

(19)



(11)

EP 2 035 709 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

25.05.2016 Bulletin 2016/21

(51) Int Cl.:

F04C 2/107 ^(2006.01)

F04C 15/00 ^(2006.01)

(86) International application number:

PCT/EP2007/005788

(21) Application number: **07764955.6**

(22) Date of filing: **29.06.2007**

(87) International publication number:

WO 2008/000506 (03.01.2008 Gazette 2008/01)

(54) **MOINEAU TYPE PUMP**

MOINEAUPUMPE

POMPE DE TYPE MOINEAU

(84) Designated Contracting States:

**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE
SI SK TR**

(30) Priority: **30.06.2006 DK 200600897**

(43) Date of publication of application:

18.03.2009 Bulletin 2009/12

(73) Proprietor: **Grundfos Management A/S**

8850 Bjerringbro (DK)

(72) Inventors:

- **GRANN, Helge**
DK-8850 Bjerringbro (DK)

• **ANDREASEN, Per Højsgaard**

DK-8900 Randers (DK)

• **GRØNBORG BRUN, Esben**

DK-9000 Ålborg (DK)

• **D'ANTONIO, Sébastien**

DK-8850 Bjerringbro (DK)

(74) Representative: **Vollmann, Heiko**

Vollmann & Hemmer

Patentanwälte

Wallstrasse 33a

23560 Lübeck (DE)

(56) References cited:

WO-A-00/29741

WO-A-99/22141

GB-A- 1 583 582

US-A- 5 857 842

US-B1- 6 361 292

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

[0001] The present invention relates to a Moineau type pump, i. e. a progressive cavity pump.

[0002] Progressive cavity pumps are usually quite complex, due to the eccentric movement of the rotating part. Normally, flexible couplings or cardan joints are necessary to connect the rotor of the pump with the motor to allow the eccentricity in the movement of the motor. This increases the overall-length of the pump and also the price and weight of the pump. Further, high precision is required when machining and assembling the parts of the pump to allow the complex eccentric movement.

[0003] Further, to assure that the pump cavity is fluid-tight even at high pressures it is necessary to make at least one, the rotor or the stator, of elastic material which assures a fluid-tight contact between rotor and stator. However, this results in higher friction and wear with a reduced reliability and durability of the pump.

[0004] In view of this, it is the object of the invention to provide a simplified Moineau type pump which allows an easier and cheaper manufacturing and has improved properties in view of wear, reliability and durability.

[0005] This object is achieved by a Moineau type pump having the features defined in claim 1. Preferred embodiments are defined in the dependent subclaims, the following description and the drawings.

[0006] The invention allows a simplified design of the Moineau type pump with reduced wear and in particular allows a simplified sealing inside the pump.

[0007] One idea of the invention is to use a magnetic drive by which a simpler and more compact pump can be obtained compared to the use of another type of drive. Furthermore, such magnetic drive does not require a complex sealing, an example of this idea is given in US 6,361,292.

[0008] The Moineau type pump according to the invention has at least one outer part (outer pump element) and at least one inner part (inner pump element) which is arranged inside the outer part. The outer part has a ring-shaped configuration with a cavity in the inside which accommodates the inner part. As usual for Moineau type pumps the inner and the outer part fulfill a relative eccentric rotational movement to one another wherein the inner part is rolling on the inner ring surface of the outer part. Further, the outer surface of the inner part and the inner surface of the outer part have a helical structure forming a progressive cavity between inner and outer part to pump the fluid. The relative movement between inner and outer part can be achieved by either rotating the inner part or by rotating the outer part. It is also possible that both, the inner and outer part, are driven to fulfill a rotating movement. Therefore, according to the invention, at least the inner or the outer part act as a rotor and is driven by a magnetic field. This means that there is a magnetic coupling between the rotor and the driving element or system. Thus, a mechanical coupling between these elements, i. e. the rotor and the drive system is not required. By this, the construction of the Moineau type pump is simplified. It is not required to arrange a flexible coupling or cardan joint between drive system and rotor as would be required if connecting both by a shaft. A further advantage is that the magnetic drive allows a more compact design of the entire pump. Further, this drive concept allows an easier sealing, since it is not necessary to introduce a mechanical driving element into the interior of the pump filled by the fluid or medium to be pumped. Thus, a shaft seal is not required and the risk of leakage is minimized.

[0009] Further, according to the invention the rotor, i. e. the inner and/or the outer part, is movable in axial direction and does not comprise an axial bearing. This further simplifies the manufacturing and assembling of the pump. Since the rotor does not have an axial bearing it is free to move in axial direction. Preferably, the rotor is kept in position only by magnetic forces and/or the pressure of the fluid or medium which is pumped and acting on this rotor. Preferably, the rotor, i. e. the inner and/or outer part or element of the pump, depending on which part is driven, is designed in a way that the axial forces produced by the pressure acting on this rotor are balanced.

[0010] Preferably, the axial force acting on the rotor due to the fluid pressure in the pump chamber or cavity defined between inner and outer part is at least partly, preferably fully compensated by the outgoing fluid pressure acting on a surface of the rotor in axial direction. There may be provided a special surface on the outlet side of the rotor, preferably the end-face on which the outgoing fluid pressure acts to compensate the axial force produced by the pressure inside the pump cavity, i. e. the progressing cavity between inner and outer part.

[0011] The inside of the outer part and the inner part have a conical geometry. This means that the cavity in the outer part has a corresponding conical shape to accommodate the conical inner part. The helical structure of the inner and outer parts is arranged on the conical outer surface of the inner part and the conical ring shaped inner surface of the cavity in the outer part.

[0012] In particular, with the conical shaped geometry it is preferred that the outgoing fluid pressure of the Moineau type pump according to the invention is acting on a surface of the rotor in a direction pressing the outer and the inner part together. The rotor, i. e. the inner and/or outer part depending on the design of the pump has an adequate surface on which the pump head or pump pressure acts. This surface preferably extends in a direction normal to the longitudinal axis of the rotor so that the pressure generates an axial force in direction of this axis and acting on the rotor. The surface may be the end-face of the rotor at the outlet end, i. e. on the pressure side of the pump. By the axial force generated by the pump pressure, the inner and outer part of the pump are pressed together. This allows designing the pump so

that the contact pressure between inner and outer part increases with increasing pump pressure. Ideally, the contact pressure or contact force is zero (0) if the pump pressure is zero (0). This results in a reduced friction and starting torque and reduced wear in the pump. With increasing pumping pressure also the contact force or pressure between inner and outer part increases so that a fluid tight contact between both parts can be achieved even at high pressures. The contact

force increases proportionally with the pump pressure.

[0013] Further, this design does not require an axial bearing of the rotor, since the rotor can be held in position by the contact between the rotor and the other part or element in one axial direction and in the other axial direction by the pump pressure acting on the surface of the rotor in axial direction. Thus, the rotor in axial direction is fixed in the other part of the pump. In case that the inner part serves as a rotor, the inner part is pressed against the outer part. In case the outer

part serves as rotor, the outer part is pressed against the inner part.

[0014] Further, by use of a magnetic drive the axial movability of the rotor can easily be achieved, since it is not required to provide a mechanical coupling which allows this axial movement in the driving system.

[0015] The magnetic drive preferably comprises at least one first magnet fixed on the rotor and one interacting second magnet fixed on a rotatable driving element. Preferably several first and several second magnets are uniformly distributed around the circumference of the rotor and the driving element. The rotatable driving element may be mounted axial and radial bearings so that it can perform a rotational movement along a rotation axis. The driving element may be driven for example by an electric motor or other suitable drive means. The torque of the rotatable driving element is transferred to the rotor of the Moineau type pump by the first and second magnets which are arranged so that the second magnet fixed on the rotatable driving element drives the first magnet which results in a rotation of the rotor. Preferably, the rotation axis of the driving element is identical to the rotation axis of the rotor, i. e. driving element and rotor are rotating in a concentric manner. Nevertheless, it is also possible that the rotor fulfils an eccentric movement whereas the driving element fulfils a rotation about its rotation axis. If there is sufficient space between the first and second magnets in radial direction a certain eccentric movement of the rotor relative to the driving element is tolerable. However, if the distance between first and second magnets is too big the efficiency of the magnetic drive is decreased. Therefore, the eccentricity of the movement of the rotor is limited to a certain amount. However, for this tolerable amount of eccentricity the drive of the rotor by use of the magnets is much simpler than a mechanical coupling which would require a flexible joint.

[0016] The use of magnets to transfer the rotational movement on the rotor has the advantage that no mechanical coupling between the driving element and the rotor is required. Further, the axial movement of the rotor is no problem with such magnetic coupling, since the magnetic coupling easily can tolerate a certain axial movement between rotor and driving element which preferably is fixed in the axial direction. Further, it is easier to seal the interior of the pump to the outside, since the magnetic field can penetrate a wall limiting the interior of the pump which is filled with the fluid or medium to be pumped. Thus, according to a preferred embodiment a rotor can be arranged between the rotor and the driving element. This allows to completely encapsulating the interior of the pump which is filled with the medium or fluid to be pumped. It is not necessary to introduce a driving shaft in this interior of the pump. The driving element can be arranged outside the rotor can or housing and the second magnets are rotating outside the rotor can. The rotor with the first magnets is arranged inside the rotor can and is driven by the at least second magnets rotating outside the rotor can.

[0017] Preferably, the first and/or the second magnets are permanent magnets. This allows an easy and reliable construction of the magnetic drive.

[0018] According to a further embodiment of the invention, seen in the longitudinal direction of the pump, the first and second magnets are positioned near the point where the eccentricity between inner and outer part has its minimum, and preferably in zero.

[0019] In a normal Moineau type pump the inner and outer part fulfil an eccentric rotational movement relative to one another. This means for example the inner part acts as a rotor and is rotating around its longitudinal axis, this longitudinal axis itself additionally is rotating around the longitudinal axis of the outer part, the stator. In Moineau type pumps having a conical design of inner and outer part as described above it is preferred that the eccentricity of the movement of inner and outer part is not constant but linearly decreasing from the thin end to the thick end of the pump. This means the longitudinal axis of the inner and outer part are intersecting in one intersection point in which the eccentricity is zero (0). According to the preferred embodiment the magnets in the longitudinal direction of the pump are placed close to, preferably directly at the point of minimum eccentricity, which preferably is the intersection point of both longitudinal or rotation axis. The magnets may extend in longitudinal direction and may in this direction extend over the point with the minimum eccentricity. At this point, the magnets will have a very limited eccentric movement which improves the efficiency of the magnetic drive. Further, this arrangement of the magnets at the point or in the area of minimum eccentricity allows a greater maximum eccentricity of the pump. Normally, by use of a magnetic drive the eccentric movement is very limited since the distance between first and second magnets, i. e. the distance between the magnets of the rotor and the drive elements must not exceed a certain maximum. Further, it is preferred that the distance is substantially constant over the revolution to assure a uniform and constant rotation and torque acting on the rotor. This situation is given at the point of minimum eccentricity.

[0020] It has to be noted that the arrangement of the first and second magnets at a position near the point where the

eccentricity between inner and outer part has its minimum is not limited to the design in which the rotor is movable in axial direction. Such arrangement of the magnets may be also used together with pumps in which the rotor is not movable in axial direction.

[0021] In a further preferred embodiment the magnetic field driving the rotor besides the rotational force generates and axial magnetic force acting between the inner and the outer part of the pump. Thus, the axial force generated by the magnetic field used to drive the rotor can be used to achieve further benefits.

[0022] The axial magnetic force may be generated by the first and second magnets; wherein at least one first magnet is fixed on a rotor and at least a second magnet is fixed on a driving element. The axial magnetic force may result from an axial displacement of at least one first magnet fixed on the rotor and at least one second magnet fixed on a rotatable driving element.

[0023] Depending on the direction of this axial displacement the axial magnetic force can act in opposite directions. This means, if for example the second magnet relative to the first magnet is displaced to a first axial end of the pump the axial force acting on the rotor is directed towards this first end, i. e. tries to move the rotor to this first end. If the second magnet is displaced to the opposite second end the axial force will act in the opposite direction towards this second end.

[0024] Depending on the direction in which the axial magnetic force is acting, this force may be used for different functions.

[0025] In case that the inside of the outer part and the inner part are of conical geometry the axial force generated by the magnetic force may be either directed to press the inner and outer part together or may be directed to force apart the inner and the outer part. In the case in which the axial magnetic force presses the inner and the outer part together this force may be used to at least partly compensate the axial force generated by the fluid pressure inside the pumping cavity between the inner and outer part of the pump. A further advantage is that the inner part can be held in contact with the outer part when the pump is not running and no fluid pressure is acting on the inner and/or outer part of the pump. In case that the axial magnetic force is directed to force apart the inner and the outer part the contrary effect may be achieved that in non-running state of the pump the inner and outer parts are held with a certain distance between both parts. Thus, when the pump is not running preferably there is no contact force and friction between inner and outer part. By this, the starting torque and the wear of the pump are reduced.

[0026] In the following preferred examples of the invention are described with reference to the accompanying drawings. In the drawings:

Fig. 1 is a schematic cross-section of a Moineau type pump according to a first embodiment of the invention,

Fig. 2 is a schematic cross-section of a Moineau type pump according to a second embodiment of the invention,

Fig. 3 is a schematic cross-section of a Moineau type pump according to a third embodiment of the invention,

Fig. 4 is schematic cross-section of a fourth embodiment of a Moineau type pump according to the invention,

Fig. 5 is a diagram showing the axial forces versus the rotational angle for several concepts of Moineau type pumps,

Fig. 6 is a schematic cross-section of a further embodiment of a Moineau type pump according to the invention,

Fig. 7 is a schematic cross-section of a further embodiment of a Moineau type pump according to the invention,

Fig. 8 is a schematic representation of an arrangement of magnets for a magnetic drive of a Moineau type pump according to the invention,

Fig. 9 is a schematic cross-section of a Moineau type pump according to a further embodiment of the invention and

Fig. 10 is a schematic cross-section of a Moineau type pump according to a further embodiment of the invention.

[0027] The preferred embodiments are improved Moineau type pumps or gears wherein the torque transfer to the rotor is effected by a magnetic field, preferably produced by permanent magnets, and wherein the rotor is conical.

[0028] These pumps are axially very compact since the drive is part of the pumping device. Further, the pumps are composed of very few parts and do not require a coupling, shaft seal, bellow no-bearing for the rotor and a rotor shaft which may cause failure. Further, the use of a magnetic coupling or drive allows making the pump fluid-tight to the outside without the risk of leakage.

[0029] A first concept or preferred embodiment of the invention is shown in Fig. 1. The real pump consists of an inner

pump part or element 2 and an outer pump part or element 4. The outer part 4 is ring-shaped having a conical cavity 6, in which the conical inner part 2 is accommodated. As usual for Moineau type pumps the inside of the cavity 6 has a helical structure and the outside of the inner part 2 has a corresponding helical structure wherein the helical structure of the outer part 4 has one more thread or tooth than the helical structure of the inner part 2.

[0030] In the embodiment according to Fig. 1 the inner part 2 acts as a stator and is fixed in the pump housing 8. The outer part acts as a rotor and is rotatable around the inner part 2, thereby making an eccentric movement relative to the inner part 2. The outer part 4 is driven by a magnetic drive. First magnets 10 are fixed on the outer circumference of the outer part 4. Second magnets 12 are fixed on a driving element 14 surrounding the outer part 4. The driving element 14 is connected with a drive motor (not shown in Fig. 1) and rotatable about its longitudinal axis. Preferable the rotational axis of the driving element 14 is identical with the longitudinal axis of the inner part 2.

[0031] The first magnets 10 and second magnets 12 are arranged so that they face each other, i. e. are arranged on circumferential surfaces of the driving element 14 and the outer part 4 facing one another. Between the driving element 14 and the outer part 4 a rotor can 16 is arranged. The rotor can 16 is fixed and sealingly connected with a pump housing 8. The rotor can 16 and the pump housing 8 define the interior of the pump which is filled with the fluid or medium to be pumped. This means the driving element 14 is arranged completely outside this interior space of the pump filled with the fluid to be pumped and does not come into contact with this fluid or medium. Since the torque is transferred to the rotor, i. e. the outer part 4 completely by the magnetic field it is not necessary to have a driving element passing through a wall of the pump housing 8 or through the rotor can 16. Thus, no shaft sealing is required.

[0032] When the drive element 14 rotates about its longitudinal axis, the magnets 12 are rotating around the outer part 4 and the magnetic field produced by the second magnets 12 drive the first magnets 10 fixed on the outer part 4 so that the outer part 4 rotates together with the driving element 14. The magnets 10 and 12 are permanent magnets. The rotor can 16 preferably made from plastic so that the magnetic field is not influenced by this rotor can.

[0033] The fluid or medium to be pumped enters the pump through inlet 18. The inlet is an inlet tube extending inside the inner part 2 in longitudinal direction. The inlet 18 is arranged to the thicker end face of the conical inner part 2. The inlet tube is opened on the thinner end of the inner part 2 and enters the pump cavity between inner part 2 and outer part 4 from the thinner end of the conical shaped inner part 2 and outer part 4. The pump cavity is axially progressing from the thinner end to the opposite other end of the outer part 4 when the outer part 4 is driven by the driving element 12. On this thicker end of the outer part 4 the fluid leaves the pump cavity between inner part 2 and outer part 4. Then, the fluid enters the space 20 between the outer part 4 and the rotor can 16 and is directed to outlet 22.

[0034] In the space 20 the pumping pressure or pump head built up by the pump acts on the outside of the outer part 4 in the direction A in Fig. 1, which is parallel to the longitudinal axis of the inner part 2. By this the outer part 4 is pressed on the inner part 2 by an axial force generated by the pump pressure acting on the outside of the outer part 4.

[0035] Since in this embodiment the outer part 4 is pressed onto the inner part 2 by the pump pressure produced by the pump no axial bearing is required for the outer part 4. The outer part 4 in axial direction is hold by a pressure balance between the pressure inside space 20 and the pressure inside the pump cavity between inner part 2 and outer part 4.

[0036] Fig. 2 shows as an example a second embodiment or concept of a Moineau type pump according to the present invention. In this second embodiment the inner part 2' is rotating inside the outer part 4' which is fixed in the pump housing 8'. As described before the cavity inside the outer part 4' and the inner part 2' are of conical shape and have helical structures on their surfaces.

[0037] The inner part 2' is driven by a driving element 14' arranged in a clearance or cavity inside the inner part 2'. The inner part 2' is cup-shaped and on the inner circumference of the inner part 2' first magnets 10' are arranged and facing inwards. A rotor can 16' is projecting into the cavity of the inner part 2' and is also cup-shaped. Inside the rotor can 16' a driving element 14' is arranged. The driving element is rotatable along its longitudinal axis and carries second magnets 12' on its outer circumference surface so that the second magnets 12' face the first magnets 10'. The driving element 14' is connected with a driving motor which is not shown in Fig. 2.

[0038] When rotating the driving element 14' the magnets 12' on the outside of the driving element 14' force the first magnets 10' fixed on the inside of the inner part 2' because of the magnetic field between the magnets 10' and 12' to rotate together with the driving element 14'. By this, the inner part 2' is rotated inside the outer part or element 4'. By this, the fluid or medium to be pumped is sucked into inlet 18' and pumped by the pump cavity 24 which is progressing in longitudinal direction. After leaving the pump cavity 24 between inner part 2' und 4' the fluid or medium flows inside the inner part 2' through the space between the outer side of rotor can 16' and inner side of inner part 2' to outlet 22'. Thus, the pump pressure of pump head is built-up inside the inner part 2' so that inner part will be pushed against the outer part 4'. Because of the larger diameter compared to the embodiment of Fig.1 this second embodiment shown in Fig. 2 can achieve more flow.

[0039] A third embodiment is shown in Fig. 3. similar to the embodiment shown in Fig. 1 also in the embodiment shown in Fig. 3 the outer part 4" is driven by a driving element (in Fig. 3 not shown). For this purpose first magnets 10" are fixed on the outer circumference of outer part 4". The outer part 4" is housed in a rotor can 16" as explained with reference to Fig. 1. Outside the rotor can 16" a driving element can be arranged similar to the embodiment in fig. 1.

[0040] The inner part 2" is fixed and connected with the pump housing 8".

[0041] The difference of the embodiment of Fig. 3 compared to the embodiment shown in Fig. 1 is the arrangement of the inlet. According to the embodiment in Fig. 3 the inlet for the fluid into the pump cavity is arranged in the middle of the inner part 2" and the outer part 4" seen in longitudinal direction. Both, the inner part 2" and the outer part 4" in this example are made of two sections 2"a, and 2"b as well as 4"a and 4"b. Each section 2"a, 4"a having a thread opposite to the thread of the other section 2"b, 4"b starting from the central channel 26 extending from the inlet channel 18" in radial direction to the pump space between inner part 2" and outer part 4". The first section 2"a, 4"a of an element 2" and outer element 4" extend to one longitudinal end of the pump, and the second sections 2"b, 4"b extend to the opposite other end. One section 2"a, 4"a has a left thread and the other section 2"b, 4"b has a right thread so that the fluid entering the room between inner part 2" and outer part 4" is pumped from channel 26 in two directions to the two opposing longitudinal ends of the pump. However, the inner and outer parts are each made as one piece with opposing threads starting from the middle and extending to the opposite ends.

[0042] Also, in this embodiment the pressure produced by the pump acts on the outside of the outer part 4" so that it is pressed on to the inner part 2" as explained for the embodiment according to Fig. 1. By optimizing angles, diameters, length, eccentricities, etc. for each section of the inner part 2" and the outer part 4" it is possible to reduce the axial force compared to the previous concepts shown in Figs. 1 and 2. Furthermore, high pump pressure will not only be applied on one surface like in the previous concept, but on sides, top and bottom. This will reduce the total area applied to the high pump pressure and therefore, reduce the axial forces.

[0043] The axial forces from the two sections 2"a, 4"a and 2"b, 4"b of inner and outer part will be added, and by having an angle between the two sections, the pulsations of the axial forces can be of higher frequency and lower amplitude as can be seen in Fig. 5 (line 38) and discussed below.

[0044] The other big advantage of this third embodiment is that the pump can be cleaned easier because there is a circulation all around the pump and there is no dead room like in the first and second embodiment. The pump according to the third embodiment has optimised balanced axial forces and is primarily meant for applications with higher pump heads or pump pressures compared to the embodiments shown in Figs. 1 and 2 which are limited due to a larger area exposed to the high pump pressure.

[0045] Fig. 4 shows an embodiment similar to the embodiment in Fig. 3. Also in the embodiment according to Fig. 4 inner part 2"" and outer part 4"" have two sections 2""a, 4""a and 2""b, 4""b, wherein the fluid is entering in the middle between both sections. The first section 2""a, 4""a of each inner part 2"" and 4"" extends from the middle of the pump where the inlet channel 28 is arranged to one longitudinal end of the pump where outlet 30 is situated. The second section 2""b, 4""b extends in opposite direction to the opposite longitudinal end. Also, in this embodiment the fluid starting from inlet channel 28 is pumped to the opposed opposite ends of inner part 2"" and outer part 4"" because the threads of the two sections are opposite to one another. Unlike the embodiment in Fig. 3 in the embodiment in Fig. 4 the inner part 2"" is driven and the outer part 4"" is fixed with the pump housing. For this first magnets 10"" are fixed on the inner circumference of a clearance or cavity inside the inner part 2"" similar to the embodiment shown in Fig. 2. A rotor can 16"" is extending into the clearance inside the inner part 2"" and can accommodate a driving element similar to the embodiment in Fig. 2 (not shown in Fig. 4).

[0046] Fig. 5 is a diagram showing the axial forces F versus the rotation angle ϕ for the embodiments discussed before. The pointed line 32 shows the pulsating axial force which appears in the embodiment according to Fig. 1. Line 34 shows the pulsating axial force versus the rotation angle for the lower section 2"b, 4"b of inner part 2" and outer part 4", i. e. the section extending to the thicker end of the pump according to Fig. 3. Line 36 shows the pulsating axial forces for the other section in Fig. 3, i. e. the section of inner part 2" and outer part 4" extending to the thinner end of the pump. Line 38 shows the resulting force from the axial forces according to lines 34 and 36, i. e. the total axial force occurring in the embodiment according to Fig. 3. As can be seen with the third concept according to Fig. 3 the total axial forces can be reduced compared with a first embodiment. This is the same for the embodiment according to Fig. 4.

[0047] Fig. 6 shows a further embodiment similar to the embodiment shown in Fig. 3. The only difference is that in this embodiment according to Fig. 6 the inner part 2" is made of two pieces 2"a and 2"b. Correspondingly, the outer part 4" is made of two separate sections 4"a and 4"b. The design of the sections 2"a and 2"b of the inner part and the section 4"a and 4"b of the outer part 4" as separate elements allows more possibilities in the design and distribution of the axial forces.

[0048] In the embodiment shown in Fig. 3 where inner part 2" and outer part 4" are made in one piece but two sections the product of eccentricity and diameter preferably remains constant if a constant flow is wanted. In the embodiment according to Fig. 6 there is a diameter jump in the middle between the section formed by outer parts 4"a and inner parts 2"a and the section formed by outer part 4"b and inner part 2"b. This means that the diameter in these two parts or sections, i. e. the diameter on one end of the first part and the second part can be chosen independently. Therefore, the axial force can be almost completely out-balanced.

[0049] Fig. 7 shows a further variation of the embodiment according to Fig. 6. The pump according to Fig. 7 has more stages. It has four times an arrangement similar to the arrangement shown in Fig. 6. in the embodiment according to

Fig. 7 the inner part 42 are driven similar to the embodiment shown in Fig. 2. Inside the inner elements 42 a rotor can 46 is arranged. Inside the rotor can 46 a driving element 48 supporting first magnets 50 is arranged. When rotating the driving element 48 the magnets 50 rotate and drive the second magnets 52 fixed on the inner parts 42. The arrangement has two inlets 52 and two outlets 56. The fluid flow is indicated by the arrows in fig. 7. The stages I and III on one side and the stages II and IV on the other side defer in the flow direction. In stages I and III the fluid flows from the middle to the opposing ends of the inner part 42 and outer part 44. In stages II and IV fluid flows from the opposing longitudinal ends to the middle of the stages formed by inner part 42 and outer part 44. The concept according to Fig. 7 has the possibility of delivering higher pressures. It is possible to arrange n sets of two inner parts 42 and two outer parts 44 so that the configuration of Fig. 7 will give n times the pressure of one set or stage of that configuration.

[0050] All the embodiments discussed before have a restriction concerning the possible eccentricity. A conical Moineau or progressive cavity pump with conical shape preferably has not a constant eccentricity. In the embodiments above the maximum eccentricity is limited in order to keep the efficiency of the magnetical transmission which will drop with the increase of the distance between the first and second opposing magnets.

[0051] Fig. 8 shows a preferred principle according to which the magnetic drive can also be used with higher eccentricities. Fig. 8 schematically shows the cone of eccentricity 58 and two possible positions of magnets 60 and 62 seen along the longitudinal axis X. Magnet 60 is arranged in conventional manner in a region where there is a great eccentricity. This limits the maximum eccentricity and the maximum length of the pump as indicated by bracket I.

[0052] According to a preferred embodiment or concept of the invention seen along the longitudinal axis X the magnet 62 is placed close or directly at the point of no eccentricity 63. Therefore, at the position of magnet 62 in a pair of inner and outer magnet the inner and outer magnets can be arranged close to each other and the magnetic transmission has a good efficiency. Furthermore, this construction allows bigger over-all eccentricities for the helical as indicated by bracket II in Fig. 8. The eccentricity of the helical effects the flow directly leading to increased flow.

[0053] Fig. 9 show a further embodiment of the invention which is preferred for example for a denser media used for example in food industry when flow and space between the teeth or threads is needed at lower speed and reduced shear in the fluid. This embodiment has a greater eccentricity than the embodiments discussed before. This means more vibration which results in a speed limitation.

[0054] The embodiment shown in Fig. 9 has a driven inner part 66 arranged in a fixed outer part 64 similar to the embodiment according to Fig. 2. Also in this embodiment inner part 66 and outer part 64 are of conical shape. As can be seen in Fig. 9 in this embodiment the first magnets 68 fixed on the inner part 66 which serves as rotor are spaced along the longitudinal axis of the inner part 66 by a distance c. This is because the first magnets 68 and the second magnets 70 are arranged close to the point of no eccentricity 63 as discussed before with reference to Fig. 8. The second magnets 70 are fixed on a driving element 72 which is coupled with a motor (not shown in Fig. 9.) Also in this embodiment a rotor can 74 is arranged between the first inner magnets 68 and the second outer magnets 70.

[0055] Fig. 10 shows a further embodiment in which a shaft seal is used instead of a rotor can as used in the embodiments discussed before. In the other aspects the embodiment according to Fig. 10 is similar to the embodiment shown in Fig. 2. Also in the embodiment according to Fig. 10 there is provided a fixed outer part 76 and a inner part 78 which is rotatable and serves as a rotor. Both are of conical shape. Further, also in this embodiment the rotor formed by the inner part 78 is can-shaped with a driving element 84 arranged inside the inner part 78. On the inner circumference of the inner part 78 first magnets 80 are fixed so that they are opposed to second magnets 82 fixed on the outer circumferential surface of the driving element 84. In this embodiment there is arranged no rotor can. Instead a shaft seal 86 is provided on the longitudinal end of the inner part 78, which is in contact with a surface 88 of the pump housing. The shaft seal is elastic to compensate an axial movement of the inner part 78. One advantage of this embodiment is that the fluid does not enter into the inner part 78. Therefore, the cleaning of the pump is possible without dead areas. Further, it is not necessary to encapsulate the magnets 80, 82, since they are not in contact with the fluid as with the foregoing embodiments.

[0056] In all embodiments discussed before the part forming the rotor, outer part 4 in fig. 1, inner part 2' in fig. 2, outer part 4" in fig. 3, inner part 2''' in fig. 4, outer part 4" in fig. 6, inner part 42 in fig. 7, inner part 66 in fig. 9 and inner part 78 in fig. 10 does not have an axial bearing. As discussed before, in all embodiments the rotor can move in axial direction and is positioned relative to the stator which is formed by the other pumping part or element just by a balance of the pressures acting on the rotor. In all embodiments the outgoing pressure produced by the pump is used to press the conical inner and outer parts together so that the inner part is hold inside the outer part.

[0057] Further; it has to be understood that also the other embodiments according to Figs. 1, 2, 3, 4, 6, 9 and 10 can be used to build up a pump having more sets or stages similar to the arrangement shown in Fig. 7.

[0058] Further, in all embodiments there can be one or more rows of magnets for each pump set or stage being composed of a rotating part and a stationary part, preferably with a number of four or more magnets per row.

[0059] Preferably, the rotating part will always have the same number of magnets as the driving part. The magnets can either be fixed on a yoke as for example shown in Fig. 10 or fixed directly on the rotating part as shown for example in Fig. 1 where the magnet 10 is directly fixed on the outer part 4.

[0060] It is always preferred that the magnets will be encapsulated to avoid that they are affected by the fluid to be

pumped, for example to avoid rust or corrosion of these magnets as they are usually of ferromagnetic origin. Only in the embodiment according to Fig. 10 this is not necessary as discussed before.

[0061] Further as shown for example in Fig. 10 the inner magnets 82 and outer magnets 80 may have a slight axial displacement d between each other. The magnets 80 and 82 have the tendency to be aligned. Therefore, in the embodiment shown in fig. 10 the inner part 78 is pushed by an axial magnetic force into the outer part 76. This holds the inner part 78 in the outer part 76, even if no pump pressure is acting on inner part 78 as discussed above. By this offset d of the magnets 80 and 82 in longitudinal direction as shown in Fig. 10 a small closing force is obtained during standstill of the pump. Further, this axial magnetic force may also be used to partially compensate or act against the axial force produced by the pump pressure inside the pump cavity between inner part 78 and outer part 76.

[0062] Alternatively, the magnets 80 and 82 may be displaced in opposite direction so that the inner magnets 82 are arranged closer to the shaft seal 86 than the outer magnets 80. Also in this arrangement the magnets 80 and 82 will have the tendency to be aligned and therefore push away the rotating part, the inner part 78, from the stationary part, the outer part 76. By this, an open pumping device is achieved when there is no pump pressure in the system.

[0063] Even if the geometry of the inner part and the outer part in all embodiments can be very different, the product of eccentricity and diameter should remain constant if the flow has to be constant.

[0064] Materials usable for all embodiments, in particular for the inner parts and the outer parts of the pump can be, for example, ceramics (alumina, silicon carbit, silicon nitrit). In case of metal a thermal spread coating, hard chromium, stainless steel and similar may be used. Further, it may also be preferred to use plastics like polymeres (thermoplastic or resin with fillers), rubber or liquid silicon rubber.

List of reference numerals

[0065]

25	2, 2', 2", 2'''	- inner part
	4, 4', 4", 4'''	- outer part
	6, 6'	- cavity
	8, 8'	- pump housing
	10, 10', 10", 10'''	- first magnets
30	12, 12'	- second magnets
	14, 14'	- driving element
	16, 16', 16", 16'''	- rotor can
	18, 18'	- inlet
	20	- space
35	22, 22'	- outlet
	24	- pump cavity
	26	- channel
	28	- inlet
	30	- outlet
40	32, 34, 36, 38	- lines
	40	- rotor can
	42	- inner parts
	44	- outer parts
	46	- rotor can
45	48	- driving element
	50	- first magnet
	52	- second magnet
	54	- inlet
	56	- outlet
50	58	- cone of eccentricity
	60, 62	- magnets
	63	- point of no eccentricity
	64	- outer part
	66	- inner part
55	68	- first magnet
	70	- second magnet
	72	- driving element
	74	- rotor can

- 76 - outer part
- 78 - inner part
- 80 - first magnets
- 82 - second magnets
- 5 84 - driving element
- 86 - shaft seal
- 88 - surface

- A - direction of axial force
- 10 d - axial displacement of magnets
- c - distance

Claims

- 15 1. Moineau type pump having at least one outer part (4; 44, 76) and one inner part (2; 42; 78) arranged inside the outer part (4; 44; 76), wherein at least one of the inner (2; 42; 78) and outer part (4; 44; 76) acts as a rotor and is driven by a magnetic field, **characterized in that** the inside of the outer part (4; 44; 76) and the inner part (2; 42; 78) have a conical geometry and the rotor is movable in axial direction and does not comprise an axial bearing.
- 20 2. Moineau type pump according to claim 1, **characterized in that** the axial force acting on the rotor due to the fluid pressure in the pump chamber between inner (2; 42; 78) and outer (4; 44; 76) part is at least partly, preferably fully compensated by the outgoing fluid pressure acting on a surface of the rotor in axial direction.
- 25 3. Moineau type pump according to claims 2, **characterized in that** the outgoing fluid pressure is acting on a surface of the rotor in a direction pressing the outer (4; 44; 76) and inner (2; 42; 78) part together.
- 30 4. Moineau type pump according to one of the preceding claims, **characterized in that** there is at least one first magnet (10; 50; 80) fixed on the rotor and one interacting second magnet (12; 52; 82) fixed on a rotatable driving element (14; 48; 84).
- 35 5. Moineau type pump according to claim 4, **characterized in that** a rotor can (16; 40) is arranged between the rotor and the driving element (14; 48).
- 40 6. Moineau type pump according to claim 4 or 5, **characterized in that** the first (10; 50; 80) and/or the second (12; 52, 82) magnet is a permanent magnet.
- 45 7. Moineau type pump according to one of the claims 4 to 6; **characterized in that** seen in the longitudinal direction of the pump the first and second magnets (62; 68, 70) are positioned near the point where the eccentricity between inner (66) and outer (64) part has its minimum.
8. Moineau type pump according to claim 7, **characterized in that** the magnets (62; 68, 70) are placed close to the intersection point of the longitudinal axes.
9. Moineau type pump according to one of the preceding claims, **characterized in that** the magnetic field driving the rotor besides the rotational force generates an axial force acting between the inner (78) and the outer (76) part.
- 50 10. Moineau type pump according to claim 9, **characterized in that** the axial force generated by the magnetic field results from an axial displacement of at least one first magnet (80) fixed on the rotor and at least one second magnet (82) fixed on a rotatable driving element (84).
- 55 11. Moineau type pump according to claim 9 or 10, **characterized in that** the inside of the outer part (76) and the inner part (78) are of conical geometry and the axial force generated by the magnetic field is directed to press the inner (78) and outer (76) part together or is directed to force apart the inner (78) and outer (76) part.

Patentansprüche

1. Moineaupumpe, die mindestens ein äußeres Teil (4; 44; 76) und ein inneres Teil (2; 42; 78) aufweist, das in dem äußeren Teil (4; 44; 76) angeordnet ist, wobei zumindest einer der inneren (2; 42; 78) und/oder äußeren Teile (4; 44; 76) als ein Rotor fungiert und von einem magnetischen Feld angetrieben wird, **dadurch gekennzeichnet, dass** das Innere des äußeren Teils (4; 44; 76) und des inneren Teils (2; 42; 78) eine konische Geometrie aufweisen und der Rotor in axialer Richtung bewegbar ist und kein Axiallager umfasst.
2. Moineaupumpe nach Anspruch 1, **dadurch gekennzeichnet, dass** die Axialkraft, die aufgrund des Fluiddrucks in der Pumpenkammer zwischen dem inneren (2; 42; 78) und äußeren (4; 44; 76) Teil auf den Rotor einwirkt, mindestens zum Teil, bevorzugt vollständig, durch den Druck des austretenden Fluids kompensiert wird, der in einer axialen Richtung auf eine Fläche des Rotors einwirkt.
3. Moineaupumpe nach Anspruch 2, **dadurch gekennzeichnet, dass** der austretende Fluiddruck auf eine Fläche des Rotors in einer Richtung einwirkt, wobei das äußere (4; 44; 76) und innere (2; 42; 78) Teil zusammengedrückt werden.
4. Moineaupumpe nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** mindestens ein erster Magnet (10; 50; 80) auf dem Rotor befestigt ist, und ein in Wechselwirkung stehender zweiter Magnet (12; 52; 82) auf einem drehbaren Antriebselement (14; 48; 84) befestigt ist.
5. Moineaupumpe nach Anspruch 4, **dadurch gekennzeichnet, dass** ein Spaltrohr (16; 40) zwischen dem Rotor und dem Antriebselement (14; 48) angeordnet ist.
6. Moineaupumpe nach Anspruch 4 oder 5, **dadurch gekennzeichnet, dass** der erste (10; 50; 80) und/oder der zweite (12; 52, 82) Magnet ein Permanentmagnet ist.
7. Moineaupumpe nach einem der Ansprüche 4 bis 6, **dadurch gekennzeichnet, dass** in der Längsrichtung der Pumpe gesehen, der erste und zweite Magnet (62; 68, 70) nahe dem Punkt positioniert sind, an dem die Exzentrizität zwischen dem inneren (66) und äußeren (64) Teil ihr Minimum aufweist.
8. Moineaupumpe nach Anspruch 7, **dadurch gekennzeichnet, dass** die Magnete (62; 68, 70) nahe dem Schnittpunkt der Längsachsen positioniert sind.
9. Moineaupumpe nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das den Rotor antreibende magnetische Feld außer der Drehkraft eine Axialkraft erzeugt, die zwischen dem inneren (78) und dem äußeren (76) Teil wirkt.
10. Moineaupumpe nach Anspruch 9, **dadurch gekennzeichnet, dass** die durch das magnetische Feld erzeugte Axialkraft von einer axialen Verschiebung mindestens eines an dem Rotor befestigten ersten Magneten (80) und mindestens eines an einem drehbaren Antriebselement (84) befestigten zweiten Magneten (82) herrührt.
11. Moineaupumpe nach Anspruch 9 oder 10, **dadurch gekennzeichnet, dass** das Innere des äußeren Teils (76) und des inneren Teils (78) eine konische Geometrie aufweisen, und die durch das magnetische Feld erzeugte Axialkraft derart gerichtet ist, dass sie das innere (78) und das äußere (76) Teil zusammendrückt, oder derart gerichtet ist, dass sie das innere (78) und äußere (76) Teil auseinanderzwingt.

Revendications

1. Pompe de type Moineau ayant au moins une partie externe (4 ; 44 ; 76) et une partie interne (2 ; 42 ; 78) disposée à l'intérieur de la partie externe (4 ; 44 ; 76), où au moins l'une de la partie interne (2 ; 42 ; 78) et de la partie externe (4 ; 44 ; 76) agit comme un rotor et est entraînée par un champ magnétique, **caractérisée en ce que** l'intérieur de la partie externe (4 ; 44 ; 76) et la partie interne (2 ; 42 ; 78) ont une géométrie conique et le rotor est mobile en direction axiale et ne comprend pas d'appui axial.
2. Pompe de type Moineau selon la revendication 1, **caractérisée en ce que** la force axiale agissant sur le rotor sous l'effet de la pression de fluide dans la chambre de la pompe entre les parties interne (2 ; 42 ; 78) et externe (4 ; 44 ; 76) est au moins partiellement, de préférence totalement, compensée par la pression de fluide sortant agissant sur

une surface du rotor dans la direction axiale.

3. Pompe de type Moineau selon la revendication 2, **caractérisée en ce que** la pression de fluide sortant agit sur une surface du rotor dans une direction pressant les parties externe (4 ; 44 ; 76) et interne (4 ; 44 ; 78) l'une contre l'autre.
4. Pompe de type Moineau selon l'une des revendications précédentes, **caractérisée en ce qu'il y a au moins un** premier aimant (10 ; 50 ; 80) fixé sur le rotor et un deuxième aimant interagissant (12 ; 52 ; 82) fixé sur un élément d'entraînement rotatif (14 ; 48 ; 84).
5. Pompe de type Moineau selon la revendication 4, **caractérisée en ce qu'une** gaine (16 ; 40) est disposée entre le rotor et l'élément d'entraînement (14 ; 48).
6. Pompe de type Moineau selon la revendication 4 ou 5, **caractérisée en ce que** le premier (10 ; 50 ; 80) et/ou le deuxième (12 ; 52 ; 82) aimant est un aimant permanent.
7. Pompe de type Moineau selon l'une des revendications 4 à 6, **caractérisée en ce que** vu dans la direction longitudinale de la pompe, les premier et deuxième aimants (62 ; 68 ; 70) sont positionnés à proximité du point où l'excentricité entre les parties interne (66) et externe (64) est à son minimum.
8. Pompe de type Moineau selon la revendication 7, **caractérisée en ce que** les aimants (62 ; 68 ; 70) sont placés près du point d'intersection des axes longitudinaux.
9. Pompe de type Moineau selon l'une des revendications précédentes, **caractérisée en ce que** le champ magnétique entraînant le rotor en plus de la force de rotation génère une force axiale agissant entre les parties interne (78) et externe (76).
10. Pompe de type Moineau selon la revendication 9, **caractérisée en ce que** la force axiale générée par le champ magnétique résulte d'un déplacement axial d'au moins un premier aimant (80) fixé sur le rotor et au moins un deuxième aimant (82) fixé sur un élément d'entraînement rotatif (84).
11. Pompe de type Moineau selon la revendication 9 ou 10, **caractérisée en ce que** l'intérieur de la partie externe (76) et la partie interne (78) sont de géométrie conique et la force axiale générée par le champ magnétique est dirigée de manière à presser les parties interne (78) et externe (76) l'une contre l'autre ou est dirigée de façon à écarter les parties interne (78) et externe (76) l'une de l'autre.

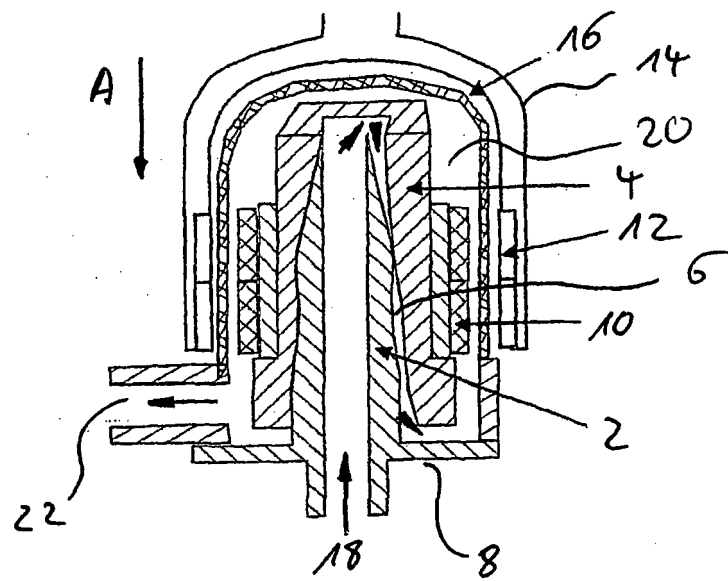


Fig. 1

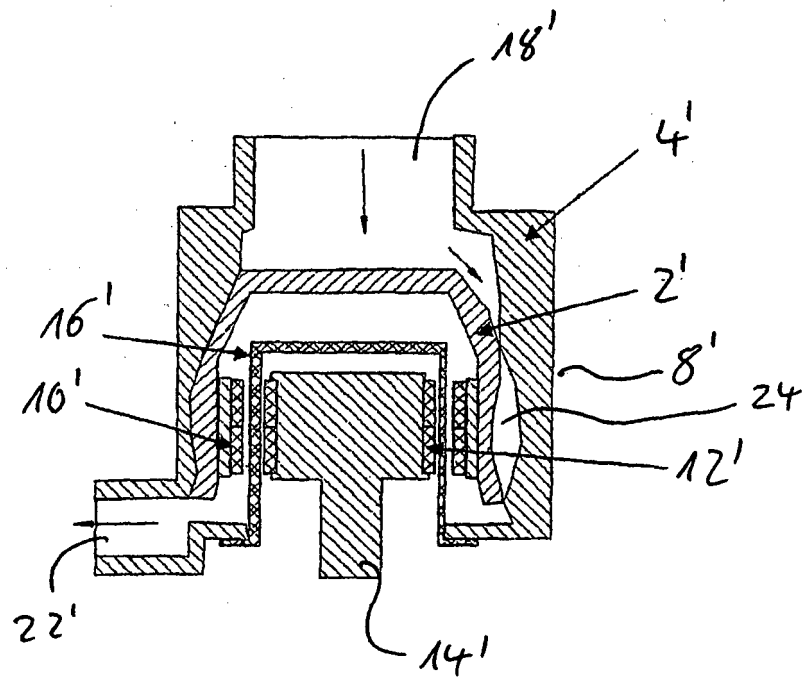


Fig. 2

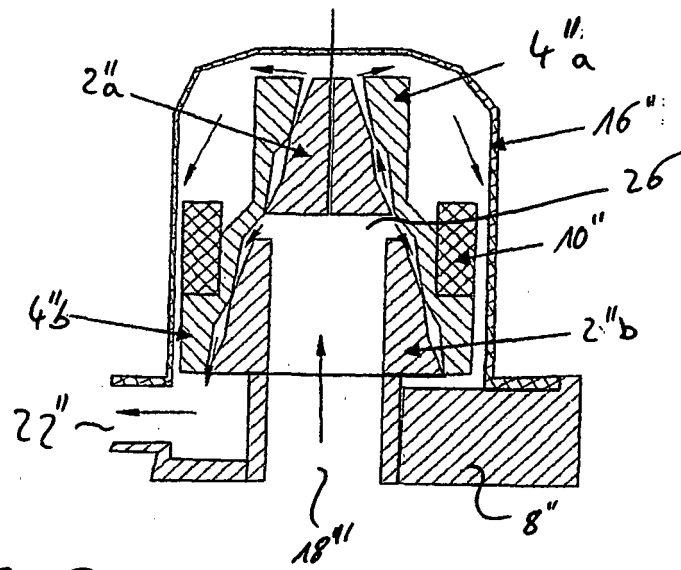


Fig. 3

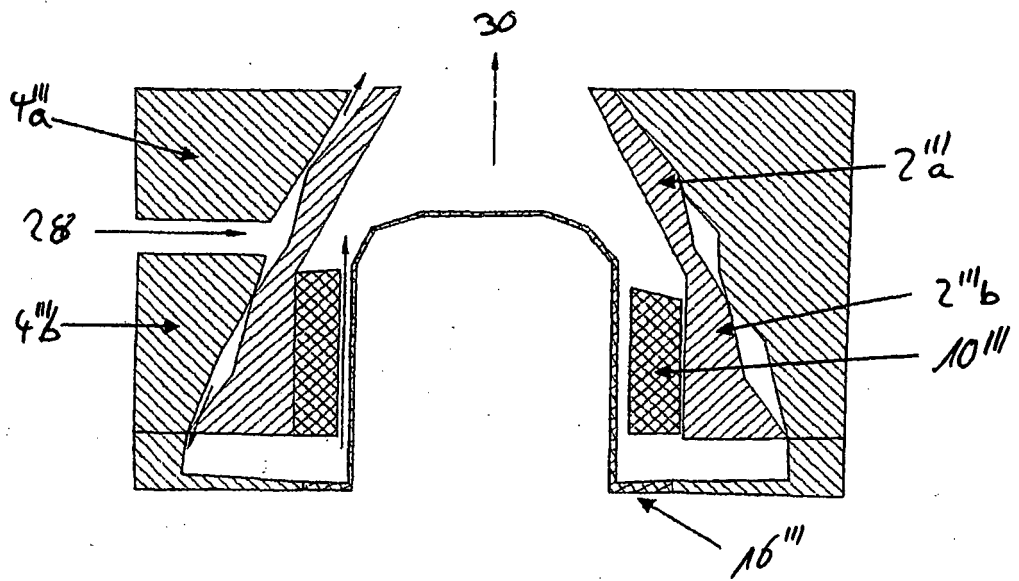


Fig. 4

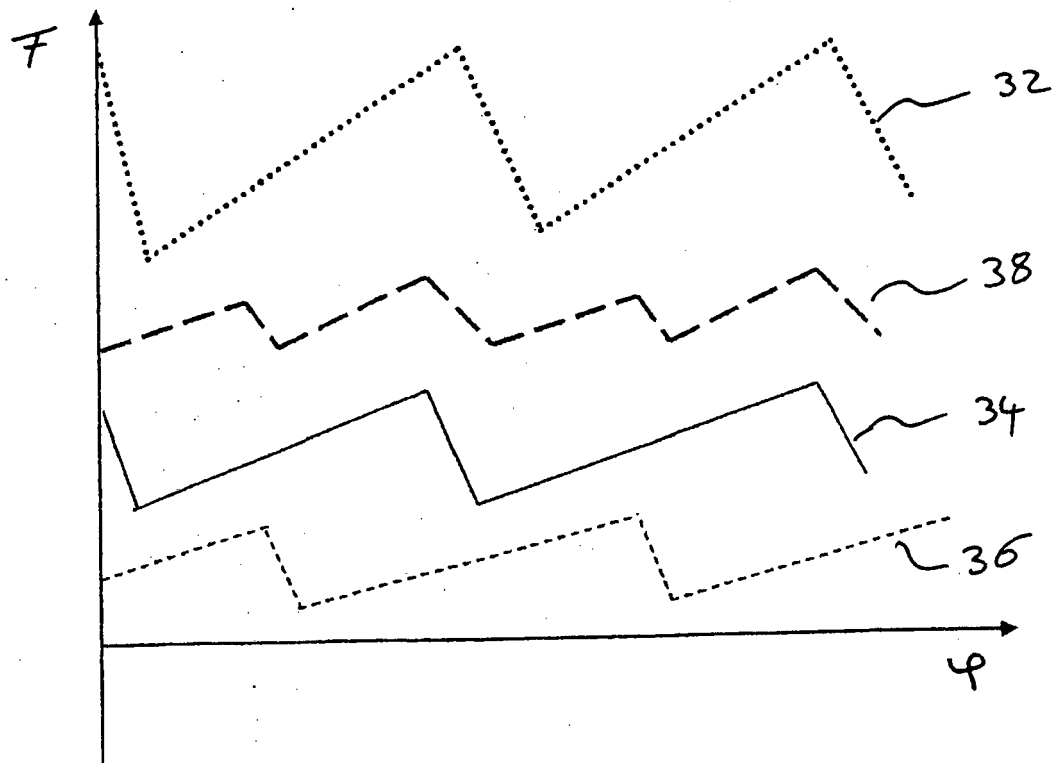


Fig. 5

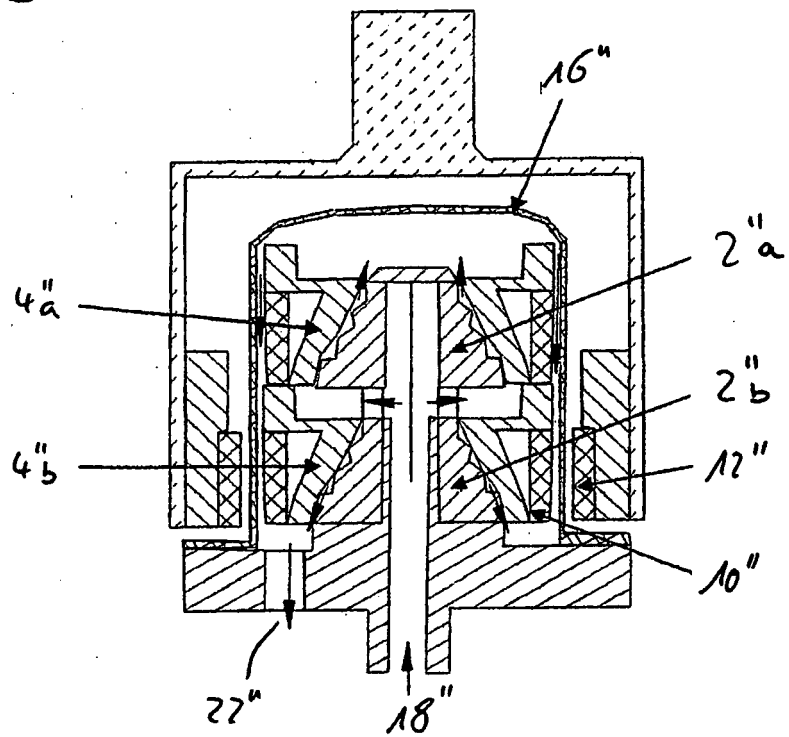


Fig. 6

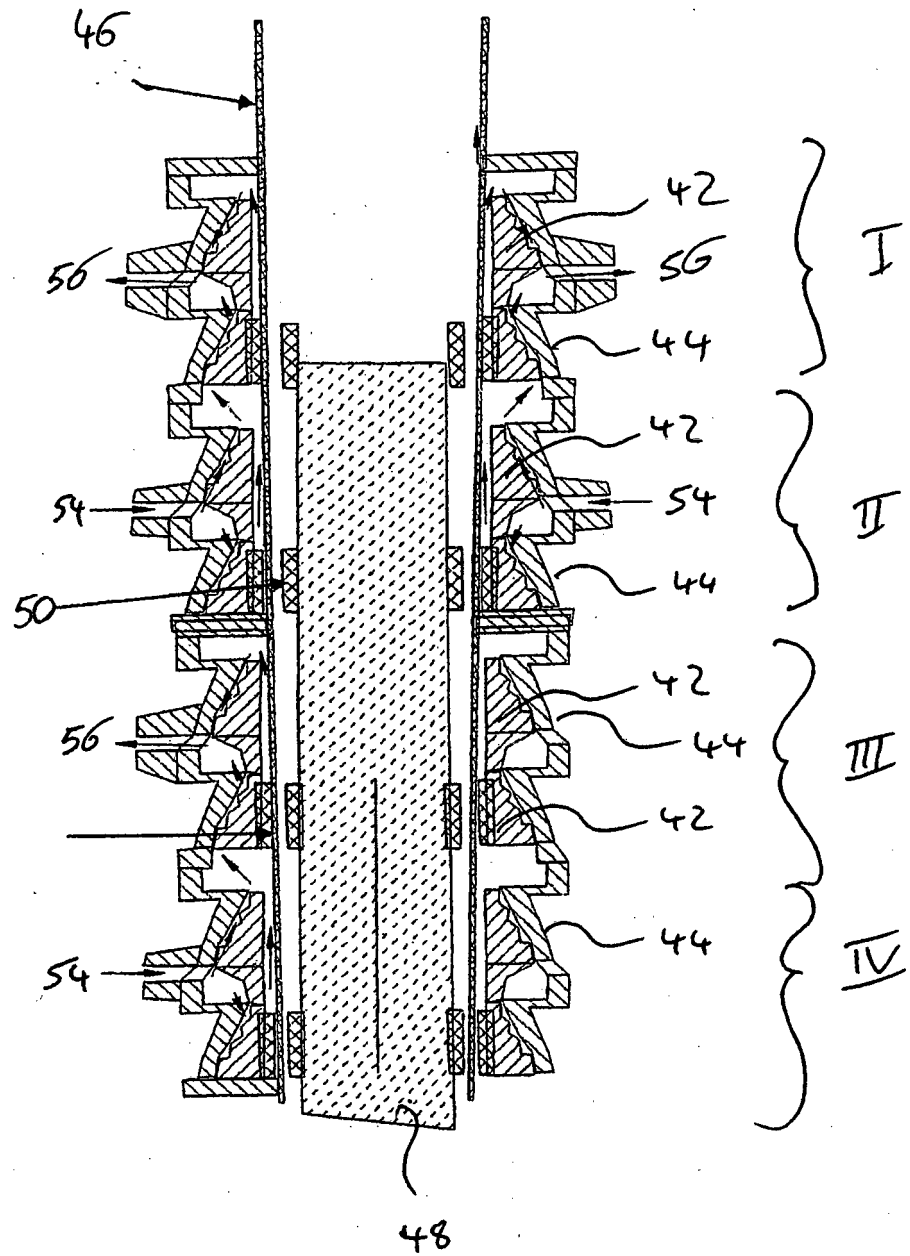


Fig. 7

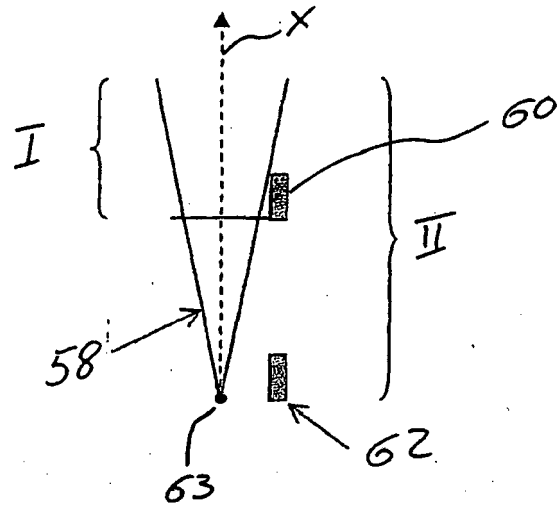


Fig. 8

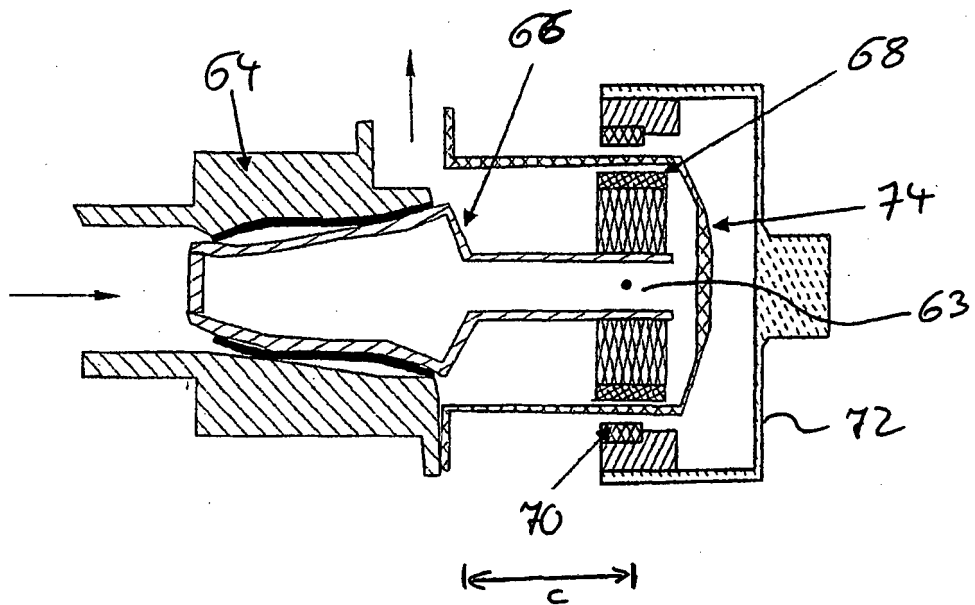


Fig. 9

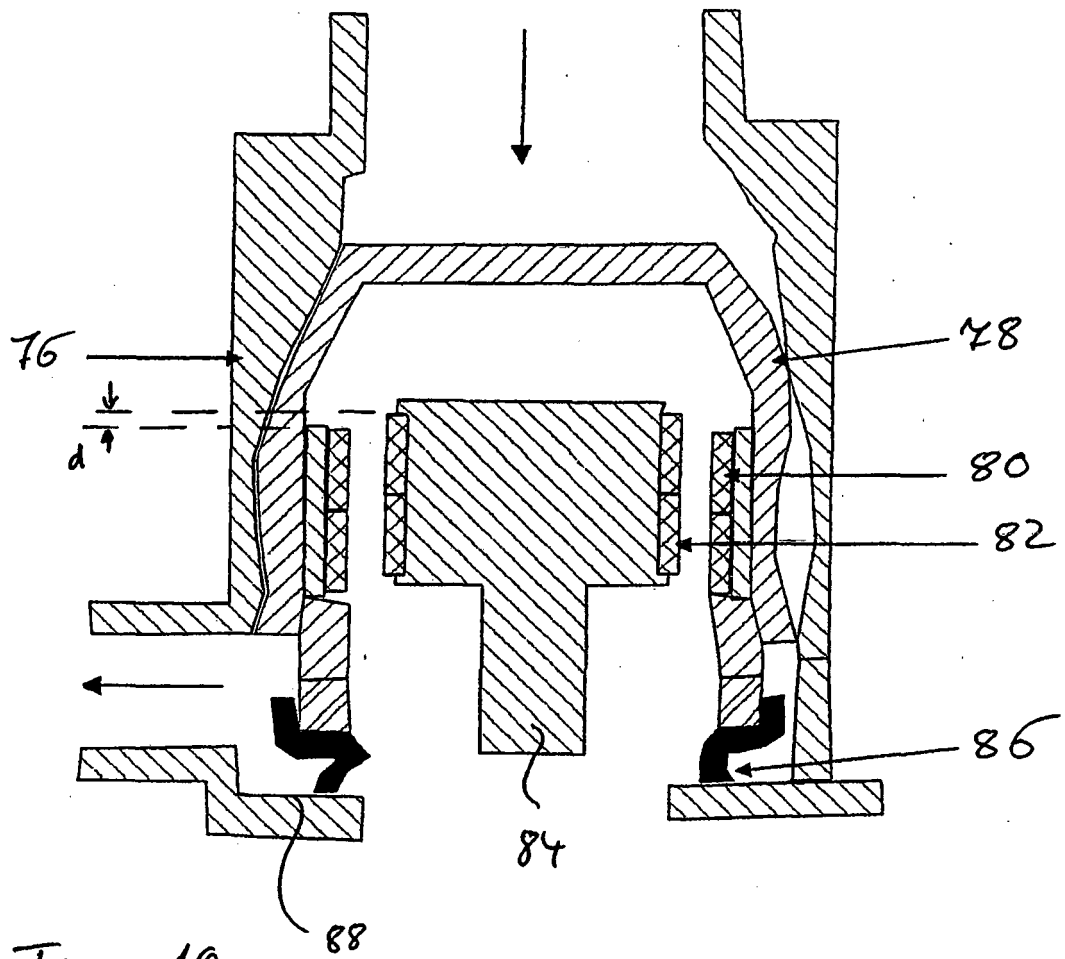


Fig. 10

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 6361292 B [0007]