comprises at least three pairs of opposing surfaces, at least one of which is provided with a helical or spiral-shaped groove. For such a length of surfaces, the prior pump needs a larger height (about twice the length of the coaxial sleeve more). The pump according to the invention can thus be constructed in more compact form. As the fitting sleeves form a labyrinth structure, the pump according to the invention is further much better optically blind than the prior pump (In the prior pump, a gas molecule present at the pre-vacuum side "sees" the high vacuum side - in the pump according to the invention this is impossible). As a result,back-leakage, in particular of light gases, is prevented better than in the prior pump, which for light gases was found not to have a good pumping speed in practice, just because of the occurring back-leakage.

In the pump according to the invention, when a plurality of pipes are used, the rotor-connected pipes or sleeves having the smaller or smallest diameters will have a lower surface velocity at a given rotation frequency than the pipes of larger diameter located more outwardly. As a consequence, the smaller pipes are subjected to lower mechanical stresses during rotation, and will expand to a lesser extent than do the larger pipes. As a result, the walls (of the stator sleeves) adjoining the smaller pipes will adjoin the rotor pipes more closely. This also results in a high compression ratio of the pump. Indeed, in a preferred embodiment of the pump according to the invention the radial dimension of the rotation gap decreases from the side of high vacuum in the pump to the side of higher pressures. Furthermore, in the pump according to the invention, the grooves in the surfaces concerned will preferably be dimensioned so that the depth of the grooves decreases from the side of high vacuum in the pump to the side of higher pressures. This, too, contributes towards improving the compression ratio and hence the pumping speed.

In the above suitable embodiment of the pump according to the invention, at the high-vacuum side, where especially the pumping speed is of importance, the construction is dimensioned more liberally, and the tolerances with regard to the dimensions are much larger than at the pre-vacuum side, where it is especially the compression ratio which is important, and where the dimensions of grooves and the rotation gap are much smaller.

The dimensions of the rotation gap are partly determined by the dynamic behaviour of the rotor, in particular wobble and vibration during run-up and during particular conditions, such as the ingress of air. The use at the top of a magnetic bearing with a high radial stiffness is favourable in this case. A magnetic bearing has additionally good properties from the point of view of vacuum engineering.

The compact instruction, the good visual blindness and the gradual transition towards a small diameter have for their result that an effective pump action is obtained, so that the rotation frequency need not be extremely high to retain a reasonable nett pumping speed at the high-vacuum side. As a result, the stress level in the rotor components will always have a tolerable level.

Towards the pre-vacuum side, the required pumping velocity becomes lower as the pressure is increasing; for this reason, therefore, it is here sufficient to have lower circumferential velocity and smaller radial groove and rotation gap dimensions; at the pre-vacuum side, the specific dimensions are generally much smaller than at the high-vacuum side.

It is further noted that, if desired, the pump according to the invention can be provided with a rotor having a bladed wheel, for example, as described in Netherlands patent application 8303927.

In a very suitable embodiment of the pump according to the invention, an outlet duct is provided in the stator between one or more pairs of successive sleeves and/or between a sleeve and an adjacent wall, said duct having a non-return valve, and said duct or ducts communicating with the surrounding space or with a pre-vacuum pump. Such a construction, in which there is always an outlet duct with non-return valves between successive pairs of walls, makes run-up of the pump simpler and permits this to be effected more rapidly. This can be further explained as follows.

When, at high pressures in the space to be evacuated, the pump is started, the pump is capable of building up a pressure higher than 1 bar already after one single compression stage, depending on the pressure in the space to be evacuated and on the rotation frequency. As soon as, for example, the pressure at the end of the first pair of walls is higher than 1 atmosphere, the first non-return valve is opened automatically, mechanically or electronically, and the gas is pumped at a high rate, even during run-up. In this way it is avoided that the gas must be compressed still further for it to be transported, i.e., pressed, through the ducts which ultimately become very narrow. As the same time it is thus achieved that even at reasonably high pressures the pump can yet be started up.

When the pressure in the high-vacuum space decreases during the starting-up procedure or thereafter, the pressure at the first valve will also decrease below 1 bar, and the valve will close automatically. A process similar to that described for the first valve will subsequently be repeated at the second valve. Thus successively all valves will be closed as evacuation is increasing, except for the last valve, and this will often be effected already before the operational speed is reached. When the pump is switched off, all valves,including the last one will normally be continuously closed. The valves should preferably be designed so, and the choice of material should be such that the leak-tightness per valve is much less than the local volume rate of the pump.

It is even possible for the pump to be constructed with rotation gaps and grooves which are so small that, at the high-pressure side, the pump directly pumps to the outside pressure of 1 atmosphere.

In the pump according to the invention, the last pressure stage (at the side of the high pressures) may, if desired, function as an air bearing. If this is not done,a conventional bearing, for example, a ball bearing or magnetic bearing, can be used.

The invention is illustrated with reference to the accompanying drawing, in which the single figure is a cross-sectional view of part of an embodiment of the high-vacuum pump according to the invention.

In the figure, an embodiment of the pump according to the invention comprises a rotor 1. Rotor 1,which is rotationally symmetrical, is only shown as to one half (the half left of the axis of rotation, which is also the axis of symmetry 2). The rotor 1 consists essentially of a cylindrical casing 3, which at the bottom terminates in a frusto-conical end 4. At the top, rotor 1 comprises a cylindrical portion 5 of a diameter larger than that of casing 3. Casing 3 and cylindrical portion 5 are interconnected by disc 6. On the outer wall of the cylindrical portion 5, blades 7 may be provided in known manner, which blades 7 with cylindrical portion 5 form a bladed wheel with the function described in Netherlands patent application 8303927.

Rotor 1 further comprises two cylindrical pipes or sleeves 8 and 9, which pipes extend coaxially with the cylindrical casing 3, have mutually different diameters, larger than that of casing 3, and are fixedly secured to disc 6.

Rotor 1 is journalled at the top in a magnetic bearing 10. Such magnetic bearings are generally known.

Disposed coaxially with rotor 1 is stator 11. Stator 11 comprises an outermost wall 12 which at the inside is provided with spiral-shaped groove 13. Groove 13 has a depth which decreases from the side opposite blades 7 on cylindrical portion 5 of rotor 1 to the bottom of the casing formed by stator 11.

Disposed coaxially within the outermost wall 12 of stator 11 is sleeve 14, which extends outwardly from the bottom of the stator casing. Sleeve 14 is provided on opposite sides with a spiral-shaped groove 15, 16, respectively. The depth of groove 15 at the outside of sleeve 14 decreases from the bottom to the free end of sleeve 14. The depth of groove 16 on the inside surface of sleeve 14 decreases from the free end to the bottom.

Disposed coaxially within sleeve 14 is sleeve 17, which extends upwardly from the bottom of the stator casing. Sleeve 17 is also provided on opposite sides with spiral-shaped grooves 18, 19, respectively with decreasing depths in corresponding directions as with grooves 15, 16, respectively, in sleeve 14.

Rotor pipes 8 and 9 extend into the system of stator sleeves 14 and 17 and stator wall 12. Rotor pipe 8 thus opposes wall 12 and the outside of stator sleeve 14 at a short distance. Rotor pipe 9 opposes the inside of stator sleeve 14 and the outside of stator sleeve 17 at a short distance. The inside of stator sleeve 17 is spaced a short distance from the outer wall of cylindrical casing 3 of rotor 1. As shown in the figure, at least one of each pair of opposing walls of rotor parts and stator parts is always provided with a spiral-shaped groove.

In the bottom of the stator casing, outlet ducts 20, 21 are provided, which respectively connect the space between wall 12 and sleeve 14, into which rotor pipe 8 extends, and the space between sleeve 14 and sleeve 17, into which rotor pipe 9 extends, with the surrounding space or with a pre-vacuum pump. Duct 20 may be provided with a non-return valve 22 and duct 21 with a non-return valve 23.

Formed in the bottom of the stator casing, in the centre thereof, is a recessed portion which accommodates the conical end 4 of rotor 1. The wall of the recessed portion of the stator casing is provided with a spiral-shaped groove 24. The recessed portion provided with groove 24 forms an air bearing for the conical end 4 of rotor 1. The end 4 is provided with a small cone 25, the end of which rests on the flat bottom of the recessed portion. Cone 25 prevents the bearing surfaces of the conical end 4 of rotor 1 from seizing to the air bearing formed by the grooved, recessed portion of the bottom of the stator casing. Formed in the flat portion of the bottom of the recessed portion is a duct 26, in which a non-return valve 27 is incorporated. Duct 26 communicates with the surrounding space or with a pre-vacuum pump.

In the embodiment of the pump according to the invention shown, rotor 1 is driven by means of an electric motor 28 disposed within the stator casing and a driving ring 29, which is secured to the cylindrical casing 3 of rotor 1.

The parts of the pump according to the invention consist of materials which are conventional for the purpose. Thus rotor pipes 8 and 9 may consist, for example, of stainless steel and have a thickness of several tenths to half a millimeter and more. The stator walls and sleeves preferably consist of an easily machined material, for example, of aluminium. The dimensions of rotor, rotor pipes, stator wall and stator sleeves are further such that the distance between pairs of opposing walls decreases from the outermost stator wall 12 to the cylindrical casing 3 of rotor 1.

CLAIMS.

1. A high-vacuum pump comprising a rotor arranged for high-speed rotation around a longitudinal axis, and a stator disposed coaxially with said rotor, said rotor and said stator having opposing surfaces spaced a short distance apart, at least a portion of one of which surfaces is provided with a helical or spiral-shaped groove, characterized in that the rotor and stator are each built up, through part of their length, of one or more coaxial sleeves or pipes of different diameters and having one free end, the systems of rotor pipes and stator sleeves being mutually oppositely directed and fittingly disposed one within the other, so that a pipe of the system of rotor pipes is disposed between two pipes or between a pipe and the wall of the system of stator sleeves, and at least one of each pair of closely-spaced opposing surfaces of stator pipe or wall and rotor pipe or wall is provided with a helical or spiral-shaped groove.

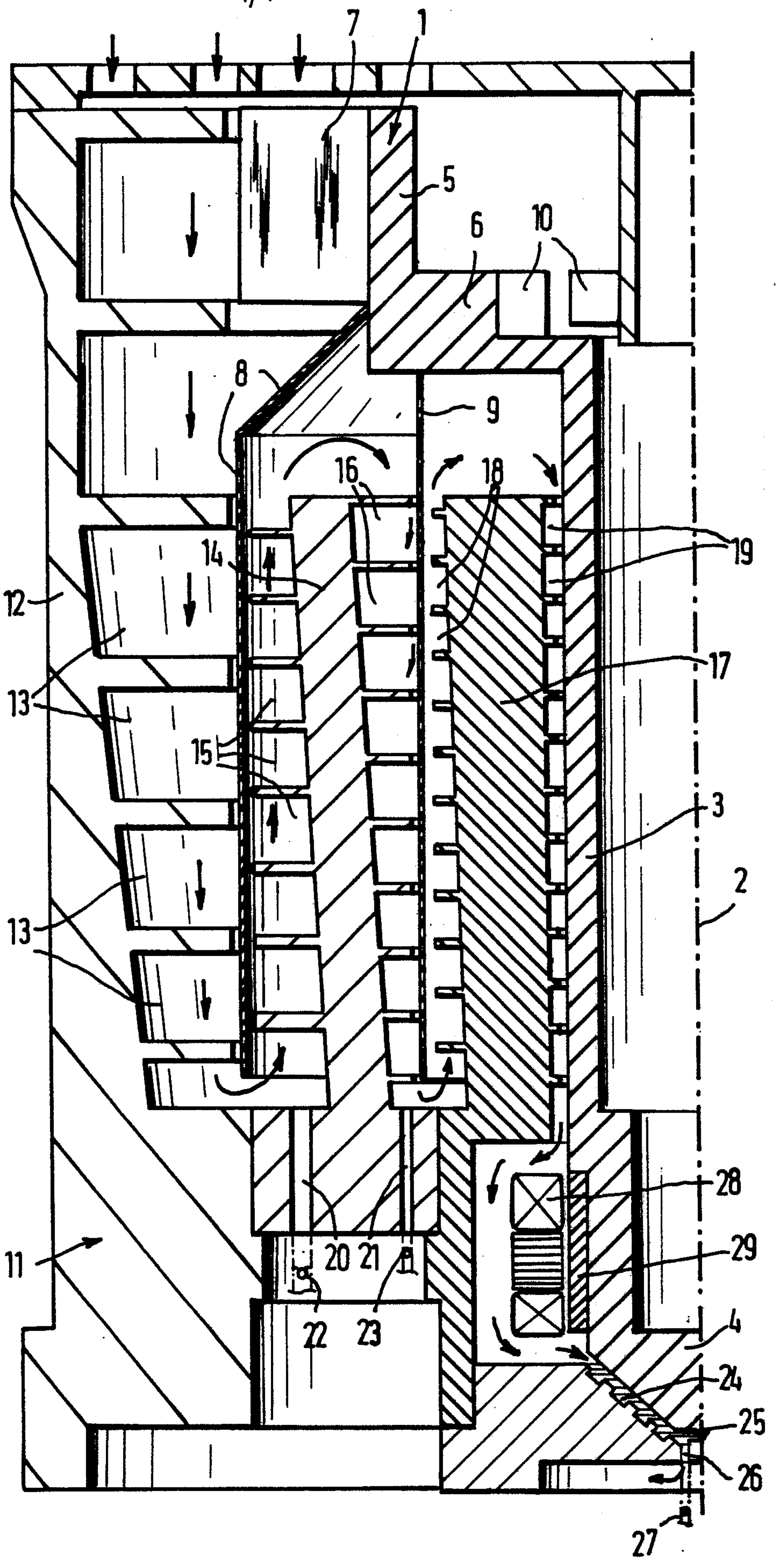
2. A high-vacuum pump as claimed in claim 1, characterized in that the grooves in the surfaces concerned are dimensioned so that the depth of the grooves decreases from the side of high vacuum in the pump to the side of higher pressures.

3. A high-vacuum pump as claimed in claims 1-2, characterized in that the radial dimension of the rotation gap decreases from the side of high vacuum in the pump to the side of higher pressure.

4. A high-vacuum pump as claimed in claims 1-3, characterized in that an outlet duct is provided in the stator between one or more pairs of successive sleeves and/or between a sleeve and an adjacent wall, said duct

having a non-return valve, and said duct or ducts communicating with the surrounding space or with a pre-vacuum pump.

5. A high-vacuum pump as claimed in claims 1-4, characterized in that the last pressure stage at the pre-vacuum side is constructed as an air bearing.


7
1
5
6
10
8
9
16
18
19
14
12
13
17
15
3
2
28
29
20
21
11
22
23
4
24
25
26
27

European Patent Office

EUROPEAN SEARCH REPORT

0260733

Application Number

EP 87 20 1531

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-2 730 297 (VAN DORSTEN) * Column 1, lines 22-38; column 1, line 67 - column 2, line 67; figures 1-4 * ---	1-3	F 04 D 19/04
X	NL-C- 75 723 (VAN DORSTEN) * Column 1, lines 33-50; figure 1 * ---	1-3	
A	DE-B-1 010 235 (A. PFEIFFER) * Column 2, lines 19-48; figure 1; column 3, lines 5-13; figure 4 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			F 04 D 19/00 F 04 D 17/00 F 01 D 1/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	01-12-1987	KAPOULAS T.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document