



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.04.2018 Bulletin 2018/15

(51) Int Cl.:
F04D 13/02 ^(2006.01) **F04D 29/041** ^(2006.01)
F04D 29/048 ^(2006.01) **F04D 29/22** ^(2006.01)
F04D 7/04 ^(2006.01)

(21) Application number: **17209162.1**

(22) Date of filing: **20.12.2017**

(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 TN

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(30) Priority: **23.12.2016 IT 201600130493**

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(54) **MAGNETIC DRIVE PUMP**

(57) The present invention relates to a magnetic drive pump, comprising: a pump body (2); a containment shell (3) mounted in the pump body (2) and internally delimiting a housing volume (7); a support body (4) integral with the pump body (2) and/or the containment shell (3) and contained at least partly in the housing volume (7); a rotatable element (8) rotatably supported by the support body (4); an impeller (10) constrained to the rotatable element (8) and housed in a volume for passage of a working fluid. The passage volume is in fluid communication with the housing volume (7), and the support body (4) and the rotatable element (8) delimit therebetween an annular gap (20) in fluid communication with the passage volume. A first magnetized element (25) of a pair of magnetized elements is fixed with respect to the pump body (2) and a second magnetized element (26) of said pair is installed on the rotatable element (8). The magnetized elements (26, 26) of said pair are configured to generate between each other a repulsive force suitable for defining a pre-determined distance between the pump body (2) and the rotatable element (8).

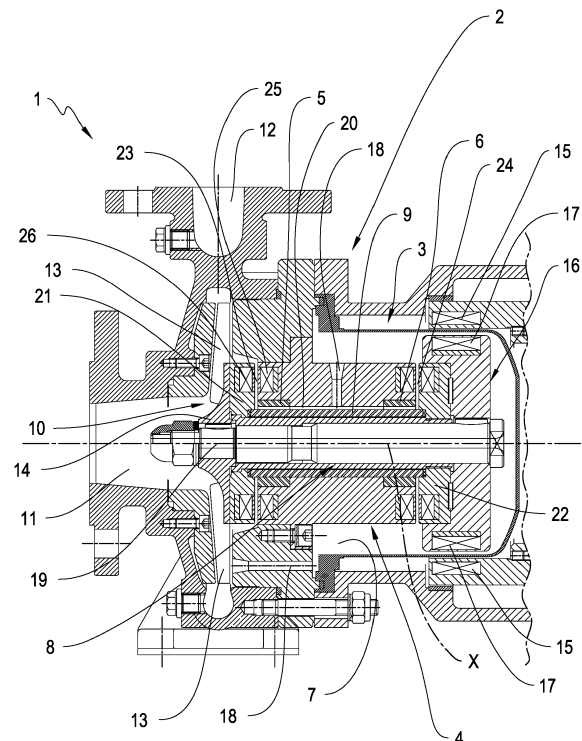


FIG.1

Description

FIELD OF THE INVENTION

[0001] The object of the present invention is a magnetic drive pump. In particular, the present invention relates to a magnetic drive pump configured to pump fluids containing solid particles. This pump can be used for example in the chemical and pharmaceutical industries for the production of liquid substances containing suspended particles.

BACKGROUND OF THE INVENTION

[0002] Magnetic drive pumps are already known per se. These pumps comprise an external pump body, a containment shell, or beaker, which is mounted in the pump body. Inside the beaker, a shaft or a sleeve integral with the pump impeller is housed so as to enable the rotation thereof. A magnetic core outside the beaker and fixed with respect to the pump body is connected to an electric motor. A magnetic core inside the beaker is integral with the shaft or the sleeve. The magnetic force that determines rotation of the impeller is transmitted from the outer core to the inner core through the wall of the beaker. The internal volume delimited by the beaker is in fluid communication with the pump impeller, that is, with the volume for passage of the fluid to be pumped, but sealingly isolated with respect to the outer magnetic core and to the outside environment (atmosphere side). The fluid thus remains sealingly confined in the beaker and in the passage volume of the pump (process side). The pumped fluid also has the function of lubricating the internal bearings/bushings and of cooling the area affected by the magnetic drive.

[0003] The magnetic drive pumps of the type described above and present on the market are designed to pump clean liquids (i.e., without solid particles) and therefore the passages between the rotating parts and the static parts are dimensioned to meet the following requirements: lubricating internal bearings, cooling the area affected by the magnetic drive, optimizing the magnetic coupling, bringing the magnets of the inner core as close as possible to those of the outer core, and improving hydraulic efficiency by adopting the impeller of the closed type in combination with a wear ring inserted in the pump body. In particular, in the pumping of clean liquids, clearances tend to be reduced so as to reduce recirculation in the suction area.

[0004] The Applicant has noted that the pumps for clean liquids are not suited for pumping liquids with solid particles as the solids have the effect of clogging the narrow passages, thus blocking the recirculation and/or the pumping of the liquid. Moreover, there are pumps specifically designed to pump liquids with the presence of solid particles, but the solutions adopted (reported below) have limitations and negative effects.

[0005] There are known magnetic drive pumps that use

wear rings (both static and rotating) to block solid particles and prevent them from reaching the rear part of the beaker. The Applicant has noted that as the wear rings have reduced clearance, in the case of cavitation of the pump, they are subject to the risk of breakage if they are made of a sintered material (e.g. silicon carbide), or to the risk of wear, if they are made of an antifriction material (e.g. PTFE/graphite).

[0006] There are also known magnetic drive pumps that comprise a filter on the delivery side, outside of the pump body. On the inside, these pumps are similar to those for clean liquids. The filtered liquid is injected in the bushing support so that the bushings and the beaker are always "wet" only by the clean liquid. The Applicant has observed that the filter is a critical element in these pumps. In fact, the filter requires maintenance (cleaning and/or replacement) to prevent it from clogging and losing its filtering characteristics. Moreover, if the filter is clogged, no more liquid reaches the bushing support and this can lead to malfunctioning and breakage. These pumps are poorly suited to treating liquids with filamentary solids and/or that tend to aggregate together, for they clog the filter mesh more easily. Additionally, the delivery pipe for the system must be adapted in order to position the filter. The fittings and the pipe between the filter and the bushing support are points at risk of leakage.

[0007] There are also known magnetic drive pumps that utilize an internal filter mounted on the bushing support. The filtered liquid is injected on the bushings and on the beaker. In this case as well, the Applicant has observed that the filter, an internal filter in this case, is a critical element for these pumps; in fact, the filter inside the pump requires constant maintenance (cleaning and/or replacement) to prevent it from clogging and losing its filtering characteristics. In the case of "clogging", the risk is that liquid may not reach the rear part of the beaker and the bushings. The filter encounters difficulty mainly in the presence of filamentary solids and/or that tend to aggregate together (clogging the mesh thereof).

[0008] There are also known magnetic drive pumps that provide for flushing with clean buffer liquid, that is, without solid particles, from an external source. The clean liquid is injected on the bushings and on the beaker at a pressure higher than the pressure of the (pumped) process liquid containing the solid particles, so as to prevent the process liquid from entering into the rear part of the beaker and wetting the bushings. This solution is complex and costly given that a pressurized system capable of supplying the compatible buffer liquid and at a pressure higher than the process pressure is required. Moreover, the buffer liquid is often quite costly.

[0009] The Applicant has also noted that many magnetic drive pumps realized for pumping liquids having solid particles employ a closed impeller that can become clogged in the presence of filamentary solids and/or that tend to aggregate together.

SUMMARY

[0010] In this regard, the Applicant has perceived the need to realize a magnetic drive pump suitable for being used with fluids containing solid particles, including filamentary particles and/or that tend to aggregate together, which involves lower costs for production, installation and maintenance and which proves to be sturdier and more reliable than those of the prior art.

[0011] In particular, the Applicant has set the following objectives:

- preventing clogging due to solid particles and thus ensuring free circulation of the process fluid and the effects originating therefrom (lubrication and cooling) at all times;
- preventing problems such as malfunctions and/or breakage due to clogging;
- drastically reducing maintenance work;
- reducing the number of pump components that require maintenance and/or replacement, such as the filter of several pumps of the prior art for example;
- generally reducing the complexity and thus the cost of magnetic drive pumps for fluids with solid particles.

[0012] The Applicant has found that the objectives indicated above, as well as other objectives, can be achieved by a magnetic drive pump configured to pump fluids, also but not only containing solid particles, equipped with permanent magnets inserted in the static part of the impeller support and in the rotating part of said impeller and that are such as to generate an axial repulsive force that ensures no contact between the rotating part and the static part, thus achieving the absence of friction between the parts and enabling free radial passage of the liquid and of the solid particles contained therein.

[0013] In an independent aspect, the present invention concerns a magnetic drive pump comprising:

a pump body;
 a containment shell mounted in the pump body and internally delimiting a housing volume;
 a support body integral with the pump body and/or the containment shell and contained at least partly in said housing volume;
 a rotatable element rotatably supported by the support body;
 an impeller constrained to the rotatable element and housed in a volume for passage of a working fluid;
 a magnetic rotor core located inside the containment shell and integral with the rotatable element, said magnetic rotor core being configured to cooperate with a magnetic coupling located externally of the containment shell, for example said magnetic rotor core being connectable to a motor, optionally an electric-type motor.

[0014] In an aspect according to the preceding aspect, the magnetic drive pump further comprises: at least one pair of magnetized elements, wherein a first magnetized element of said at least one pair is fixed with respect to the pump body and a second magnetized element of said at least one pair is installed on the rotatable element, wherein at least one radial passage is delimited between the pump body and the rotatable element, said radial passage having an axial thickness; wherein the magnetized elements of the pair are suitable for generating between each other a repulsive force along an axial direction to maintain said axial thickness.

[0015] In one aspect according to any one of the preceding aspects, the support body and the rotatable element delimit therebetween an annular gap.

[0016] In one aspect according to any one of the preceding aspects, said radial passage communicates with the annular gap.

[0017] In one aspect according to any one of the preceding aspects, said radial passage is in fluid communication with the passage volume.

[0018] In one aspect according to any one of the preceding aspects, the passage volume is in fluid communication with the housing volume.

[0019] In one aspect according to any one of the preceding aspects, the annular gap is in fluid communication with the passage volume.

[0020] The Applicant has verified that the pair of magnetized elements defines an axial magnetic bearing that eliminates "axial" contact between static portions and rotating portions, thereby eliminating wear phenomena.

[0021] Moreover, the axial thickness, which the magnetic repulsion ensures, enables the free passage of the fluid, also including possible solid particles, and the fluid can thus flow into the annular gap and lubricate any bushings that may be present there, owing to the formation of a liquid film.

[0022] The magnetic repulsion contributes to facilitating the circulation of the fluid also in the housing volume and thus to optimizing the cooling of the containment shell if the latter is made of a metal material. In fact, between the magnetic coupling, which specifically has a magnetic core that is external and can be associated with the motor, and the inner magnetic rotor core, the containment shell, or beaker, is subjected to a magnetic field induced by the rotating cores, and if the beaker is made of a metal material, an eddy current develops with heating of the same beaker as a result. In addition to lubricating the bushings, the optimized circulation of the pumped fluid effectively cools the area affected by the magnetic drive force. This circulation is made possible by exploiting the differences in pressure present inside the pump.

[0023] In at least one of the aspects stated above, the present invention can have one or more of the additional preferred aspects described herein below.

[0024] In one aspect, said first and second magnetized elements face each other and delimit therebetween said radial passage communicating with the annular gap and

in fluid communication with the passage volume.

[0025] In one aspect, said axial thickness is equal to at least 2.5 mm, optionally ranging between about 3 mm and about 4 mm. These dimensions ensure the passage of solid particles, including filamentary solids and/or that tend to aggregate together, which are present in the liquid and they make it possible to have the fluid and the solids contained therein to recirculate freely inside the pump.

[0026] In one aspect, the pump comprises a first pair of magnetized elements and a second pair of magnetized elements located at a respective first radial passage and a respective second radial passage.

[0027] In one aspect, the first magnetized elements are axially positioned inside with respect to the second magnetized elements, or, vice versa, the first magnetized elements are axially positioned outside with respect to the second magnetized elements, so as to determine the axial position of the rotatable element with respect to the support body.

[0028] The axially internal/external magnetized elements tend to push the axially external/internal magnetized elements in opposite directions, so that in addition to the axial thicknesses, the axial position of the support body is also determined by opposite axial magnetic forces.

[0029] In one aspect, the first magnetized element of said at least one pair is installed on the support body or on the pump body or on the containment shell.

[0030] In one aspect, the first magnetized element and/or the second magnetized element are permanent magnets. The axial magnetic bearing is therefore of a passive type and does not require particular maintenance.

[0031] In one aspect, the first magnetized element and/or the second magnetized element are rings, which are optionally concentric to an axis of rotation of the impeller.

[0032] In one aspect, the first magnetized element and/or the second magnetized element are housed in respective recesses. Therefore, their realization and implementation in the pump are relatively economical.

[0033] In one aspect, said recesses of the first magnetized element and of the second magnetized element face each other.

[0034] In one aspect, the first and the second magnetized element are set into the respective recesses and covered by a lining.

[0035] In one aspect, said first and second magnetized elements are not part of the electric motor.

[0036] In one aspect, the pump comprises at least a first bushing associated with the support and at least a second bushing coupled to the rotatable element, wherein said first and second bushings are concentric and delimit therebetween said annular gap in fluid communication with the passage volume.

[0037] In one aspect, said annular gap extends axially along the entire support body and/or the rotatable element.

[0038] In one aspect, said annular gap has axially opposite openings.

[0039] In one aspect, the axially opposite openings communicate with the first and the second radial passage, respectively.

[0040] In one aspect, the support body is a sleeve and the rotatable element is a shaft inserted so as to be rotatable in the sleeve. Therefore, the pump is of the type with a dynamic shaft.

[0041] In one aspect, the first pair of magnetized elements and the second pair of magnetized elements are located at opposite ends of the sleeve.

[0042] In one aspect, the first magnetized element of the first pair is mounted at a first end of the sleeve and the second magnetized element of the first pair is mounted at the impeller.

[0043] In one aspect, the first magnetized element of the second pair is mounted at second end of the sleeve and the second magnetized element of the second pair is mounted at the magnetic rotor core, particularly on the inner rotor core arranged inside the containment shell.

[0044] In a different aspect, the support body is a fixed shaft and the rotatable element is a sleeve located on the fixed shaft so as to be rotatable about said fixed shaft.

Therefore, the pump is of the type with a static shaft.

[0045] In one aspect, the pairs of magnetized elements are located at opposite ends of the sleeve and/or on opposite sides of the impeller.

[0046] In one aspect, the pump comprises a plurality of pairs of bushings that are optionally spaced away from each other, each pair being equipped with said first and said second bushing.

[0047] In one aspect, the pump comprises a plurality of first bushings and only one second bushing or vice versa.

[0048] In one aspect, said at least one first bushing has lubrication through-channels.

[0049] In one aspect, said lubrication through-channels are axial and/or radial.

[0050] In one aspect, said axial lubrication through-channels are in fluid communication with the radial lubrication through-channels.

[0051] In one aspect, said lubrication through-channels are defined by surface grooves.

[0052] In one aspect, lubrication through-channels are afforded on a radially inner surface or a radially outer surface of the first bushing.

[0053] In one aspect, lubrication through-channels are afforded on a lateral surface of the first bushing.

[0054] In one aspect, each one of the lubrication through-channels has a passage section ranging between about 20 mm² and about 25 mm².

[0055] In one aspect, the annular gap has a radial thickness of at least 2.5 mm, optionally ranging between about 3 mm and about 4 mm.

[0056] These dimensions ensure the passage of the solid particles, including filamentary solids and/or that tend to aggregate together, which are present in the fluid

and they make it possible to have the fluid and the solids contained therein to recirculate freely inside the pump.

[0057] All the passages between the rotating parts and the static parts are thus designed not to contrast the circulation of the fluid even in the presence of the solid particles mentioned hereinabove.

[0058] In one aspect, a radial clearance between the magnetic rotor core (the core located inside the containment shell) and the containment shell is greater than about 2.5 mm, optionally ranging between about 3 mm and about 4 mm.

[0059] The increase beyond 2.5 mm in the clearance between the containment shell and the magnetic rotor core (the core located inside the containment shell) makes it possible to pump, without problems, fluids with the presence of solids of a particle size exceeding 1.2 mm approximately.

[0060] In one aspect, the impeller is a closed type impeller. The closed type impeller comprises two circular walls coaxial with the axis of rotation and spaced apart from each other, wherein the blades extend between said two walls. The walls and the blades delimit closed blade compartments.

[0061] In a different aspect, the impeller is an open type impeller. The open type impeller comprises blades that extend radially and in an overhung manner from the axis of rotation and they are not enclosed between walls. The open type impeller makes it possible to pump liquids with the presence of solids without becoming blocked up (as there are no closed blade compartments). Its geometry reduces the axial thrusts to which a closed type impeller is normally subjected.

[0062] In one aspect, the impeller is at least partly made of plastic.

[0063] In one aspect, the impeller has a metal core and it is realized as a single piece without sealing gaskets between the part made of plastic and the internal metal.

[0064] In one aspect, the impeller and the rotatable element are made as a single piece, for example made of plastic.

[0065] In one aspect, the impeller is supported at a first end of the shaft and the magnetic rotor core (the core located inside the containment shell) is supported at a second end of the shaft.

[0066] In one aspect, a locking element is snap-fitted on the second end so as to axially lock at least the magnetic rotor core (the core located inside the containment shell) on said shaft, and/or the bushings and/or the second magnetized elements on said shaft. This solution facilitates the assembly of the unit.

[0067] In one aspect, through-conduits are afforded through the support body and/or the pump body, so as to set the passage volume, the housing volume and the annular gap in fluid communication with each other.

[0068] In one aspect is provided an use of magnetic drive pump according to any one of the preceding aspects (according to any one of the aspects described above) for pumping of liquids with solids, optionally liquids com-

prising solid particles.

[0069] Further characteristics and advantages will become more apparent from the detailed description of preferred, but not exclusive, embodiments of a magnetic drive pump according to the present invention.

Description of the drawings

[0070] This description is provided herein below with reference to the attached drawings, which are provided solely for purpose of providing approximate and thus non-limiting examples, and of which:

- Figure 1 illustrates an axial section of a magnetic drive pump in accordance with the present invention.
- Figure 1A is an enlargement of a part of the pump appearing in Figure 1.
- Figure 2 illustrates an axial section of a part of a magnetic drive pump in accordance with a variant of the present invention.
- Figure 3 illustrates a schematic axial section of a magnetic drive pump in accordance with a further variant of the present invention.
- Figure 4 is a schematic enlarged representation of a portion of the pumps appearing in Figures 1 and 2.
- Figure 5 illustrates a magnetized element that is part of the pumps appearing in the preceding figures.
- Figure 6 illustrates a bushing that is part of the pumps appearing in Figures 1 and 2.
- Figure 7 illustrates the impeller of the pump of Figure 1.
- Figure 8 illustrates an axial section of another part of a magnetic drive pump in accordance with a further variant of the present invention;
- Figure 9 schematically illustrates an axial section of a magnetic drive pump in accordance with a further alternative embodiment of the present invention; the pump is illustrated during a operative condition in which this latter pumps a liquid containing solid particles.

DEFINITIONS AND CONVENTIONS

[0071] It should be noted that in the present detailed description corresponding parts illustrated in the various figures are indicated with the same reference numerals. The figures may illustrate the object of the invention through representations that are not drawn to scale. Therefore, the parts and components illustrated in the figures relating to the object of the invention may only be schematic representations.

[0072] In the following description, the term pump body 2 is understood as the body generally identified as the lantern or lantern body in this sector.

DETAILED DESCRIPTION

[0073] With reference to the figures cited, a magnetic

drive pump in accordance with the present invention is indicated in its entirety by the reference number 1.

[0074] The pump 1 comprises a pump body 2, made of stainless steel for example, inside of which a containment shell 3 shaped in the form of a beaker or a cup is fixed. The pump body 2 comprises a portion that extends radially inwards and is integrally connected to a support body 4 shaped in the form of a sleeve, that is, in the form of a tube. The support body 4 has a central through-cavity that has an axis of symmetry "X". Two first bushings 5, 6, made of a sintered material for example, are installed in the central through-cavity at axially opposite ends of said cavity.

[0075] The portion of the pump body 2 that extends radially inwards is positioned at a mouth of the containment shell 3 and the support body 4 extends in an overhung manner from said portion to the inside of said containment shell 3. In other words, the containment shell 3 internally delimits a housing volume 7 and the support body 4 is partly contained in said housing volume 7.

[0076] A rotatable element in the form of a shaft 8 is inserted so as to be rotatable in the central through-cavity of the support body 4 about an axis of rotation that coincides with the axis of symmetry "X" of the through-cavity and with the axis of symmetry of the containment shell 4.

[0077] A second bushing 9 is arranged around the shaft 8 and it is integral with it. The second bushing 9 extends axially for a good part of the axial extension of the shaft 8 and lies radially facing both of the first bushings 5, 6. In other words, the first bushings 5, 6 are axially spaced one away from the other and the second bushing 9 has radially internal portions coaxial with both of the first bushings 5, 6. Between the first bushings 5, 6 and the second bushing 9, there is a certain radial clearance that is in fluid communication with the passage volume so as to enable the formation of a fluid lubrication film.

[0078] An impeller 10 is constrained to a first end of the shaft 8 which protects beyond the support body 4. The impeller 10 is housed in a volume for passage of the process fluid afforded in the pump body 2. The pump body 2 further defines an axial inlet 11 for the process fluid to enter the passage volume and the impeller 10, and an outlet 12 for the process fluid to exit the passage volume and the impeller 10.

[0079] The impeller 10 appearing in Figures 1 and 7 is an open type impeller, and it comprises, but is not limited to, four curved blades 13 that extend radially and in an overhung manner from a central hub 14. The open type impeller 10 makes it possible to pump liquids with the presence of solids without becoming blocked up. The impeller appearing in Figures 1 and 7 is made of metal and it is constrained to the shaft by means of a bolt. In other embodiments, the impeller 10 can be partly made of plastic, and/or have a metal core and a plastic lining. In another embodiment, the impeller 10 and the shaft 8 are realized as a single piece, for example made of plastic or of metal lined with plastic.

[0080] Magnets of a magnetic coupling 15 are located

around the containment shell 3, the magnetic coupling comprising an outer magnetic rotor core 15 and the magnets being connectable to a motor, for example an electric motor that is already known per se and thus not illustrated in detail.

[0081] A cylindrical element 16 is mounted on a second end of the shaft 8, said end being axially opposite the first end, and said cylindrical element 16 supports on an external peripheral edge thereof a plurality of magnets that are part of a magnetic rotor core 17. The cylindrical element 16 has a radial dimension larger than the support body 4.

[0082] The magnetic coupling 15 radially flanks the containment shell 3. The magnetic rotor core 17 also flanks a radially inner surface of the containment shell 3, but it has a radial clearance "p" (Figure 1A) - defined as the radial distance between said magnetic rotor core 17 and said radially inner surface of the containment shell 3 - greater than about 2.5 mm, for example equal to about 3 mm. This dimension enables the free passage of solid particles of a particle size exceeding 1.2 mm approximately, through an annular passage delimited between the cylindrical element 16 and the containment shell 3.

[0083] As can be noted in Figure 1, the support body 4 and the portion of the pump body 2 extending radially inwards close the mouth of the containment shell 3.

[0084] The shaft 8 internally delimits an axial through-conduit 19 that sets the inlet 11 in communication with a rear portion of the housing volume 7.

[0085] During rotation of the impeller 10 and the shaft 8, an annular gap 20 is delimited between the first bushings 5, 6 and the second bushing 9, and it is in fluid communication with the passage volume and also with the housing volume 7. The annular gap 20 is delimited also between the second bushing 9 and a surface of the support body 4 interposed between the two first bushings 5, 6. Therefore, the annular gap 20 extends for the entire axial length of the support body 4. Through-conduits 18 are afforded through the support body 4 and/or the portion of the pump body 2 that radially extends inwards, so as to set the passage volume, the housing volume 7 and the annular gap 20 in communication with each other. Said through-conduits 18, of which two are visible in Figure 1, have a passage section, for example of $25 \div 30 \text{ mm}^2$, such as to enable the passage of solid particles of a particle size exceeding 1.2 mm approximately.

[0086] According to that which is illustrated in Figure 1, a first through-conduit 18 axially extends through the portion of the pump body 2, which radially extends inwards, and sets the passage volume in communication with the housing volume 7. A second through-conduit 18 radially extends through the support body 4 and sets the housing volume 7 in communication with the annular gap 20 at a point axially comprised between the two first bushings 5, 6.

[0087] A first end of the support body / sleeve 4 faces the impeller 10, more precisely it faces a first annular body 21 integral with the impeller 10 and with the shaft

8 and axially interposed between the impeller 10 and the support body 4. A second end of the support body / sleeve 4, which is axially opposite the first end, faces the cylindrical element 16, more precisely it faces a second annular element 22 integral with the shaft 8 and interposed between the support body 4 and the cylindrical element 16.

[0088] The first end of the support body 4 and the first annular element 21 delimit therebetween a first radial passage 23. Said first radial passage 23 radially opens inwards towards the annular gap 20 and radially opens outwards towards the volume for passage of the process fluid.

[0089] The second end of the support body 4 and the second annular element 22 delimit therebetween a second radial passage 24. Said second radial passage 24 radially opens inwards towards the annular gap 20 and radially opens outwards towards the housing volume 7.

[0090] The fluid passing through the pump from the inlet 11 to the outlet 12 is also guided inside of the all passages described above. In particular, fluids can pass through the radial passages 23, 24 to reach the annular gap 20; the fluids which reach the annular gap 20 lubricate and cool the bushes 5 and 6. Moreover, thanks to the through-conduit 18 and to the conduit 19, the fluids can reach the housing volume 7 and in particular the magnetic rotor core 17; in this way, the fluids can advantageously cool the whole pump and in particular the area of the magnetic rotor core 17. The fluid recirculation is schematically illustrated in Figure 9. The specific size of the conduits and passages of the fluid (radial passages, annular gap 20, conduit 18 and conduit 19) ensures the correct passage of fluids even in the presence of solids: dimensions have been studied so that fluids with solid particles can easily pass through the pump without creating clogging of the same passages and thus allow lubrication and cooling of the pump components.

[0091] The first end of the support body / sleeve 4 has a respective annular recess in which a first magnetized element 25 is located, said first magnetized element 25 being defined by a permanent magnet that is ring-shaped, coaxial with the axis of rotation "X" and axially magnetized. As illustrated more clearly in Figure 5, the first magnetized element 25 has opposite polarities "N", "S" aligned along the axis of rotation "X".

[0092] A second magnetized element 26, having a structure substantially identical to the first magnetized element, is housed in a respective recess afforded in the first annular body 21. The opposite polarities of the first and the second magnetized element 25, 26 face each other, so as to generate an axial repulsive magnetic force between the first and the second magnetized element 25, 26 and thus between the first annular element 21 and the support body 4.

[0093] The second end of the support body / sleeve 4 also has a respective annular recess in which a first magnetized element 25 is found and a second magnetized element 26 is located in a recess in the second annular

element 22. The opposite polarities of these first and second magnetized elements 25, 26 also face each other, so as to generate an axial repulsive magnetic force between the second annular element 22 and the support body 4.

[0094] The two pairs of magnetized elements 25, 26 located at opposite ends of the support body 4 define an equal number of axial magnetic bearings that keep the first and the second annular element 21, 22 spaced away from the first and the second end of the support body 4, respectively, so as to define the first and the second radial passage 23, 24 and to maintain a predetermined axial thickness "t" (Figure 4) of each one of said radial passages 23, 24.

[0095] These magnetized elements 25, 26 are not part of the magnetic coupling for transmitting rotational movement and therefore they perform a function that differs from that of the outer and inner magnetic rotor cores 15, 17.

[0096] The axial thickness "t" is such as to enable the passage of solid particles, including filamentary particles and/or that tend to aggregate together. For example, this axial thickness "t" is equal to about 3 mm.

[0097] These axial repulsive forces also define the relative axial position of the rotatable element 8 and the support body 4.

[0098] In the embodiment illustrated in Figures 1, 2 and 4, the first and the second magnetized element 25, 26 are set into the respective recesses and covered by a lining 27 that lies flush (see Figure 4) with the adjacent surfaces of the support body 4 or of the first annular element 21 or of the second annular element 22. Therefore, at the magnetized elements 25, 26, the radial passages 23, 24 are delimited by said lining 27.

[0099] In use, when the impeller 10 rotates, performing its pumping function, driven by the motor, the process fluid, which enters from the inlet 11 and flows through the passage volume, passes through the through-conduit 18 afforded through the portion of the pump body that radially extends inwards, and reaches the housing volume 7. The fluid passes between the magnetic coupling 15 and the magnetic rotor core 17 as far as rear portion of the containment shell 3. The fluid passes through the second radial passage 24 and flows into the annular gap 20. The fluid also passes through the second through-conduit 18, which extends radially through the support body 4, and flows into the annular gap 20. In said annular gap 20, the fluid moves axially towards the impeller 10 and flows out through the first radial passage 23. From said rear portion of the containment shell 3, the fluid enters into the axial through-conduit 19 and flows out through an opening afforded on a nose of the impeller 10.

[0100] During rotation of the impeller 10, by virtue of the film of fluid in the annular gap 20, a radial thickness "r" of said annular gap 20 is equal to about 3 mm. The radial thickness "r" is such as to enable the passage of solid particles, including filamentary particles and/or that tend to aggregate together.

[0101] In order to facilitate even further the free passage of the fluid and any solid particles, the first bushings 5, 6, that is, the fixed bushings, can non-limitedly comprise axial surface grooves 28 and radial surface grooves 29 (visible in Figure 6) that define lubrication through-channels. In the example embodiment appearing in Figure 6, the axial surface grooves 28 are afforded in a radially inner surface of the first bushing 5 that lies facing the second bushing 9. The radial surface grooves 29 are afforded on a lateral face of the first bushing 5 and each one extends continuously from a respective axial groove 28. The radial surface grooves 29 enter into the respective radial passage 23, 24 so as to increase the passage section for passage of the fluid. For example, each one of the lubrication through-channels 28, 29 has a passage section of about 20 mm².

[0102] Figure 6 illustrates a non-limiting embodiment of the invention in which the pump is equipped with two magnetized elements 25, 26 and the bushings 5, 6 have the grooves 28 and 29. However, the possibility of realizing a pump with magnetized elements 25, 26 and in which the bushings are without grooves for passage of the fluid is not excluded. In fact, the magnetized elements alone are actually capable of ensuring sufficient passage of a fluid for lubrication and cooling of the components of the pump.

[0103] Figure 2 illustrates a variant embodiment of the pump 1 of Figure 1 and that differs from the pump appearing in Figure 1 in that the impeller 10 is a closed type impeller. The closed type impeller 10 comprises a disc-shaped rear wall 30 and an annular front wall 31 with a central opening 32. The blades 13 extend between said two walls 30, 31. The walls 30, 31 and the blades 13 delimit closed blade compartments.

[0104] Figure 3 illustrates a different embodiment of the pump 1 according to the invention and in which the shaft is a static shaft, that is, the support body 4 is defined by a shaft fixed to the containment shell 3 and therefore fixed with respect to the pump body 2. The rotatable element 8 supporting the impeller 10 is a rotatable sleeve inserted on the fixed shaft 8 so as to be rotatable about said fixed shaft 8.

[0105] In this embodiment, the pairs of first and second magnetized elements can be located at the opposite ends of the sleeve 4 and/or on opposite sides of the impeller 10, in the areas indicated by circles A, B and/or C in Figure 3.

[0106] In this embodiment, the first bushing(s), that is, the bushings that are fixed with respect to the pump body 2 (not illustrated in Figure 4), is/are installed on the fixed shaft 4 or on the pump body 2. The lubrication through-channels are afforded on a radially outer surface of the first bushing(s).

[0107] The second bushing or bushings, that is, the rotating bushings (not illustrated in Figure 4) are installed on the rotatable sleeve 8 and/or on the impeller 10.

[0108] Figure 8 illustrates a further variant of the pump 1 of Figures 1 and 2, and in which the cylindrical element

16 that supports the magnetic rotor core 17 and the other elements inserted on the shaft 8 are retained by a snap-fitted locking element 33 that is snap-fitted on the second end of the shaft 8.

ADVANTAGES OF THE INVENTION

[0109] The magnetic drive pump according to the present invention allows to obtain considerable advantages with respect to known pumps.

[0110] The magnetized elements 25, 26 correctly support the shaft 8 bearing the impeller 10 so as to keep the radial passages 23 and 24 open and thus ensure a continuous flow of the fluid, even with solid particles, inside the moving elements of the pump in such a way that they can be properly cooled and lubricated. It should also be noted that the magnetized elements 25 and 26 are configured to counteract axial thrusts acting on the shaft and generated by the impeller 10; if advantageously an impeller 10 of the open type is used, as it is structured, it generates a limited axial thrust on the shaft and at the same time facilitates the passage of fluids containing solids; the reduced axial thrust generated by the impeller 10 allows the magnetized elements to easily maintain the shaft 8 in position and thereby ensure the passage of fluid from the radial passages 23 and 24.

[0111] The bushes 5 and 6, on the other hand, allow the shaft 8 to be supported radially, minimizing, in particular zeroing, the vibrations; the passages defined on the bushings guarantee the correct passage of fluids even in the presence of solids. The presence of the magnetized elements 25, 26 for supporting only the axial thrusts allows to minimize, in particular zero, the vibrations avoiding unwanted stresses which could damage the pump.

Claims

1. A magnetic drive pump, comprising:

- a pump body (2);
- a containment shell (3) mounted in the pump body (2) and internally delimiting a housing volume (7);
- a support body (4) integral with at least one of the pump body (2) and the containment shell (3), said support body being contained at least partly in said housing volume (7);
- a rotatable element (8) rotatably supported by the support body (4);
- an impeller (10) constrained to the rotatable element (8) and housed in a volume for passage of a working fluid, wherein the passage volume is in fluid communication with the housing volume (7), wherein the support body (4) and the rotatable element (8) delimit therebetween an annular gap (20) in fluid communication with the

passage volume;

a magnetic rotor core (17) located inside the containment shell (3) and integral with the rotatable element (8), said magnetic rotor core (17) being configured to cooperate with a magnetic coupling (15) located externally of the containment shell (3), for example said magnetic rotor core (17) being connectable to a motor, optionally an electric-type motor;

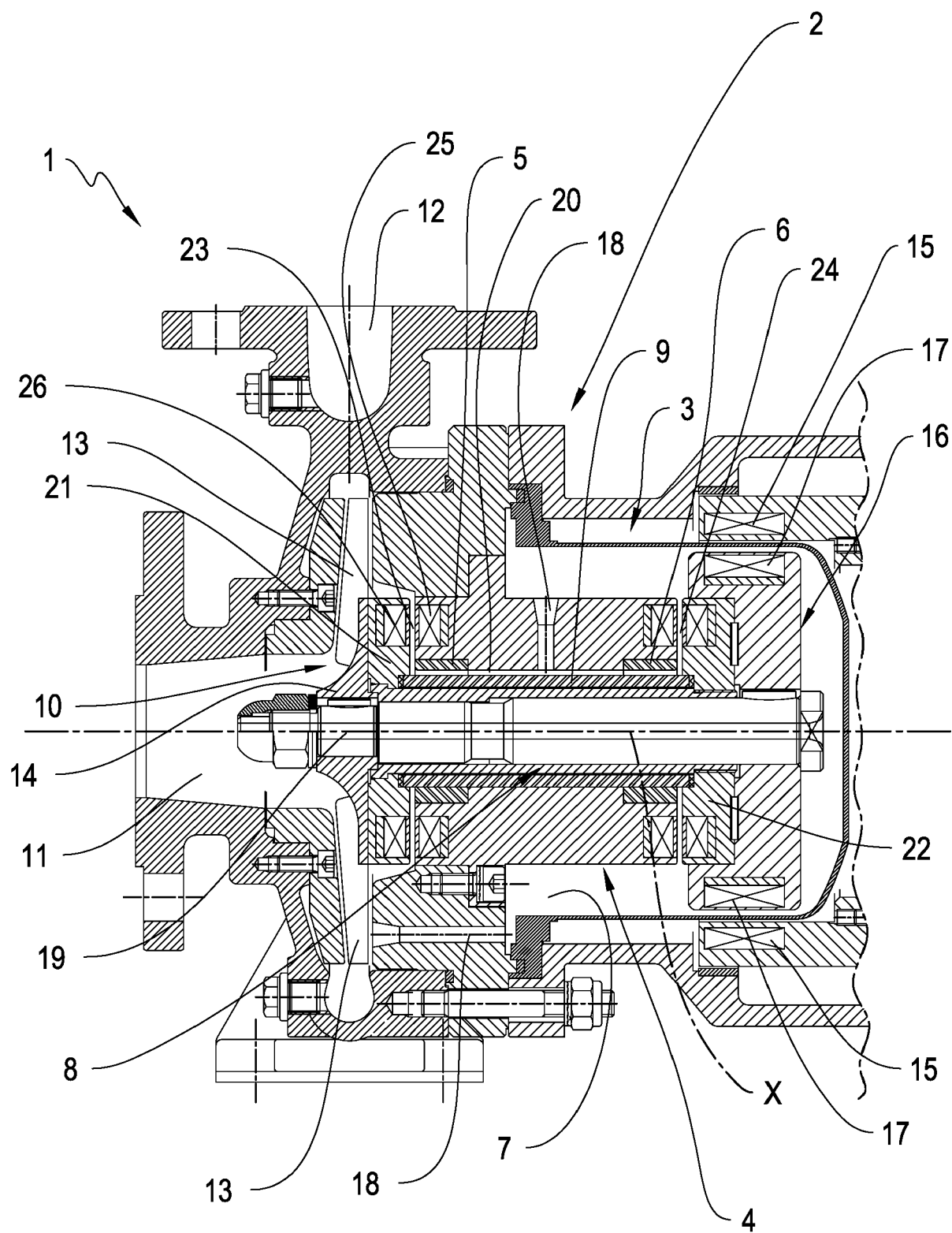
at least one pair of magnetized elements (25, 26), wherein a first magnetized element (25) of said at least one pair is fixed with respect to the pump body (2) and a second magnetized element (26) of said at least one pair is installed on the rotatable element (8);

wherein the magnetized elements (25, 26) of said pair are configured to generate between each other a repulsive force suitable for defining a predetermined distance between the pump body (2) and the rotatable element (8).

2. The pump according to claim 1, wherein the magnetized elements (25, 26) of said pair, owing to the repulsive force generated between the pump body (2) and the rotatable element (8), are configured to delimit at least one radial passage (23, 24) between the latter in communication with the annular gap (20) and with the passage volume.
3. The pump according to the preceding claim, wherein the radial passage (23, 24) has an axial thickness (t), wherein the magnetized elements (25, 26) of the pair are configured to generate between each other a repulsive force along an axial direction to maintain said axial thickness (t).
4. The pump according to claims 2 or 3, comprising a first pair of magnetized elements (25, 26) and a second pair of magnetized elements (25, 26) located at a respective first radial passage (23) and a respective second radial passage (24); wherein the first magnetized elements (25) are axially positioned inside with respect to the second magnetized elements (26) or, vice versa, the first magnetized elements (25) are axially positioned outside with respect to the second magnetized elements (26), so as to determine the axial position of the rotatable element (8) with respect to the support body (4).
5. The pump according to any one of the preceding claims, wherein the first magnetized element (25) of said at least one pair is installed on the support body (4) or on the pump body (2) or on the containment shell (3).
6. The pump according to any one of the preceding claims, wherein the first magnetized element (25)

and the second magnetized element (26) are permanent magnets and wherein, optionally, the first magnetized element (25) and the second magnetized element (26) are rings concentric to an axis of rotation (X) of the impeller (10).

7. The pump according to one of the preceding claims, wherein the support body (4) is a sleeve and the rotatable element (8) is a shaft inserted so as to be rotatable in the sleeve (4); and wherein the first pair of magnetized elements (25, 26) and the second pair of magnetized elements (25, 26) are located at opposite ends of the sleeve (4).
8. The pump according to the preceding claim, wherein the impeller (10) is supported at a first end of the shaft (8) and the magnetic rotor core (17) is supported at a second end of the shaft (8); wherein a locking element (33) is snap-fitted on the second end so as to axially lock at least the magnetic rotor core (17) on said shaft (8).
9. The pump according to one of the preceding claims, comprising at least a first bushing (5) associated with the support (4) and at least a second bushing (6) coupled to the rotatable element (8), wherein said first and second bushings (5, 6) are concentric and delimit therebetween said annular gap (20), wherein said at least a first bushing (5) has lubrication through-channels (28, 29), each one having a passage section ranging between about 20 mm² and about 25 mm².
10. The pump according to the preceding claim, wherein said lubrication through-channels (28, 29) are axial and/or radial, and wherein, optionally, said lubrication through-channels (28, 29) are defined by surface grooves.
11. The pump according to one of the preceding claims, wherein a radial clearance (p) between the magnetic rotor core (17) and the containment shell (3) is greater than about 2.5 mm, optionally ranging between about 3 mm and about 4 mm.
12. The pump according to one of the preceding claims, wherein the impeller (10) is an open type impeller.



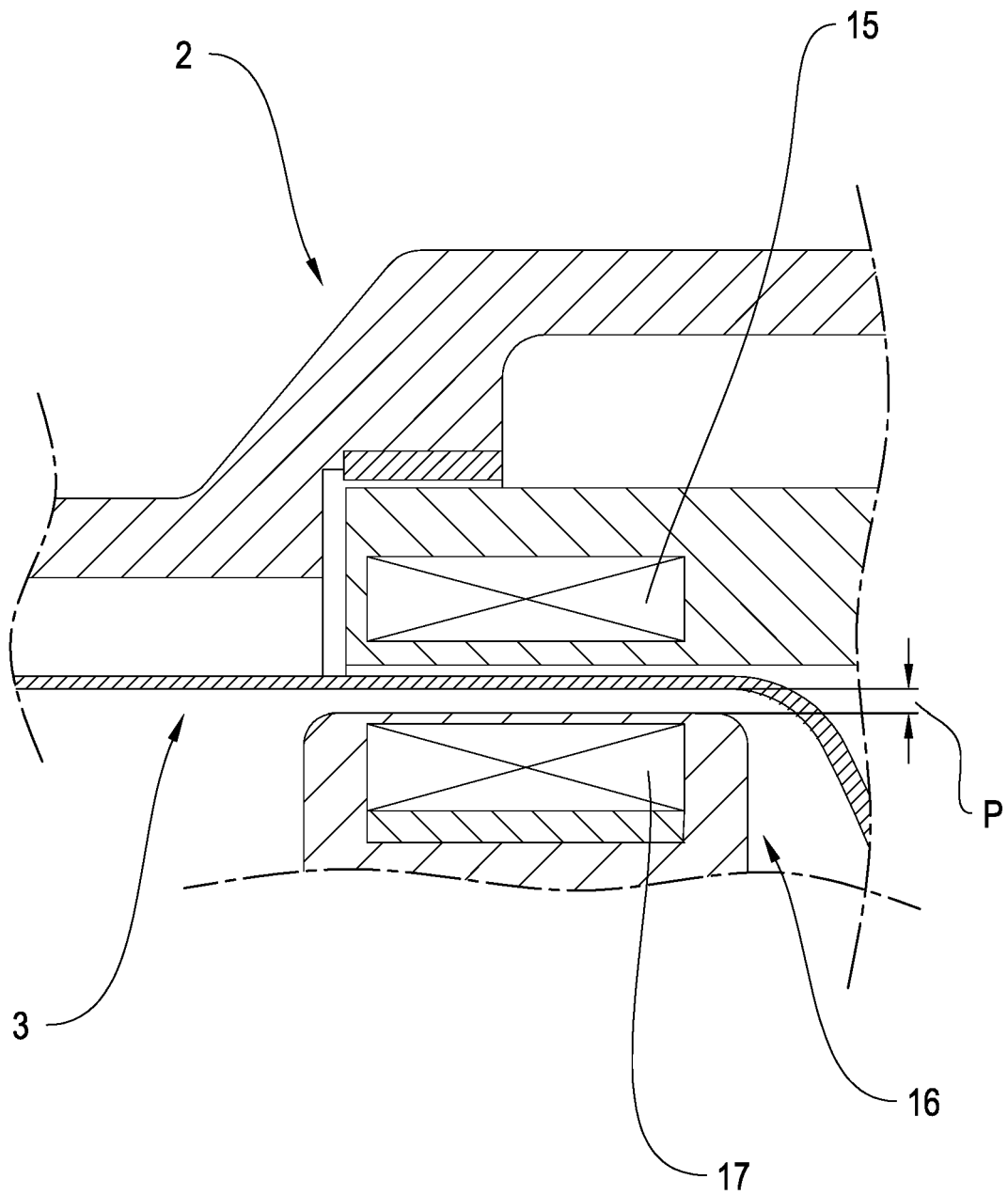


FIG.1A

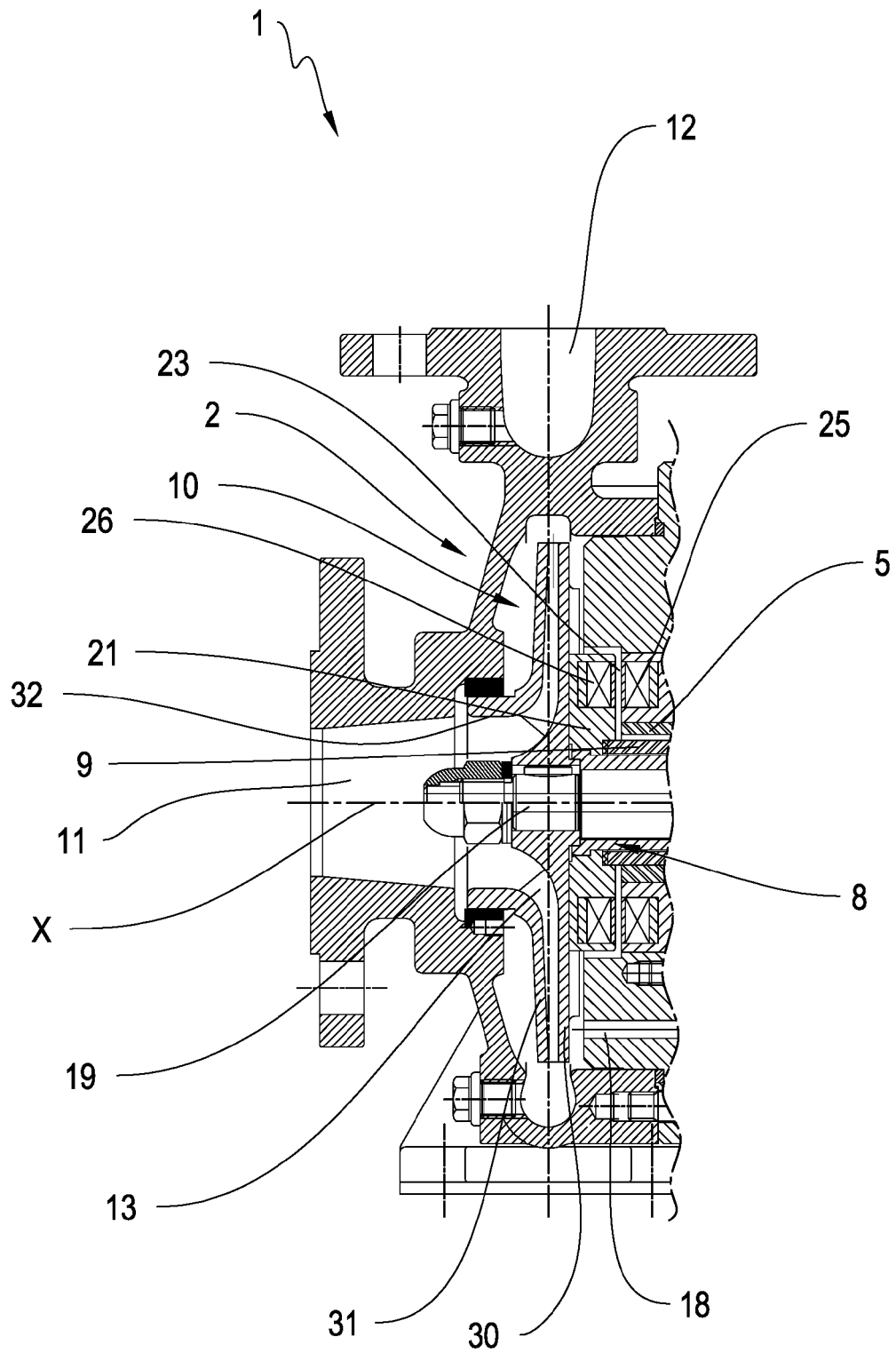


FIG.2

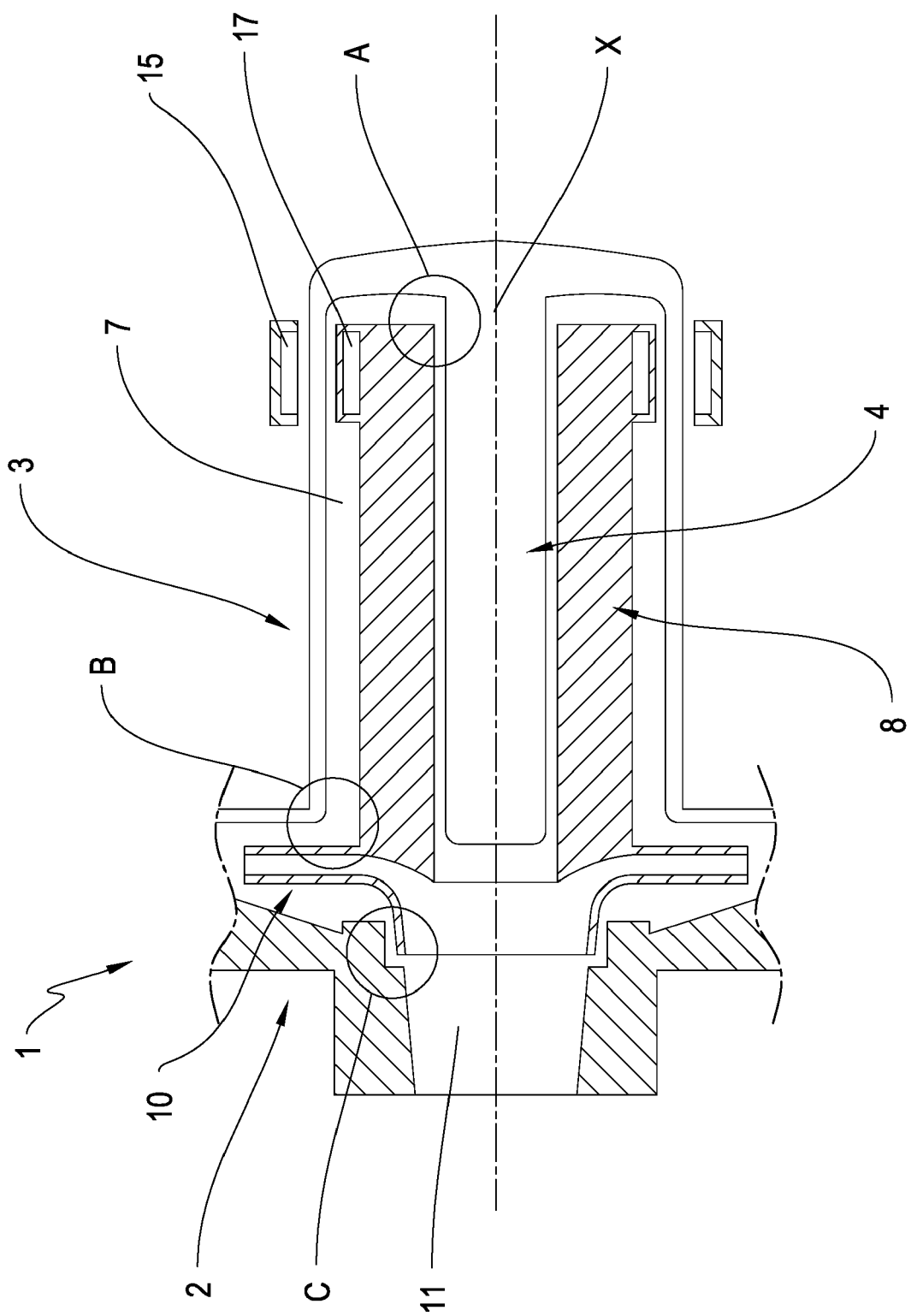


FIG. 3

FIG.4

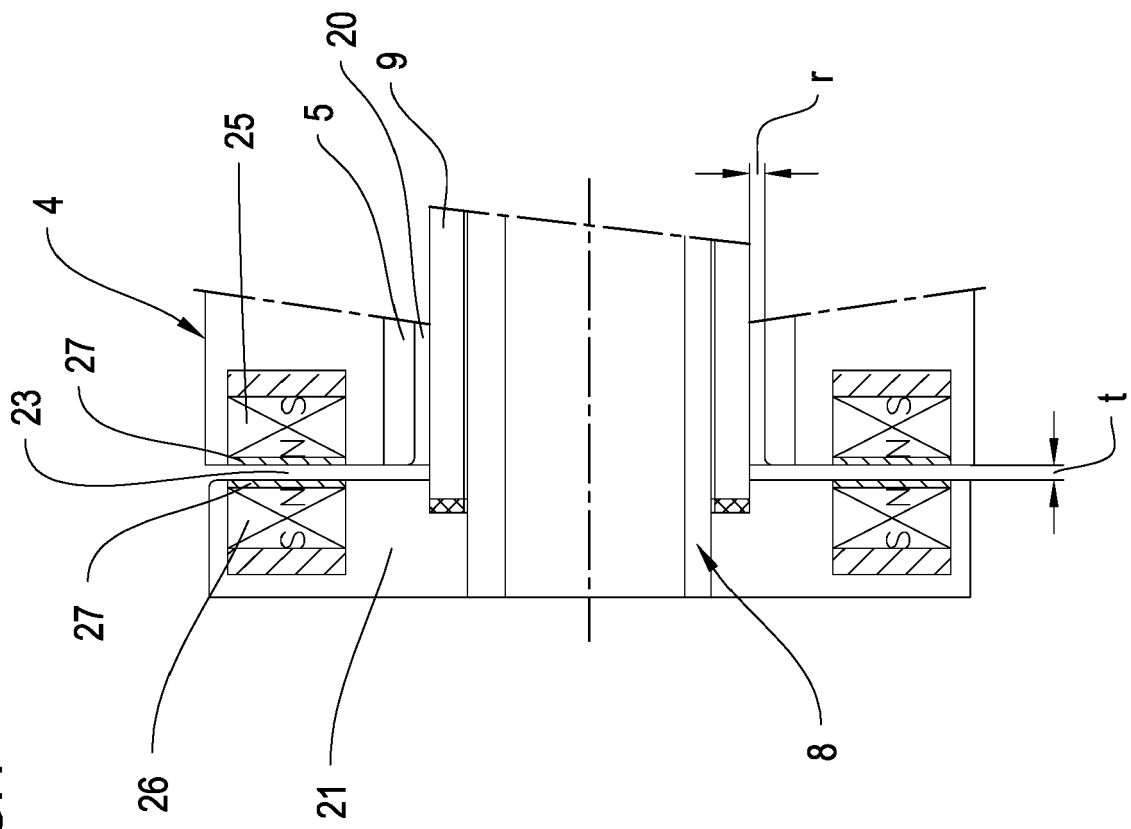


FIG.5

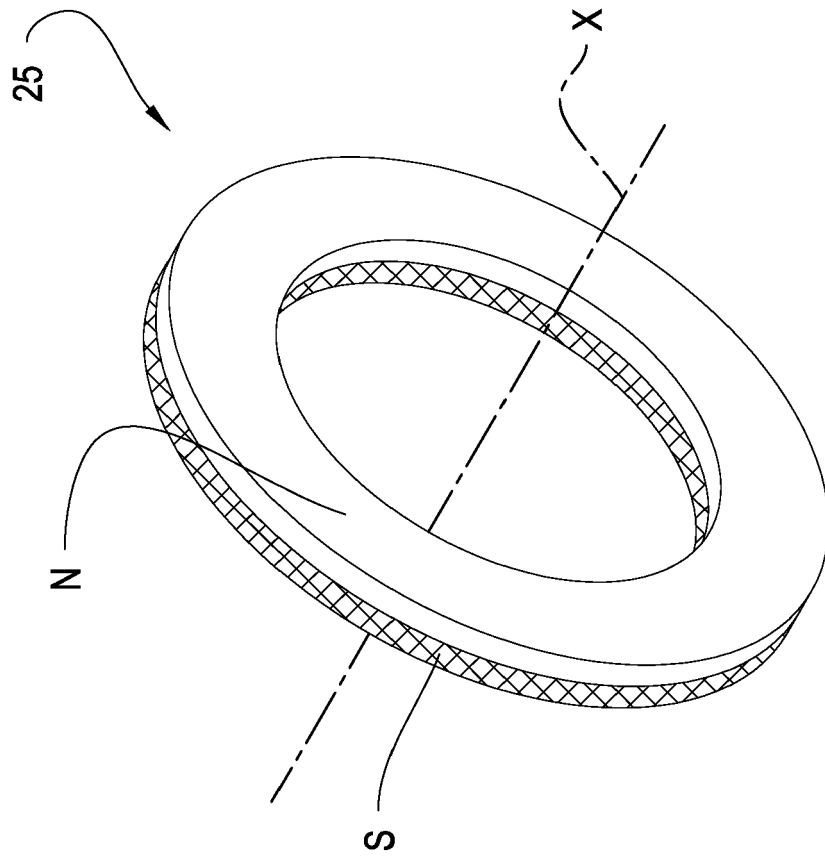


FIG.6

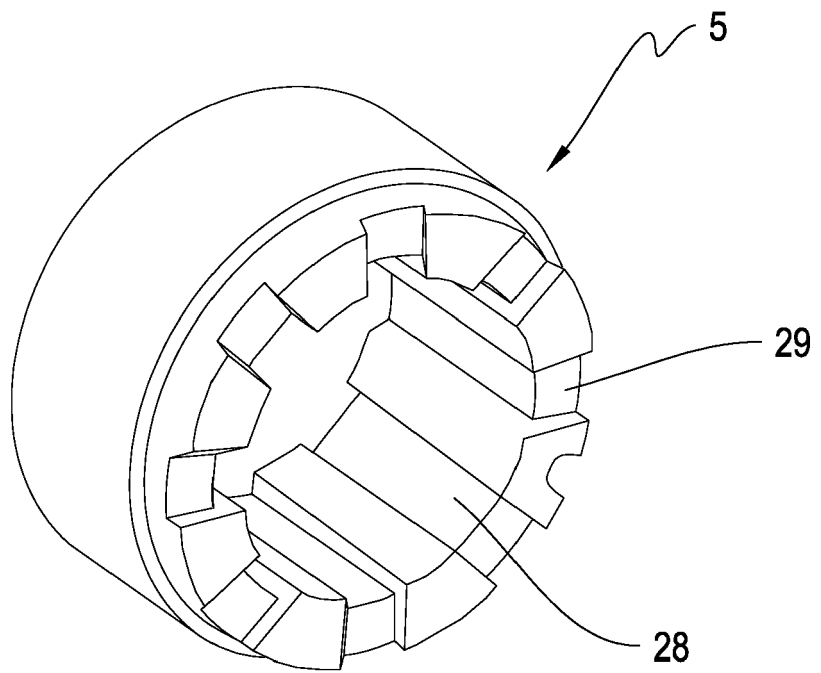


FIG.7

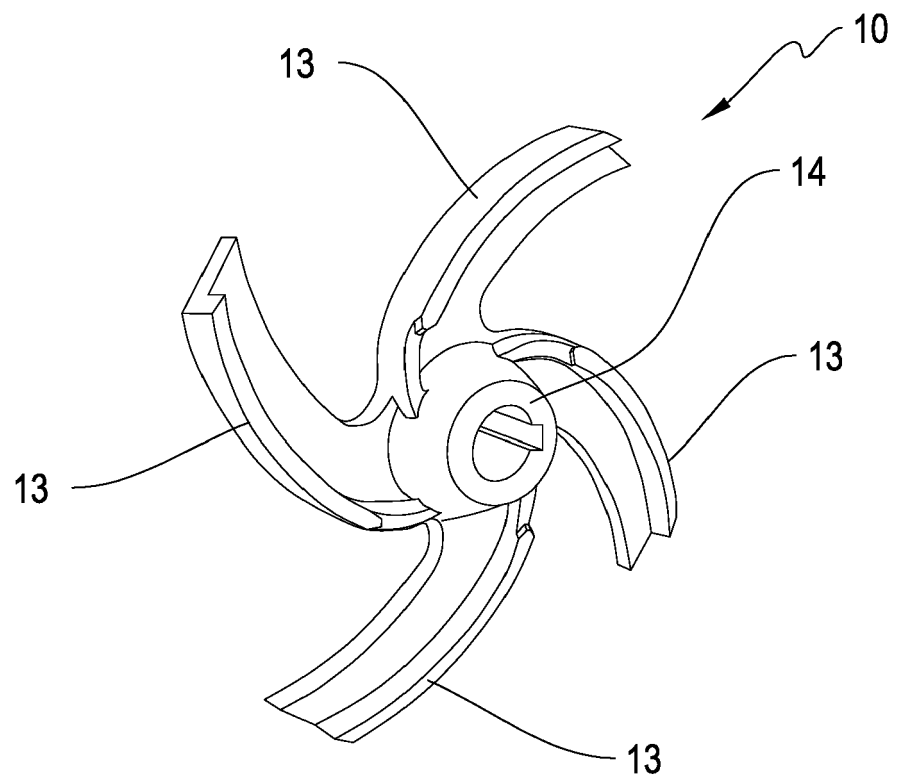


FIG.8

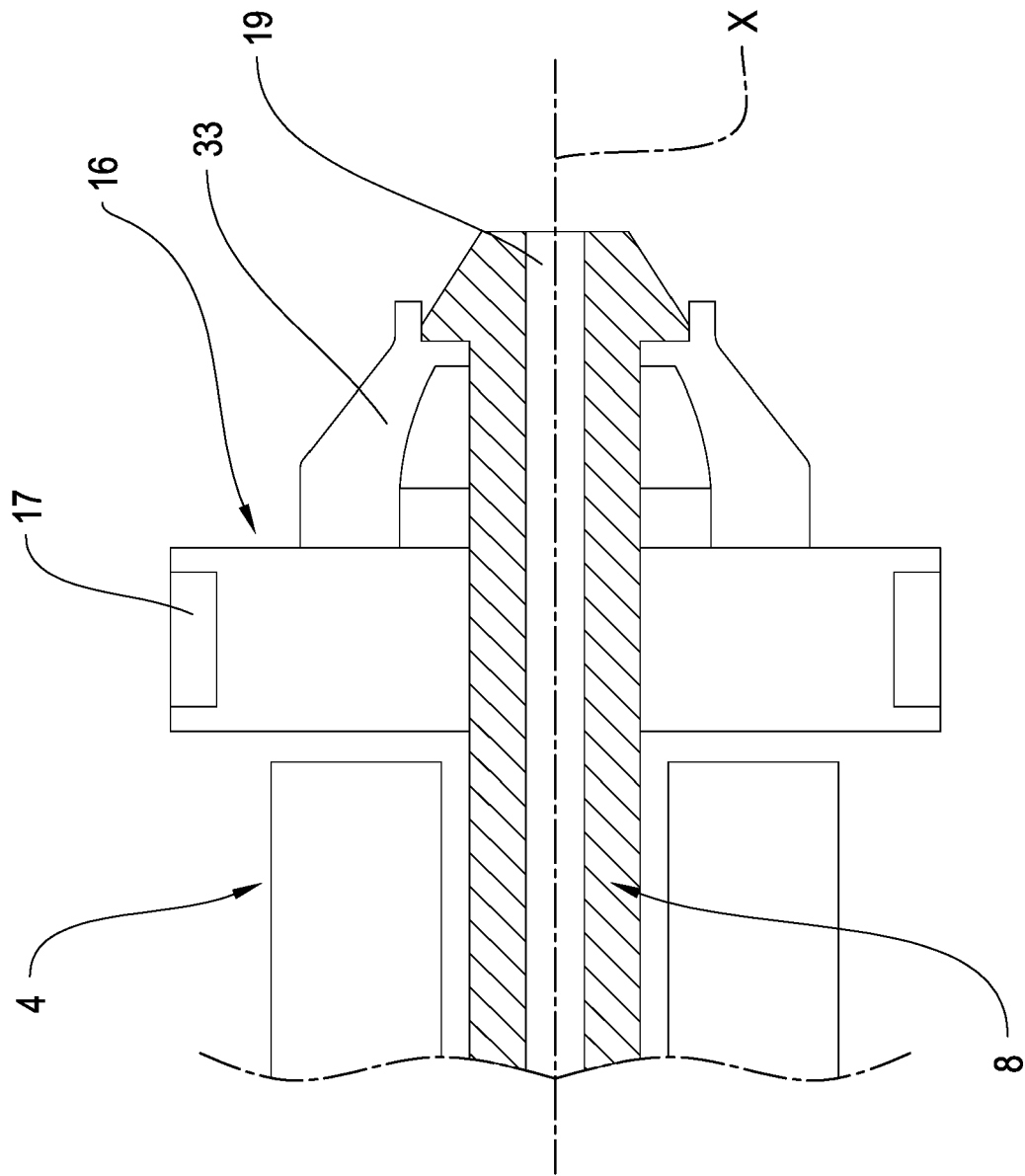
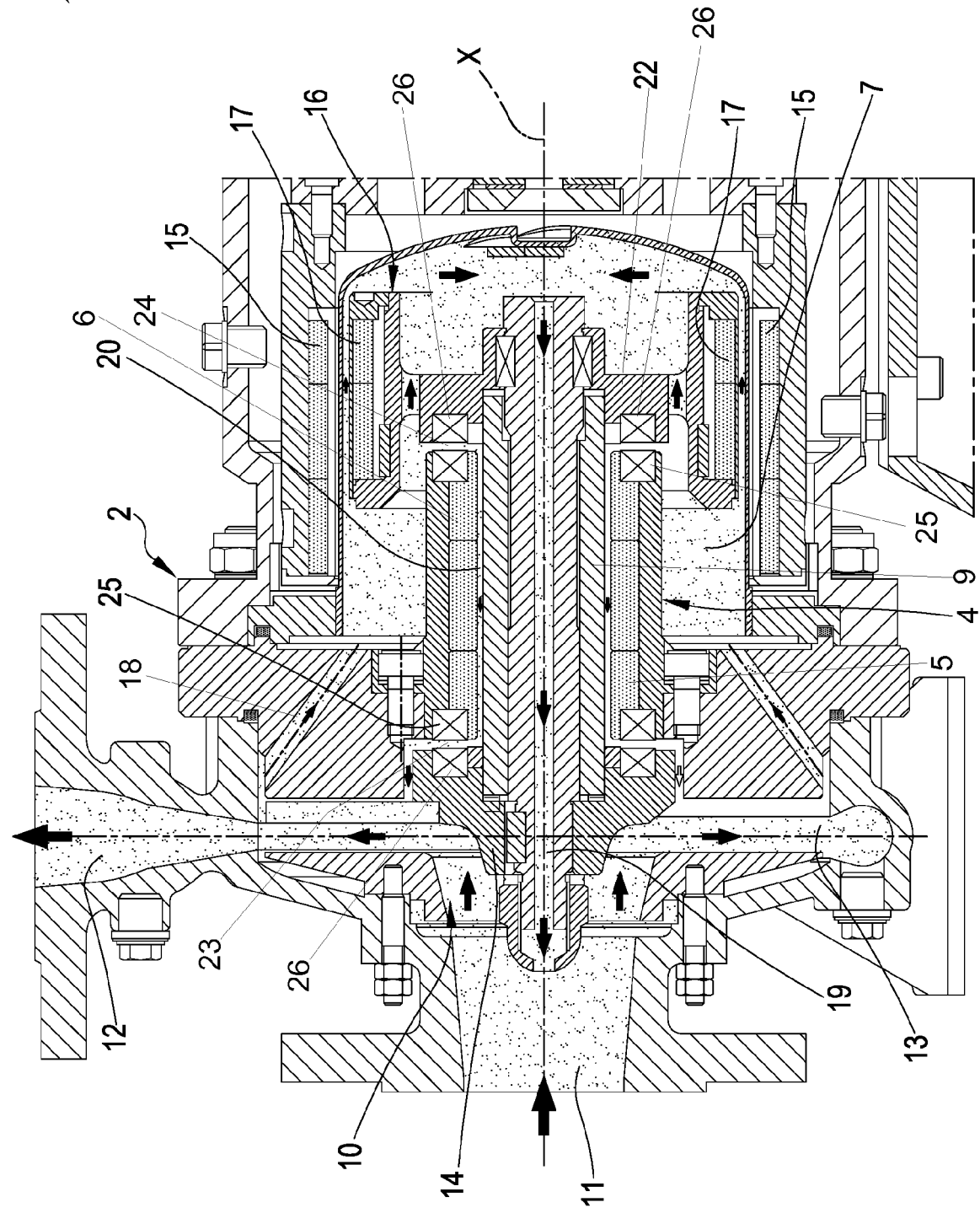


FIG.9





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Application Number
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