

(19)



(11)

EP 3 361 099 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
15.08.2018 Bulletin 2018/33

(51) Int Cl.:
F04C 25/02 (2006.01)

(21) Application number: **17382068.9**

(22) Date of filing: **10.02.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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Remarks:

Claim 16 is deemed to be abandoned due to non-payment of the claims fee (Rule 45(3) EPC).

(54) **METHOD OF MANUFACTURING AND ASSEMBLING A PUMP AND VACUUM PUMP**

(57) The invention relates to a method for manufacturing and assembling a pump (1), the method comprising the steps of providing a housing (2), providing a rotor (3) with a rotor axis (31) and determining an optimal distance (g_{opt}) between the housing and the rotor (3). The next step comprises varying the distance between the

housing (2) and the rotor axis (31) in a tangency direction (d), so that the distance between the rotor (3) and the housing (2) is substantially equal to the optimal distance (g_{opt}). Finally, the last step comprises affixing the relative position between the housing (2) and the rotor axis (3).

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Description

TECHNICAL FIELD

[0001] This invention belongs to the field of pumps comprising a rotor with one or more vanes inserted in it, the rotor being in turn contained in a housing, where sub-spaces are created between the vane or vanes and the housing wall and the rotor when the rotor is moved.

STATE OF THE ART

[0002] Many applications need pumps, either a vacuum pump for magnifying the effect of a force or any other type of pump. These pumps usually comprise a housing and a rotor housed inside the housing. This rotor comprises one or more slots, so that a vane is at least partially introduced in each one of said slots. The housing houses this rotor, but the inner volume of the housing is greater than the volume occupied by the rotor and the vanes. Thus, when the rotor rotates, the vanes have some space to exit the rotor due to centrifugal force or any other force provided in the pump. This inner volume of the housing is designed such that the vane or vanes go in and out the rotor alternatively, in such a way that the subchambers which are created between two consecutive vanes and the corresponding portion of the housing wall and the rotor have a variable volume, depending on the position of the rotor. In the event of one single vane with a single slot, the slot allows the single vane exiting the rotor in two diametrically opposed locations, so that the vane divides the main chamber in different subchambers.

[0003] The design of these pumps always requires thorough calculations and accurate manufacturing processes.

DESCRIPTION OF THE INVENTION

[0004] The invention provides a solution for this problem by means of a method for manufacturing and assembling a pump according to claim 1 and a vacuum pump according to claim 13. Preferred embodiments of the invention are defined in dependent claims.

[0005] In a first inventive aspect, the invention provides a method for manufacturing and assembling a pump. This method comprises the steps of

providing a housing;
providing a rotor or the rotor mock-up and a rotor axis, the rotor or the rotor mock-up being arranged to rotate around the rotor axis;
determining an optimal distance between the housing and the rotor;
varying the distance between the housing and the rotor axis in a tangency direction, so that the distance between the rotor or the rotor mock-up and the housing is substantially equal to the optimal distance; and
affixing the relative position between the housing and

the rotor or the rotor mock-up.

[0006] To make adequate use of the whole inner volume of the housing, the rotor must be placed eccentrically with respect to the housing, and this eccentricity must be carefully chosen to achieve a maximum ratio between the maximum subchamber volume and the minimum subchamber volume.

[0007] Theoretically, this eccentricity is determined by the tangency contact between the rotor and the housing in one point, which will be called tangency point. In other words, the eccentricity distance is, theoretically, the housing radius minus the rotor radius. However, in the real assembly, to assume a real tangency implies a physical contact between a part which is rotating, potentially at high speed, and a static component. Therefore, this contact will cause continuous friction and therefore loss of useful torque and further it could damage those parts. As a consequence, a gap between the rotor and the housing is needed. Additionally, the tolerances of the components as well as of those existing in their relative positioning, could lead not only in friction but, also, in physical interference between the rotor and the housing.

[0008] However, the fact of ensuring a gap in the tangency point between rotor and housing is not enough in order to obtain a correct performance of the product, since having a real contact between both components is not the only negative effect that an inadequate gap distance may cause into the pump.

[0009] If the rotor is placed too near (the gap distance being too low), there are also further problems, related to the fact that when a vane overcomes the last output port of the pump, there is a subchamber which includes this vane and the tangency point. If the gap distance is too low, the tangency point will act as a physical barrier for fluid trapped inside this subchamber, and pressure may rise excessively, potentially increasing the necessary running torque of the pump motor and even damaging the pump.

[0010] On the other hand, if the rotor is placed too far, a bad performance is obtained, since the aforementioned ratio between the maximum volume subchamber and the minimum volume subchamber decreases, and there is more risk of air leakages between the two portions of the subchamber comprising the tangency point.

[0011] This method manufactures a pump with a controlled gap between the rotor and the housing, making this pump able to effectively select this gap distance regardless dimensional and geometrical tolerances affecting the parts comprised in this pump. Different parameters, such as pump speed, lubrication effect or performance values may be used to calculate an optimum distance, which may depend on the customer's choices. This method allows the customer and/or pump manufacturer to obtain a determined gap distance in an easy and reliable way.

[0012] The tangency direction turns out to be a direction which joins the point of the rotor which is closer to

the housing and the point of the housing which is closer to the rotor, when the rotor is located in its operation position. In the event the rotor and the housing make contact, the tangency direction is perpendicular to the common tangent line. When both rotor and housing have a circular shape, this tangency direction is the direction joining the centre of the housing and the centre of the rotor. As these two elements are placed eccentrically, both centres define a direction, which is the tangency direction. In other cases, when the housing is not circular, this direction also contains the centre of the rotor. There may be cases wherein the arrangement of rotor and housing make the rotor make contact with two opposite points of the housing. Even in this case, the tangency direction is perfectly defined, since these two opposite points are in the same line as the points of the housing which are closer to each one of them.

[0013] The use of a rotor mock-up instead of a rotor is another possibility which makes this method feasible.

[0014] In a particular embodiment, the step of varying the distance between the housing and the rotor axis comprises

reducing the distance between the housing and the rotor axis in a tangency direction, until the housing and the rotor or the rotor mock-up make contact; and increasing the distance between the housing and the rotor axis in a tangency direction, so that the distance between the rotor or the rotor mock-up and the housing is substantially equal to the optimal distance.

[0015] This way of varying the distance between the rotor and the housing is simple and effective, since the contact is made between final parts, without requiring restrictive dimensional and geometrical tolerances for the related components.

[0016] In a particular embodiment, the step of varying the distance between the housing and the rotor axis comprises

locating an intermediate element between the housing and the rotor or the rotor mock-up, the width of the intermediate element being substantially equal to the optimal distance;
reducing the distance between the housing and the rotor axis in the tangency direction, until the housing and the rotor or the rotor mock-up make contact with the intermediate element; and
remove the intermediate element.

[0017] This way of varying the distance between the housing and the rotor takes one step less compared to the previous embodiment, thanks to an intermediate element, which is interposed between the housing and the rotor.

[0018] In a particular embodiment, the method further comprises the step of providing sensing means which are suitable for measuring the relative position between

the rotor or the rotor mock-up and the housing.

[0019] These sensing means are useful during the steps of reducing and/or increasing the distance between the housing and the rotor. Some sensors may be used to detect the moment where housing and rotor make contact, thus avoiding hitting the rotor with an uncontrolled force, and some different sensors may be used to check that the housing reaches the optimal distance, thus obtaining a final positioning of the housing in a reliable way.

[0020] In a particular embodiment, the step of varying the distance between the housing and the rotor axis is carried out by displacing the housing with respect to the rotor axis.

[0021] Housing is usually easier to displace than the rotor, which usually needs to be displaced together with the electric motor and other parts.

[0022] In a particular embodiment, the housing comprises handling means, such as a tab, a flange or a handle.

[0023] These handling means allow a calibrated machine grabber grab the housing and move it more precisely. However, in other embodiments, there is no need to contact the housing to vary the distance between the housing and the rotor; this variation may be carried out by using a magnetic device, by vacuum or by blowing.

[0024] In a particular embodiment, the steps of reducing and/or increasing the distance between the housing and the rotor axis is carried out with the housing being open.

[0025] The housing being open allows a better control for the operation of varying the distance between the rotor and the housing.

[0026] In a particular embodiment, the step of varying the distance between the housing and the rotor axis is carried out with the housing being closed (either by a previous operation or by design, being a closed cover).

[0027] In a particular embodiment, in the step of providing a housing, the housing comprises an opening, and the method further comprises the step of closing the opening after varying the distance between the housing and the rotor axis.

[0028] This opening allows the operator or any artificial vision device to visually control the operations of reducing and/or increasing the distance, which makes visual control easier in the event this process is not easily seen from an upper position. Alternatively, this opening allows the adjustment of the distance by using a measurement sensor or any other device through itself. The opening must be closed afterwards, for the housing to be gastight.

[0029] In a particular embodiment, the step of varying the distance between the housing and the rotor axis is carried out with the aid of some guiding means, such as pins and slots.

[0030] Guiding means help the relative movement occur according to the tangency direction. In the event the guiding means are slots; these slots must be therefore oriented in the tangency direction.

[0031] In some particular embodiments, the step of af-

fixing the relative position between the housing and the rotor axis is by means of attaching means such as screws, clamps, rivets or adhesive joint.

[0032] In some particular embodiments, the step of affixing the relative position between the housing and the rotor axis is made by reversible fixation means, which may be removed during the pump lifetime and rearranged after maintenance operations.

[0033] Reversible fixation means provide the opportunity of being able to recalibrate the distance between the rotor and the housing in the event that operation may misadjust the position of these elements.

[0034] In some particular embodiments, the method further comprises the step of making the rotor or the rotor mock-up rotate with respect to the rotor axis while the step of varying the distance between the housing and the rotor axis is being executed.

[0035] Advantageously, the fact of making the rotor rotate saves the influence of some additional tolerances in this process.

[0036] In another inventive aspect, the invention provides a vacuum pump manufactured by a method according to any of the preceding claims, the vacuum pump comprising

- a housing;
- a rotor at least partially housed in the housing;
- a rotor axis, the rotor being arranged to rotate around the rotor axis; and
- means for affixing the distance between the housing and the rotor axis.

[0037] This pump may be advantageously manufactured and assembled with less restrictive requirements for dimensional and geometrical tolerances, since the distance between the rotor and the housing may be adjusted independently.

[0038] In a particular embodiment, the vacuum pump further comprises handling means, such as a tab, a flange or a handle.

[0039] These handling means allow a calibrated machine grab the housing and move it more precisely.

[0040] In some particular embodiments, the means for affixing the distance between the housing and the rotor axis are attaching means, such as screws, clamps, rivets or adhesive joint. In different embodiments, the means for affixing the distance between the housing and the rotor axis are reversible fixation means, which may be removed during the assembly process or the pump lifetime and rearranged after maintenance operations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] To complete the description and in order to provide for a better understanding of the invention, a set of drawings is provided. Said drawings form an integral part of the description and illustrate an embodiment of the invention, which should not be interpreted as restricting

the scope of the invention, but just as an example of how the invention can be carried out.

[0042] The drawings comprise the following figures:

5 Figures 1a to 1d show three different steps of a first embodiment of a method for manufacturing and assembling a pump according to the invention.

10 Figure 2 shows a particular way of performing two steps of a method for manufacturing and assembling a pump according to the invention.

15 Figure 3 shows a graphic with information regarding the relation between the distance between the housing and the rotor and the output pressure in a vacuum pump according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

20 **[0043]** Figures 1a to 1d show three different steps of a first embodiment of a method for manufacturing and assembling a pump 1 according to the invention.

[0044] Figure 1a shows the provision of a housing 2 and a rotor 3 placed on a rotor axis 31.

25 **[0045]** In different calculations, an optimal distance g_{opt} between the housing 2 and the rotor 3 has been determined.

[0046] Figure 1b shows the next step of this method. This step comprises reducing the distance between the housing 2 and the rotor axis 31 in a tangency direction d, until the housing 2 and the rotor 3 make contact.

[0047] For this step, some sensing means are provided. These sensing means are suitable for measuring the relative position between the rotor and the housing. Although the distance is reduced until the housing 2 and the rotor 3 make contact, this should be made in a careful way, not to cause damage in any of these elements.

[0048] In other embodiments, instead of reducing the distance until the housing 2 and the rotor 3 make contact, and then increasing this distance until the optimal distance g_{opt} , an intermediate element is located between the housing and the rotor. The width of the intermediate element is substantially equal to the optimal distance. Once this intermediate element is located, the distance between the housing and the rotor axis is reduced in a tangency direction, until the housing and the rotor make contact with the intermediate element. Finally, the intermediate element is removed.

[0049] In the preferred embodiment shown in this figure, it is the housing 2 which is displaced towards the rotor axis 31, but in other embodiments, it is the rotor axis 31 which may be displaced towards the housing 2. The displacement of the housing 2 may be performed with the aid of some handling means, such as a tab, a flange or a handle. A calibrated machine may make use of these handling means for a more controlled movement of the housing 2.

[0050] Figure 1c shows a further step of this method.

This step comprises increasing the distance between the housing 2 and the rotor axis 31 in a tangency direction d , until the distance between the housing 2 and the rotor 3 is substantially equal to the optimal distance g_{opt} .

[0051] The target relative position between the housing 2 and the rotor 3 can be achieved during the assembly process by the sensing means. In some particular embodiments of the invention, these sensing means comprise known elements to control the distance between two points. Some sensing means which could be used are: a stroke sensor, a travel transducer, force sensors, vision sensors, gauges, calibrated parts, any combination of them or any equipment or procedure which may allow the control of the required value for this distance between the housing 2 and the rotor 3. Different sensing means may be used during the steps of reducing and increasing the distance between the housing 2 and the rotor 3. Some sensors may be used to detect the moment where housing 2 and rotor 3 make contact, and some different sensors may be used to check that the housing 2 reaches the optimal distance g_{opt} .

[0052] One way of ensuring that the movement between the housing and the rotor is carried out according to the tangency direction d is providing slots 51 and pins 52, one of them being comprised in the housing 2 or in a piece which is solidly attached to the housing, and the other being comprised in the base of the rotor 32 or in a piece which is solidly attached to the base of the rotor, just for setting a position reference. In the embodiment shown in figure 1d, the slots 51 are comprised in a housing support 21, which is part of the housing 2 and the pins 52 are solidly attached to the base of the rotor 32. The slots are oriented in the tangency direction d , in such a way that when pins 52 move within the slots 51, the rotor 3 displaces relatively to the housing 2, and the distance between the rotor 3 and the housing 2 is therefore adjusted.

[0053] One way of making this movement easier is the use of handling means 4, such as a tab, a flange or a handle or some similar element, located in the housing 2.

[0054] There is also a further step of this method. This step comprises affixing the relative position between the housing 2 and the rotor axis 3.

[0055] In the embodiment shown in these figures, the step of affixing the relative position between the housing 2 and the rotor axis 31 will be performed by means of attaching means such as screws, clamps, rivets or adhesive joint, although this step is not illustrated by the figures. Welding or crimping may also be used for this purpose. A final attachment is therefore achieved, so that the pump works its entire lifetime with the same settings.

[0056] In some embodiments, this step of affixing the relative position between the housing and the rotor axis is made by reversible fixation means, which may be removed during the pump lifetime and rearranged after maintenance operations.

[0057] These embodiments may be useful when the pump is easily accessible, or the cost of rearranging the

distance between the rotor and the housing is worth it, due to the overall cost of replacing the whole pump.

[0058] Figure 2 shows a particular way of performing the steps of reducing and increasing the distance between the housing and the rotor axis.

[0059] This figure 2 shows a housing 2 with an opening 22, so that the steps of reducing and increasing the distance between the housing and the rotor axis may be visually controlled by this opening 22, either by an operator or by any artificial vision device, or even using sensing means through the opening. This opening must be closed afterwards, so that the final housing 2 is gastight.

[0060] Figure 3 shows the influence of this distance between the housing and the rotor (called in this graphic " g ") in the operation of a vacuum pump. Five different values for this distance g have been used and, as discussed before, the lower this gap in the pump, the lower the absolute pressure in the output of this vacuum pump and the quicker the vacuum generation.

[0061] In this particular embodiment, just as a reference, the rotor is circular, with a diameter of 38 mm, the housing is also circular, with a diameter of 48 mm. The optimal distance g_{opt} , taking into account other considerations, such as required power and efficiency, should be set preferably between 0.05 and 0.25 mm.

[0062] The optimal distance g_{opt} between the rotor and the housing is set, apart from the measurements of the sensing devices, from the specific product requirements (maximum vacuum level, required efficiency) and physical features of the vacuum pump (position of inlet and outlet ports or other design features).

[0063] In this text, the term "comprises" and its derivations (such as "comprising", etc.) should not be understood in an excluding sense, that is, these terms should not be interpreted as excluding the possibility that what is described and defined may include further elements, steps, etc.

[0064] The invention is obviously not limited to the specific embodiments described herein, but also encompasses any variations that may be considered by any person skilled in the art (for example, as regards the choice of materials, dimensions, components, configuration, etc.), within the general scope of the invention as defined in the claims.

Claims

1. Method for manufacturing and assembling a pump (1), the method comprising the steps of
 - providing a housing (2);
 - providing a rotor (3) or a rotor mock-up and a rotor axis (31), the rotor (3) or the rotor mock-up being arranged to rotate around the rotor axis (31);
 - determining an optimal distance (g_{opt}) between the housing (2) and the rotor (3);

- varying the distance between the housing (2) and the rotor axis (31) in a tangency direction (d), so that the distance between the rotor (3) or the rotor mock-up and the housing (2) is substantially equal to the optimal distance (g_{opt}); and
 affixing the relative position between the housing (2) and the rotor (3) or the rotor mock-up.
2. Method according to claim 1, wherein the step of varying the distance between the housing (2) and the rotor axis (31) comprises
- reducing the distance between the housing (2) and the rotor axis (31) in a tangency direction (d), until the housing (2) and the rotor (3) or the rotor mock-up make contact; and
 increasing the distance between the housing (2) and the rotor axis (31) in a tangency direction (d), so that the distance between the rotor (3) or the rotor mock-up and the housing (2) is substantially equal to the optimal distance (g_{opt}).
3. Method according to claim 1, wherein the step of varying the distance between the housing (2) and the rotor axis (31) comprises
- locating an intermediate element between the housing (2) and the rotor (3) or the rotor mock-up the width of the intermediate element being substantially equal to the optimal distance (g_{opt});
 reducing the distance between the housing (2) and the rotor axis (31) in a tangency direction (d), until the housing (2) and the rotor (3) or the rotor mock-up make contact with the intermediate element; and
 remove the intermediate element.
4. Method according to any of claims 1 or 2, further comprising the step of providing sensing means which are suitable for measuring the relative position between the rotor (3) or the rotor mock-up and the housing (2).
5. Method according to any of the preceding claims, wherein the step of varying distance between the housing (2) and the rotor axis (31) is carried out by displacing the housing (2) with respect to the rotor axis (31).
6. Method according to any of the preceding claims, wherein the housing (2) comprises handling means (4), such as a tab, a flange or a handle.
7. Method according to any of the preceding claims, wherein the step of varying the distance between the housing and the rotor axis is carried out with the housing (2) being open.
8. Method according to any of the preceding claims, wherein the step of providing a housing comprises providing a housing (2) with an opening (22), and the method further comprises the step of closing the opening (22) after varying the distance between the housing and the rotor axis.
9. Method according to any of the preceding claims, wherein the step of varying the distance between the housing and the rotor axis is carried out with the aid of some guiding means, such as pins and slots.
10. Method according to any of the preceding claims, wherein the step of affixing the relative position between the housing and the rotor axis is by means of attaching means such as screws, clamps, rivets, an adhesive joint, crimping or welding.
11. Method according to any of the preceding claims, wherein the step of affixing the relative position between the housing and the rotor axis is made by reversible fixation means, which may be removed during the pump lifetime and rearranged after maintenance operations.
12. Method according to any of the preceding claims, further comprising the step of making the rotor (3) or the rotor mock-up rotate with respect to the rotor axis (31) while the step of varying the distance between the housing (2) and the rotor axis (31) is being executed.
13. Vacuum pump (1) manufactured and assembled by a method according to any of the preceding claims, the vacuum pump (1) comprising
- a housing (2);
 a rotor (3) at least partially housed in the housing (2);
 a rotor axis (31), the rotor being arranged to rotate with respect to the rotor axis (31); and
 means for affixing the distance between the housing (2) and the rotor axis (31).
14. Vacuum pump (1) according to claim 13, further comprising handling means (4), such as a tab, a flange or a handle.
15. Vacuum pump (1) according to claim 13, wherein the means for affixing the distance between the housing (2) and the rotor axis (31) are attaching means, such as screws, clamps, rivets or adhesive joint.
16. Vacuum pump (1) according to claim 13, wherein the means for affixing the distance between the

housing (2) and the rotor axis (31) are reversible fixation means, which may be removed during the assembly process or during the pump lifetime and rearranged after maintenance operations.

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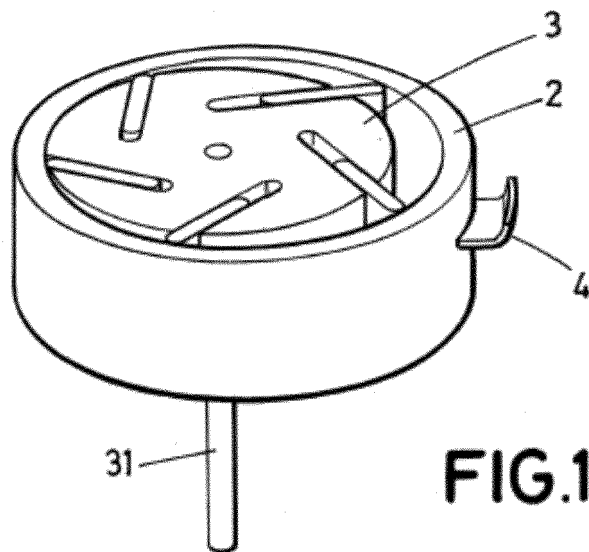


FIG. 1a

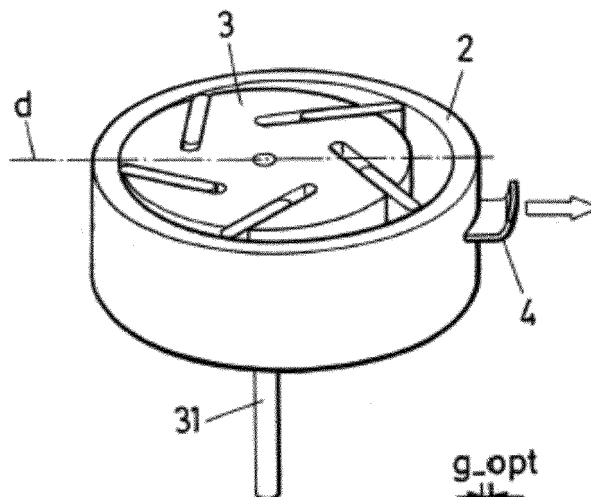


FIG. 1b

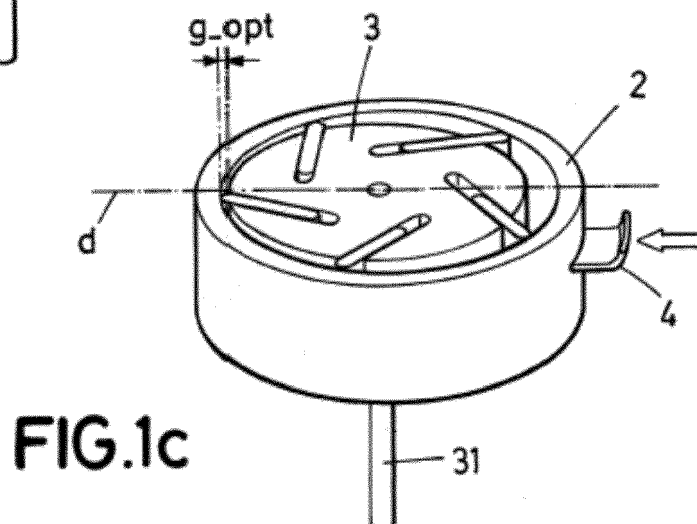


FIG. 1c

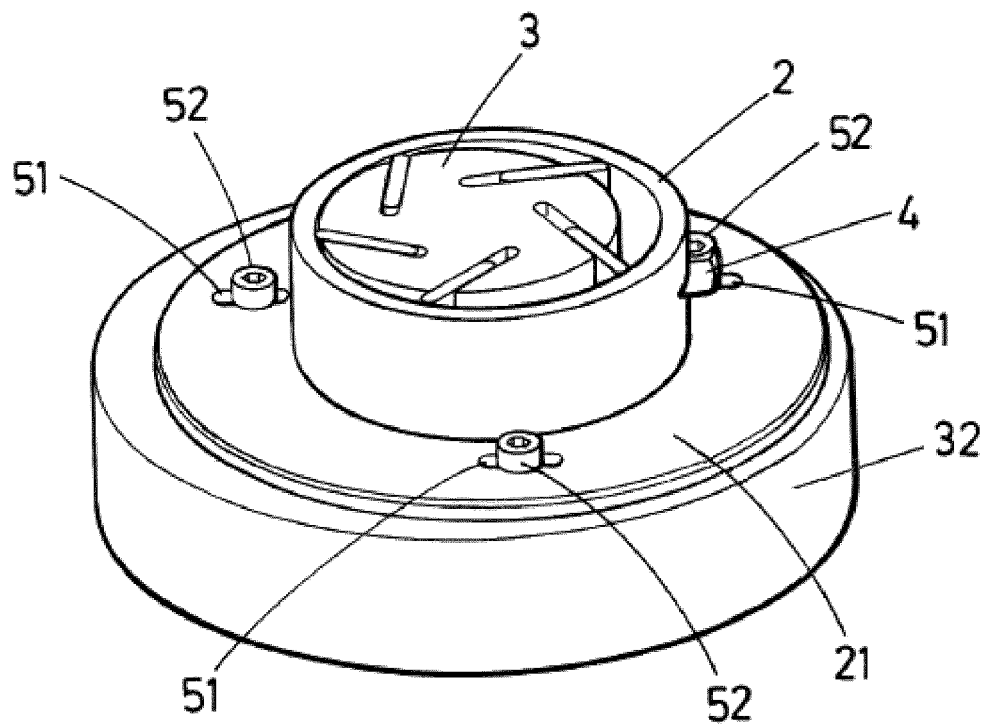


FIG. 1d

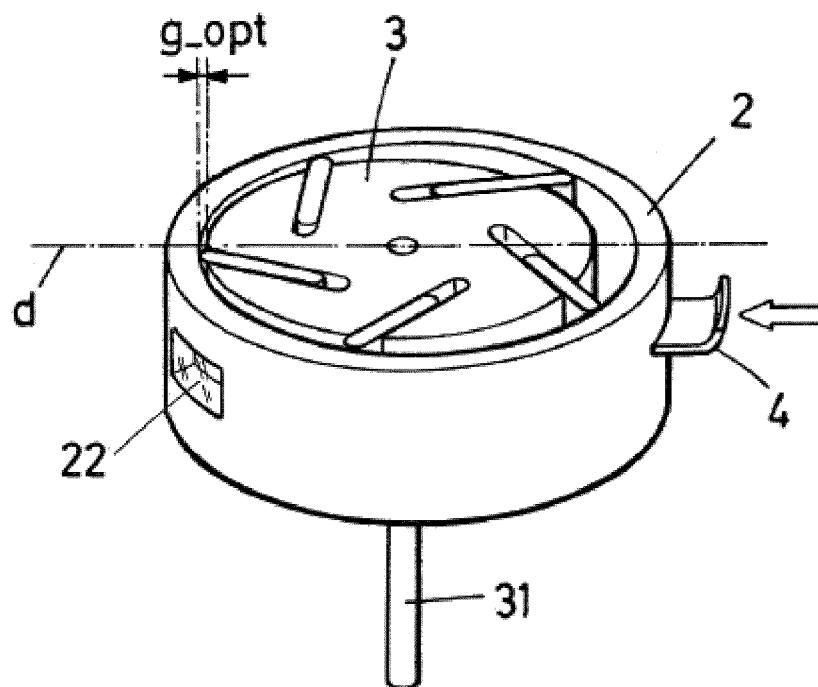


FIG. 2

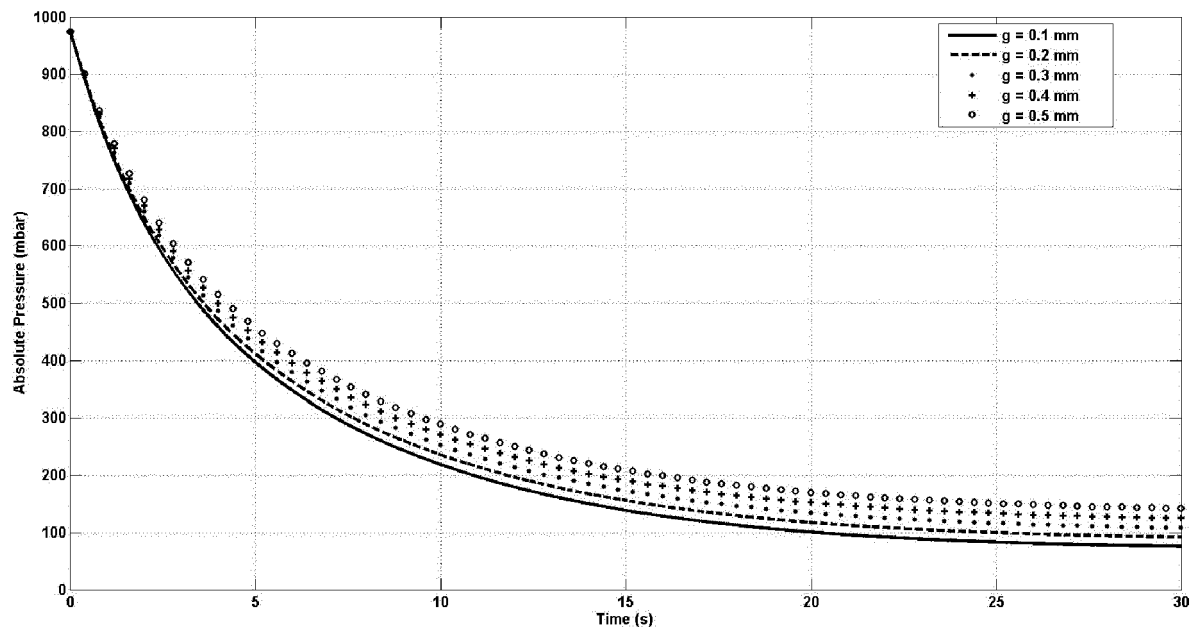


FIG. 3



EUROPEAN SEARCH REPORT

Application Number
EP 17 38 2068

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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
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Place of search		Date of completion of the search	Examiner
Munich		19 December 2017	Grilli, Muzio
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			

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EPO FORM 1503 03/02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 38 2068

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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