(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 959 140 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
20.08.2008 Bulletin 2008/34

(51) Int Cl.:
F04B 43/02 *(2006.01)* ***F04B 43/08*** *(2006.01)*

(21) Application number: **08001765.0**

(22) Date of filing: **31.01.2008**

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

(30) Priority: **14.02.2007 DE 102007007906**

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(54) Diaphragm delivery pump and pumping diaphragm for a diaphragm delivery pump

(57) A delivery pump for a delivery fluid comprises at least one valve plate (4), at least one actuatable pumping diaphragm (3) attached to the at least one valve plate (4) in a fluid-tight manner for delivering the delivery fluid, said pumping diaphragm (3) defining at least one pumping chamber (2) together with the at least one valve plate (4) and having at least one free fold (16), extending over at least one circumferential area of the at least one pumping diaphragm (3), for changing the volume of the at least one pumping chamber (2), at least one inlet opening (7) disposed in the at least one valve plate (4) for guiding the delivery fluid into the at least one pumping chamber (2), and at least one outlet opening (8) disposed in the at least one valve plate (4) for guiding the delivery fluid out of the at least one pumping chamber (2).

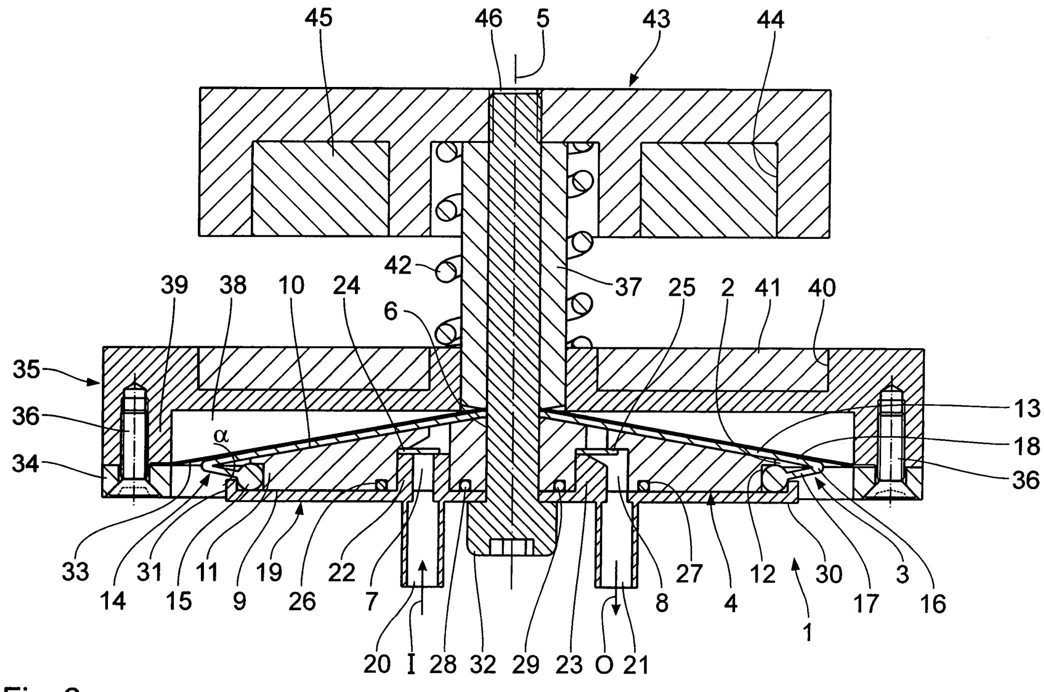

Fig. 2

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Description

[0001] The invention relates to a diaphragm delivery pump for a delivery fluid and a pumping diaphragm for a diaphragm delivery pump. The invention relates in particular to a diaphragm delivery pump to be used in portable fuel cells, electronics cooling devices, gas detecting devices, anesthesia control devices and the like as well as a corresponding pumping diaphragm for such a diaphragm delivery pump. The delivery fluid is to be understood as a medium to be delivered, such as a liquid, a gas or a liquid-gas mixture.

[0002] A multitude of diaphragm delivery pumps comprising pumping diaphragms are known from the prior art. If these diaphragm delivery pumps are made to have a small size, the delivery rate thereof is generally unsatisfactory.

[0003] Thus it is the object of the invention to provide a diaphragm delivery pump having a high delivery rate and at the same time a small size. Moreover, a pumping diaphragm is to be created that allows for the provision of such a diaphragm delivery pump having a high delivery rate and at the same time a small size.

[0004] This object is attained according to the invention by the features of claim 1 and 20. The crux of the invention is that the pumping diaphragm has at least one free fold extending over at least one circumferential area. The circumferential area may be an internal or external circumferential area of the pumping diaphragm. The at least one free fold serves to change the volume of the at least one pumping chamber during the operation. A fold is substantially to be understood as a crease which may also be a rolling crease, for example. The valve plate may be moved with respect to the pumping diaphragm. Conversely, it is also possible to move the pumping diaphragm with respect to the valve plate.

[0005] Further advantageous embodiments of the invention are stated in the subclaims.

[0006] The following is a description of several preferred embodiments of the invention, taken in conjunction with the enclosed drawings, in which

Fig. 1 shows an exploded view of a diaphragm delivery pump according to a first embodiment;

Fig. 2 shows a longitudinal section through an assembled diaphragm delivery pump according to the first embodiment, with the pumping diaphragm being situated in its lower extreme position;

Fig. 3 shows another longitudinal section through the diaphragm delivery pump according to the first embodiment corresponding to Fig. 2, with the pumping diaphragm being situated in its central position;

Fig. 4 shows another longitudinal section through the diaphragm delivery pump according to the first embodiment corresponding to Fig. 2, with the pumping diaphragm being situated in its upper extreme position;

Fig. 5 shows another longitudinal section through the diaphragm delivery pump according to the first embodiment corresponding to Fig. 2, with the pumping diaphragm being situated in its central position;

Fig. 6 shows a longitudinal section through the separately shown pumping diaphragm according to the invention of the diaphragm delivery pump according to the first embodiment, with the shape of said pumping diaphragm illustrated thereby corresponding to the shape of the pumping diaphragm shown in Fig. 2;

Fig. 7 shows a longitudinal section through the separately shown pumping diaphragm of the diaphragm delivery pump according to the first embodiment, with the shape of said pumping diaphragm illustrated thereby corresponding to the shape of the pumping diaphragm shown in Figs. 3 and 5;

Fig. 8 shows a longitudinal section through the separately shown pumping diaphragm of the diaphragm delivery pump according to the first embodiment, with the shape of said pumping diaphragm illustrated thereby corresponding to the shape of the pumping diaphragm shown in Fig. 4;

Fig. 9 shows an exploded view of a diaphragm delivery pump according to a second embodiment;

Fig. 10 shows a longitudinal section through an assembled diaphragm delivery pump according to the second embodiment, with the pumping diaphragms being situated in an upper extreme position;

Fig. 11 shows a longitudinal section through a diaphragm delivery pump according to the second embodiment corresponding to Fig. 10, with the pumping diaphragms being situated in a transition position between the upper and lower extreme positions;

Fig. 12 shows a perspective assembled view of the diaphragm delivery pump according to the second embodiment;

Fig. 13 shows a longitudinal section through a diaphragm delivery pump according to a third embodiment;

Fig. 14 shows a perspective view of a separately shown pumping diaphragm according to the second and third embodiments;

Fig. 15 shows a longitudinal section through the pumping diaphragm shown in Fig. 14 the shape of which illustrated thereby substantially corresponds to the shape of the pumping diaphragms shown in Fig. 10;

Fig. 16 shows a longitudinal section through the pumping diaphragm shown in Fig. 14 the shape of which illustrated thereby substantially corresponds to the shape of the pumping diaphragms shown in Fig. 13;

Fig. 17 shows a longitudinal section through the pumping diaphragm shown in Fig. 14 the shape of which illustrated thereby is situated in a lower extreme position of operation;

Fig. 18 shows a longitudinal section through a diaphragm delivery pump according to a fourth embodiment; and

Fig. 19 shows a longitudinal section through a separately shown pumping diaphragm according to the fourth embodiment.

[0007] The following is a description, taken in conjunction with Figures 1 to 5, of a first embodiment of a diaphragm delivery pump 1 according to the invention. The description initially focuses on the position of a pumping diaphragm 3 shown in Fig. 2. The diaphragm delivery pump 1 has a pumping chamber 2 with a variable volume, said pumping chamber 2 being defined, or delimited, by the flexible, actuatable, thin-walled pumping diaphragm 3 and a rigid valve plate 4. When the pumping diaphragm 3, which is made of a fluid-tight elastomer material in this example, is externally actuated, this causes a delivery fluid to be delivered due to changing the volume of the pumping chamber 2. The diaphragm delivery pump 1 has a central longitudinal axis 5 and is substantially designed as a solid of revolution.

[0008] The valve plate 4 is circular in shape, with a round, central, axial fixing hole passing through said valve plate 4. Moreover, an inlet opening 7 and an outlet opening 8 pass through the valve plate 4 in an axial direction, with the two latter openings 7, 8 being disposed in the valve plate 4 at an off-center position. The valve plate 4 has a lower, plane contact surface 9. An inclined surface 10 is situated opposite the contact surface 9. The thickness of the valve plate 4 steadily increases substantially from its circumferential outer edge area 11 towards the central fixing hole 6; due to the inclined surface 10, the thickness of the valve plate 4 is smaller at the edges than at the center thereof. The contact surface 9 is shorter with respect to the inclined surface 10, thus forming an annular mount 12 in the outer edge area 11 having a circumferential contact surface facing outward.

[0009] The expression "lower", which is used in this disclosure, refers to the orientation of the diaphragm delivery pump 1 shown in the respective figure. The same applies to corresponding expressions used below for other embodiments.

[0010] The pumping diaphragm 3 is formed in one-piece, has a circular outer shape and is attached to the edge area of the valve plate 4 in a fluid-tight manner. The pumping diaphragm 3 may also have a non-circular shape. The pumping diaphragm 3 has a boundary wall 13 situated above the inclined surface 10, with a pivotable outer side wall 14 adjoining said boundary wall 13. A sealing bead 15 having a circular cross-section is formed at the free end of the side wall 14. The sealing bead 15 bears against the contact surface inside the mount 12 and against an annular protrusion formed by the inclined surface 10.

[0011] The height of the side wall 14 is substantially reduced by half by a circumferential, freely movable fold 16 which permits folding or unfolding, respectively, thereby obtaining a lower side wall portion 17 and an upper side wall portion 18. The lower side wall portion 17 extends from the sealing bead 15 to the fold 16 while the upper side wall portion 18 extends from the fold 16 to the boundary wall 13. The projected height of the lower side wall portion 17 substantially corresponds to the projected height of the upper side wall portion 18. The area of the boundary wall 13 approximately corresponds to the projected area of the inclined surface 10.

[0012] In the position of the pumping diaphragm 3 shown in Fig. 2, at least part of the surface of the boundary wall 13 bears against the inclined surface 10 in a way that the volume of the pumping chamber 2 is virtually zero. The upper side wall portion 18 thereby forms an elongation of the boundary wall 13. From the mount 12, the lower side wall portion 17 extends radially outward towards the top, thereby forming an acute angle α between the lower side wall portion 17 and the upper side wall portion 18. The fold 16, which defines an exact crease line for the side wall 14, radially protrudes beyond the outer edge area 11 of the valve plate 4.

[0013] At least part of the surface of a circular, one-piece connection plate 19 bears against the contact surface 9 of the valve plate 4, with an axially protruding, hollow inlet connection 20, which extends along an inlet direction I, and an axially protruding, hollow outlet connection 21, which extends along an outlet direction O, being formed thereon. The inlet connection 20, which is to be connected to a delivery line feeding in the delivery fluid, and the outlet connection 21, which is to be connected to a delivery line for discharging the delivery fluid, extend away from the valve plate 4 and are situated in the area of the inlet opening 7 or the outlet opening 8, respectively. An axial pair of fixing plates 22 and an axial fixing protrusion 23 are provided on the side of the connection plate 19 facing towards the valve plate 4. The pair of fixing plates 22 is formed by two spaced-apart, parallel fixing plates and projects into the inlet opening 7. The fixing plates are situated opposite the inlet connection 20, with their outer surfaces, facing away from one other, bearing against the valve plate 4. One side of a flexible valve reed 24 is fixed between the valve plate 4 and the radially outer fixing plate, i.e. the left-hand fixing plate in Figs. 2 to 5. The free, i.e. non-fixed end of the valve reed 24 is pivotable between two extreme positions. When in a shut-off position, the underside of the horizontal valve reed 24 bears against the free end of the fixing plates, thus closing the inlet opening 7 in a fluid-tight manner in a direction opposite to an inlet direction. When in an open position, the free end of the valve reed 24 is lifted off the respective fixing plate, thus enabling the delivery fluid to pass through the inlet opening 7. The open position is shown in Fig. 3, while the shut-off position is shown in Figs. 2, 4 and 5.

[0014] The fixing protrusion 23, on the other hand, engages with the outlet opening 8 and is situated opposite the outlet connection 21. One side of a flexible valve reed 25, whose free end is pivotable between two extreme positions as well, is clamped between the fixing protrusion 23 and the valve plate 4. When in the horizontal shut-off position, the valve reed 25 shuts off, or closes, the outlet opening 8 in a fluid-tight manner in the direction opposite to the outlet direction whilst enabling the delivery fluid to pass through said outlet opening 8 when in the open position. The shut-off position is shown in Figs. 2 to 4, while the open position is shown in Fig. 5.

[0015] The valve reed 25 is pivotable downward from its shut-off position, i.e. in the direction of the contact surface 9, whereas the valve reed 24 is pivotable upward from its shut-off position, i.e. away from the contact surface 9. Pivoting of the valve reeds 24, 25 is limited by corresponding, inclined surfaces of the valve plate 4. The valve-reeds 24, 25 are pressure-controlled.

[0016] The valve plate 4 is provided with an angular groove 26 and an angular groove 27, each of which receiving a sealing ring 28 or 29, respectively. The annular groove 26 surrounds the inlet opening 7, with the sealing ring 28 placed therein bearing against the inside of the connection plate 19 in a sealing manner. The annular groove 27, on the other hand, surrounds the outlet opening 8, with the sealing ring 29 placed therein bearing against the inside of the connection plate 19 in a sealing manner as well. The sealing rings 28, 29 ensure a fluid-tight connection between the valve plate 4 and the connection plate 19.

[0017] The circular connection plate 19 protrudes beyond the valve plate 4 in the radial direction. In its outer edge area 30, the connection plate 19 has an annular web 31 protruding towards the inclined surface 10 in the axial direction. The sealing bead 15 of the pumping diaphragm 3 is held in place by means of the edge area 30, the annular web 31, the contact surface of the valve plate 4 and the annular protrusion formed by the inclined surface 10. Together, the latter elements form the mount 12 the sealing bead 15 is squeeze-fixed in. with the lower side wall portion 17 extending outward from the mount 12 and towards the top.

[0018] The connection plate 19 and the valve plate 4 are securely interconnected by means of a central, axially oriented connecting screw 32 which is further described below. The connection plate 19 bears against the head of the connecting screw 32.

[0019] A separate, circular layer of fabric 33 is attached to the surface of the side of the boundary wall 13 of the pumping diaphragm 3 facing away from the valve plate 4, said layer of fabric 33 protruding beyond the boundary wall 13 in the radial direction. According to another embodiment, the pumping diaphragm 3 is integral with the layer of fabric 33.

[0020] The free outer edge area of the flexible layer of fabric 33 is clamped between a rigid diaphragm ring 34 and a circular, rigid anchor plate 35, with the diaphragm ring 34, which is situated below the anchor plate 35 according to the drawings, being screwed to the anchor plate 35 by means of four fixing screws 36. By means of a central, circular hole, the anchor plate 35 is mounted for axial movement on a plain bearing bush 37 surrounding the connecting screw 32.

[0021] The anchor plate 35 has a central, circular recess 38 which is open towards the bottom and is delimited on one side by an annular web 39 receiving the fixing screws 36. Moreover, it has an annular recess 40 into which an anchor insert 41 of a magnetizable material, such as soft iron, is securely inserted. The annular recess 40 is situated on the side of the anchor plate 35 facing away from the recess 38 and is open towards the top.

[0022] Both the pumping diaphragm 3 and the layer of fabric 33 are clamped on the inside between an inner edge area of the inclined surface 10 of the valve plate 4 and the lower free end of the bearing bush 37.

[0023] A helical compression spring 42 engages with the side of the anchor plate 35 in which the annular recess 40 is situated as well, said helical compression spring 42 being slid over the axial bearing bush 37 in a way as to rest against a circular, immovable stator plate 43. The stator plate 43 is provided with an annular recess 44 which is open towards the bottom and carries a fixed electric annular coil 45. The annular coil 45, which is conductively connected to a controllable current source (not shown), is disposed opposite the anchor insert 41 and cooperates therewith during the operation of the diaphragm delivery pump 1.

[0024] The end area of the connecting screw 32 is screwed into a thread of an axial, central bore 46 formed in the stator plate 43 in a way that the stator plate 35 is immovably fixed with respect to the valve plate 4. The connecting screw 32 passes centrally through the connection plate 19, the valve plate 4 adjacent thereto, the pumping diaphragm 3, the layer of fabric 33, the bearing bush 37 and the anchor plate 35, including the diaphragm ring 34, surrounding the latter. The connecting screw 32 finally ends in the stator plate 43. The connecting screw 32 ensures that the connection plate 19, the valve plate 4, the bearing bush 37 and the stator plate 43 are immovably fixed with respect to each other.

[0025] The following is a description of the function of the described diaphragm delivery pump 1 based on Fig. 2. According to Fig. 2, both the inlet opening 7 and the outlet opening 8 are shut-off in a fluid-tight manner by means of the corresponding valve reed 24 or 25, respectively. The valve reeds 24, 25 are in their rest position. At least part of the surface of the boundary wall 13 bears against the inclined surface 10 of the valve plate 4, with the pumping chamber 2 thus having a minimum volume approaching zero. The side wall 14 is folded up. An angle α is formed between the lower side wall portion 17 and the upper side wall portion 18 in the area of the fold 16, said angle α being acute. The fold 16 protrudes beyond the valve plate 4 in the radial direction. In this example, the annular coil 45 is current-less. The helical compression spring 42 has moved the anchor plate 35 to a position that corresponds to the maximum possible distance between the stator plate 43 and the anchor plate 35. The valve plate 4 is substantially situated in the recess 38 of the anchor plate 35. In this position, the clamped layer of fabric 33 presses the boundary wall 13 against the inclined surface 10 of the valve plate 4.

[0026] The annular coil 45 is now supplied with an electrical current. The magnetic field of the annular coil 45 thus generated causes the anchor plate 35, which is mounted for axial movement, to be attracted towards the stator plate 43 against the force of the helical compression spring 42 by means of the magnetized anchor insert 41. When this happens, the boundary wall 13 is lifted off the valve plate 4 by means of the layer of fabric 33, which is clamped between the diaphragm ring 34 and the anchor plate 35, thereby causing the volume of the pumping chamber 2 to increase. In a central position, the entire boundary wall 13 now lies in a plane, as can be seen from Fig. 3. The lifting of the boundary wall 13 causes the side wall 14 to unfold in the area of the fold 16. Consequently, the angle α becomes more obtuse, with the fold 16 moving in the direction towards the central longitudinal axis 5. The lifting of the boundary wall 13 causes a delivery fluid to be drawn into the pumping chamber 2 in an inlet direction I through the inlet connection 20 and the inlet opening 7. The influent delivery fluid has pivoted the self-acting valve reed 24 from its rest position to the open position, as shown on the left-hand side of Fig. 3. In Fig. 3, the outlet opening 8 is still closed by the valve reed 25. During the suction process, it is impossible for the valve reed 25 to open the outlet opening 8. The valve plate 4 has moved out of the recess 38 of the anchor plate 35.

[0027] In Fig. 4, the anchor plate 35 has been entirely attracted towards the stator plate 43 by magnetic force, i.e. against the force of the helical compression spring 42, with the boundary wall 13 having been moved out of the plane according to Fig. 3 by the clamped layer of fabric 33. Starting from the central area of the pumping diaphragm 3, the boundary wall 13 now extends outward at an upward angle. In this position, both the inlet opening 7 and the outlet opening 8 are shut off by the corresponding valve reed 24 or 25, respectively. The pumping chamber 2 has a maximum volume. The bearing bush 37 has a chamfer at its lower end so as not to obstruct the upward movement of the boundary wall 13.

[0028] The absolute value of the angle between a horizontal line and the boundary wall 13 approximately equals that of the angle between the horizontal line and the inclined surface 10. Compared to Fig. 3, the angle α between the lower side wall portion 17 and the upper side wall portion 18 has become even more obtuse. Compared to Fig. 3, the fold 16 has moved further in the direction of the central longitudinal axis 5. The volume of the pumping chamber 2 is related to the size of the angle α in the area of the fold 16.

[0029] In Fig. 5, the annular coil 45 is now current-less again. The helical compression spring 42 has pushed the anchor plate 35 away again from the stator plate 35, thereby reducing the volume of the pumping chamber 2 in a way that the delivery fluid has been discharged from the pumping chamber 2 in the outlet direction O, i.e. through the outlet opening 8 and the outlet connection 21. During this process, the valve reed 25 was pivoted from its rest position to the open position in a self-acting manner while the inlet opening 7 is shut off by the valve reed 24 to avoid an unwanted backflow of delivery fluid.

[0030] The helical compression spring 42 subsequently pushes the anchor plate 35 in the position shown in Fig. 2, thus reverting back to the position shown in Fig. 2.

[0031] The diaphragm delivery pump 1 virtually comprises an electric linear drive which performs the described axial up-and-down movement of the unit consisting of the anchor plate 35 and the diaphragm ring 34, and therefore that of the boundary wall 13 as well, by means of magnetic forces. In an initial extreme position, the boundary wall 13 extends outward from its central area towards the bottom and, in a subsequent extreme position, from its central area towards the top. During this process, the side wall 14 delimiting the side of the pumping chamber 2 is unfolded and folded, thus pivoting outwards and inwards, with the fold 16 being displaced. The position of the fold 16 is related to the current volume of the pumping chamber 2 during the operation. The pumping diaphragm 3 is single-acting, i.e. the delivery fluid comes in contact with only one side of the boundary wall 13 delimiting the pumping chamber 2 towards the top. A movement of the pumping diaphragm 3 causes bending of the portion of the side wall 14 adjoining the sealing bead 15.

[0032] Figs. 6 to 8 once again show separate views of various positions of the used pumping diaphragm 3. Reference is made to the corresponding previous description of the pumping diaphragm 3. When the pumping diaphragm 3 is actuated, the side wall 14 thereof is folded inwards and outwards again, with the fold 16 being displaced in the radial direction.

[0033] The following is a description, taken in conjunction with figures 9 to 12, of a second embodiment of the diaphragm delivery pump 1' according to the invention. Identical parts are referred to with the same reference numerals as used for the previous embodiment to the description of which reference is made.

[0034] In contrast to the already described diaphragm delivery pump 1 according to the first embodiment, the diaphragm delivery pump 1', which is shown in Figs. 9 to 12, comprises two separate pumping diaphragms 3 and a rotary drive. Compared to the previous diaphragm delivery pump 1, the diaphragm delivery pump 1' also has two separate pumping chambers 2 which are defined by the two pumping diaphragms 3 and the two valve plates 4. According to another embodiment, the two pumping diaphragms 3 are integral with one another. In this case, the pumping diaphragm 3 is double-acting, having one pumping chamber 2 each on either side.

[0035] In this embodiment, an external, conventional electric rotary motor 47 is assigned to the diaphragm delivery pump 1'. The electric rotary motor 47 has a drive shaft 48, which may be driven by rotation and extends horizontally according to the figures, and is attached to a fixing bracket 49 substantially having the shape of an L, with the electric rotary motor 47 being screwed to a vertical arm 50 of the fixing bracket 49 by means of two fixing screws 51. The drive shaft 48 is guided through a bore 52 formed in the arm 50. Moreover, the fixing bracket 49 has a horizontal arm 53 adjoining the vertical arm 50, thus serving as a base plate. A horizontally angled support plate 54 adjoins the upper end of the vertical arm 50, with a mounting protrusion 55 having a circular cross-section vertically protruding from the center of said support plate 54.

[0036] At least part of the surface of the connection plate 19 bears against the support plate 54, with the inlet connection 20 and the outlet connection 21 of said connection plate 19 being oriented downwards, as in the previous embodiment shown in Figs. 1 to 5. The valve plate 4 adjoins said connection plate 19. The inclined surface 10 of the valve plate 4 again faces away from the connection plate 19. An upper valve plate 4 is provided opposite the lower valve plate 4, the inclined surface 10 thereof facing towards the inclined surface 10 of the lower valve plate 4. Thus, there is a free space between the two valve plates 4 the height of which increases gradually from the inside to the outside due to the inclined surfaces 10. Another connection plate 19 bears against the contact surface 9 of the upper valve plate 4, the inlet connection 20 and outlet connection 21 of said connection plate 19 extending upward in the opposite direction of the inlet connection 20 and outlet connection 21 of the lower valve plate 4. The two inlet connections 20 of the two connection plates 19 are flush with each other, with the two outlet connections 21 of the two connection plates 19 also being aligned with one another. The valve plates 4 are identical. The connection plates 19 also correspond to one another. The connecting screw 32 is replaced by the mounting protrusion 55 which passes centrally through the connection plate 19 and the valve plate 4.

[0037] A fixing nut 56 bearing against the upper connection plate 19 is screwed on the end of the mounting protrusion 55, thus ensuring that the connection plates 19 and the valve plates 4 are securely fixed on the mounting protrusion 55.

[0038] Two identical pumping diaphragms 3, with a layer of fabric 33 disposed therebetween, are disposed between the two valve plates 4, with the mounting protrusion 55 passing centrally through both pumping diaphragms 3 an inner area of which is pressed together by the valve plates 4. At least part of the surface of the boundary walls 13, which are disposed opposite one another, bears against the layer of fabric 33. The side wall 14 again starts at the point where the boundary wall 13 is no longer securely attached to the layer of fabric 33. Thus, a pumping diaphragm 3 is disposed on either side of the layer of fabric 33, with the side walls 14 extending away from the layer of fabric 33. As already mentioned, an integral design comprising the two pumping diaphragms 3 and the layer of fabric 33 disposed therebetween is also conceivable.

[0039] In this embodiment, the layer of fabric 33 is clamped between the diaphragm ring 34 and a connecting rod 57. The connecting rod 57 comprises a clamping ring 58 which has a central vertical axis and is screwed to the diaphragm ring 34 in a way as to clamp the layer of fabric 33. Moreover, the connecting rod 57 has a beam 66 with a horizontal bore 59 having an eccentric 61 being mounted therein which is connected to the drive shaft 48 in a non-rotational manner by means of a rolling-element bearing 60 disposed therebetween.

[0040] The following is a short description of the function of this second embodiment. The function roughly corresponds to the function of the embodiment described before in great detail. During the operation of the electric rotary motor 47, the drive shaft 48 thereof is set in rotation, thus resulting in a rotation of the eccentric 61. Due to the connecting rod 57, the rotation of the eccentric 61 in turn translates into an approximately linear vertical axial movement of the clamped layer of fabric 33.

[0041] Fig. 10 shows an extreme position of the pumping diaphragms 3. In this position, the boundary wall 13 of the upper pumping diaphragm 3 virtually bears against the inclined surface 10 of the upper valve plate 4. Thus, the upper pumping chamber 2 has a minimum volume while the lower pumping chamber, on the other hand, has a maximum volume. As can be seen in Fig. 10, the side wall 14 of the upper pumping diaphragm 3 is again folded outwards, thus forming an acute angle α, while the side wall 14 of the lower pumping diaphragm 3 is pulled apart, thus forming a more obtuse angle α. The fold 16 of the upper pumping diaphragm 3 protrudes beyond the fold 16 of the lower pumping diaphragm 3 in the radial direction. The inlet openings 7 and the outlet openings 8 are closed by the valve reeds 24 or 25, respectively.

[0042] During a further rotation of the eccentric 61, the connecting rod 57 moves the layer of fabric 33 downwards in the direction of the inclined surface 10 of the lower valve plate 4. Thus, the volume of the upper pumping chamber 2 increases while the volume of the lower pumping chamber 2 is simultaneously reduced. When the size of the upper pumping chamber 2 increases, delivery fluid is drawn into the upper pumping chamber 2, thus causing the valve reed 24 to open the inlet opening 7 of the upper valve plate 4. The outlet opening 8 of the upper valve plate 4 is closed. When the size of the lower pumping chamber 2 is reduced, delivery fluid is forced, or pressed, out of the lower pumping chamber 2, thus causing the valve reed 25 to open the outlet opening 8 of the lower valve plate 4. As can be seen from Fig. 11, the inlet opening 7 of the lower valve plate 4 is closed during this process. The shape of the lower and upper pumping diaphragms 3 corresponds to the first embodiment. As far as the further stages are concerned, reference is made to the previous description.

[0043] A connecting hose 62 is provided in Fig. 12 which establishes a flow connection between the outlet connection 21 of the upper connection plate 19 and the inlet connection 20 of the lower connection plate 19. The two pumping chambers 2 are thus connected in series so as to obtain a higher compression as compared to the first embodiment. A serial connection is also obtained by connecting the outlet connection 21 of the lower connection plate 19 to the inlet connection 20 of the upper connection plate 19. The diaphragm delivery pump 1' may of course also be operated with the pumping chambers 2 being connected in parallel, thus enabling a higher flow rate to be obtained as compared to the first embodiment.

[0044] The following is a description, taken in conjunction with Fig. 13, of a third embodiment of the invention. Identical parts are referred to with the same reference numerals as used for the previous embodiment to the description of which reference is made. In contrast to the second embodiment, the connection plates 19 and the valve plates 4 are rigidly interconnected by means of a central, axial hollow pipe 63 which replaces the mounting protrusion 55 according to the previous embodiment. The hollow pipe 63 has a radially protruding contact web 64 bearing against the outside of the upper connection plate 19. A fixing nut 65 is screwed on the hollow pipe 63, thus fixing the connection plates 19 and the valve plates 4 with respect to each other. The hollow pipe 63 provides for connecting connection pipes on both sides of the diaphragm delivery pump 1". As can be seen from Fig. 13, a curved pipe portion 67 is connected to the lower end of the hollow pipe 63 and additionally, to the outlet connection 21 of the lower connection plate 19. This design allows to interconnect the individual connections 20, 21 without requiring longer, obstructive pipes. In particular, the two outlet connections 21 may also be interconnected within the valve plates 4. This allows for the construction of a very compact diaphragm delivery pump 1".

[0045] The following is a description, taken in conjunction with Figs. 14 to 17, of an integral unit comprising two pumping diaphragms 3 according to the second and third embodiments. A separate layer of fabric 33 is not provided. This unit is double-acting, with both sides of the boundary wall 13 coming in contact with delivery fluid during the delivery of a delivery fluid.

[0046] The diaphragms 3 of the embodiments disclosed herein have a sealing bead 15 for sealing against the corresponding valve plate 4. Other designs providing a sealed attachment are of course also conceivable. What is essential is to obtain a secure attachment and, simultaneously, a hermetically sealed connection.

[0047] The diaphragm delivery pumps 1, 1', 1" according to the invention have a much higher throughput as compared to similar diaphragm pumps of an identical size. They may be produced in a simple and cost-effective manner. What is essential is that the side wall 14 folds when the volume of the pumping chamber 2 changes. This is what the fold 16 is provided for. The side wall 14 may also be provided with several folds 16 disposed one above the other. Moreover, the fold 16 may also extend over a partial area of the side wall 14 only, thus allowing an outward movement of this partial area of the side wall 14 only. Only the central part and the edges of the pumping diaphragm 3 are attached to the corresponding valve body 4. The fold 16 is freely movable, with neither its inward nor outward movement being determined by external means. A multitude of other options are suitable for driving. In this respect, it is not important whether the pumping diaphragm 3 is moved with respect to the valve plate 4 or whether the valve plate 4 is moved with respect to the pumping diaphragm 3.

[0048] According to an alternative embodiment, a drive is provided comprising a disc made of piezoelectric ceramics. When an electric voltage is applied in one direction, said disc is deformed, thereby actuating the pumping diaphragm 3. This drive is applicable to both the single-acting pumping diaphragm 3 and the double-acting pumping diaphragm. Piezoelectric ceramics acquires its special properties in a specific production process enabling the material to convert an electric voltage into a mechanical movement or oscillation, and is therefore suitable for use as a component for a drive.

[0049] The already described embodiments are provided with an outer side wall 14 delimiting the pumping chamber 2 towards the outside. According to an alternative embodiment, a pumping diaphragm has a side wall comprising at least one free fold for changing the volume of the at least one pumping chamber, said free fold extending over at least one circumferential area of the pumping diaphragm and, in contrast to the previous embodiments, folding inwards when the volume of the pumping chamber 2 is reduced by actuating the pumping diaphragm 3. Starting from the outer edge area of the valve plate 4, the fold 16 thus folds inwards, i.e. into the pumping chamber 2. When in the outermost position, said fold 16 is situated above the outer edge area. This design is in particular intended for vacuum pumps. Otherwise, this diaphragm substantially corresponds to the previous diaphragms.

[0050] In the first embodiment of the diaphragm delivery pump shown in Figs. 1 to 5, the pumping chamber 2 is - as already described - defined by the pumping diaphragm 3 and the valve plate 4. A closer look reveals that the pumping chamber 2 is delimited towards the outside by the side wall 14 of the pumping diaphragm 3 in the radial direction, and by the boundary wall 13 of the pumping diaphragm 3 and the valve plate 4 in the axial direction. Thus, the boundary wall 13 closes the pumping chamber 2 towards the top while the valve plate 4 delimits the pumping chamber 2 towards the bottom.

[0051] As already mentioned, the diaphragm delivery pumps 1', 1" are provided with two separate pumping chambers 2 disposed one above the other. The upper pumping chamber 2 is defined by the upper valve plate 4 and the upper pumping diaphragm 3 while the lower pumping chamber 2 is defined by the lower valve plate 4 and the lower pumping diaphragm 3. A closer look reveals that the upper pumping chamber 2 is delimited by the side wall 14 of the upper pumping diaphragm 3 in the radial direction, by the upper valve plate 4 towards the top, and by boundary wall 13 of the upper pumping diaphragm 3 towards the bottom. Similarly, this also applies to the lower pumping chamber 2. A closer look reveals that said lower pumping chamber 2 is delimited by the side wall 14 of the lower pumping diaphragm 3 in the radial direction, by the boundary wall 13 of the lower pumping diaphragm 3 towards the top, and by the lower valve plate 4 towards the bottom. A layer of fabric 33 is disposed between the two boundary walls 13 which may be actuated externally from the side. As already described, a one-piece design comprising the two pumping diaphragms 3 and the layer of fabric 33 is also conceivable.

[0052] As shown in Figs. 14 to 17, a one-piece unit comprising in fact two pumping diaphragms 3 is also conceivable, with no layer of fabric 33 being provided. Thus, it is virtually obtained a common, single boundary wall 13 which serves to axially delimit the two pumping chambers 2. This unit may again be actuated externally from the side. Therefor, an actuating element is advantageously provided for actuation which engages with the unit of pumping diaphragms 3 externally from the side substantially in the area of the boundary wall 13, thereby enabling the unit to be actuated. This element may for example be an actuating plate having an opening adapted to the diameter of the boundary wall 13. This element is situated virtually at the height of the boundary corner 13 between the side walls 14 and acts upon the unit externally from the side. However, a separate actuating layer which is suitable for transmitting forces may also be provided therefor. The actuating element takes over the function of the layer of fabric 33 which also forms an actuating element.

[0053] The lower pumping chamber 2 may be regarded as first pumping chamber 2 while the upper pumping chamber 2 may be regarded as second pumping chamber 2.

[0054] In all embodiments, actuation of the pumping diaphragm 3 is performed externally from the side by means of a moving element substantially surrounding the side wall or side walls 14, respectively, via an above-described actuating element. The moving element thus applies corresponding forces for axially actuating the pumping diaphragms 3 in the radial direction via an actuating element. This type of actuation thus fundamentally differs from conventional bellows pumps in which actuating forces are only applied in the axial direction. According to the first embodiment of the diaphragm delivery pump 1, the circumferential moving element is formed by the diaphragm ring 34 and the anchor plate 35 while in the diaphragm delivery pump 1', said moving element is formed by the diaphragm ring 34 and the clamping ring 58. The pumping diaphragm/s 3 are thus situated virtually inside the moving element. The moving element acts upon the radially outer edges of the diaphragm actuating element configured as a layer of fabric 33, with at least part of the surface thereof being attached to the boundary wall 13 of the pumping diaphragm 3. Movement of the pumping diaphragm 3 thus occurs from the radially outer end and not from the central surface, as in other pumps, thus enabling an increased displacement or swept volume to be obtained. The fold 16 is situated in an external circumferential area of the pumping diaphragm 3.

[0055] The following is a description, taken in conjunction with Figs. 18 and 19, of a fourth embodiment of the invention. Identical parts are referred to with the same reference numerals as used for the previous embodiments to the description of which reference is made.

[0056] Like the diaphragm delivery pumps 1' and 1" according to the second and third embodiments, the diaphragm delivery pump 1''' shown in Fig. 18 has two separate pumping chambers 2 disposed one above the other. The diaphragm delivery pump 1''' is housed in a substantially two-part housing 68 comprising a lower pot-like housing part 69 and a pot-like cover part 70. The housing part 69 and the cover part 70 may be snap-locked with one another for interconnection, with a sealing ring 113 being disposed therebetween so as to obtain a sealed connection.

[0057] The one-piece housing part 69 has a plate-shaped bottom element 71 having a central recess 72. A central guide opening 73 is formed in the recess 72. The guide opening 73 is surrounded by inlet openings 74 which are still situated in the recess 72, therefore passing through the bottom element 71. A side wall 75 adjoins the outer edge of the bottom element 71, said side wall 75 being a component of the housing part 69. An outwardly projecting retaining shoulder 76 is formed in the side wall 75 in a way that the side wall 75 expands in a step-like manner with respect to the bottom element 71 in the area of the retaining shoulder 76. An outwardly projecting flange 77 is formed at the end of the side wall 75 facing away from the bottom element 71, said flange 77 being provided with several snap-lock openings 78.

[0058] The one-piece cover part 70 has a cover plate 79 which is parallel to the bottom element 71 and has a central projection 80. The projection 80 defines a chamber and projects outward from the cover plate 79. The projection 80 and the guide opening 73 are flush with each other. The projection 80 is surrounded by inlet openings 81 which are situated in the cover plate 79, thus passing through the latter. The cover plate 79 extends outward from the projection 80, thus forming a retaining step 82 projecting towards the bottom element 71. A side wall 83 adjoins the edge of the cover plate 79. A reinforced end piece is situated at the lower end of the side wall 83, with several resilient snap-lock bodies 84 projecting downward being attached to said end piece. The snap-lock bodies 84 are dimensioned and disposed in a way as to cooperate with the snap-lock openings 78 formed in the flange 77 in a snap-locking manner. The snap-lock bodies 84 and the corresponding snap-lock openings 78 enable the housing part 69 and the cover part 70 to be detachably interconnected, with the cover part 70 defining an upper partial housing space 85 and the housing part 69 defining a lower partial housing space 86. The two partial housing spaces 85, 86 are interconnected in a way as to obtain a common housing space 87 defined by the housing 68.

[0059] The actual diaphragm delivery pump 1''' is housed in the housing space 87. The diaphragm delivery pump 1''' has - as mentioned - two separate pumping chambers 2 and a magnetic drive. The diaphragm delivery pump 1 according to the first embodiment is provided with a magnetic drive as well to which reference is principally made. However, other drives are conceivable for this embodiment as well.

[0060] Accordingly, the diaphragm delivery pump 1''' has a lower and an upper or a first and a second pumping chamber 2, respectively, having a variable volume, with each of which being defined by a pumping diaphragm 3' and a valve plate 4'. According to another embodiment, the two pumping diaphragms 3' are integral with one another. The pumping diaphragm 3' according to said integral design is double-acting, having a pumping chamber 2 on either side.

[0061] Each valve plate 4' has an outer annular base body 88 and an inner annular retaining body 89. The inner retaining bodies 89 oppose one another while the base bodies 88 virtually face away from one another. An outer edge area of the upper base body 88 bears against the inside of the retaining step 82, thereby fixing the upper base body 88. Each retaining body 89 has at least one projection 90 engaging with at least one corresponding recess 91 disposed in the adjacent base body 88 so as obtain a secure connection between said bodies 88, 89. A flexible valve element 92 is clamped between each base body 88 and the corresponding retaining body 89, said valve element 92 being self-acting or pressure-controlled, respectively.

[0062] Several inlet openings 7' projecting into the corresponding, adjacent pumping chamber 2 are formed in each base body 88. When in their respective shut-off position, corresponding areas of the valve elements 92 cover the inlet openings 7', thereby closing the latter in a fluid-tight manner. In Fig. 18, all valve elements 92 are situated in said shut-off position. In an open position, not shown, the respective area of the valve element 92 is lifted off the corresponding base body 88, thus opening the corresponding inlet opening 7' for the delivery fluid to enter the corresponding pumping chamber 2. Each retaining body 89 has outlet openings 8' which are in a flow-connection with the respective pumping chamber 2.

[0063] In a shut-off position, the valve elements 92 also close the end sides of the respective outlet openings 8' by means of other areas. The corresponding areas of the valve elements 92 may be lifted off said shut-off position in a pressure-controlled manner.

[0064] Each pumping diaphragm 3' forms one piece and has an inner boundary wall 13', with an inner side wall 14' pivotally disposed adjacent thereto. A sealing bead 15 having a circular cross-section is formed at the free end of the side wall 14'. The height of each side wall 14' is reduced by half by a circumferential fold 16 which allows for folding in a way that a lower side wall portion 17 and an upper side wall portion 18 are obtained. In the intermediate position of the pumping diaphragms 3' shown in Fig. 18, the folds 16 radially protrude towards the inside with respect to the base bodies 88, with the side wall portions 17, 18 of the pumping diaphragm 3' radially converging in the inward direction. The fold 16 is situated in an internal circumferential area of the pumping diaphragm 3'. The bead 15 of the upper pumping diaphragm 3' is situated in a mount 12' between the cover plate 79 and the upper base body 88 disposed adjacent thereto.

[0065] As can be seen from Fig. 18, the two pumping diaphragms 3' are interconnected via the surfaces of their boundary walls 13', with the respective side walls 14' extending away from one another, starting from the boundary walls 13'. A radially outer edge area 93 of the boundary walls 13' of the pumping diaphragms 3' is fixed between the retaining bodies 89. The edge area 93 is fixed by means of a radially outer edge area 94 of the retaining bodies 89.

[0066] The upper pumping chamber 2 is delimited towards the bottom by the boundary wall 13' and radially towards the inside by the side wall 14' of the upper pumping diaphragm 3'. The upper pumping chamber 2 is delimited both radially towards the outside and towards the top by the upper valve plate 4'.

[0067] The lower pumping chamber 2 is delimited towards the top by the boundary wall 13' and radially towards the inside by the side wall 14' of the lower pumping diaphragm 3'. The lower pumping chamber 2 is delimited both radially towards the outside and towards the bottom by the lower valve plate 4'.

[0068] A radially inner edge area 95 of the pumping diaphragms 3' is fixed to an actuating rod 96. The side walls 14' extend away from said edge area 95 of the boundary walls 13' thereof. The actuating rod 96 has a fixing portion 97 so as to provide a connection between the pumping diaphragms 3' and the actuating rod 96, said fixing portion 97 being encircled by an upper and a lower fixing ring 98. The edge area 95 is clamped between the two fixing rings 98 for fixing, with the side walls 14' encircling the fixing portion 97 and the fixing rings 98. The fixing portion 97 and the fixing rings 98 are thus situated in the centre of the pumping diaphragms 3'. The central longitudinal axis of the fixing portion 97 is aligned with the central longitudinal axis of the pumping diaphragms 3'.

[0069] The actuating rod 96 is mounted for displacement in an upper mounting unit 99 and a lower mounting unit 100, with the upper mounting unit 99 being inserted into the cover plate 79 in the area of the projection 80 and the mounting unit 100 being inserted into the bottom element 71 in the area of the recess 72.

[0070] The bead 15 of the lower pumping diaphragm 3' is situated in a mount 12' which is provided between the lower base body 88 and a fixing plate 101 disposed adjacent to the latter.

[0071] The fixing plate 101 has a mounting opening 102 in its centre into which a mounting unit 103 is inserted for mounting the actuating rod 96. A driving portion 104 of the actuating rod 96 passes through the mounting unit 103, said driving portion 104 adjoining the lower end of the fixing portion 97. The fixing plate 101 has an external retaining protrusion 105 in the radial direction which rests upon the retaining shoulder 76 of the housing part 69 in a way that the fixing plate 101 is supported by the housing part 69.

[0072] Moreover, the fixing plate 101 is provided with inlet openings 106 which are flush with the inlet openings 7'. The fixing plate 101 supports the valve plates 4' and the pumping diaphragms 3'.

[0073] The actual drive unit of the diaphragm delivery pump 1''' is situated below the fixing plate 101. The drive unit comprises an annular coil 45' which is conductively connected to a controllable current source. The annular coil 45' encircles an internal space 107 penetrated by the driving portion 104 of the actuating rod 96. According to Fig. 18, a magnet body 108 comprising two magnets 109, 111 and a piece of iron 110 disposed therebetween is situated on the driving portion 104 in the internal space 107 of the annular coil 45'.

[0074] The drive unit is situated in the housing part 69 along with the lower valve plate 4' and the lower pumping diaphragm 3'. The upper valve plate 4' and the upper pumping diaphragm 3', on the other hand, are situated in the cover part 70.

[0075] The following is a description of the function of the diaphragm delivery pump 1''' based on the intermediate position shown in Fig. 18. When the annular coil 45' is supplied with an electrical current, an alternating magnetic field is generated which acts upon the magnet body 108, thereby causing an upward/downward movement of the actuating rod 96 along its central longitudinal axis or the central longitudinal axis 5, respectively. This also causes the two pumping diaphragms 3' to be actuated radially from the inside, said pumping diaphragms 3' being rigidly connected to the actuating rod 96 by means of the fixing rings 98. On the outside, however, the pumping diaphragms 3' are radially fixed. When the actuating rod 96 moves upwards in the direction of the cover plate 79, the volume of the lower pumping chamber 2 increases while the volume of the upper pumping chamber 2 is simultaneously reduced to a corresponding extent. When the volume of the lower pumping chamber 2 increases, the fold 16 moves from the inside to the outside in the radial direction, thus causing the angle α to become more obtuse. The fold 16 thus moves away from the central longitudinal axis 5. The increasing volume of the lower pumping chamber 2 causes a delivery fluid to be drawn into the lower pumping chamber 2 through the inlet openings 74, 106, 7', with the valve element 92 being correspondingly lifted off the inlet opening 7' due to the influent delivery fluid. During this process, the outlet openings 8' are closed by the valve element 92. When the lower pumping chamber 2 increases in size, the upper pumping chamber 2 is reduced in size. This reduction causes the free fold 16 of the upper pumping diaphragm 3' to move radially inwards in the direction of the central longitudinal axis 5. The delivery fluid in the upper pumping chamber 2 is discharged from the upper pumping chamber 2 through the outlet openings 8', with the valve element 92 being correspondingly lifted off the outlet openings 8' by the delivery fluid, and the delivery fluid being discharged from the housing 68 through an outlet 112. The outlet 112 in the shape of a connection is a component of the cover part 70. When the upper pumping chamber 2 is reduced in size, the inlet openings 7' are closed by the valve elements 92. For complete draining, each of the retaining bodies 89 has an inclined surface 10 serving as a rest for the boundary wall 13'.

[0076] During the described movement, the upper end of the actuating rod 96 furthermore penetrates into the chamber defined by the projection 80 of the cover plate 79 while the magnet body 108 partially moves out of the internal space 107 of the annular coil 45'. A corresponding actuation of the annular coil 45' allows the polarity of the generated magnetic field to be reversed, thereby causing a downward movement of the actuating rod 96 in the direction of the bottom element 71. The upper description applies correspondingly. The upper pumping chamber 2 is thus increased in size while that of the lower pumping chamber 2 is reduced. When the upper pumping chamber 2 increases in size, a delivery fluid is drawn into the upper pumping chamber 2 through the openings 81 and 7', thereby again actuating the valve element 92. At the same time, the delivery fluid in the upper pumping chamber 2 is discharged from the housing 68 through the outlet openings 8' and the outlet 112. When the actuating rod 96 moves downwards, the magnet body 108 moves into the recess 72.

[0077] An oscillating vibration drive is formed by the annular coil 45' and the magnet body 108, said vibration drive operating the pumping diaphragms 3', thereby effecting the above processes.

[0078] In contrast to the previous embodiments, the pumping diaphragms 3' of this embodiment are actuated internally from the side by means of fixing rings 98 which are situated within the side walls 14' of the pumping diaphragms 3'. The boundary wall 13' applies forces to the boundary walls 3' from inside in the radial direction, thereby actuating the pumping diaphragms 3'.

[0079] The diaphragm delivery pumps 1, 1', 1'', 1''' may be produced in a particularly cost-effective manner. Moreover, the pumping chambers 2 are hermetically sealed. This is due to the fact that each of the pumping chambers 2 is only defined by a pumping diaphragm 3, 3' and a valve plate 4, 4'. Conventional bellows pumps, on the other hand, generally require a valve plate, a cylindrical bellows and a closure element disposed opposite the valve plate. The bellows must therefore be attached to both the valve plate and the closure element in a fluid-tight manner.

Claims

1. Delivery pump for a delivery fluid comprising

a) at least one valve plate (4; 4');
b) at least one pumping diaphragm (3; 3') which is displaceable with respect to the valve plate (4; 4') for delivering the delivery fluid, said diaphragm (3; 3')

i) being attached to the at least one valve plate (4; 4') in a fluid-tight manner whilst defining at least one pumping chamber (2) together with the at least one valve plate (4; 4'), and
ii) having at least one free fold (16) for changing the volume of the at least one pumping chamber (2), said fold (16) extending over at least one circumferential area of the at least one pumping diaphragm (3; 3');

c) at least one inlet opening (7; 7') disposed in the at least one valve plate (4; 4') for guiding the delivery fluid into the at least one pumping chamber (2), and
d) at least one outlet opening (8; 8') disposed in the at least one valve plate (4; 4') for guiding the delivery fluid out of the at least one pumping chamber (2).

2. Delivery pump according to claim 1, **characterized in that** the at least one pumping diaphragm (3; 3') has a circular outer shape.

3. Delivery pump according to claim 1 or 2, **characterized in that** the at least one free fold (16) extends over the entire circumference of the at least one pumping diaphragm (3; 3').

4. Delivery pump according to one of the preceding claims, **characterized in that** the at least one free fold (16) is situated in a side wall (14; 14') of the at least one pumping diaphragm (3; 3').

5. Delivery pump according to one of the preceding claims, **characterized in that** the at least one valve plate (4) has an outer edge area (11), with the at least one pumping diaphragm (3) being attached to the outer edge area (11) in a fluid-tight manner.

6. Delivery pump according to claim 5, **characterized by** a central longitudinal axis (5), with the at least one free fold (16) protruding beyond the outer edge area (11) in the radial direction.

7. Delivery pump according to one of the preceding claims, **characterized in that** the at least one free fold (16) defines at least one crease line for the at least one pumping diaphragm (3; 3').

8. Delivery pump according to claim 7, **characterized in that** the crease line causes the side wall (14; 14') to fold.

9. Delivery pump according to one of the preceding claims, **characterized in that** the at least one pumping diaphragm (3; 3') furthermore comprises a boundary wall (13; 13') for axially delimiting the at least one pumping chamber (2).

10. Delivery pump according to claim 9, **characterized in that** the boundary wall (13; 13') adjoins the side wall (14; 14').

11. Delivery pump according to claim 9, **characterized in that** the at least one pumping chamber (2) is defined by a valve plate (4; 4'), a side wall (14; 14') and a boundary wall (13; 13').

12. Delivery pump according to one of the preceding claims, **characterized by** two valve plates (4; 4'), with the two valve plates (4; 4') and the at least one pumping diaphragm (3; 3') defining two pumping chambers (2).

13. Delivery pump according to claim 12, **characterized in that** each pumping chamber (2) is defined by a side wall (14; 14') and a boundary wall (13; 13').

14. Delivery pump according to one of the preceding claims, **characterized in that** the boundary wall (13; 13') is actuatable for relative displacement of the at least one pumping diaphragm (3; 3') with respect to the at least one valve plate (4; 4').

15. Delivery pump according to claim 14, **characterized in that** the relative displacement between the at least one pumping diaphragm (3) and the at least one valve plate (4) is forced by lateral external forces.

16. Delivery pump according to one of the claims 1 to 4 and 7 to 14, **characterized in that** the relative displacement between the at least one pumping diaphragm (3') and the at least one valve plate (4') is forced by lateral internal forces.

17. Delivery pump according to claim 16, **characterized in that** the at least one free fold (16) radially protrudes beyond an inner edge area of the at least one valve plate (4').

18. Delivery pump according to claim 16 or 17, **characterized in that** an actuating element (96) passes through the at least one pumping diaphragm (3') for actuating the same.

19. Delivery pump according to claim 18, **characterized in that** the side wall (14') extends adjacent to the actuating element (96) and encircles the latter.

20. Pumping diaphragm for a delivery pump having at least one pumping chamber (2), comprising at least one free fold (16) for changing the volume of the at least one pumping chamber (2), with the at least one free fold (16) extending over at least one circumferential area of the at least one pumping diaphragm (3; 3').

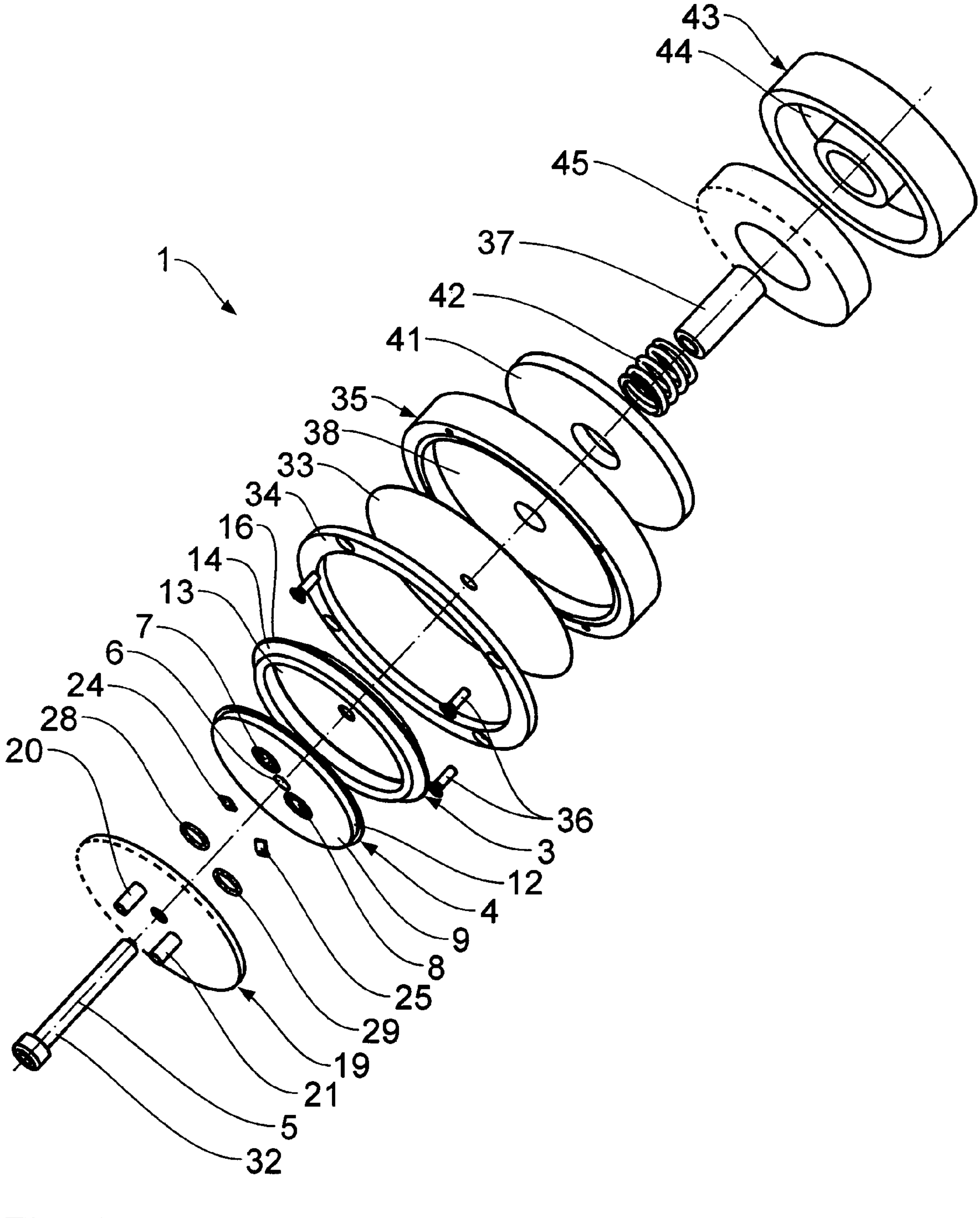
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Fig. 1

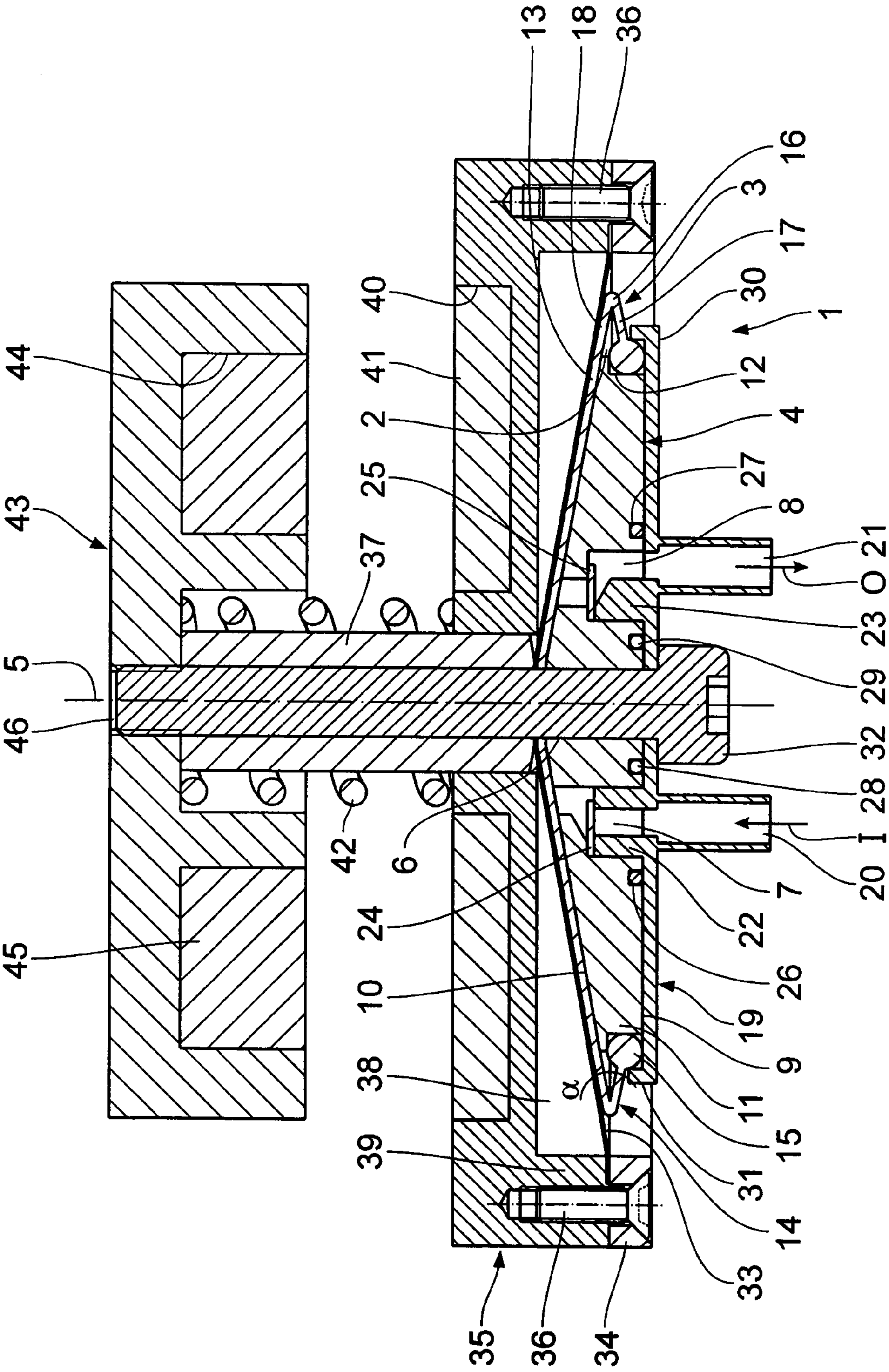
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Fig. 2

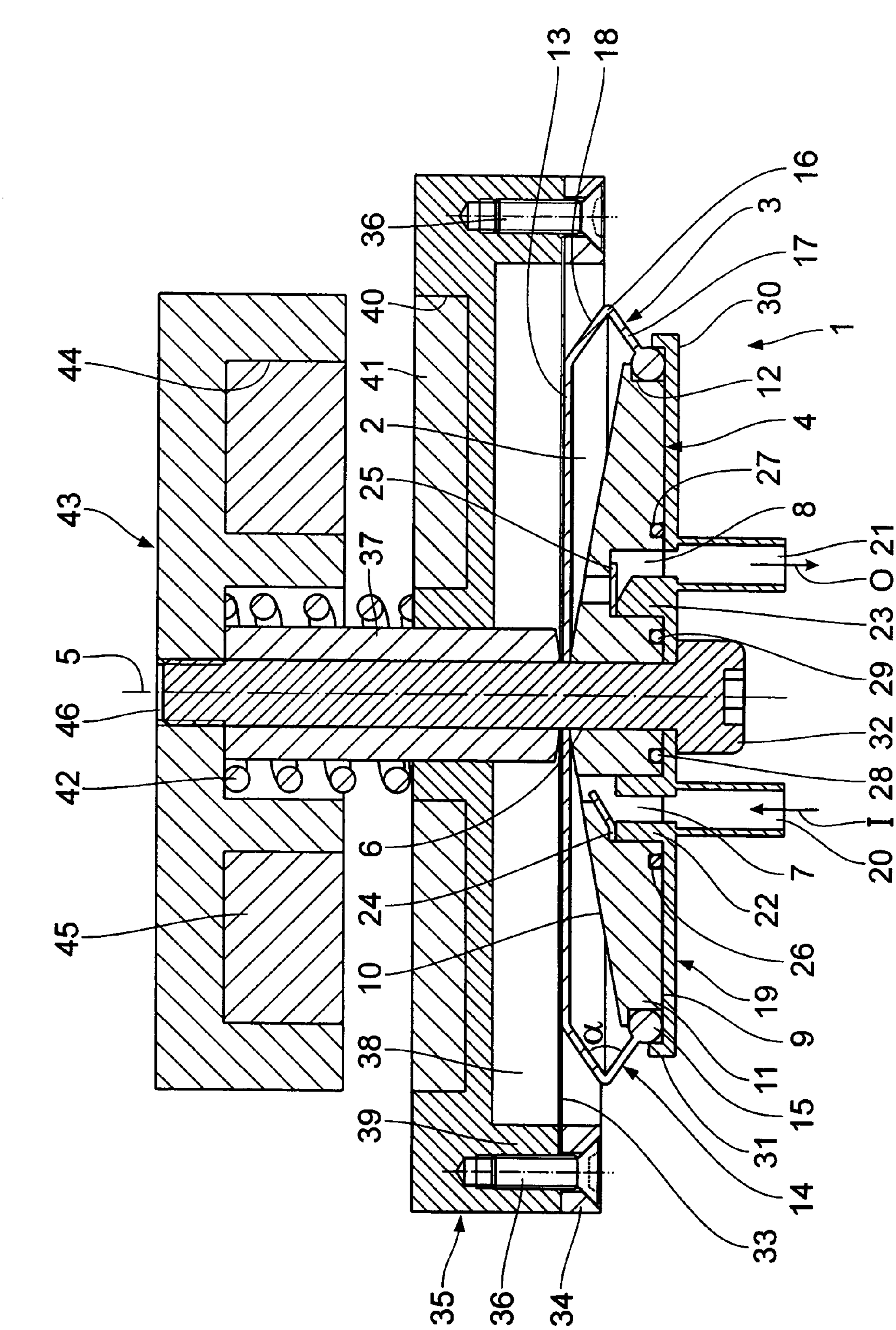

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Fig. 3

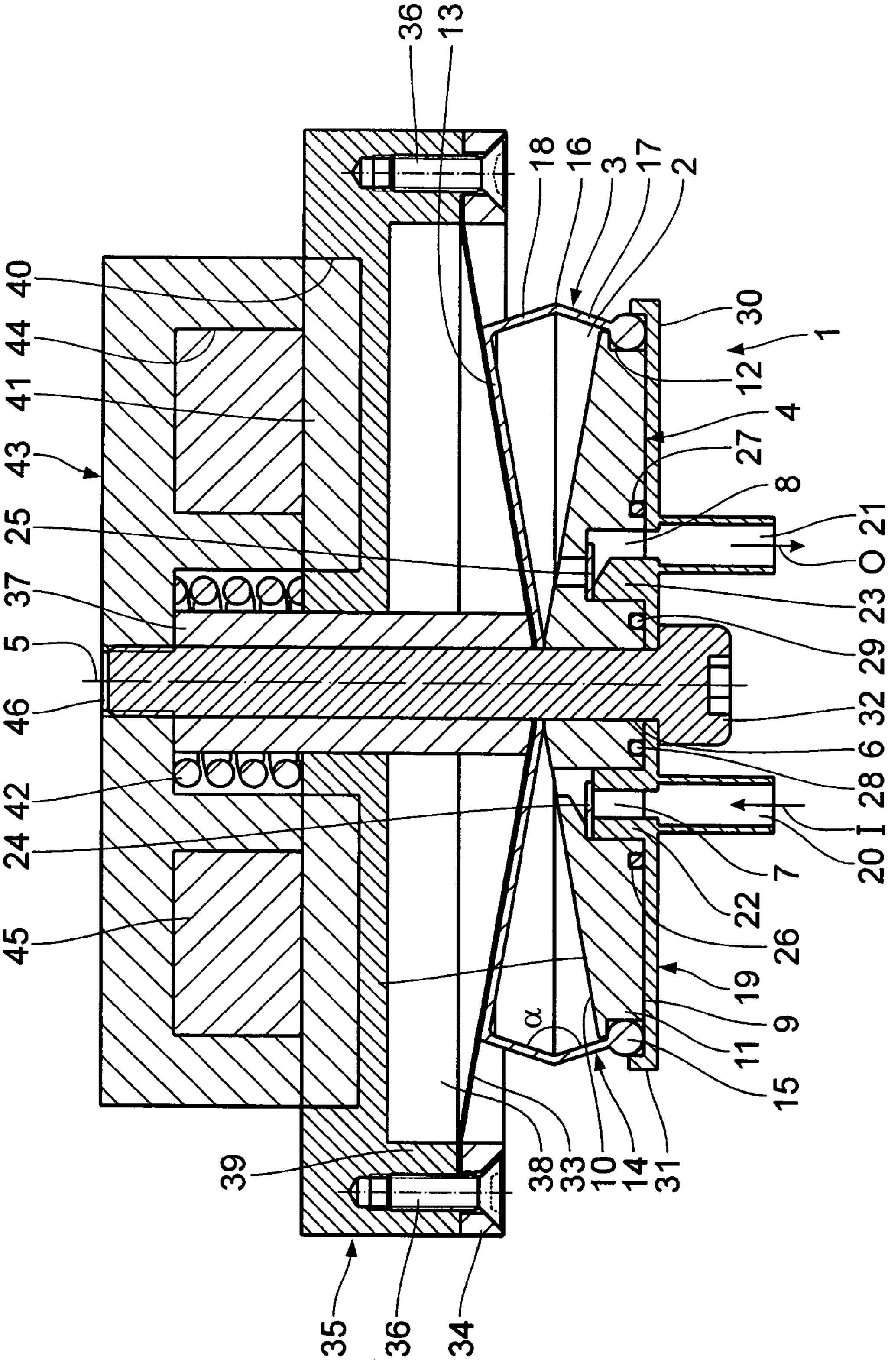
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Fig. 4

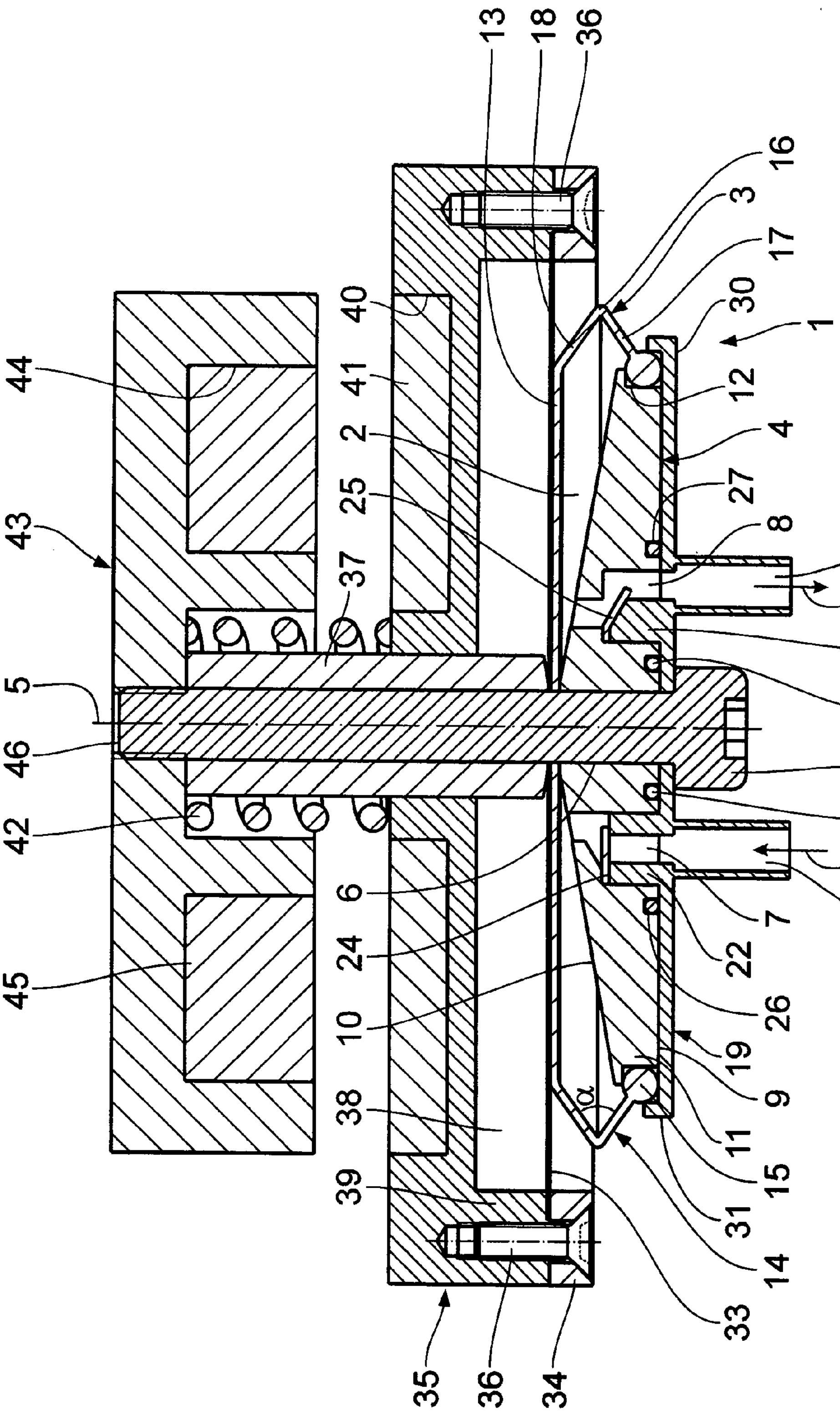

Fig. 5

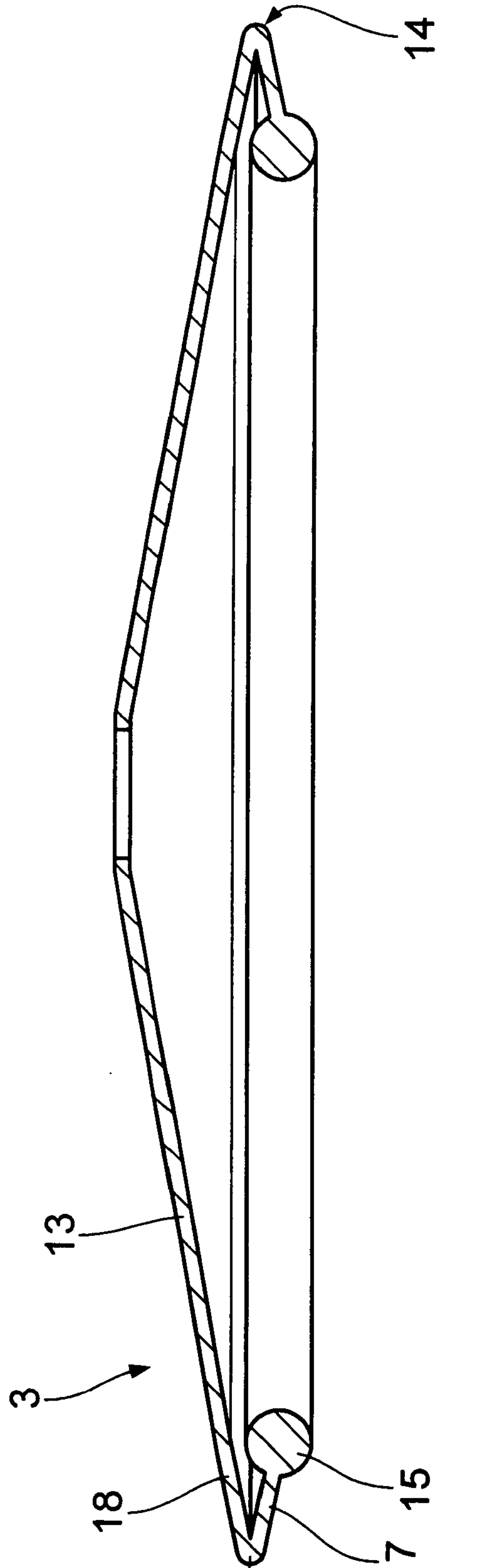

Fig. 6

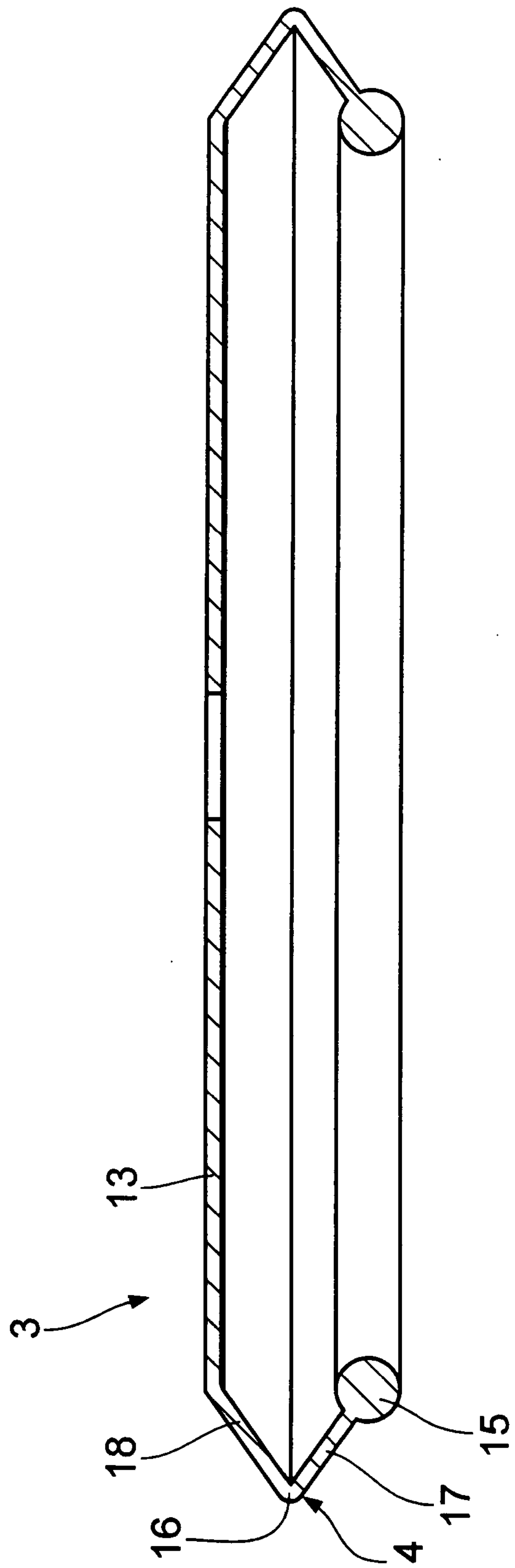

Fig. 7

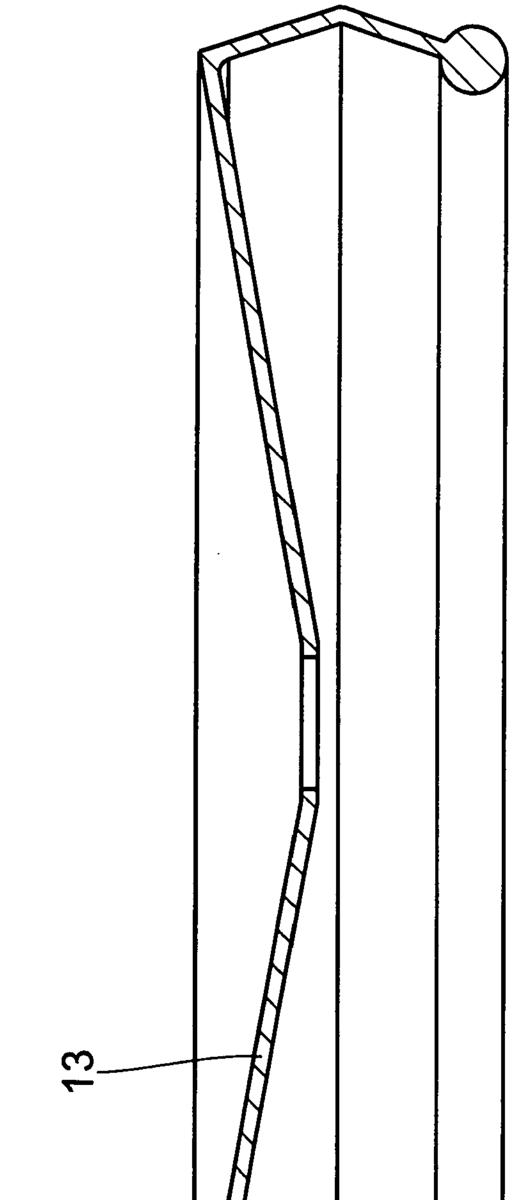

Fig. 8

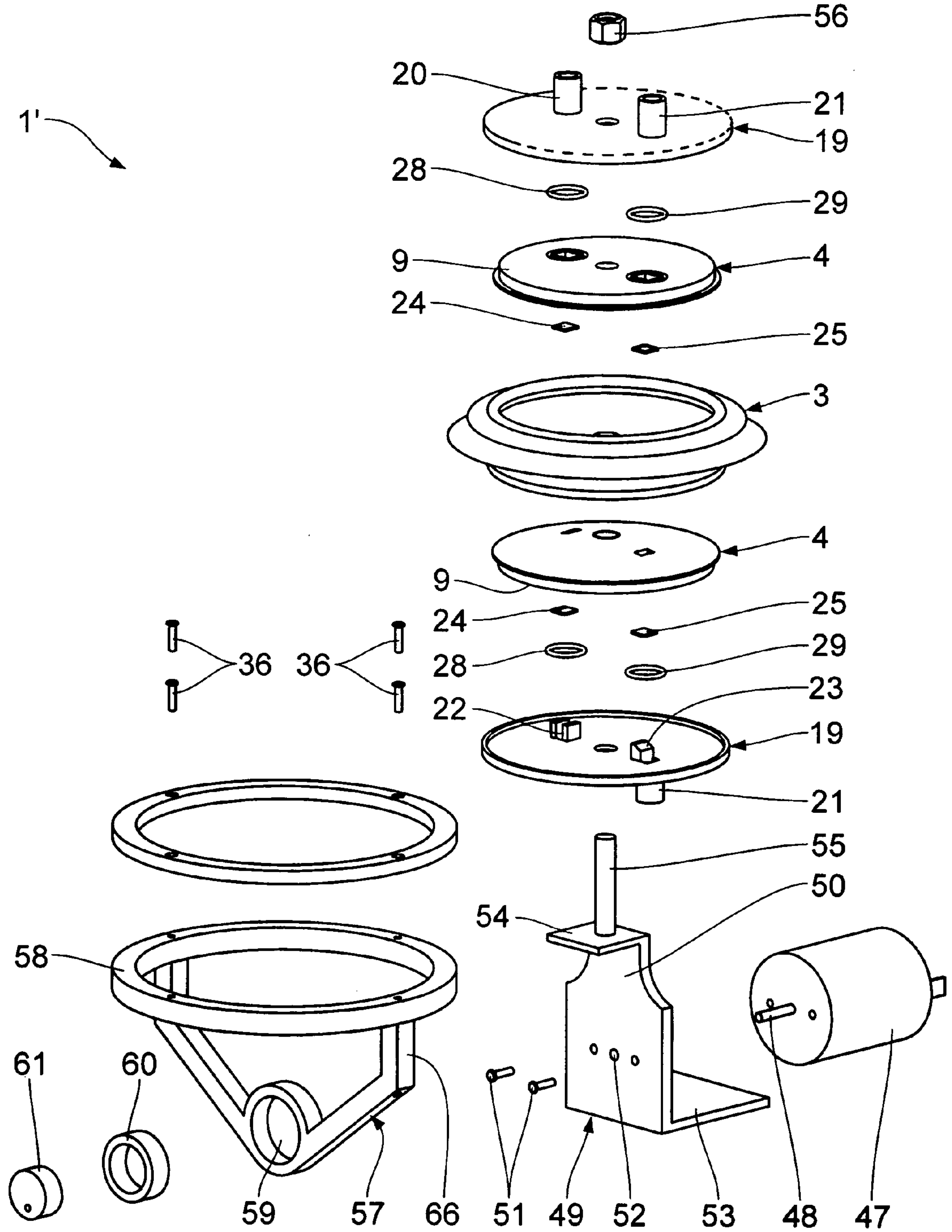

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Fig. 9

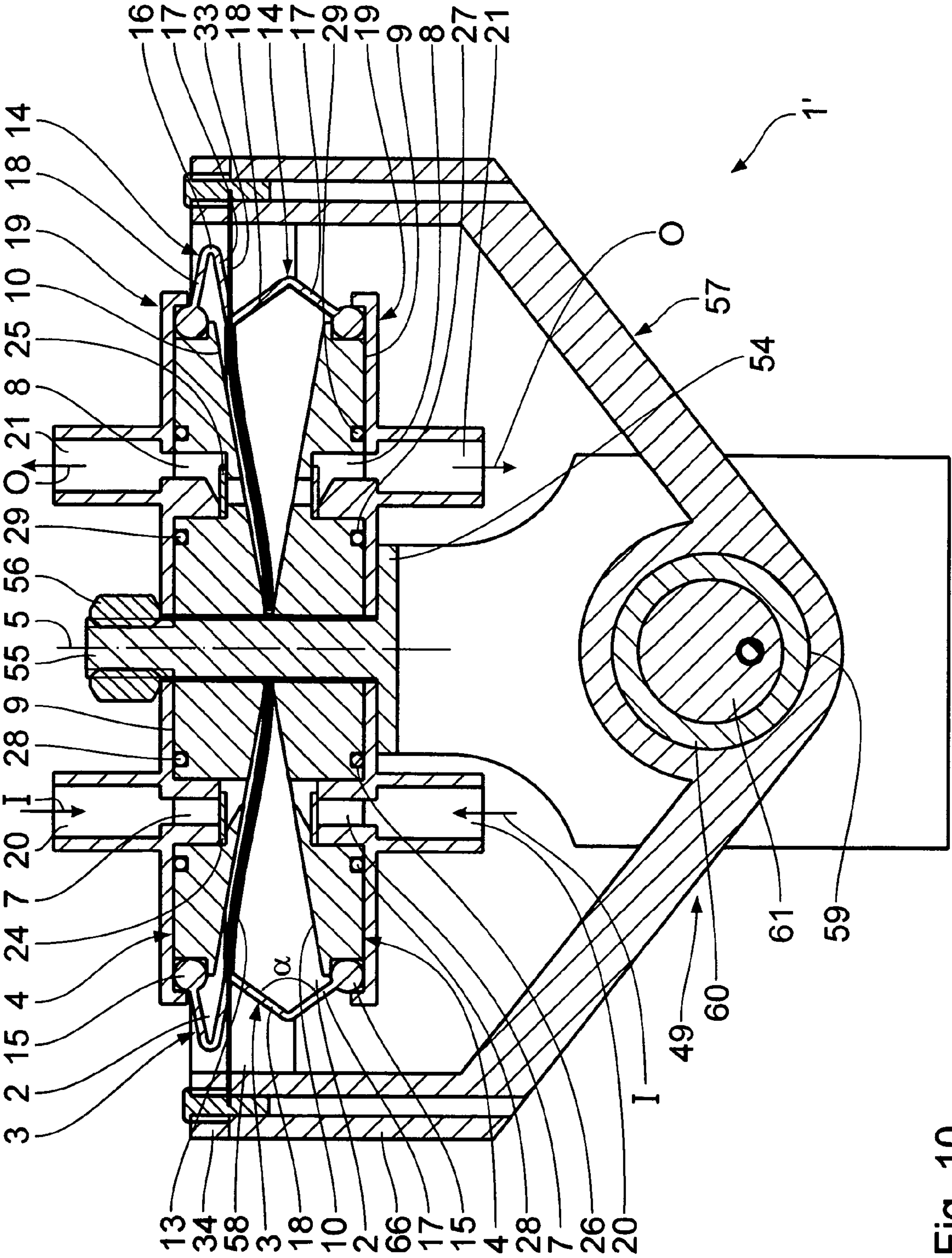


Fig. 10

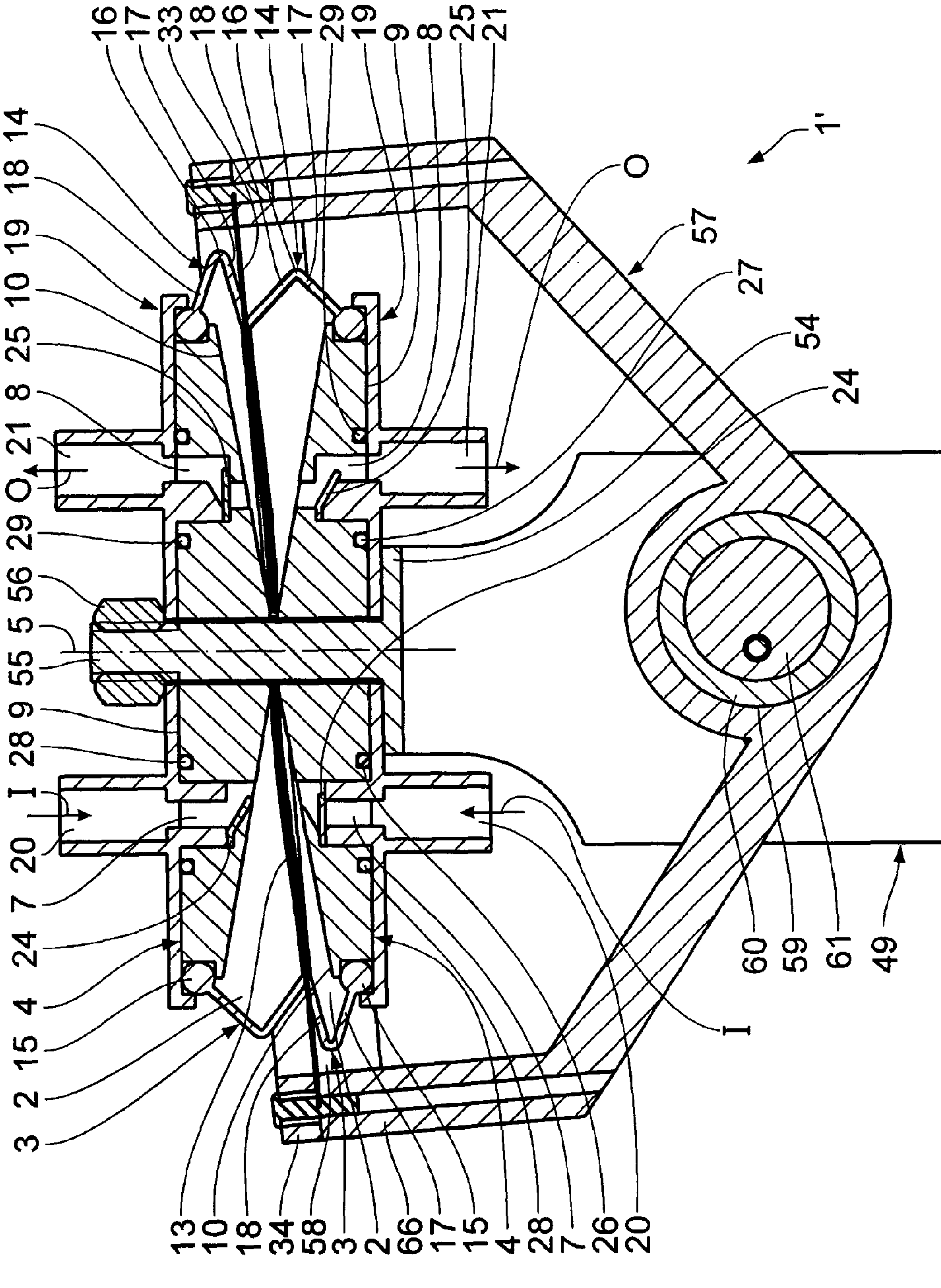


Fig. 11

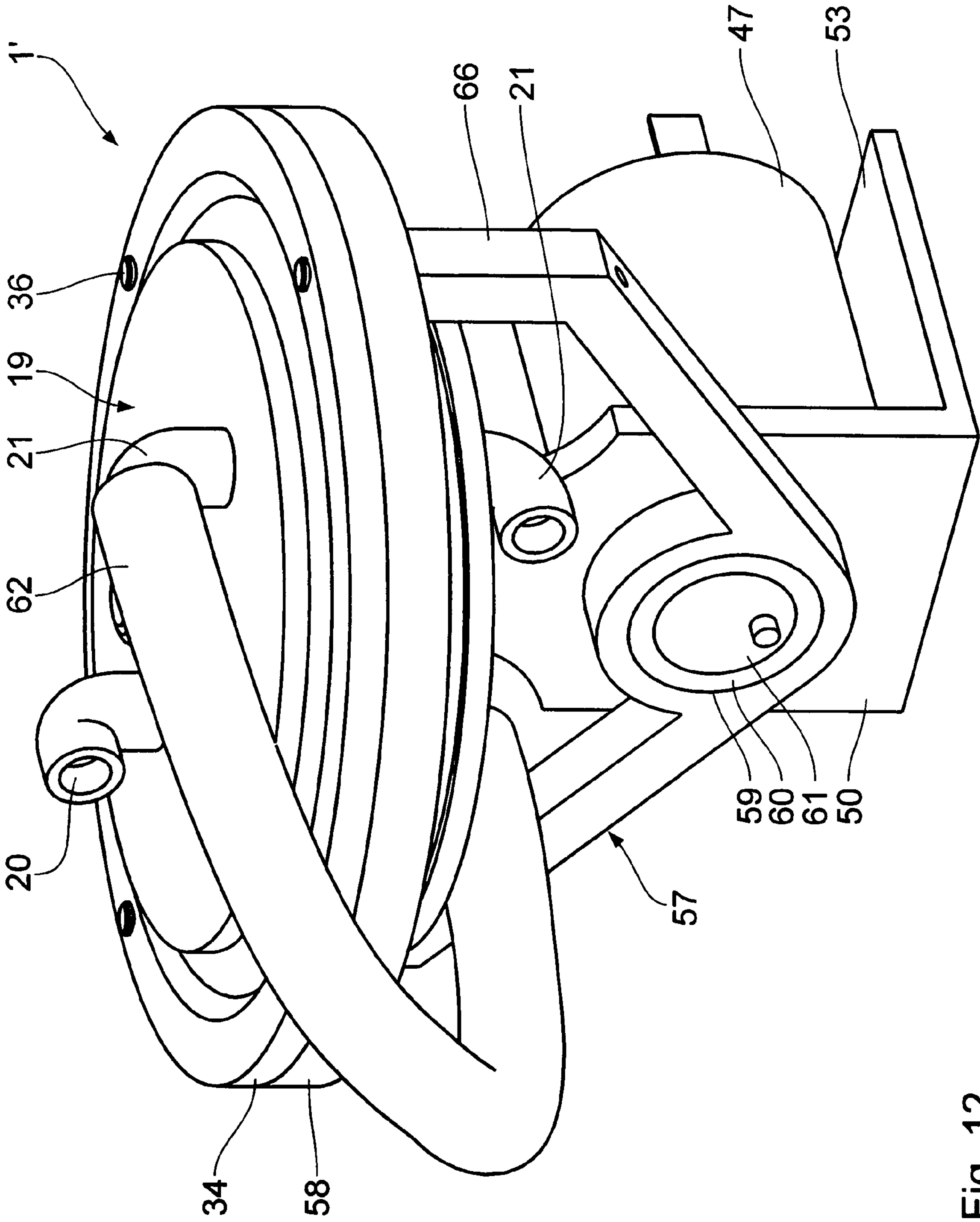
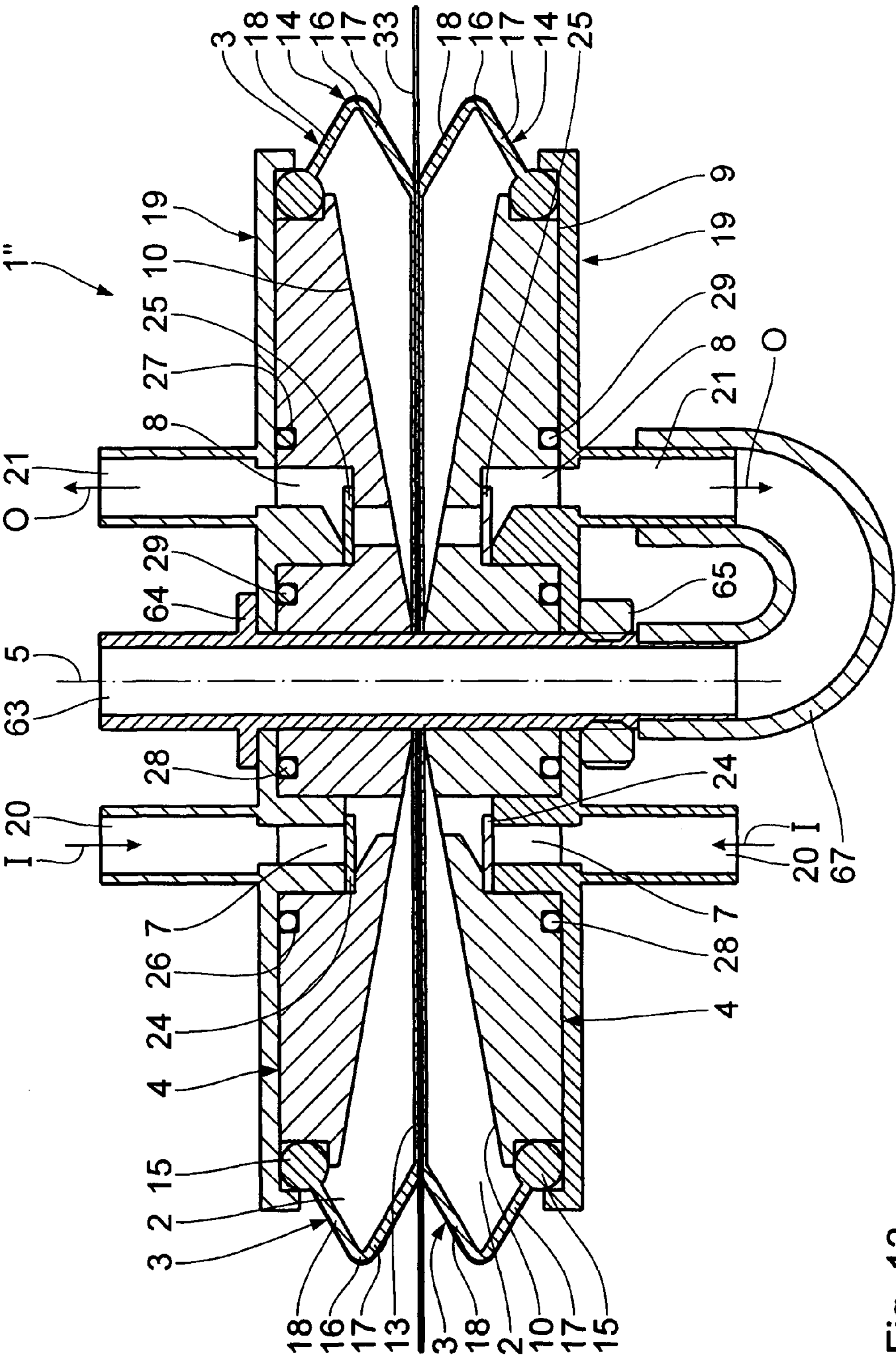


Fig. 12


1"
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9 19 29 8 21 O 65 67 I 20 24 7 28 4
18 16 17 13 3 18 2 10 17 15

Fig. 13

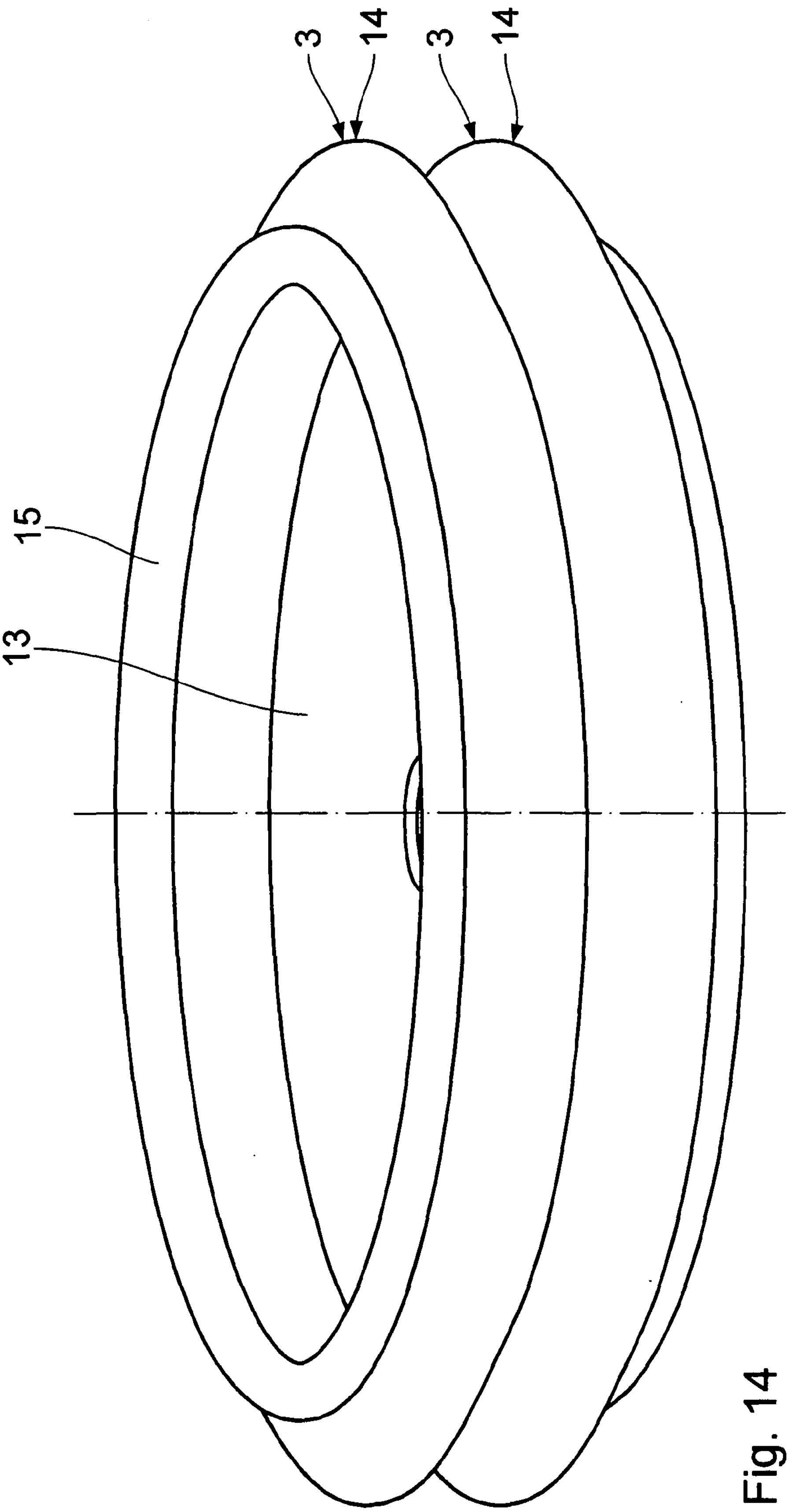

Fig. 14

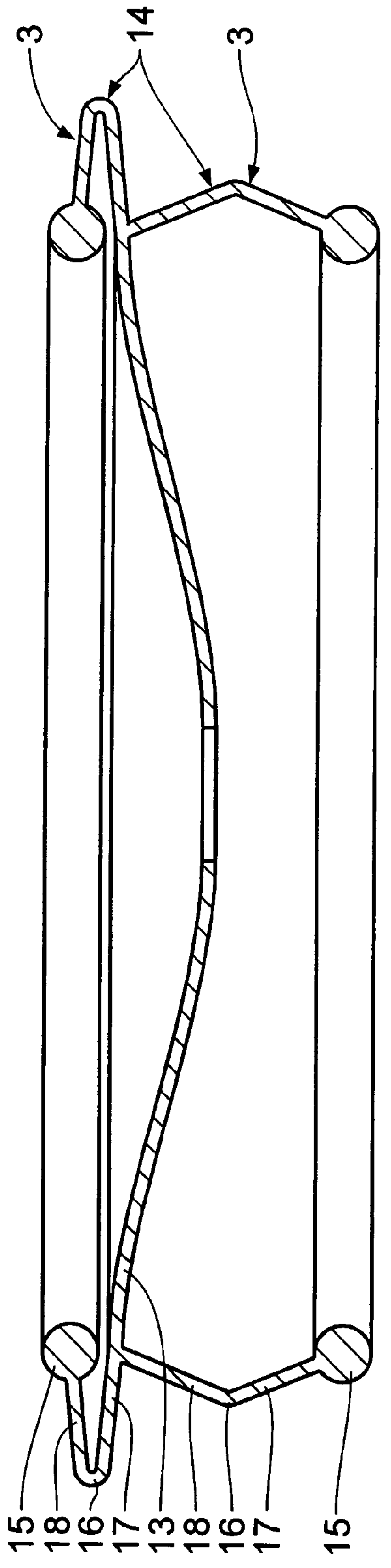

Fig. 15

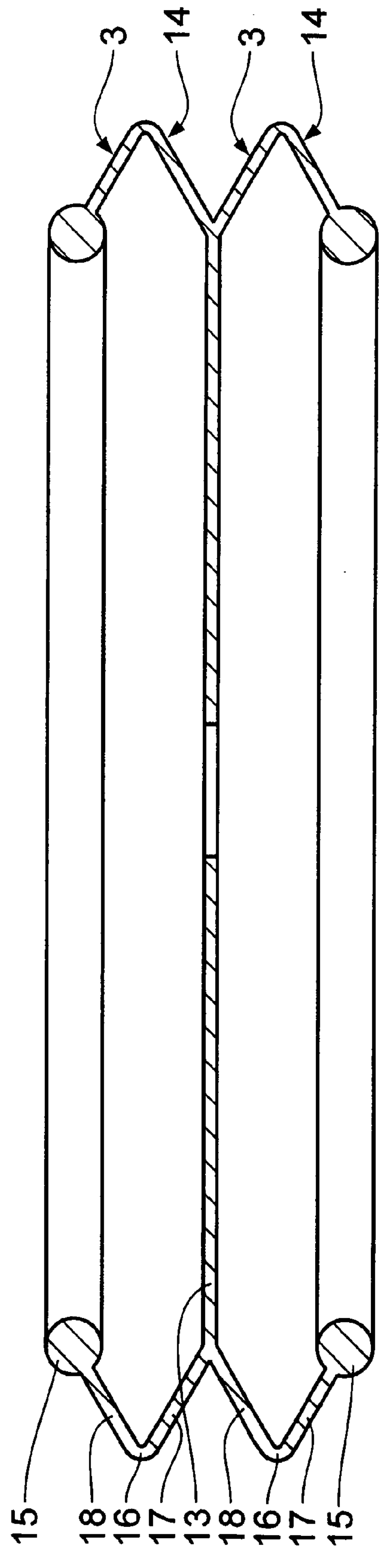

Fig. 16

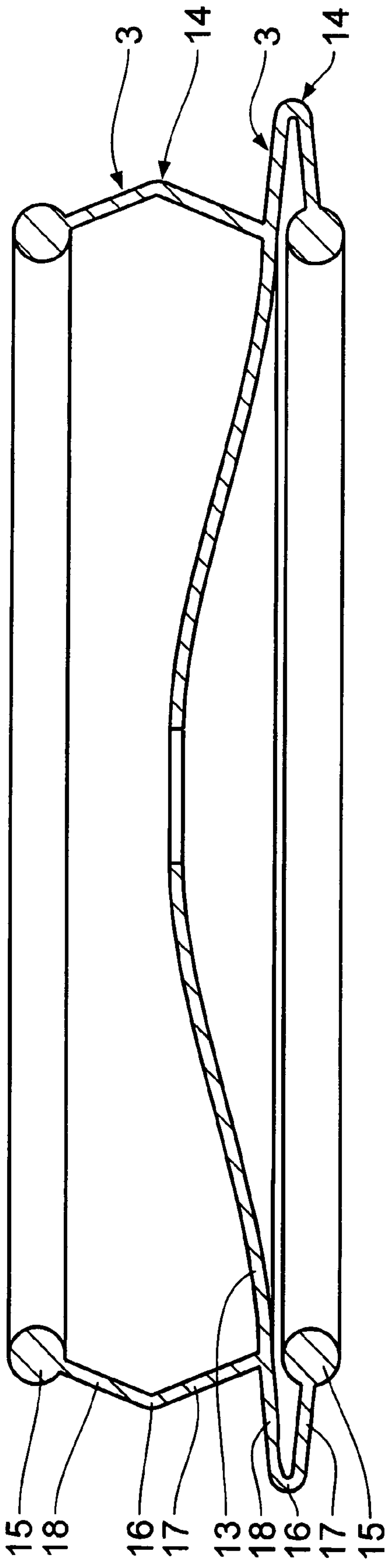

Fig. 17

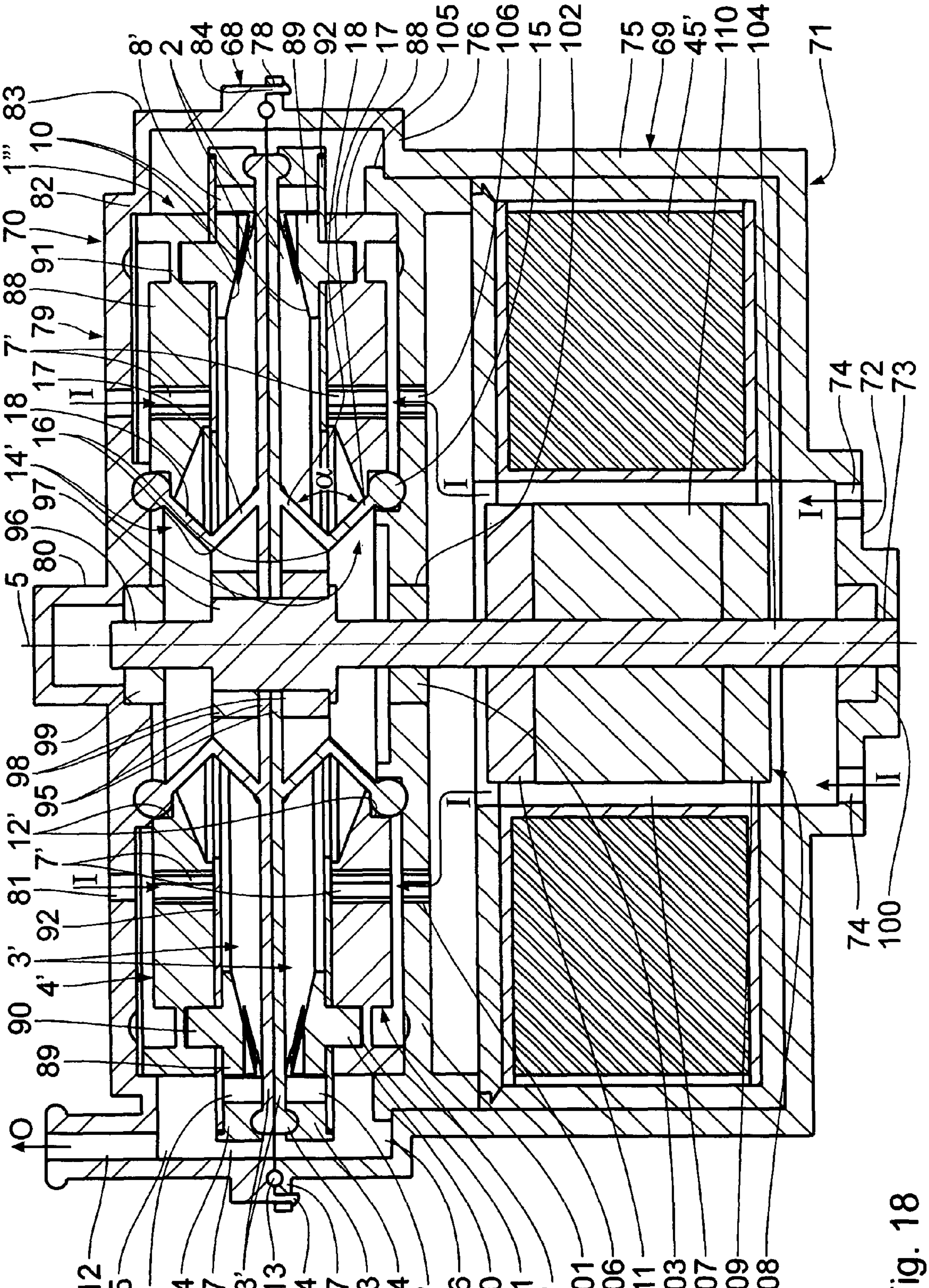

Fig. 18

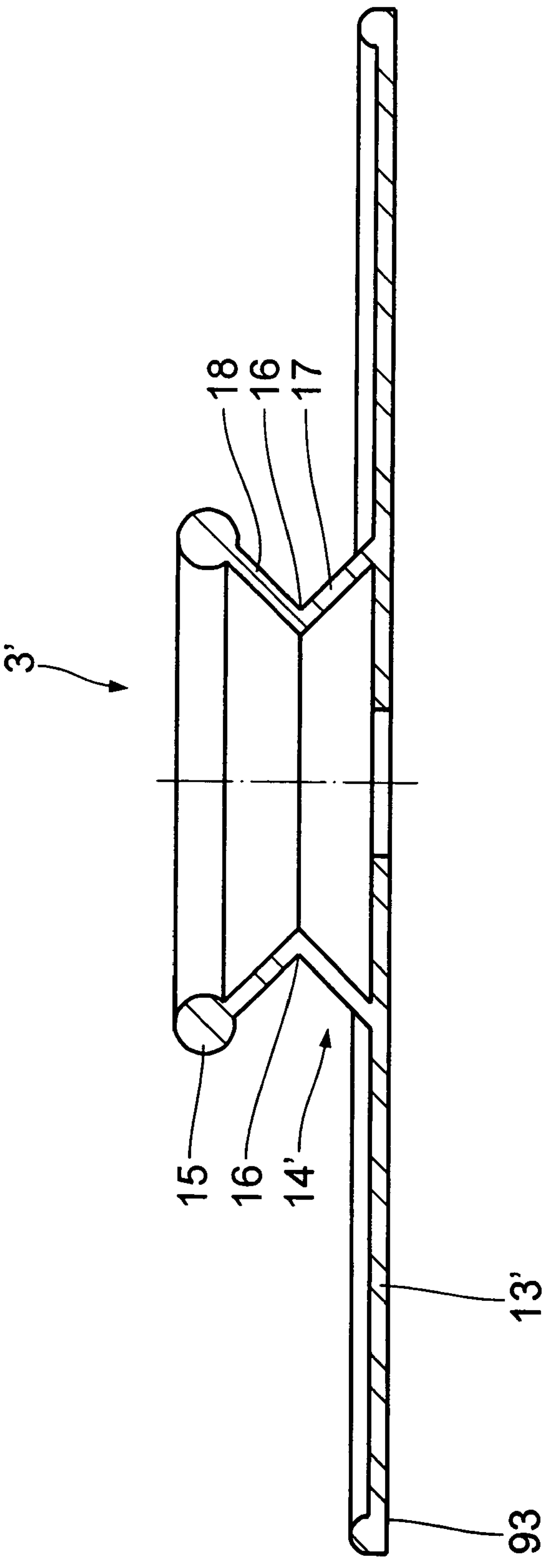

Fig. 19

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 00 1765

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	28 April 2008	Pinna, Stefano

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