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(54) **A CENTRIFUGAL PUMP WITH BALANCING MEANS, A BALANCING DISC AND A METHOD OF BALANCING AXIAL FORCES OF THE CENTRIFUGAL PUMP**

(57) The present invention relates to single- or multi-stage centrifugal pumps having novel disc- type means for balancing the axial forces of the pump. The disc-type balancing means are provided with two permanent magnets (60, 62’) facing one another and fastened to the balancing disc (54) and its counter member (56).

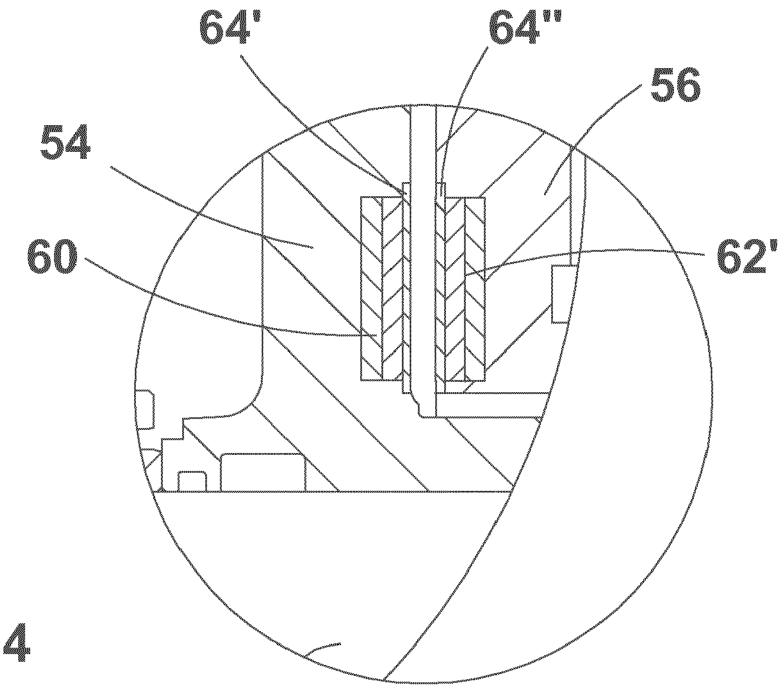

Fig. 4

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Description

Technical field

[0001] The present invention relates to a centrifugal pump with balancing means in accordance with the preamble of claim 1, a balancing disc for a centrifugal pump in accordance with the preamble of claim 9 and a method of balancing axial forces of the centrifugal pump in accordance with the preamble of claim 12. More specifically the present invention relates to single- or multi-stage centrifugal pumps having novel disc-type means for balancing the axial forces of the pump.

Background art

[0002] The means for balancing axial forces of centrifugal pumps are normally in use in multistage pumps, which have a high pressure head, and are provided with several subsequent centrifugal impellers on the same shaft. An axial force is generated while an impeller, or a plurality of impellers, draws liquid axially in the pump and discharges the liquid radially from the pump. The axial force tends to draw the impeller/s towards the pump inlet, whereby the bearings of the pump are subjected to a considerable axial force when keeping the pack of impellers in place. In order to reduce the axial force subjected to the bearings, and, thus, to make it possible to use smaller or lighter bearings or different types of bearings means for balancing the axial force have been developed.

[0003] Prior art knows two basic types of means for balancing the axial force. One is a so- called drum-type balancing means, and the other a disc-type balancing means. Also hybrid balancing means are known, i.e. one comprising both a balancing drum and a balancing disc. In most cases the balancing means are positioned on the pump shaft behind the last impeller when viewed from the pump inlet towards the pump outlet. However, it is possible, if desired, to construct a centrifugal pump such that the balancing means are between the stages of a multi-stage centrifugal pump or in front of the impeller/s thereof. The disc-type balancing means may be considered as the preferred choice of the two basic balancing means as it adjusts its operation automatically, i.e. slight wear does not affect the operation of the balancing means at all, whereas even the slightest wear of the drum-type balancing means results in a change in the balancing capability of the balancing means. Furthermore, the disc-type balancing means occupies also less space in the axial direction than drum-type balancing means.

[0004] The disc-type balancing means is formed of a balancing disc fastened on the shaft of the pump and a stationary counter member. In most cases the counter member is arranged to extend from the pump volute or casing radially inwardly between the impeller or one of the impellers and the balancing disc. Often the stationary counter member is the rear wall of the last pumping stage of the centrifugal pump. The balancing disc and the counter member leave a radially extending cavity, so called balancing cavity, therebetween. Either the balancing disc or the counter member or both have an annular axial extension, sometimes a separate circular ring, at the outer periphery of the balancing disc for reducing the axial dimension of the cavity between the balancing disc and the counter member in order to limit the leakage flow of the pressurized liquid from the pump. However, it should be understood that the balancing means, i.e. balancing disc, its counter member and the balancing cavity, may also be located in front of the impeller/s when viewed from the direction of the inlet opening of the pump. In such a case it is required that the pressurized liquid is taken to the balancing cavity along a separate flow passage.

[0005] The disc-type balancing means functions such that a part of the liquid pressurized by the impeller or the pack of impellers enters, as is well known in centrifugal pumps, to the cavity behind the impeller of the last pumping stage, and finds its way via the gap between the shaft of the pump or the shaft sleeve of the balancing disc and the stationary counter member to a radially extending balancing cavity between the balancing disc and the stationary counter member. Now that the pressure of the liquid is, in practice, not reduced the full pressure of the pumped liquid effects on the rotary balancing disc pushing the balancing disc away from the inlet of the pump, i.e. contrary to the axial force created by the impellers. Thereby, the axial thrust loading the bearings of the pump is the difference of the two axial forces having opposite directions. By properly dimensioning the balancing means the two opposite forces may be equalized resulting in zero thrust, whereby the shaft bearings may be changed into slide bearings that are not able to carry any axial load.

[0006] However, while the pressurized liquid flows radially outwardly in the balancing cavity between the balancing disc and its counter member, the liquid reaches the annular extension or ring and enters the annular gap between the annular extension or ring and its counter surface. Now that the annular gap is very thin, i.e. its axial depth is very small, and the pressure difference radially over the ring is relatively high (depending mostly on the head of the pump), the flow velocity of the liquid in the thin gap is high. Due to the high velocity of the liquid the pressure in the gap between the balancing disc and the counter member is low resulting in that in the area of high flow velocity, i.e. at the ring area, the disc is not able to create any significant axial force. The result, in appropriate conditions, is that a part of the liquid flow entering the gap between the ring and its counter surface evaporates temporarily to vapor. Especially in such a condition that the pressure difference over the balancing means is high compared to how far from the steam pressure the balancing means operates. The temporary evaporation of the liquid in the thin gap results easily in mechanical contact between the ring and its counter surface, which, in the least, increases friction losses, and raises the temperature of the surfaces. Also, sudden evaporation of the liquid may lead to impacts between the counter surfaces as they hit one another. Both the friction and the impacts may, in the long run, cause wear, which may over time lead to need for replacing the balancing means with a new one. In other words, the first problem that may be seen in the operation of the balancing means is high power consumption combined with fluctuations in the power consumption due to the balancing means operating, alternatingly, in both low-friction and high-friction conditions.

[0007] The above described problems, first of all the mechanical contact between the counter surfaces, have been suggested to be solved by increasing the effective area of the balancing disc by increasing the diameter of the balancing disc. It results in considerable increase in the power consumption of the balancing means without, however, preventing the liquid from boiling in all operating conditions of the pump. In other words, the prior art improvement leads to increased power consumption and occasional wear-related problems.

[0008] Prior art proposes, in US-A-5,613,831, for solving the above problem a pressure compensation system for a rotary pump, which aims at preventing the axial displacement of the pump shaft to such an extent that mechanical contact between the disc type balancing means is avoided. The improvement in the means for pressure or thrust compensation includes a first set of permanent magnets arrayed around and attached to the shaft and a second set of permanent magnets arrayed on the pump housing at the shaft opening and facing the first set of permanent magnets. The second set of permanent magnets magnetically attracts the first set of permanent magnets to hold the pump shaft at a fixed position along the major axis of the shaft with respect to the pump housing. Upon rotation of the shaft generating the axial thrust along the major axis of the shaft, the first set of permanent magnets and the second set of permanent magnets oppose movement of the shaft along the major axis of the shaft with respect to the housing.

[0009] In principle the above discussed idea of using permanent magnets to prevent the axial movement of the pump shaft is good, but the way it is done in the cited US patent includes a few problems. Firstly, the positioning of the permanent magnets on the shaft and on the housing increase the longitudinal dimension of the pump, whereby a larger space is needed for the pump installation. Secondly, as the permanent magnets are in axial direction relatively far from the balancing means, i.e. balancing disc, where there is a risk of mechanical contact, changes in the temperature of the liquid to be pumped should be taken into account. The risk of mechanical contact is, naturally, the greatest when a cold pump is started to pump liquids the temperature of which may exceed 100 degrees. Thus, if the permanent magnets are properly aligned when the pump is cold, heating of the pump shaft may move the surfaces of the balancing means towards one another to such an extent that a contact is possible. The sensitivity to temperature requires specific attention, if the temperature of the liquid to be pumped is changed significantly, i.e. for instance the pump is moved from pumping hot liquid to pumping cold liquid. A third problem involved in the pump of the US- document may be seen in the weakened operation of the balancing means. In other words, by keeping or trying to keep the shaft axially immobile the permanent magnets prevent the balancing means from operating in the manner it is designed to function, i.e. automatically adjusting the thin axial gap between the working surfaces of the balancing means.

[0010] Thus an object of the present invention is to design such a novel balancing means for a centrifugal pump that prevents mechanical contact between the balancing disc and its counter member.

[0011] Another object of the present invention is to design such a novel balancing means for a centrifugal pump that utilizes the permanent magnets but avoids the problems involved in the prior art use of the permanent magnets.

[0012] A further object of the present invention is to develop such a novel balancing means for a centrifugal pump that, while effectively preventing mechanical contact between the balancing disc and its counter member still allows the balancing means to adjust automatically its operating clearance.

Disclosure of the Invention

[0013] At least one of the above discussed problems is solved and at least one of the objects of the present invention are met with a centrifugal pump comprising a pump casing with an inlet and an outlet, a shaft sealed and mounted with bearings to the pump casing, at least one impeller fastened on the shaft for rotation therewith and a means for balancing axial forces the balancing means comprising a balancing disc fastened on the shaft for rotation therewith and having an outer circumference, and a stationary counter member arranged in connection with the pump casing; the balancing disc and the counter member leaving therebetween a balancing cavity, wherein a first permanent magnet is arranged in connection with the balancing disc and a second permanent magnet is arranged in connection with the counter member, the first and the second permanent magnets facing one another such that either the north poles or the south poles of the permanent magnets face each other.

[0014] At least one of the above discussed problems is solved and at least one of the objects of the present invention are met with a method of balancing an axial thrust of a centrifugal pump, the centrifugal pump comprising a pump casing with an inlet and an outlet, a shaft sealed and mounted with bearings to the pump casing, at least one impeller fastened on the shaft for rotation therewith and a means for balancing axial forces the balancing means comprising a balancing disc fastened on the shaft for rotation therewith and having an outer circumference, and a stationary counter member arranged in connection with the pump casing; the balancing disc and the counter member leaving therebetween radially inwardly from the outer circumference a thin gap and radially inwardly thereof a balancing cavity, the method comprising the step of:

- providing the balancing disc with at least one first permanent magnet and the counter member with at least one second permanent magnet,
- arranging the at least one first and the at least one second permanent magnets in relation to one another such that either their north poles or their south poles face one another,
- arranging the at least one first and the at least one second permanent magnets in such an axial distance from one another that, when the pressure in the balancing cavity is reduced to a certain level, the at least one first and the at least one second permanent magnets start repelling one another and thus prevent mechanical contact between the balancing disc and its counter member.

[0015] Other characteristic features of the present invention become apparent in the appended dependent claims.

[0016] The present invention brings about the following advantages over the prior art balancing means

- does not add the length of the pump,
- insensitive to changes in temperature by placing the thrust compensation to such a position that changes in temperature do not have any effect in the risk of mechanical contact,
- does not prevent the thin axial gap from automatically adjusting in accordance with the pump operation,
- simplifies the dimensioning of the thrust compensation system, as there are no space or temperature demands,
- no mechanical contact between the balancing disc and its counter member, possibilities to modular production and selling as an accessory,
- no or very small fluctuations in the power consumption, and
- lower power consumption than traditional disc-type balancing means, as mechanical contact between the balancing disc and its counter member, while starting and stopping the pump, is avoided.

Brief Description of Drawings

[0017] The present invention is discussed more in detail below with reference to the accompanying drawings, in which

Fig. 1 illustrates schematically, and in an axial cross section, a prior art multi-stage centrifugal pump including disc-type balancing means;

Fig. 2 illustrates in more detail the prior art balancing means of Figure 1,

Fig. 3 illustrates how the prior art balancing means of Fig. 2 are replaced with improved balancing means in accordance with a first preferred embodiment of the present invention;

Fig. 4 illustrates in more detail the improved balancing means in accordance with the first preferred embodiment of the present invention; and

Fig. 5 illustrates in more detail the improved balancing means in accordance with a second preferred embodiment of the present invention.

Detailed Description of Drawings

[0018] Figure 1 illustrates an axial cross section of a prior art multi-stage centrifugal pump having a casing 10 with an inlet 12 and an outlet 14, the casing 10 housing a plurality of, here four, impellers 16 attached on a shaft 18 for rotation therewith and a balancing means 20.

[0019] Figure 2 illustrates schematically an axial, more detailed cross section of the balancing means 20 and the end part of the prior art centrifugal pump. Here the prior art balancing means 20 is formed of a balancing disc 22 attached on the shaft 18 for rotation therewith. In connection with the balancing disc 22 there may be a separate sleeve or the balancing disc may be provided with an integrated axial extension, i.e. a cylindrical sleeve 24, either one of the sleeves extending from the disc up to the hub of the impeller. The balancing means 20 further comprises a counter member 28 extending from the pump casing 10 radially inwardly between the balancing disc 22 and the impeller. The counter member 28 may be either the rear wall of the centrifugal pump or a specific part attached thereto. In more general terms, the counter member is a part of the casing of the centrifugal pump or a specific part attached thereto. The balancing disc 22 has an outer circumference immediately inside of which a thin gap 32 is arranged between the balancing disc 22 and its counter member 28 (here in this embodiment the counter ring 34 is the part of the counter member 28 facing the balancing disc 22). Radially inside of the thin gap 32 there is a balancing cavity 30 between the counter member 28 and the balancing disc 22. In operation, a part of the pumped liquid enters along the shaft or shaft sleeve to the balancing cavity 30 between the balancing disc 22 and its counter member 28 and passes the thin gap 32 and, in normal operating conditions, the pressure conditions in the balancing cavity 30 keep the gap 32 open and prevent any mechanical contact between the surfaces of the balancing disc 22 and its counter member

28. Usually, the above mentioned surfaces are, at the area of the thin gap 32, specifically designed, i.e. coated or otherwise finished, slide surfaces that take into account the momentary mechanical contact of the surfaces while starting or stopping the pump.

[0020] However, to prevent the mechanical contact in abnormal operating conditions the prior art, i.e. US-A-5,613,831, proposes a pressure compensation system 40 comprising a first set 42 of permanent magnets arrayed around and attached to a circular disc 44 arranged to the free end of the shaft 18 and a second set 46 of permanent magnets arrayed on a cylindrical extension 48 of the pump housing at the shaft opening and facing the first set 42 of permanent magnets. The second set 46 of permanent magnets magnetically attracts the first set 42 of permanent magnets to hold the pump shaft 18 at a fixed position along the major axis of the shaft with respect to the pump housing. Upon rotation of the shaft generating the axial thrust along the major axis of the shaft, the first set 42 of permanent magnets and the second set 46 of permanent magnets oppose movement of the shaft 18 along the major axis of the shaft with respect to the housing 10. However, as discussed already earlier, the permanent magnet arrangement of prior art occupies space and is not able to take into account possible changes in the temperature of the liquid to be pumped, and also of the shaft of the pump. Furthermore, the permanent magnets used in the manner described above prevent the thin gap from adjusting automatically as a function of the pressure in the balancing cavity, as the magnets aim at keeping the shaft immobile in axial direction.

[0021] Figs. 3 and 4 illustrate how the prior art balancing means of Fig. 2 are replaced with improved balancing means 50 in accordance with a first preferred embodiment of the present invention. In the improved balancing means 50 the pressure compensation system 52 is arranged in connection with the balancing means 50. In the illustrated first preferred embodiment of the present invention both the balancing disc 54 and its counter member 56 are provided radially inside the slide surfaces of the thin gap 32 at the sides of the balancing cavity 30 with annular grooves 58' and 58" (Fig. 3) or an annularly arranged series of depressions that face one another. The grooves or depressions are provided with permanent magnets 60 and 62 (Fig. 4) such that either the north or south poles thereof face one another. In another words, the magnets are positioned in relation to one another such that they repel one another. The annular grooves 58' and 58" or depressions are covered by lids 64' and 64", preferably fastened and sealed to the balancing disc 54 and its counter member 56, i.e. sealed from the balancing cavity 30 by means of O-rings, for instance, such that the liquid to be pumped cannot get into contact with the magnets. As a further variant of the present invention the grooves or depressions may be replaced with separate annular or sector-shaped "cups", manufactured of appropriate material, into which the permanent magnets are positioned whereafter the "cups' are fastened, for instance by means of screws, on at least one of the balancing disc and its counter member. In other words, the "cups" may be positioned such that they face permanent magnets positioned in grooves or depressions on one of the balancing disc and the counter member, or such that they face one another.

[0022] Figure 5 illustrates the pressure compensation system in accordance with a second preferred embodiment of the present invention. Here the permanent magnet 60 and its lid 64' arranged in connection with the balancing disc are equal to that shown in Figure 4. The permanent magnet 62" in the counter member 56 is arranged in a slightly different manner, as the permanent magnet/s 62" is/are inserted in its annular groove 58'" or in their depressions from the direction of the axis of the pump. The annular groove 58'" is or the depressions are covered by means of a lid 64'" or lids.

[0023] The pressure or thrust compensation system is designed such that the distance from the magnet 60 to the surface of the balancing disc and the distance from the magnet 62' or 62" to the surface of the counter member is as short as possible, preferably of the order of one or a few millimeters. In the embodiment of Fig. 4 it equals to the thicknesses of the lids 64' and 64". And in the embodiment of Fig. 5 the thickness of the lid 64' and that of the land area between the groove 58'" or the depressions and the balancing cavity 30. The same dimension applies, naturally, to the thickness of the bottoms of the "cups" discussed above. As to the material of the lids or cups, the major issues are that the material is strong or thick enough to endure mechanical stresses subjected thereto, it is water-tight such that the liquid to be pumped does not enter the cavity where the magnets are and it is insensitive to corrosion either in itself or by means of a coating applied thereon.

[0024] As is well-known in the art the pair of permanent magnets function such than when either the south poles or the north poles thereof are facing one another the magnets repel each other. The repelling action starts at a certain distance between the magnets and the force the magnets repel each other grows exponentially when the distance between the magnets decreases further. Therefore, it is not only the thicknesses of the lids or the lid and the land area that matter but also the distance between the balancing disc and its counter member (thickness of the balancing cavity 30). Thus, the sum of the three thicknesses or distances have to be taken into account when choosing the permanent magnets to result in the desired function. In other words, the thickness of the balancing cavity may be designed smaller than in prior art balancing means.

[0025] The thrust compensation system of the present invention allows the floating of the pump shaft on its slide bearings such that the axial clearance of the balancing means may be adjusted automatically, i.e. just as the basic operation principle of disc type balancing means is, as long as there is sufficient pressure in the balancing cavity. However, when the pressure is lower than needed, i.e. while, for instance, starting or stopping the pump, the thrust compensation system of the present invention prevents the mechanical contact between the balancing disc and its counter member. This is opposite to the teachings of the US-A-5,613,831 where the thrust compensation system resists the axial movement of the shaft immediately after the shaft tends to move out of the rest position of the magnets. In other words, in the construction of the US-A-5,613,831 the thrust compensation system and the balancing means interfere in the functions of one another even though such is, in practice, not needed.

[0026] The material for the permanent magnets may be chosen to correspond to the temperature requirements the liquid to be pumped subjects to the pump and the materials used. For the highest temperatures Samarium Cobolt (SmCo) magnets are applicable. The magnets used in the present invention may be formed as continuous magnet rings facing one another, magnet segments facing one another or as a magnet ring facing to a number of magnet segments. Also, the magnets may be divided in radial direction into several magnet rings or as several magnet segments.

[0027] While the invention has been described herein by way of examples in connection with what are, at present, considered to be the most preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but is intended to cover various combinations or modifications of its features, and several other applications included within the scope of the invention, as defined in the appended claims. The details mentioned in connection with any embodiment above may be used in connection with another embodiment when such combination is technically feasible.

Claims

1. A centrifugal pump, comprising a pump casing (10) with an inlet (12) and an outlet (14), a shaft (18) sealed and mounted with bearings to the pump casing (10), at least one impeller (16) fastened on the shaft (18) for rotation therewith and a means (20,50) for balancing axial forces the balancing means (20, 50) comprising a balancing disc (22, 54) fastened on the shaft (18) for rotation therewith and having an outer circumference, and a stationary counter member (28, 56) arranged in connection with the pump casing (10); the balancing disc (22, 54) and the counter member (28, 56) leaving therebetween radially inwardly from the outer circumference a thin gap (32) and radially inwardly thereof a balancing cavity (30), **characterized in** at least one first permanent magnet (60) arranged in connection with the balancing disc (54) and at least one second permanent magnet (62’, 62") arranged in connection with the counter member (56), the at least one first and the at least one second permanent magnets (60; 62’, 62") facing one another such that either the north poles or the south poles of the permanent magnets (60; 62’, 62") face each other.

2. The centrifugal pump in accordance with claim 1, **characterized in** the balancing disc (54) being provided with an annular groove (58’) or a series of depressions for the at least one first permanent magnet (60) and the counter member (56) being provided with an annular groove (58", 58"’) or a series of depressions for the at least one second permanent magnet (62’, 62").

3. The centrifugal pump in accordance with claim 2, **characterized in** the grooves (58’; 58", 58’") or a series of depressions being provided with lids (64’; 64", 64’").

4. The centrifugal pump in accordance with claim 3, **characterized in** the grooves (58’; 58", 58’") or a series of depressions being sealed from the balancing cavity (30).

5. The centrifugal pump in accordance with claim 2, **characterized in that** the annular grooves (58’, 58", 58"’) or a series of depressions for the at least one first and the at least one second permanent magnets (60, 62’, 62") are located at sides of the balancing cavity (30) radially inside the thin gap (32).

6. The centrifugal pump in accordance with any one of the preceding claims, **characterized in that** the at least one first and the at least one second permanent magnets (60, 62’, 62") are formed of continuous annular rings.

7. The centrifugal pump in accordance with any one of the preceding claims, **characterized in that** the at least one first and the at least one second permanent magnets (60, 62’, 62") are formed of a number of segments.

8. The centrifugal pump in accordance with any one of the preceding claims, **characterized in that** one of the at least one first and the at least one second permanent magnets (60, 62’, 62") is formed of an annular ring and the other of the at least one first and the at least one second permanent magnets (60, 62’, 62") is formed of a number of segments.

9. A balancing disc for a centrifugal pump, the balancing disc having an outer circumference and radially inwardly thereof an annular slide surface, **characterized in** the balancing disc (54) being provided with at least one permanent magnet (60) radially inside the annular slide surface.

10. A balancing disc as recited in claim 9, **characterized in** the balancing disc (54) being provided, radially inside of the annular slide surface, with an annular groove (58') or with a series of annularly arranged depressions into which the at least one permanent magnet (60) is positioned.

11. A balancing disc as recited in claim 10, **characterized in** the annular groove (58') or the series of annularly arranged depressions being provided with a lid (64') fastened and sealed to the balancing disc (54).

12. A method of balancing an axial thrust of a centrifugal pump, the centrifugal pump comprising a pump casing with an inlet (12) and an outlet (14), a shaft (18) sealed and mounted with bearings to the pump casing (10), at least one impeller (16) fastened on the shaft (18) for rotation therewith and a means (20, 50) for balancing axial forces the balancing means (20, 50) comprising a balancing disc (22, 54) fastened on the shaft (18) for rotation therewith and having an outer circumference, and a stationary counter member (28, 56) arranged in connection with the pump casing (10); the balancing disc (22, 54) and the counter member (28, 56) leaving therebetween radially inwardly from the outer circumference a thin gap (32) and radially inwardly thereof a balancing cavity (30), the method comprising the step of:

- providing the balancing disc (54) with at least one first permanent magnet (60) and the counter member (56) with at least one second permanent magnet (62', 62")
- arranging the at least one first and the at least one second permanent magnets (60; 62', 62") in relation to one another such that either their north poles or their south poles face one another,
- arranging the at least one first and the at least one second permanent magnets (60; 62', 62") in such an axial distance from one another that, when the pressure in the balancing cavity (30) is reduced to a certain level, the at least one first and the at least one second permanent magnets (60; 62', 62") start repelling one another and thus prevent mechanical contact between the balancing disc (54) and its counter member (56).

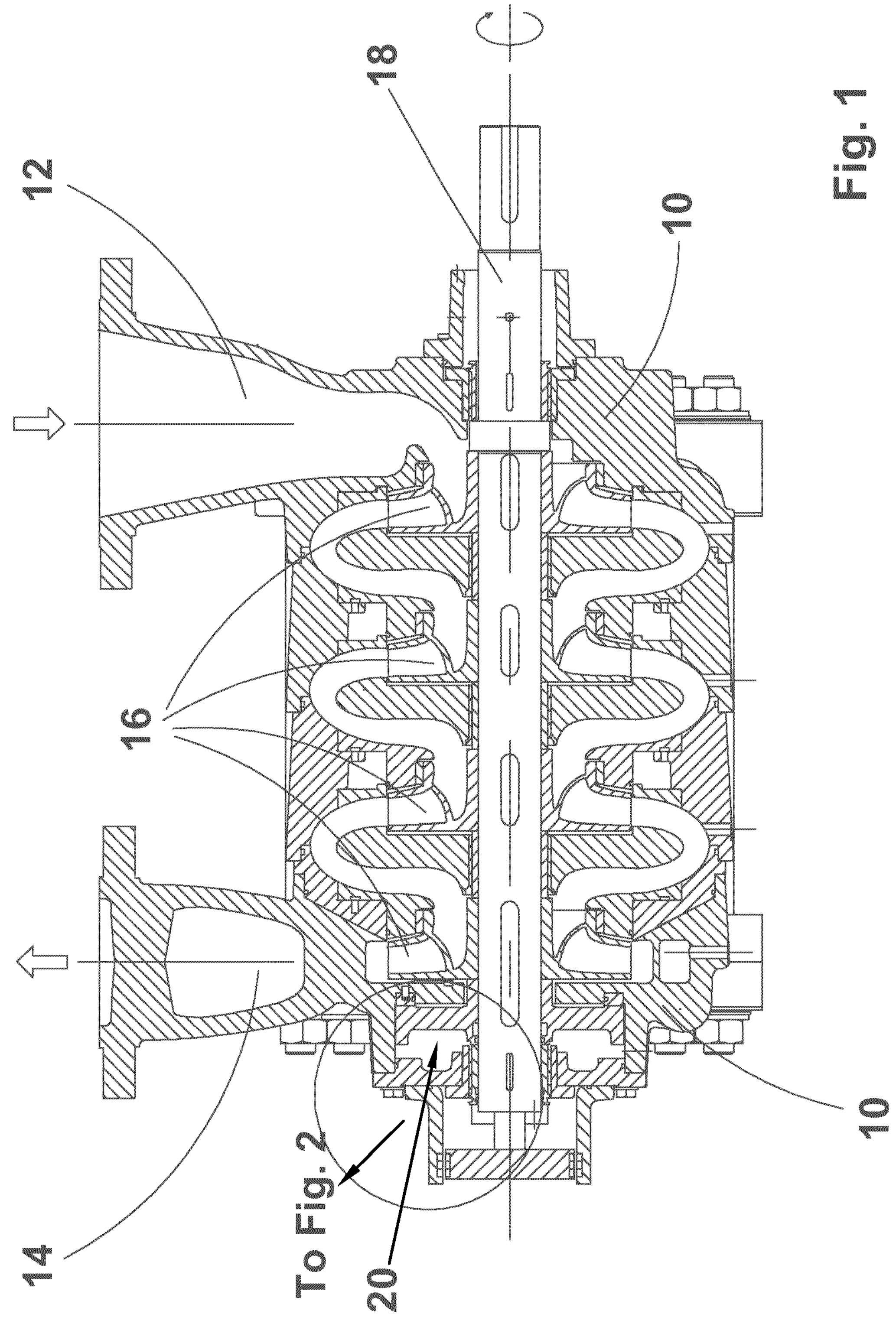

Fig. 1

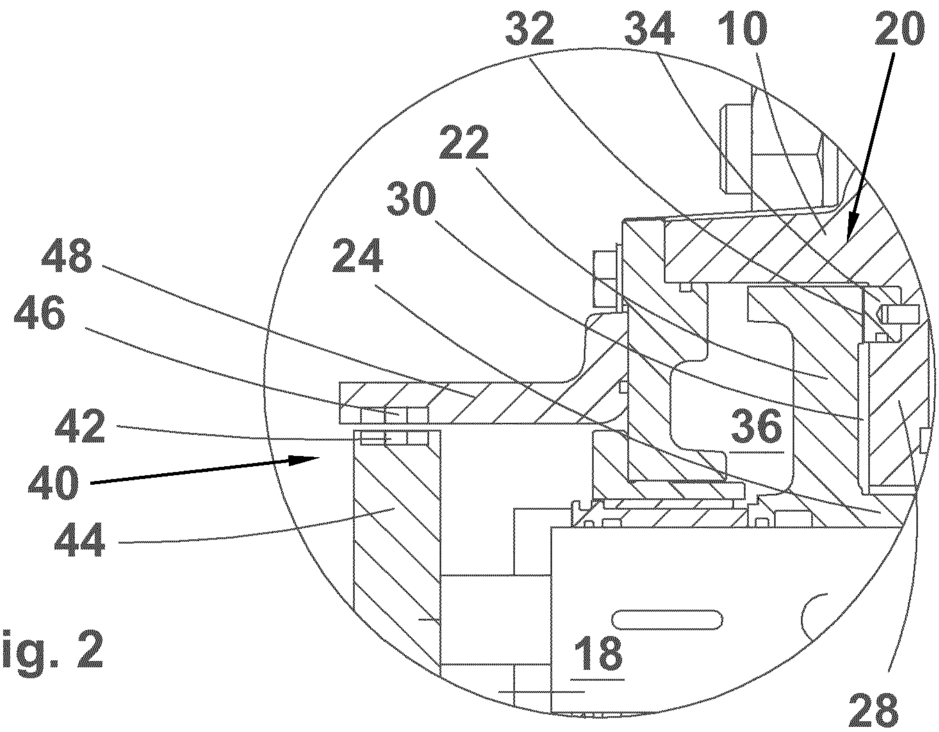
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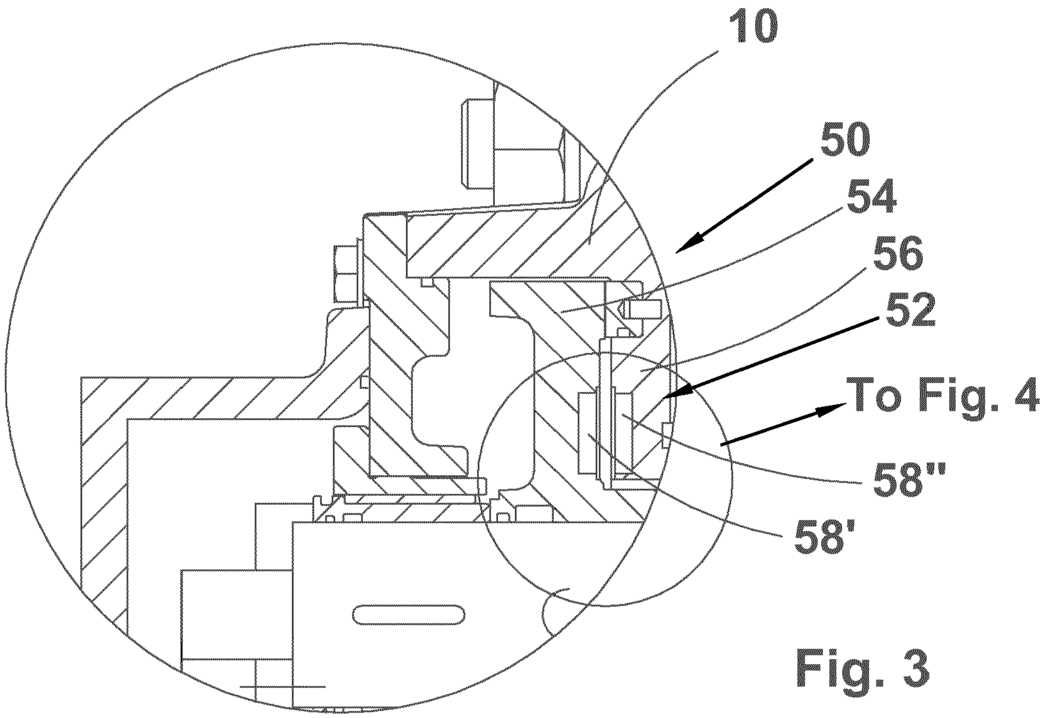
Fig. 2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To Fig. 4
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Fig. 3

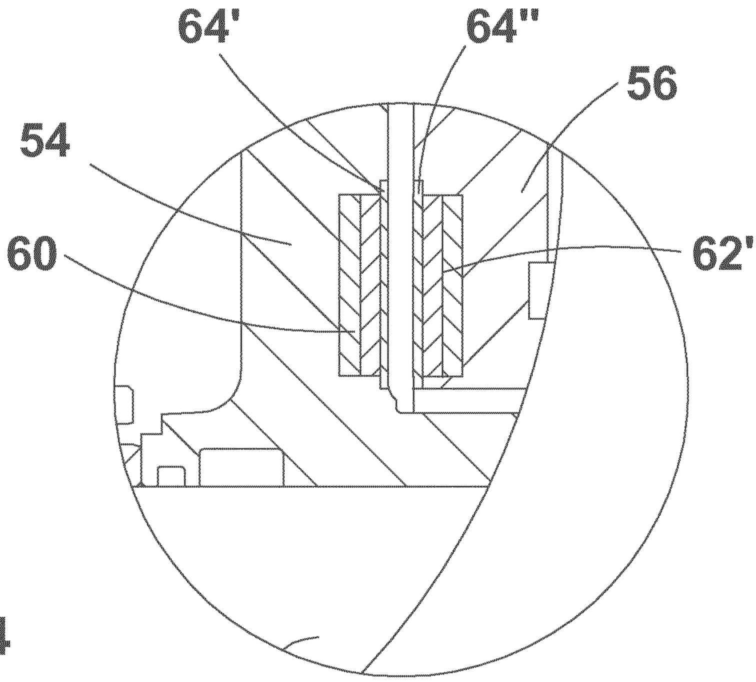

Fig. 4

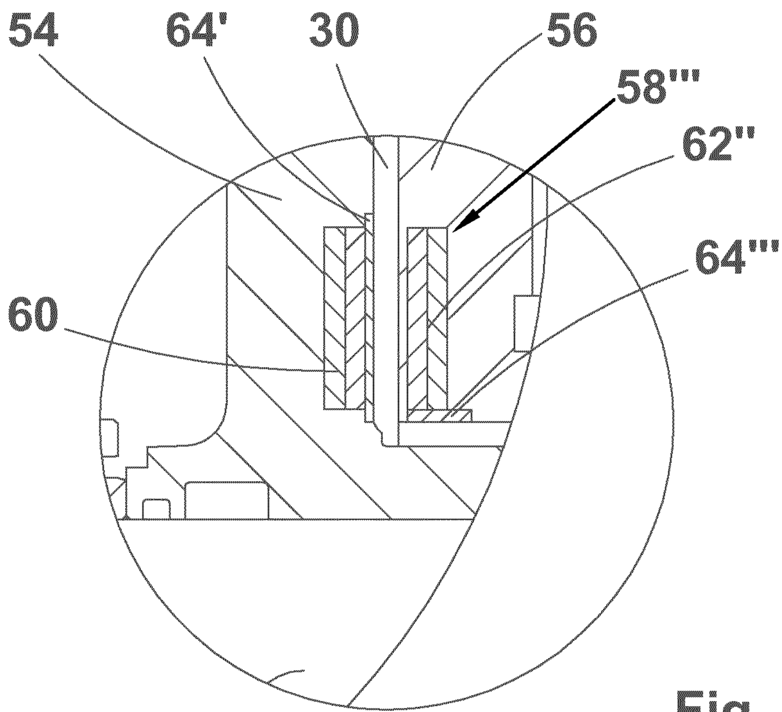

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 18 16 1862

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 38 02 950 A1 (KLEIN SCHANZLIN & BECKER AG [DE]) 10 August 1989 (1989-08-10) * column 2, line 53 - column 3, line 1 * * figures 1,2 * -----	1-12	INV. F04D1/06 F04D29/041
A	DE 10 2010 041234 A1 (BOSCH GMBH ROBERT [DE]) 29 March 2012 (2012-03-29) * paragraphs [0022], [0056] * * figures 3,7 * -----	1-4,9-12	

TECHNICAL FIELDS SEARCHED (IPC)
F04D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	14 August 2018	Gombert, Ralf

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 16 1862

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 The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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DE 102010041234 A1	29-03-2012	DE 102010041234 A1	29-03-2012
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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