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(54) **Rotary vane volumetric compressor or expander**

(57) Rotary vane volumetric compressor or expander composed of at least one static component and at least one mobile component, **characterised in that** it comprises at least one rolling bearing (8, 8'; 14, 14') or another equivalent device positioned between said mobile component and the internal surface of said static component.

Said rolling bearing (8, 8'; 14, 14') or another equivalent device allows the dragging of the vanes (13, 13'; 16, 16') in relation to the internal surfaces of the static component to be limited, increasing the yield of the device compared to known compressors or expanders and also allowing oil-free applications.

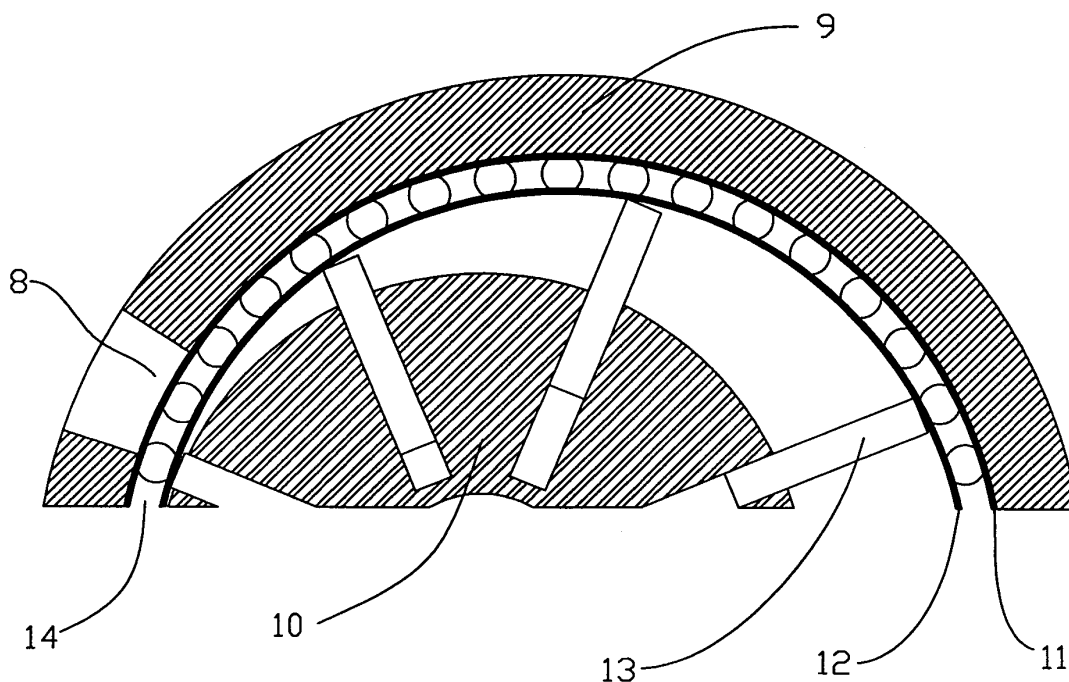


Fig. 3

Description

[0001] The present invention relates to systems of compression of pure and non-pure fluids - gaseous, liquid or liquid-vapour mixtures, hereinafter referred to generically as "work fluids", performed with rotary vane volumetric compressors.

[0002] Rotary vane volumetric compressors are made up of a rotor which is housed inside slots in the vanes which, during rotation, exit due to the centrifugal force and drag on the internal surface of a stator. The vanes also drag laterally on the covers of the stator.

[0003] Rotor and stator usually have a circular section yet can have elliptical, lobed shapes, etc. according to the specific features sought by the manufacturer.

[0004] The work fluid is compressed thanks to the eccentricity of the rotor in relation to the stator and to the reciprocal movement of the two: since the axis of rotation of the rotor is displaced in relation to the longitudinal axis of the stator, during rotation the volume of fluid contained between two adjacent vanes undergoes a decrease, consequently increasing in pressure.

[0005] Reliable operation of a compressor is possible thanks to the continuous injection of oil inside the compression vanes, each vane being defined between the external surface of the rotor, the internal surface of the stator and two adjacent vanes.

[0006] The injection of oil in these types of compressors is essential for creating a film on the surfaces of contact between stator and apex of the rotary vanes, in addition to between the covers of the stator and the lateral surface of said vanes, thus ensuring a lower friction coefficient which allows wear of the vanes and of the surface of the stator to be limited, in addition to lowering of the power dissipated through friction. Through said film the work fluid is contained inside the compression vane, minimising the leaks and the internal recirculation and increasing the volumetric yield. The injection of oil at a temperature lower than that of the work fluid and of the compression vane also allows cooling of said fluid during compression, increasing the overall yield of the machine.

[0007] The oil injected is discharged together with the work fluid through the delivery port or ports and is appropriately separated by the same. Yet however effective separation of the oil from the fluid may be, it can never take place completely so that the compressed work fluid sent to the phase of use always contains small quantities of oil.

[0008] Some applications exploit this residual oil to lubricate the instruments fed with the compressed work fluid, yet in some sectors, such as food, medical and other special applications, the albeit minimal presence of oil is not tolerable due to rules on contamination. These applications are also in addition to the environmental ones relating to the reduction in air pollution: the particles of oil, in fact, with a complex chemical composition and definitely of the synthesis type, can create situations of pollution of the air, water and soil, in confined and non-con-

finied areas, with the related environmental damage.

[0009] For these applications the work fluid has to be compressed without oil (oil-free) with the consequent disadvantages: wear of the surfaces of the components in mutual contact, high forces of friction which produce local overheating with consequent damage, leaks of work fluid and low values of volumetric yield of the compressor. These situations limit the use of oil-free rotary vane volumetric compressors. Albeit with injected oil, moreover, it is not possible to reach high rotation speeds in that as they increase, the centrifugal force with which the vanes are pushed onto the stator increases, to the extent of destroying the film of oil present and annulling its lubricant effect. Remembering that the increase in rotation speed causes an increase in the volumetric and mass flow rate produced by the compression, on a par with the dimensions of the machine, oil-free applications are intrinsically characterised by reduced flow rates or in any case restricted by the limits imposed on the rotation speed.

[0010] The object of the present invention is to provide a vane compressor able to function with and without injection of oil, allowing its use in applications wherein an oil-free compressed work fluid is required.

[0011] Another object of the present invention is to provide a vane compressor able to function also at high rotation speeds.

[0012] An additional object of the present invention is to provide a vane compressor with a low degree of wear between the parts in relative motion and local overheating due to internal friction.

[0013] These and other aspects are made clearer on reading a preferred embodiment of the invention, to be read by way of a non-limiting example of the more general principle claimed. The following description refers to the accompany drawings, in which:

- Fig. 1 is the sectioned view of the stator and of the rotor of a rotary vane volumetric compressor known in the state of the art.
- Fig. 2 is the sectioned view of the stator and of the rotor of the rotary vane volumetric compressor according to the present invention.
- Fig. 3 is a sectioned view of the detail of the bearing between stator and rotor according to the present invention.
- Fig. 4 is a blown-up view of the volumetric compressor according to the present invention.
- Fig. 5 is a sectioned view of the volumetric compressor according to another embodiment of the present invention.

[0014] Referring to Fig. 1, the stator 1 is made up of a hollow cylindrical body made in a usually metal material with, in its interior, the rotor 2 with a cylindrical shape and

provided with slots 4 which house in their interior the vanes 5.

[0015] The rotor 2 rotates around the axis 3, which is displaced in relation to the central axis of the stator 1. Said rotation causes the exiting from the slots 4 of the vanes 5, which go to drag with their distal end on the internal surface of the stator 1. The volume of the compression vane 6, since the rotor 2 turns anticlockwise, increases progressively as the vane moves in the aspiration zone A. When the vane enters the compression zone C, the volume is maximum and, continuing to rotate anticlockwise, the compression phase starts.

[0016] Once the delivery port 7 has been reached, the compression vane has minimum volume and consequently the work fluid has maximum pressure. The difference in pressure between the compression vane and the conduits downstream of the exit port 7, in addition to the motion of the vanes, releases the work fluid.

[0017] The compression vane is thus free, once the aspiration zone A has been reached, to restart a new cycle.

[0018] Referring to Fig. 2, which shows the vane compressor according to the present invention, there is a rolling bearing 8 of a known type between the stator 9 and the rotor 10.

[0019] Referring to Fig. 3, the external fifth wheel 11 of the bearing 8 is integral with the stator 9, while the internal fifth wheel 12 is in contact with the vane 13 of the rotor 10.

[0020] The rotation of the rotor 10 means that the fin 13, exited due to the centrifugal force, draws with it the internal fifth wheel 12 of the bearing 8, causing said internal fifth wheel 12 to rotate in relation to the external fifth wheel 11. The effect of this relative rotation is a marked reduction in the dragging between the apex of the vane 13 and the internal fifth wheel 12: this dragging would be null if rotor 10 and stator 9 were concentric, but since the eccentricity of the two components is functional for achieving compression of the fluid as illustrated previously, there is a residual dragging proportional only to the eccentricity of the rotor in relation to the stator and to the speed of rotation of the rotor.

[0021] In a compressor of the known type such as the one described in Fig. 1, the speed of dragging of the apex of the vane is proportional to the distance between the centre of the rotor 2 and the internal surface of the stator 1, much greater than the distance between the centres of rotor and stator. Consequently the dragging in a rotary vane compressor of the known type is distinctly greater in relation to the dragging in the compressor according to the present invention. This greatly reduces the problem of contact between the moving surfaces as regards wear, surface damage and overheating, allowing functioning of the compressor without the need for use of oil or other lubricants, even at high rotation speeds.

[0022] In fact on the contact surfaces between the vane 13 and the fifth wheel 12 in Figure 3, the speed of dragging can be estimated from the formula:

$$v_r \approx \omega \cdot e$$

the speed being in m/s if the speed of rotation of the rotor ω is expressed in radians/s and the eccentricity e in m. It is deduced that the extent is very limited compared to the typical speed of dragging between apex of the vane 5 and stator 1, of the compressor of the known type shown in Figure 1, given by

$$v_r = \omega \cdot R_{psals}$$

R_{psals} being the radius of the apex of the vane in m.

[0023] Referring to Fig. 3, between the external fifth wheel 11 and the internal fifth wheel 12 a watertight element of the known type is mounted, so as to avoid leaks of the work fluid through the gap 14.

[0024] In a second embodiment of the present invention, should the material of the finish of the internal surface of the fifth wheel 12 not allow adequate sliding of the vane 13, the positioning is provided of a ring integral with said fifth wheel 12, not shown here, made in such a way as to ensure a lower friction coefficient between the vane 13 and said ring.

[0025] As can be seen in Fig. 4, the bearing 8 is placed at one end of the stator 9, while another bearing 8' is positioned at the opposite end. On the bearings 8 and 8' the watertight elements 19 and 19' are present, suitable for preventing leaks of work fluid. The presence of two bearings 8, 8' means that the central part of the vanes 13, 13' is not in contact with any surface. The ends of the vanes 13, 13' rest in fact on the internal fifth wheels 12, 12' of the bearings 8, 8' and said fifth wheels have a slightly smaller diameter than the diameter of the internal surface of the stator 9, thus allowing the central part of the vanes 13, 13' not to come into contact with said internal surface.

[0026] This feature means that only the ends of the vanes 13, 13' drag, in a limited manner, on the internal fifth wheels 12, 12' of the bearings 8, 8', thus developing very limited friction and thus restricting the power dissipated.

[0027] The limited wear between sliding parts also allows accurate limitation of the play between the apex of the vanes 13, 13' and the internal surface of the stator, leading to a reduction in the leaks of the work fluid, to a high volumetric flow rate and a superior yield of the compressor compared to known compressors.

[0028] Referring to Fig. 5, a third embodiment of the present invention provides for the bearings 14, 14' to be placed, instead of on the stator as in the previous embodiments, inside the covers 15, 15'. The vanes 16, 16' are provided with ends 17, 17' which are interposed between the rotor 18 and the internal fifth wheels of said bearings 14, 14'.

[0029] Thus a volumetric vane compressor is provided which does not need the injection of oil, with limited wear of the parts and the ability to withstand high rotation speeds.

[0030] Should there be no need for a work fluid completely free of oil, the integration is provided of an injector of lubricant of the known type with the present invention, so as to reduce the friction further and allow even higher rotation speeds and yields.

Claims

1. Rotary vane volumetric compressor or expander composed of at least one static component and at least one mobile component, **characterised in that** it comprises at least one rolling bearing (8, 8', 14, 14') or another equivalent device positioned between said mobile component and the internal surface of said static component. 5
2. Rotary vane compressor or expander according to the previous claim, wherein said static component is composed of at least one stator (9) and at least one cover (15, 15'), and said mobile component is made up of at least one rotor (10, 18) and two or more vanes (13, 13', 16, 16') sliding inside housings present on said rotor, **characterised in that** between said at least one static component and said at least one mobile component is positioned at least one rolling bearing (8, 8', 14, 14') or another equivalent device such as to limit the dragging of said two or more vanes (13, 13', 16, 16') in relation to said at least one static component. 10
3. Rotary vane compressor or expander according to the previous claim, **characterised in that** the external fifth wheel (11) of said at least one rolling bearing (8, 8') or another equivalent device is integral with said stator (9) and the internal fifth wheel (12) of said rolling bearing (8) or another equivalent device is in contact with the apices of said two or more vanes (13, 13'). 15
4. Rotary vane compressor or expander according to claim 2, **characterised in that** the external fifth wheel of said at least one rolling bearing (14, 14') or another equivalent device is integral with said at least one cover (15, 15') and the internal fifth wheel of said rolling bearing (14, 14') or another equivalent device is in contact with the ends (17, 17') of said two or more vanes (16, 16'). 20
5. Rotary vane compressor or expander according to the previous claims, **characterised in that** between said internal fifth wheel of said at least one rolling bearing (8, 8', 14, 14') or another equivalent device and said at least two or more vanes (13, 13', 16, 16') a ring is positioned, integral with said internal fifth wheel, so as to guarantee a low friction coefficient between said at least two or more vanes and said ring. 25
6. Rotary vane compressor or expander according to any one of the previous claims, **characterised in that** said at least one rolling bearing (8) or another equivalent device is positioned at one end of said stator (9) and at least one second rolling bearing (8') or another equivalent device is positioned at the opposite end of said stator (9). 30
7. Rotary vane compressor or expander according to any one of claims 2 to 5, **characterised in that** said at least one rolling bearing (14) or another equivalent device is positioned inside said at least one cover (15) placed at one end of said stator, and at least one second rolling bearing (14') or another equivalent device is positioned inside at least one second cover (15') placed at the opposite end of said stator. 35
8. Rotary vane compressor or expander according to the previous claims, **characterised in that** between said external fifth wheel and said internal fifth wheel of said at least one rolling bearing (8, 8', 14, 14') at least one watertight element (19, 19') of the known type is attached. 40
9. Rotary vane compressor or expander according to claim 1, **characterised in that** it comprises a circuit for injection of oil or another lubricant, of the known type. 45

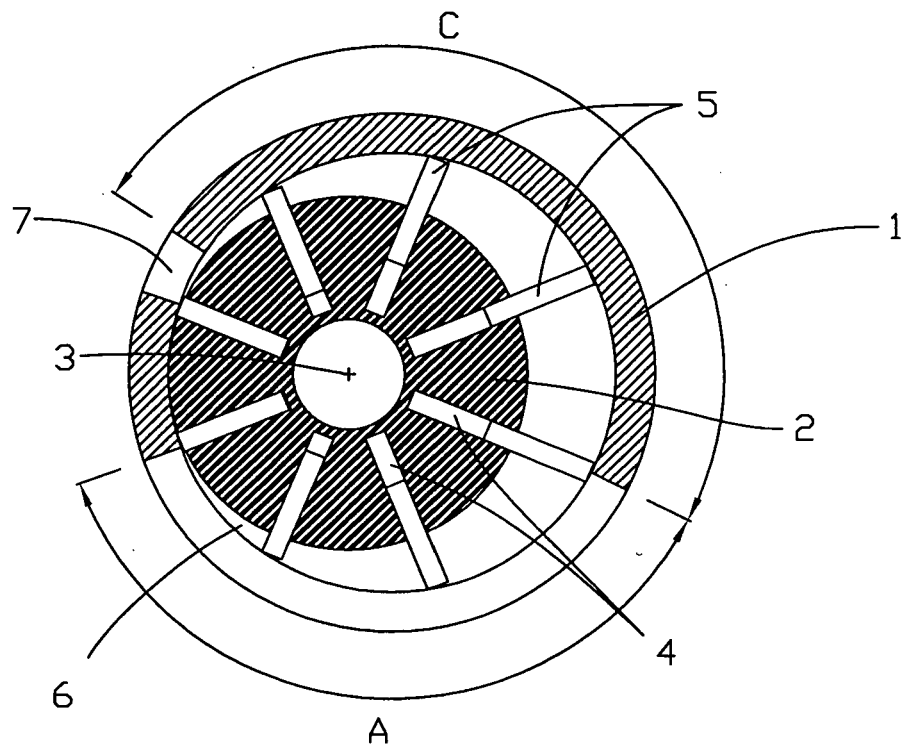


Fig. 1

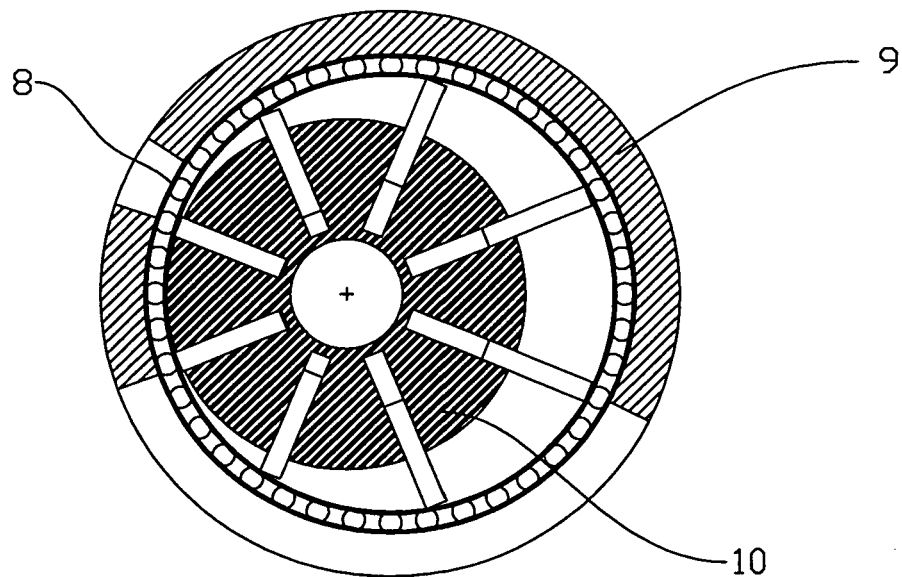


Fig. 2

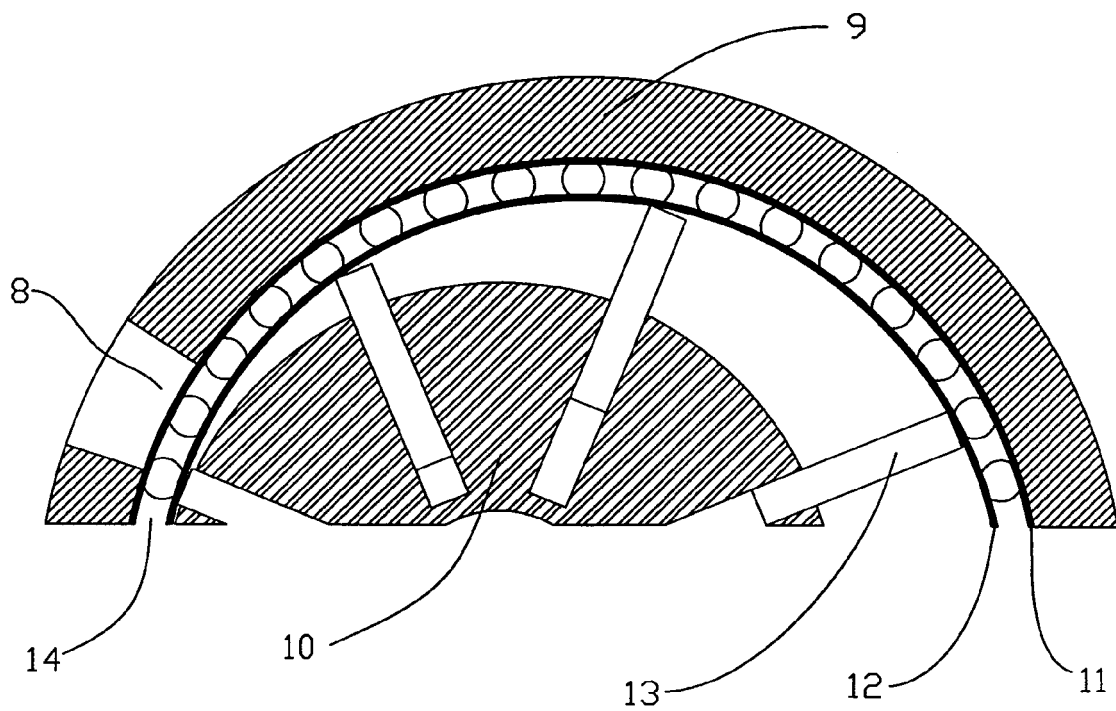


Fig. 3

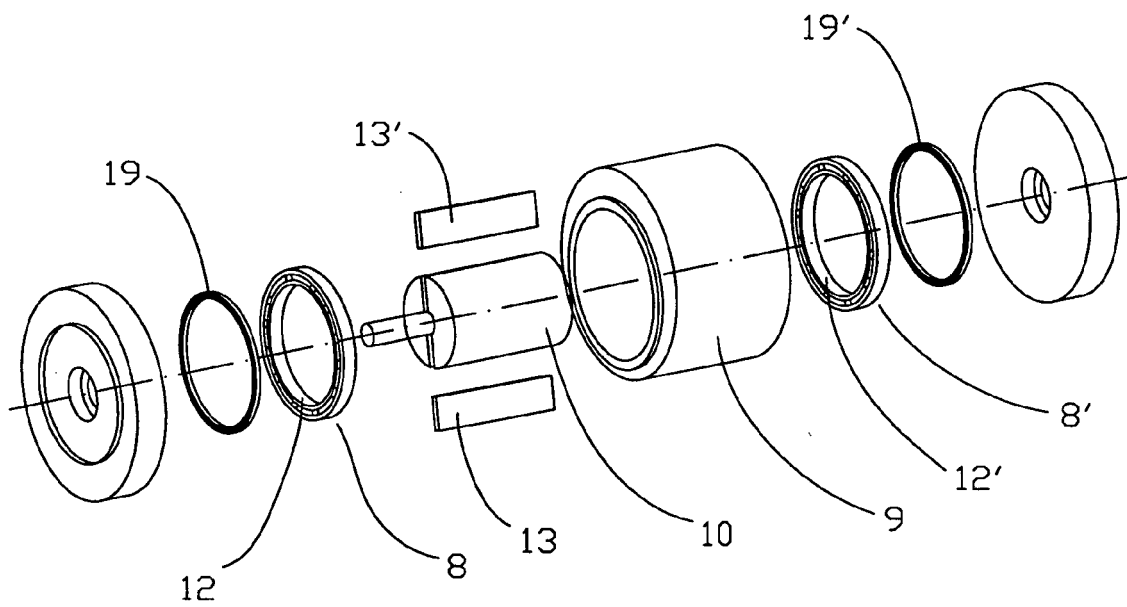


Fig. 4

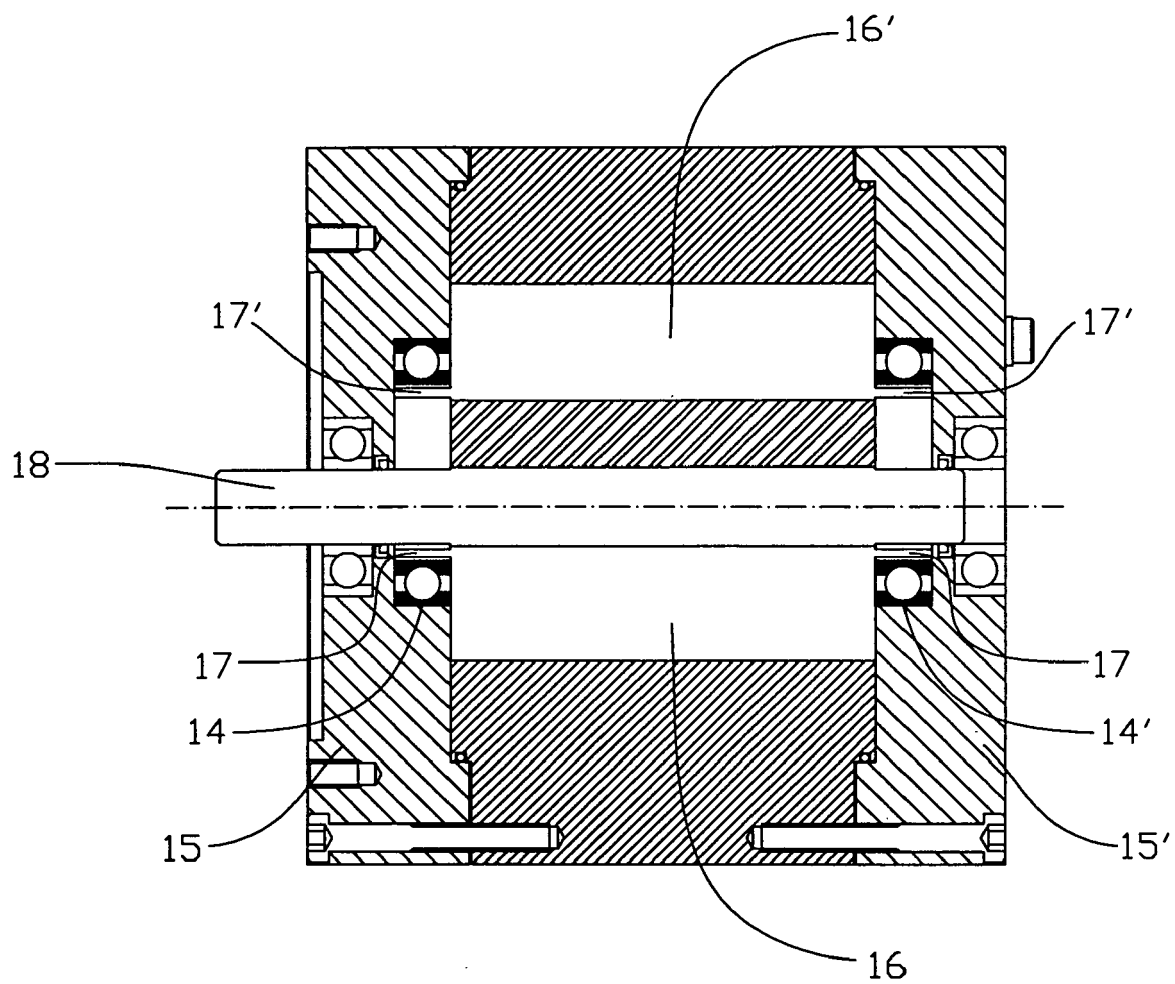


Fig. 5



EUROPEAN SEARCH REPORT

Application Number
EP 09 00 3516

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 16 July 2009	Examiner Biloen, David
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			

 2
EPO FORM 1503 03.82 (P04C01)



EUROPEAN SEARCH REPORT

Application Number
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Place of search The Hague		Date of completion of the search 16 July 2009	Examiner Biloen, David
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			

2
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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