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(54) **Rotary displacement pump for pumping flowable materials of high viscosity**

(57) A rotary displacement pump (2) according to the present invention is for pumping flowable, relatively viscous materials and comprises a liner (26, 36); a rotor (28) configured to be driven by a shaft (8); said rotor (28) including a shaft portion (30) and a radially protruding web (32) having a configuration of an undulatory disk type; a scraper gate (38) having an engagement slot of predetermined radial height and predetermined axial width, said engagement slot engaging said protruding web (32) of said rotor (28); said scraper gate (38) being supported by a scraper gate guide (40) so as to be retained in circumferential direction and to allow a reciprocating movement in a substantially axial direction; a pump housing (14) comprising a front end part (52) and a rear end part, said pump housing (14) enclosing said liner (26, 36), said rotor (28), said scraper gate (38) and said scraper gate guide (40), said shaft (8) extending through said rear end part of said pump housing (14); said liner (26, 36) including a first liner element (26) and a second liner element (36), said first and second liner elements (26, 36) abutting to each other laterally along a radially outer abutment portion so as to form a liner channel through which said radially protruding web (32) of said rotor (28) runs and to define an enclosure that encircles a portion of said radially protruding web (32) of said rotor (28); an inlet chamber and an outlet chamber being defined by said liner (26, 36), said scraper gate (38) and said scraper gate guide (40) or by said liner, said pump housing, said scraper gate and said scraper gate guide; said scraper gate (38) together with said scraper gate guide (40) forming a partition between said inlet chamber and said outlet chamber; said inlet and outlet chambers being provided with respective inlet and outlet ports (16, 18); said liner channel extending from said inlet chamber to said outlet chamber; said web (32) of said rotor (28) being rotatable through said inlet chamber, said liner channel, said outlet chamber and said slot of said scraper gate (38); wherein said scraper gate (38) and/or said liner (26, 36) comprises 85 to 95 Vol-% of a Polyethylene basis material of ultra-high molecular weight and 5 to 15 % Vol-% of glass particles having a rounded shape distributed within said Polyethylene basis material, such that the surface of said scraper gate (38) and/or said liner (26, 36) comprising rounded surface portions formed by such glass particles constitutes a hard slide face for the flowable, relatively viscous materials to be pumped.

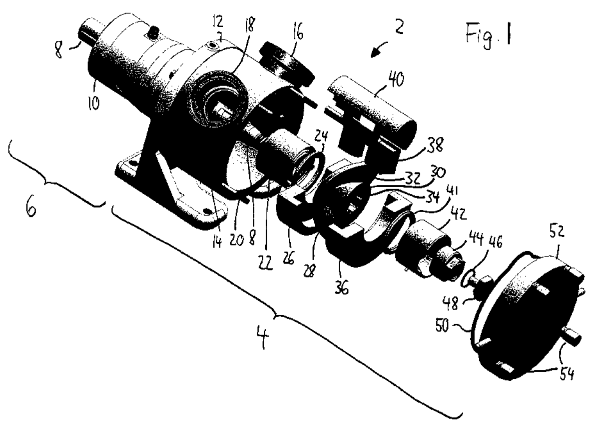

Fig. 1

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Description

[0001] The present invention relates to a rotary displacement pump for pumping flowable, relatively viscous materials.

[0002] From the EP 1 807 624 B1, a rotary displacement pump is known which allows for pumping flowable, relatively viscose materials in the food stuff industry, the chemical and biochemical industry, the medical industry and the cosmetic industry. Examples of materials that can be pumped by such rotary displacement pump are yoghurt, soup, sauce, mayonnaise, fruit juice, cheese material, chocolate, paint, cosmetic cream, and lipstick material.

[0003] Although such rotary displacement pump have proven to pump such flowable, relatively viscose materials in a reliable manner, it has been discovered that the efficiency of such pump decreases over time and such pumps have to be taken out of operation for maintenance reasons and for replacing those parts that are liable to wear due to the high mechanical stress suffered.

[0004] It is therefore an object of the present invention to provide a rotary displacement pump with an improved efficiency in pumping operation that has a longer operating time before maintenance works have to be carried out and highly stressed parts have to be replaced. Such a rotary displacement pump shall be capable for pumping flowable, relatively viscose materials in the food stuff industry, the chemical and biochemical industry, the medical industry and the cosmetic industry.

[0005] This object is attained by the subject-matter of independent claim 1. Advantageous embodiments are defined in the sub-claims.

[0006] A rotary displacement pump according to the present invention is for pumping flowable, relatively viscous materials and comprises a liner; a rotor configured to be driven by a shaft; said rotor including a shaft portion and a radially protruding web having a configuration of an undulatory disk type; a scraper gate having an engagement slot of predetermined radial height and predetermined axial width, said engagement slot engaging said protruding web of said rotor; said scraper gate being supported by a scraper gate guide so as to be retained in circumferential direction and to allow a reciprocating movement in a substantially axial direction; a pump housing comprising a front end part and a rear end part, said pump housing enclosing said liner, said rotor, said scraper gate and said scraper gate guide, said shaft extending through said rear end part of said pump housing; said liner including a first liner element and a second liner element, said first and second liner elements abutting to each other laterally along a radially outer abutment portion so as to form a liner channel through which said radially protruding web of said rotor runs and to define an enclosure that encircles a portion of said radially protruding web of said rotor; an inlet chamber and an outlet chamber being defined by said liner, said scraper gate and said scraper gate guide or by said liner, said pump housing, said scraper gate and said scraper gate guide; said scraper gate together with said scraper gate guide forming apartition between said inlet chamber and said outlet chamber; said inlet and outlet chambers being provided with respective inlet and outlet ports; said liner channel extending from said inlet chamber to said outlet chamber; said web of said rotor being rotatable through said inlet chamber, said liner channel, said outlet chamber and said slot of said scraper gate; wherein said scraper gate and/or said liner comprises 85 to 95 Vol-% of a Polyethylene basis material of ultra-high molecular weight and 5 to 15 Vol-% of glass particles having a rounded shape distributed within said Polyethylene basis material, such that the surface of said scraper gate and/or said liner comprising rounded surface portions formed by such glass particles constitutes a hard slide face for the flowable, relatively viscous materials to be pumped.

[0007] According to an underlying idea of the invention, the inventors have found out that the material to be pumped often collects at the scraper gate and/or the liner which results in dead areas and a loss in efficiency during pumping operation. Moreover, the inventors have discovered that the material that is pumped may not be treated with a rough surface, the material to be pumped rather has to be treated carefully by a smooth surface having a very low frictional coefficient. Resulting therefrom the inventors have identified the need to select a material for the surfaces coming into contact with the material to be pumped that provides for very low friction.

[0008] According to a further underlying idea of the invention, the inventors have found out that it is the scraper gate and/or the liner that is prone and liable to wear and have/has to be replaced first and that there is a need for a very hard surface material for the scraper gate and/or the liner.

[0009] At the same time, such scraper gate and/or liner material must have an excellent resistance against chemicals, since pumps that are used especially in the chemical and biochemical industry, the medical industry and the cosmetic industry have to withstand coming into contact with such chemicals under high pressure.

[0010] Moreover the scraper gate and/or the liner material must be permitted to be used in the food industry since many rotary displacement pumps of the scraper gate type, and particularly the rotary displacement pumps of the present invention are used for pumping food like yoghurt, soup, sauce, mayonnaise, fruit juice, cheese material, chocolate and the like.

[0011] A wide variety of different materials including plastics materials have been tested if they would comply with all these criteria, however for a long time it seemed that none of those materials show all of the desired properties and meet all the criteria developed, until the inventors discovered the scraper gate and/or liner material as described herein and as defined by the claims.

[0012] All the desired properties are unified by the scraper gate and/or liner material as defined in claim 1. Such scraper gate and liner material comprises 85 to 95

Vol-% of a Polyethylene basis material of ultra-high molecular weight and 5 to 15 Vol-% of glass particles having a rounded shape distributed within said Polyethylene basis material.

[0013] The surface comprising the Polyethylene basis material of ultra-high molecular weight and rounded surface portions formed by the glass particles that protrude out constitutes a hard slide face for the flowable, relative viscous materials to be pumped which leads to a very long operating time and significantly longer replacement intervals. Such material has a very low frictional coefficient and treats the material to be pumped very carefully, contrary to e.g. fibre class reinforced plastics materials. It has an excellent resistance against chemicals and is harmless for health which means it can be used in the food industry. The glass particles are embedded within the Polyethylene basis material of the high molecular weight and can be spread evenly within the Polyethylene basis material of high molecular weight.

[0014] Such material is perfectly suited for high pressure operating conditions that exist during pumping operation of the rotary displacement pump according to the present invention.

[0015] The rounded surface portions of the glass particles are to be understood as continuous surface portions avoiding sharp edges or spikes and they comprise portions of an oval basic shape, a spherical basic shape, an egg-like basic shape or any other non-symmetric rounded basic shape.

[0016] The liner can also be called stator, which terms are synonyms, and, likewise, the liner element(s) can also be called stator element(s), which terms are synonyms. For consistency reasons, the terms liner and liner element are used throughout the description and the claims.

[0017] According to an embodiment of the invention, the rotary displacement pump further comprises a ring-formed front sliding insert arranged in axial direction between said shaft portion of said rotor and a front shaft sleeve/bearing element being secured to the front end portion of said shaft. This ring-formed front sliding insert provides for a reliable sealing between the shaft portion of said rotor and the front shaft sleeve/bearing element and prevents material to be pumped from getting to the shaft.

[0018] According to a further embodiment of the invention, the front shaft sleeve/bearing element has an annular groove in its rear side facing said shaft portion of said rotor, said ring-formed front sliding insert being placed with an anchoring portion thereof in such annular groove. By providing the front shaft sleeve/bearing element with such annular groove and by placing said ring-formed front sliding insert with its anchoring portion in such annular groove, the ring-formed front sliding insert can be held in place reliably during pumping operation and secured against getting out of place.

[0019] According to a further embodiment of the invention, the rotary displacement pump further comprises a ring-formed rear sliding insert arranged in axial direction between a rear shaft sleeve sealing element being secured to said shaft and said shaft portion of said rotor. This ring-formed rear sliding insert provides for a reliable sealing between the shaft portion of said rotor and the rear shaft sleeve sealing bearing element and prevents material to be pumped from getting to the shaft.

[0020] According to a further embodiment of the invention, the rear shaft sleeve sealing element has an annular groove in its front side facing said shaft portion of said rotor, said ring-formed rear sliding insert having a substantially rectangular cross-section or a T-shaped cross-section being placed with an anchoring portion thereof in such annular groove. By providing the rear shaft sleeve sealing element with such annular groove and by placing said ring-formed rear sliding insert with its anchoring portion in such annular groove, the ring-formed rear sliding insert can be held in place reliably during pumping operation and secured against getting out of place.

[0021] According to a further embodiment of the invention, at least one of the front and rear sliding inserts has a T-shape with an anchoring portion being placed in the respective annular groove and with an abutment portion abutting against the respective shaft portion of said rotor. By such T-shape a particularly good positioning and sealing function of such front and/or rear sliding insert can be attained. At the same time the ring-formed front and rear sliding inserts and the front shaft sleeve/bearing element having such annular groove and said rear shaft sleeve sealing element having such annular groove can be manufactured and assembled easily and at reasonable costs. Such front and rear sliding inserts can also come into contact with the materials to be pumped.

[0022] According to a further embodiment of the invention, at least one element of the front sliding insert, the rear sliding insert and the front shaft sleeve/bearing element comprises 85 to 95 Vol-% of a Polyethylene basis material of ultra-high molecular weight and 5 to 15 % Vol-% of glass particles having a rounded shape evenly distributed within said Polyethylene basis material, such that surface of said sliding insert comprising said Polyethylene basis material and glass particles protruding out of the same forms a rounded and hard slide face for the flowable, relatively viscous materials to be pumped. By manufacturing the front and rear sliding inserts of such Polyethylene basis material of ultra-high molecular weight with glass particles distributed therein the same advantages as have been explained in detail with regard to the scraper gate and the liner being made of such material are attained as well, especially low friction, excellent hardness and durability, high resistance against wear, high resistance against chemicals, capability to handle and treat chemicals and food, capability to handle the materials to be pumped with care.

[0023] According to a further embodiment of the invention, said glass particles are of spherical or oval shape. Such glass particles of spherical or oval shape contribute to providing a surface with good hardness and durability and a low frictional coefficient.

[0024] According to a further embodiment of the invention, the diameter of said glass particles is 10 - 40 μm, particularly 20 - 30 μm, and more particularly around 24 μm. Such diameter of glass particles has been proven to further improve the surface properties, in particular the excellent hardness, the excellent durability and the low frictional coefficient.

[0025] According to a further embodiment of the invention, the molecular weight of said Polyethylene basis material is 0.8 * 10^6 g/mol to 1.2 * 10^6 g/mol, particularly around 1.0 * 10^6 g/mol. The Polyethylene basis material having such molecular weight provides for an excellent hardness and durability of the scraper gate, liner and, if applicable, of the front and rear sliding inserts, and guarantees a long lifetime of such parts and considerably longer maintenance intervals or intervals between points in time when the parts have to be replaced.

[0026] According to a further embodiment of the invention, the Polyethylene basis material withstands operating temperatures of up to 100°C without softening. By using such Polyethylene basis material withstanding operating temperatures of up to 100 °C without softening the rotary displacement pump can be used for pumping materials that require higher operating temperatures or for pumping materials where the operating temperatures get that high which enables the rotary displacement pumps to be used for a wider variety of applications.

[0027] According to a further embodiment of the invention, the first liner element and the second liner element are generally semi-circular arc-formed. In such embodiment the semi-circular arc-formed liner elements only occupy part of the inner space of the pump housing, in particular the lower half of the inner space of the pump housing, and the inlet and outlet chambers are formed by the liner, the pump housing, the scraper gate and the scraper gate guide.

[0028] According to a further embodiment of the invention, the enclosure that encircles a portion of said radially protruding web of said rotor is generally semi-circular arc-formed. In operation of the pump, the material is actually pumped through such channel or enclosure from the inlet to the outlet chamber.

[0029] According to another embodiment of the invention, the first liner element and the second liner element are generally cup shaped and define a circumferential wall. These generally cup-shaped first and second liner elements mainly occupy the entire circumferential space within the pump housing, and the inlet chamber adjacent to the inlet port is formed by said liner elements and the outlet chamber adjacent to the outlet port is formed by such liner elements, with the inlet and the outlet port separated from each other by the scraper gate and the scraper gate guide.

[0030] According to a further embodiment of the invention, said scraper gate and/or said scraper gate guide are completely arranged within said liner.

[0031] According to a further embodiment of the invention, said scraper gate guide is supported by said liner. For this reason the liner elements comprise appropriate fixing means, especially cavities, limit stops and the like.

[0032] Embodiments of the invention are described in greater detail below with reference to the figures, wherein:

Fig. 1 shows an exploded view of a rotary displacement pump according to an embodiment of the invention showing the parts involved; and

Fig. 2 shows an exploded view of a further rotary displacement pump according to an alternative embodiment of the invention showing the parts involved.

[0033] The terms "front" and "back/rear" are to be understood in the forthcoming figures with respect to the axis of the shaft 8, the terms "left" and "right" are to be understood in the forthcoming figures with respect to the axis of the shaft 8, when seen from the back (substantially left-hand in Figs. 1 and 2) to the front (substantially right-hand in Figs. 1 and 2) of the shaft 8, such that the parts of the pump that lie, with respect to the shaft, on the closer side to the viewer in Fig. 1 and 2 are positioned "right" and the parts of the pump that lie, with respect to the shaft, on the farther side from the viewer in Fig. 1 and 2 are positioned "left".

[0034] Fig. 1 shows an entire rotary displacement pump 2 comprising a pump part 4 or pump proper 4 and a support part 6.

[0035] At the left-hand side of Fig. 1, an end portion of a shaft 8 protrudes from the support part 6. A drive motor, not shown, typically an electric motor serves to apply torque to the shaft 8, either by being directly or through a coupling coupled to the shaft 8 or for example through a gear or a pulley etc. The support part 6 comprises a support part housing 10 in which appropriate roller bearings (not shown) for the shaft 8 can be provided.

[0036] The support part housing 10 has a substantially cylindrical shape, and the front end of the support part housing 10 is encircled and fixed by a mounting frame 12 that has a lower mounting plate in order to fix the entire rotary displacement pump 2 to an appropriate base.

[0037] To the front side of the mounting frame 12 there is attached a pump housing 14 having the following main parts: a tubular cylindrical body 14, the rear end of which is mounted by appropriate mounting pins or the like (not shown) to the front side of the mounting frame 12, a rear end plate (not shown) having a central aperture through which the shaft 8 extends and which rear end plate is either formed by the front side of the mounting frame 12 itself, by a bottom plate integral with the tubular cylindrical body 14 or by a separate rear end plate provided before the front side of the mounting frame 12, a circular front end plate 52 that can be tightly attached to the front side of the tubular cylindrical body 14 by means of mounting pins 20 protruding out from the annular front side of the tubular cylindrical body 14 and through corresponding through-holes disposed in appropriate locations of the front end plate 52 and by means of nuts 54 that engage with corresponding threads of the mounting pins 20 in order to fix the pump housing 14 and the front end plate 52 tightly together, an inlet pipe socket/inlet port 16 provided with an inlet port flange, and an outlet pipe socket/ outlet port 18 provided with an outlet port flange. The inlet and outlet ports 16, 18 can be welded to the tubular cylindrical body of the pump housing 14.

[0038] The inlet pipe socket/inlet port and the outlet pipe socket/outlet port can also be arranged the other way round with the inlet pipe socket/inlet port being situated on the right (closer to the viewer) and with the outlet pipe socket/outlet port being situated on the left (farther from the viewer). In that case the scraper gate and the scraper gate guide would have to be turned around as compared to Fig. 1 with their inlet chamber sides being situated on the right (closer to the viewer) and with their outlet chamber sides being situated on the left (farther from the viewer).

[0039] In the present non-limiting embodiment, the axes of the inlet and outlet ports 16 and 18 intersect at 90°. However, the inlet and outlet ports 16 and 18 can also be arranged such that their axes intersect at another angle, for example at an angle of 180°. Accordingly, the tubular cylindrical body 14 has two openings corresponding to the diameter of the inlet and outlet ports 16 and 18.

[0040] The tubular cylindrical body and the inlet and outlet port 16, 18 as well as the front end plate 52 can consist of stainless steel.

[0041] The middle to front portion of the shaft 8 is provided with axially extending recesses that engage with the corresponding protrusions of the rotor 28, particularly with the shaft portion 30 of the rotor 28 to be described in further detail below, and, if appropriate, with other rotating parts of the pump part 4. The tip of the shaft 8 is tapering.

[0042] The rotor 28 is keyed to the shaft 8 and rotates with it.

[0043] The following parts, from back to front, surround the shaft 8: a rear shaft sleeve sealing element 22, a rear sliding insert 24, the rotor 28, a front sliding insert 41, a front shaft sleeve/bearing 42, a locking nut 44, a sealing ring 46 and a locking screw 48.

[0044] An inner portion of the rear shaft sleeve sealing element 22 rotates together with the shaft 8, an outer cylindrical portion of the rear shaft sleeve sealing element 22 that can well be seen in Fig. 1 surrounds the inner portion circumferentially and remains standing still in operation, and dynamic sealing means are provided between the rotating inner portion and the non-rotating outer cylindrical portion of the rear shaft sleeve sealing element 22.

[0045] The hub of the rotor 28 is clamped by means of the locking screw 48 in axial direction against the rear shaft sleeve sealing element 22 and against the front shaft sleeve 42.

[0046] The shaft 8, the inner portion of the rear shaft sleeve sealing element 22, the rotor 28, the locking nut 44, the sealing ring 46 and the locking screw 48 rotate and form a rotor assembly together.

[0047] The outer cylindrical portion of the rear shaft sleeve sealing element 22, the rear sliding insert 24, the front sliding insert 41, and the front shaft sleeve/bearing 42 do not rotate, but stand still in operation.

[0048] The rotor 28 comprises a shaft portion 30 of basically cylindrical shape surrounding the shaft 8. The radially inner substantially ring-formed face of the shaft portion 30 engaging in the assembled state with the shaft 8.

[0049] The rotor 28 further comprises a radially protruding web 32 having a axial thickness and a predetermined outer diameter. The web 32 has a rear surface and a front surface. If one follows, for example with a finger tip, the front surface along the circular line of the outer diameter, the finger tip will describe a curved sinus-type line seen in radial view (not necessarily in the strict mathematical sense), undulating with respect to a middle plane intersecting the axis of the shaft 8 at a right angle. Along a 360° circle there are two full periods of the sine curve, i. e. the first time from completely left-hand in Fig. 1 to completely right-hand in Fig. 1 and back. The same description as made with respect to the front face applies to the rear face as well. For simplicity, this undulating form of the radially protruding web 32 of the rotor 28 is only depicted schematically in the figures.

[0050] A liner lines the lower part of the inside of the housing 14. The liner consists of a generally semi-circular arc-formed rear liner element 26 and of a generally semi-circular arc-formed front liner element 36, that can be formed separately, as in Fig. 1, or integrally with the front end plate 52 and, respectively the rear end plate. The liner elements can be formed as liner elements fixed in the pump housing 14. In the assembled state of the rotary displacement 2, the front liner element 36 abuts with its front face against the corresponding circular section of the rear face of the front end plate 52.

[0051] The same description as made with respect to the front liner element 36 applies in an analogous manner to the rear liner element 26. Generally speaking, the rear liner element 26 is a mirror-image to the front liner element 26, and the rear liner element 26 abuts with its outer surface against a corresponding portion of an inner face of the rear end plate (not shown) of the pump housing 14.

[0052] In a radial sectional cut, the front liner element 36 has the profile of a reversed "L" with the radially oriented portion of the profile forming a radial wall for the radially protruding web 32 and with the axially oriented portion of the profile forming a circumferential wall for the radially protruding web 32. Accordingly, the rear/inner end (term "inner" is to be understood opposite to the term "outer", see below) of the circumferential wall forms a lateral abutment face that abuts in the mounted state to the opposite lateral abutment face of the rear liner element 26. The face of the circumferential wall that is oriented towards the shaft axis forms a liner channel bottom face and the inner face of the radial wall forms a lateral liner channel face.

[0053] In a radial sectional cut, the rear liner element 26 has the profile of an "L" with the radially oriented portion of the profile forming a radial wall for the radially protruding web 32 and with the axially oriented portion of the profile forming a circumferential wall for the radially protruding web 32. Accordingly, the front/inner end (term "inner" is to be understood opposite to the term "outer", see below) of the circumferential wall forms a lateral abutment face that abuts in the mounted state to the opposite lateral abutment face of the front liner element 36. The face of the circumferential wall that is oriented towards the shaft axis forms a liner channel bottom face and the inner face of the radial wall forms a lateral liner channel face.

[0054] Following a central opening of the rear end plate (not shown) there is a recess provided both in the rear and front liner elements 26 and 36 so that the shaft 8 can extend through both the central opening and the central recesses. The upper end faces of the generally semicircular arc-formed liner elements 26 and 36 are straight and form a straight horizontal inlet chamber bottom part (to the right in Fig. 1) and a straight horizontal outlet chamber bottom part (to the left in Fig. 1).

[0055] In the upper part of the inside of the pump housing 14 there are provided an inlet chamber adjacent to the inlet port 16 and an outer chamber adjacent to the outlet port 18. The inlet chamber is provided in the upper right quadrant of the inside of the pump housing 14 that is located farther from the viewer of Fig. 1, and the outlet chamber is provided in the upper left quadrant of the inside of the pump housing 14 that is located closer to the viewer in Fig. 1.

[0056] A rear shaft sleeve sealing element 22 has a cylindrical outer shape the diameter of which correspond to the outer diameter of the shaft portion 30 of the rotor 28 and the diameter of the central recess in the rear liner element 26. The front end of the rear shaft sleeve sealing element 22 is sealingly connected to the rear end of the rotor 28, particularly to the rear end of the shaft portion 30 thereof by means of the rear sliding insert 24, that can be formed as an O-ring.

[0057] The rear sliding insert 24 has, in a radial sectional cut the form of a "T" lying in axial direction, with its T-bar forming an anchoring portion extending rearwards and being inserted, in the mounted state, in a corresponding annular groove in the front face of the rear shaft sleeve sealing element 22 and abutting with its planar annular front face against a corresponding portion of the rear face of the shaft portion 30 of the rotor 28.

[0058] Alternatively, the rear sliding insert 24 can have a rectangular cross-section.

[0059] Like the rear shaft sleeve sealing element 22, the front shaft sleeve/bearing 42 also has a substantially cylindrical shape, the outer diameter of which corresponds to the outer diameter of the shaft portion 30 of the rotor 28 and to the diameter of the recess in the front liner element 36. The front shaft sleeve/bearing 42 is sealingly connected to the rotor 28, particularly to the shaft portion 30 thereof by means of the front sliding insert 41, that can be formed as an O-ring.

[0060] Like the rear sliding insert 24, the front sliding insert 41 also has, in a radial sectional cut, the form of a "T" lying in axial direction, with its T-bar forming an anchoring portion extending forwards. The T-bar of the front sliding insert 41 is inserted into a corresponding annular groove in the rear side of the front shaft sleeve 42 and it abuts with its planar annular rear face to a corresponding annular portion of the front face of the shaft portion 30 of the rotor 28.

[0061] Alternatively, the front sliding insert 41 can have a rectangular cross-section.

[0062] By means of the rear and front sliding inserts 24, 41 material to be pumped by the rotary displacement pump is reliably prevented from getting into the direction of the shaft 8.

[0063] The rear shaft sleeve sealing element 22, the rear sliding insert 24, the rotor 28, the front sliding insert 41 and the front shaft sleeve 42 are fixed to the shaft 8 such that they rotate together with it by means of a locking nut 44 and a front locking screw 48 engaging in axial direction into a corresponding hole at the tip of the shaft 8, said hole being provided with a thread. By means of a sealing ring 46 provided between the locking nut 44 and the locking screw 48 the tip portion is also reliably sealed against material entering from the front.

[0064] Between the front end plate 52 and the tubular cylindrical body of the pump housing 14 there is provided an additional sealing ring 50.

[0065] When the parts of the pump proper 4 are assembled, the inlet chamber is confined by the straight upper inlet chamber faces of the liner elements 26 and 36 located to the right in Fig. 1, by the parts of the rear shaft sleeve sealing element 22 and the front shaft sleeve 42 and the sliding inserts 24 and 41 lying in the upper right quadrant of the inside of the pump housing 14, by the right-hand sides of the scraper gate 38 and the scraper gate guide 40 and by the inner face of the tubular cylindrical body 14 within the upper right quadrant. Likewise, when the parts of the pump proper 4 are assembled, the outlet chamber is confined by the straight upper outlet chamber faces of the liner element 26 and 36 located to the left in Fig. 1, by the parts of the rear shaft sleeve sealing element 22 and the front shaft sleeve 42 and the sliding inserts 24 and 41 lying in the upper left quadrant of the inside of the pump housing 14, by the left-hand sides of the scraper gate 38 and the scraper gate guide 40 and by the inner face of the tubular cylindrical body 14 within the upper left quadrant.

[0066] The scraper gate 38 has generally the configuration of a rectangular plate, but has an engagement slot of a predetermined radial height and predetermined axial width into which the radially protruding web 32 of the rotor 28 engages. The transitions between the narrowest portion of the engagement slot and the inlet and outlet chamber-facing surfaces are curved. The axial dimension of the engagement slot at its smallest portion is just a little wider than the axial dimension of the radially protruding web 32 of the rotor 28, so that the engagement slot can be placed over the radially protruding web 28, the scraper gate 38 straddling the web 32. The curved transitions take into account the curved or undulatory configuration of the web 32 as contrasted to a plane configuration.

[0067] The scraper gate 38 is supported by a scraper gate guide 40 that is firmly mounted in the pump housing 14 especially in an upper position of the pump housing 14 extending in an axial direction and in particular between the front end plate 52 and the rear end plate which can be formed integrally with the pump housing 14.

[0068] The scraper gate guide 40, in the exemplary embodiment of Fig. 1, has a basically cylindrical outer shape with an axial guiding recess extending from its bottom to a portion just below its top end, the scraper gate 38 being inserted, in the assembled state of the pump, in such axial recess and being held there in circumferential direction and being guided so as to allow a reciprocating movement following the reciprocating back and forth movement of the radially protruding web 32. The side of the scraper gate guide 40 being positioned in the outlet chamber, in Fig. 1 located to the left, has, in the exemplary embodiment of Fig. 1, openings/breakthroughs at the front and the rear sides thereof.

[0069] In operation of the rotary displacement pump 2 depicted in Fig. 1, the shaft 8 is driven and the web 32 of the rotor 28 rotates through the inlet chamber, the liner channel, the outlet chamber and the slot of the scraper gate element 38 which scraper gate element 38 moves from left to right and right to left in a reciprocating manner following the sinus form of the web 32 and by doing so material to be pumped that has entered the inlet chamber through the inlet port 16 is pumped through the liner channel to the outlet chamber from which it is discharged through the outlet port 18.

[0070] Fig. 2 shows an entire rotary displacement pump 62 comprising a pump part 4 or pump proper 4 and a support part 6.

[0071] Like the first rotary displacement pump 2 shown in Fig. 1, the second displacement pump 62 also comprises a pump part or pump proper 4 and a support part 6, and the pump housing 14 with inlet and outlet ports 16 and 18 and front end plate 52 and rear end plate 12 correspond to those in Fig. 1. Also the rotor 28 with its shaft portion 30 and its radially protruding web 32 corresponds to the rotor 28 of Fig. 1. Therefore these elements are provided with corresponding reference numerals, and the description thereof is not repeated, but omitted for brevity.

[0072] The liner of the second rotary displacement pump 62 also consists of two liner elements, namely a rear liner/liner element 70 and a front liner/liner element 80, however, different than the liner 26, 36 of the first rotary displacement pump 2, the liner 70, 80 lines completely the inner surface of the housing 14, and the rear liner element 70 is generally cup-shaped and the front liner element 80 is also generally cup-shaped with the plane faces of the liner elements 70, 80 being oriented in an outer axial direction and the cup portions of the liner elements 70, 80 being oriented in an inner direction, the terms "inner" and "outer" being understood with respect to the rotor 28.

[0073] The rear liner element 70 has, in its lower portion (constituting approximately the lower half of the rear liner element 70), a lower bottom wall portion having a substantially larger thickness than the thickness of the upper bottom wall portion. The rear liner element 70 comprises, in its central portion, a cylindrical opening that is confined in its lower portion by the thicker lower bottom wall portion and in its upper portion by a cylindrical wall having the same thickness as the lower bottom wall portion. The front faces of the thicker lower bottom wall portion and of the cylindrical wall form a radial, and the thinner upper bottom wall portion also forms a radial plane being set back with respect to the front faces of the thicker lower bottom wall portion and of the cylindrical wall. The rear face of the rear liner element 70 (not visible in Fig. 2) also forms a radial plane. The rear liner element 70 is surrounded by a circumferential cylindrical wall having in its lower half a higher wall thickness than in its upper half. The upper part of the thinner cylindrical circumferential wall is provided with two rounded recesses at positions corresponding to the inlet and outlet ports 16 and 18, and the diameter of these rounded recesses also correspond to the diameter of the inlet and outlet port 16 and 18.

[0074] Generally speaking, the front liner/liner element 80 is a mirror-image to the rear liner element 70 with a first relevant exception that instead of a central opening there is a closed bottom wall in the front liner element 80 provided with a circular recess in the middle that accommodates the end portion of the rotor assembly, namely the locking screw 76.

[0075] Although not being visible in Fig. 2, the front liner element 80 comprises in its lower portion (constituting approximately the lower half of the front liner element 80), a bottom wall of a substantially larger thickness the front face of which forms a radial plane together with a cylindrical wall confining the central recess, and in its upper portion a bottom wall portion also forming a substantially radial plane, which is set back with respect to the inner face of the thicker lower bottom wall portion and of the cylindrical wall. The front liner element 80 is also surrounded by a circumferential cylindrical wall having in its lower half a higher wall thickness than in its upper half. Rounded recesses are formed in the thinner upper circumferential wall portion at positions and having diameters corresponding to those of the inlet and outlet ports 16 and 18.

[0076] In the assembled state of the rotary displacement pump 62, the rear liner element 70 abuts with its rear face towards the front face of the rear end plate 12, and the front liner element 80 abuts with its front face against the rear face of the front end plate 52. The front face of the cylindrical wall of the the rear liner element 70 abuts against the rear face of the cylindrical wall of the front liner element 80. The openings that are formed by the corresponding recesses of the rear and front liner elements 70 and 80 align with the inlet and outlet ports 16 and 18.

[0077] The following parts, from rear to front, are fixedly connected to the shaft 8 in the assembled state of the rotary displacement pump 62: element 64 comprising a number of sealing rings, a rear shaft sleeve sealing element 66, the rotor 28 with its shaft portion 30 and its radially protruding web 32 and a front locking screw 76 fixed to a corresponding hole in the tip of the shaft 8 provided with a thread, and a sealing ring 74 that can be an O-ring sitting on the outer diameter of the locking screw 76.

[0078] In the exemplary embodiment of Fig. 2, there is a central recess in the front face of the shaft portion 30 of the rotor 28, the diameter of which corresponds to the outer diameter of the locking screw 76.

[0079] A sealing ring 68 can be provided that can be an O-ring sitting on the outer diameter of the rear shaft sleeve sealing element 66, and the rear face of the shaft portion 30 of the rotor 28 that can also be provided with a recess the diameter of which corresponds to the outer diameter of the front face of the rear shaft sleeve sealing element 66 (not shown).

[0080] As in the first rotary displacement pump 2, the second rotary displacement pump 62 also comprises a scraper gate element 82 and a scraper gate guide 84, and the scraper gate 82 has an engagement slot of predetermined radial height and predetermined axial width into which, in the assembled state, the protruding web 32 of the rotor 28 engages. The scraper gate guide 84 also supports the scraper gate 82 such that the scraper gate 82 is retained in a circumferential direction and a reciprocating movement in a substantially axial direction following the sinusoidal back and forth movement of the web 32 of the rotor 28 is allowed.

[0081] The scraper gate guide 84 is a plate with a generally rectangular recess in its middle portion. The scraper gate guide 84 is fixed in the liner 70, 80 by means of grooves in the liner elements 70, 80, a part of the groove can be seen on top of the circular wall of the rear liner element 70. The scraper gate element 82 itself has a guiding groove in axial direction at its upper side and guiding grooves in radial direction at its front and rear sides, and the scraper gate element 82 is inserted such that the bottom of its groove in its upper side abuts against the lower edge of the rectangular recess of the scraper gate guide 84. Since the distance between the bottoms of the grooves in the front and end sides of the scraper gate element 82 is considerably smaller than the distance between the front and rear edges of the rectangular recess of the scraper gate guide 84, the scraper gate element 82 can be held in circumferential direction by the scraper gate guide 84, and a reciprocating movement of the scraper gate element 82 in a back and forth direction following the sinusoidal movement of the radially protruding web 32 of the rotor 28 is allowed.

[0082] When the parts of the pump proper 4 are assembled, the inlet chamber is formed is in the upper right quadrant within the liner 70, 80, and the outlet chamber is formed in the upper left quadrant within the liner 70, 80, with the inlet and the outlet chambers being separated from each other by the scraper gate guide 84 and the scraper gate element 82. In particular, the bottoms of the inlet and outlet chambers are formed by the substantially straight horizontal portion connecting the thicker lower bottom wall portion to the thinner upper bottom wall portion, by the parts of the cylindrical wall lying in the upper right/upper left quadrant, by the right/left sides of the scraper gate element 82 and the scraper gate guide 84 and by the inner face of the thinner upper cylindrical wall portion of the liner 70, 80. The liner channel is formed by the upper face of the thicker lower cylindrical wall portion, by the radially extending inner faces of the thicker bottom wall portion and by the cylindrical outer face of the shaft portion 30 of the rotor 28.

[0083] In operation, material to be pumped that has entered the inlet chamber through the inlet port 16 is pumped through the liner channel by means of the radially protruding web 32 of the rotor 28 to the outlet chamber from which it is discharged through the outlet port 18.

[0084] In both embodiments described, the liner elements 26, 36; 70, 80 and/or the scraper gate elements 38; 82 can be made of a material that the inventors of the present subject-matter have newly developed, namely a material comprising 85 to 95 Vol-% of a Polyethylene basis material of ultra-high molecular weight and 5 to 15 % Vol-% of glass particles having a rounded shape distributed within said Polyethylene basis material.

[0085] In addition, in the embodiment of Fig. 1 the sliding inserts 24 and 41 and the front shaft sleeve/bearing 42 can be made of such material.

[0086] The surfaces of these elements and in particular the surfaces of the inlet and outlet chambers and the liner channel that are formed by these elements and come into contact with the material to be pumped comprise rounded surface portions formed by such glass particles and they constitute a hard slide face for the flowable, relatively viscous materials to be pumped. These elements and the surfaces thereof exhibit excellent material properties, in particular a very low friction coefficient that improves the material flow and the efficiency of the entire pump and avoids packing and collecting material at those surface portions, very high hardness and durability which enhances the lifetime of these elements which are actually the elements that are subjected to the highest stress during pumping operation and regularly suffer wear and material loss. These parts are made of the material that the inventors of the present subject-matter have newly developed and therefore withstand this stress much better and have to be replaced much less frequently.

[0087] Moreover since this material is resistant to chemicals and at the same time very well suited for treating and handling food, the rotary displacement pump according to the present invention can be used for a very wide variety of applications including pumping flowable, relatively viscous materials in the food stuff industry, the chemical and biochemical industry, the medical industry and the cosmetic industry.

List of reference numerals

[0088]

2 rotary displacement pump
4 pump part
6 support part
8 shaft
10 support part housing
12 mounting frame
14 pump housing
16 inlet port
18 outlet port
20 mounting pins
22 rear shaft sleeve sealing element
24 rear sliding insert
26 rear liner/liner element
28 rotor
30 shaft portion
32 radially protruding web
34 front sliding insert
36 front liner/liner element
38 scraper gate element
40 scraper gate guide
41 front sliding insert
42 front shaft sleeve/bearing
44 locking nut
46 sealing ring
48 locking screw
50 sealing ring
52 front end plate
54 nuts
62 rotary displacement pump
64 sealing element
66 rear shaft sleeve sealing element
68 sealing ring
70 rear liner/liner element
72 sealing ring
74 sealing ring
76 locking screw
78 sealing ring
80 front liner/liner element
82 scraper gate element
84 scraper gate guide

Claims

1. A rotary displacement pump (2; 62) for pumping flowable, relatively viscous materials, said rotary displacement pump comprising:

   a liner (26, 36; 70, 80);
   a rotor (28) configured to be driven by a shaft (8);
   said rotor (28) including a shaft portion (30) and a radially protruding web (32) having a configuration of an undulatory disk type;
   a scraper gate (38; 82) having an engagement slot of predetermined radial height and predetermined axial width, said engagement slot engaging said protruding web (32) of said rotor (28);
   said scraper gate (38; 82) being supported by a scraper gate guide (40; 84) so as to be retained in circumferential direction and to allow a reciprocating movement in a substantially axial direction;
   a pump housing (14) comprising a front end part (52) and a rear end part, said pump housing (14) enclosing said liner (26, 36; 70, 80), said rotor (28), said scraper gate (38; 82) and said scraper gate guide (40; 84), said shaft (8) extending through said rear end part of said pump housing (14);
   said liner (26, 36; 70, 80) including a first liner element (26; 70) and a second liner element (36; 80), said first and second liner elements (26, 36; 70, 80) abutting to each other laterally along a radially outer abutment portion so as to form a liner channel through which said radially protruding web (32) of said rotor (28) runs and to define an enclosure that encircles a portion of said radially protruding web (32) of said rotor (28);
   an inlet chamber and an outlet chamber being defined by said liner (26, 36), said scraper gate (38) and said scraper gate guide (40) or by said liner (70, 80), said pump housing (14), said scraper gate (82) and said scraper gate guide (84);
   said scraper gate (38; 82) together with said scraper gate guide (40; 84) forming a partition between said inlet chamber and said outlet chamber;
   said inlet and outlet chambers being provided with respective inlet and outlet ports (16, 18);
   said liner channel extending from said inlet chamber to said outlet chamber;
   said web (32) of said rotor (28) being rotatable through said inlet chamber, said liner channel, said outlet chamber and said slot of said scraper gate (38; 82);

   wherein said scraper gate (38; 82) and/or said liner (26, 36) comprises 85 to 95 Vol-% of a Polyethylene basis material of ultra-high molecular weight and 5 to 15 % Vol-% of glass particles having a rounded shape distributed within said Polyethylene basis material, such that the surface of said scraper gate (38; 82) and/or said liner (26, 36; 70, 80) comprising rounded surface portions formed by such glass particles constitutes a hard slide face for the flowable, relatively viscous materials to be pumped.

2. The rotary displacement pump (2) of claim 1, further comprising a ring-formed front sliding insert (41) arranged in axial direction between said shaft portion (30) of said rotor (28) and a front shaft sleeve/bearing element (42) being secured to the front end portion of said shaft (8).

3. The rotary displacement pump (2) of claim 2, wherein the front shaft sleeve/bearing element (42) has an annular groove in its rear side facing said shaft portion (30) of said rotor (28), said ring-formed front sliding insert (41) being placed with an anchoring portion thereof in such annular groove.

4. The rotary displacement pump (2) of any of the preceding claims, further comprising a ring-formed rear sliding insert (24) arranged in axial direction between a rear shaft sleeve sealing element (22) being secured to said shaft (8) and said shaft portion (30) of said rotor (28).

5. The rotary displacement pump (2) of claim 4, wherein the rear shaft sleeve sealing element (22) has an annular groove in its front side facing said shaft portion (30) of said rotor (28), said ring-formed rear sliding insert (24) having a substantially rectangular cross-section or a T-shaped cross-section being placed with an anchoring portion thereof in such annular groove.

6. The rotary displacement pump (2) of any of claims 2 to 5, wherein at least one of the front and rear sliding inserts (24, 41) has a T-shape with an anchoring portion being placed in the respective annular groove and with an abutment portion abutting against the respective shaft portion (30) of said rotor (28).

7. The rotary displacement pump (2) of any of claims 2 to 6, wherein at least one element of the front sliding insert (24), the rear sliding insert (24, 41) and the front shaft sleeve/bearing element (42) comprises 85 to 95 Vol-% of a Polyethylene basis material of ultra-high molecular weight and 5 to 15 % Vol-% of glass particles having a rounded shape evenly distributed within said Polyethylene basis material, such that surface of said sliding insert (24, 41) comprising said Polyethylene basis material and glass particles protruding out of the same forms a rounded and hard slide face for the flowable, relatively viscous materials to be pumped.

8. The rotary displacement pump (2; 62) of any of the preceding claims, wherein said glass particles are of spherical or oval shape.

9. The rotary displacement pump (2; 62) of any of the preceding claims, wherein the diameter of said glass particles is 10 - 40 μm, particularly 20 - 30 μm, and more particularly around 24 μm.

10. The rotary displacement pump (2; 62) of any of the preceding claims, wherein the molecular weight of said Polyethylene basis material is 0.8 * 10^6 g/mol to 1.2 * 10^6 g/mol, particularly around 1.0 * 10^6 g/mol and/or wherein the Polyethylene basis material withstands operating temperatures of up to 100°C without softening.

11. The rotary displacement pump (2) of any of the preceding claims, wherein the first liner element (26) and the second liner element (36) are generally semi-circular arc-formed.

12. The rotary displacement pump (2) of claim 11, wherein the enclosure that encircles a portion of said radially protruding web (32) of said rotor (28) is generally semi-circular arc-formed.

13. The rotary displacement pump (62) of any of claims 1 to 11, wherein the first liner element (70) and the second liner element (80) are generally cup shaped and define a circumferential wall.

14. The rotary displacement pump (62) of claim 13, wherein said scraper gate (82) and/or said scraper gate guide (84) are completely arranged within said liner (70, 80).

15. The rotary displacement pump of claim 13 or 14, wherein said scraper gate guide (84) is supported by said liner (70, 80).

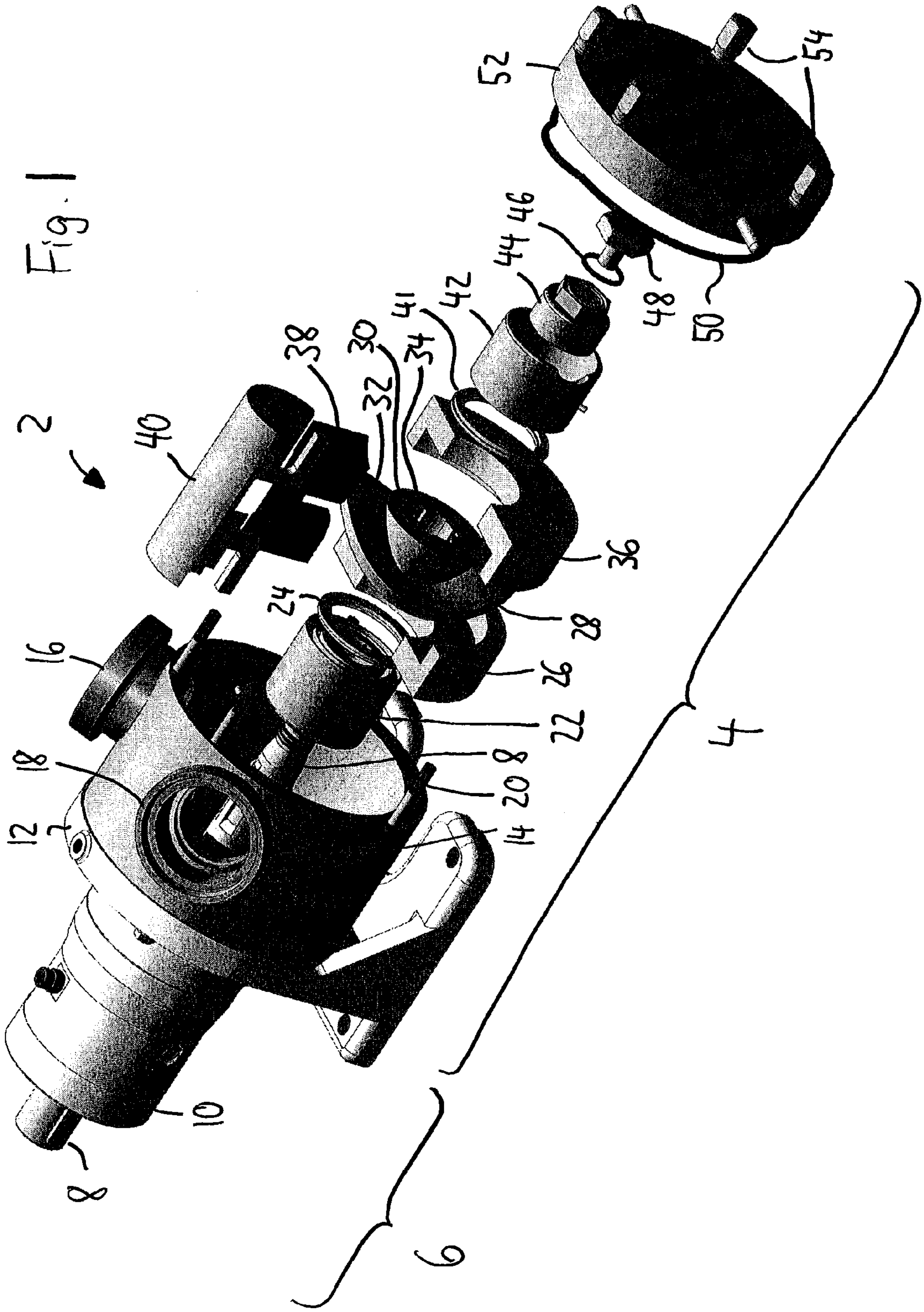
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Fig. 1

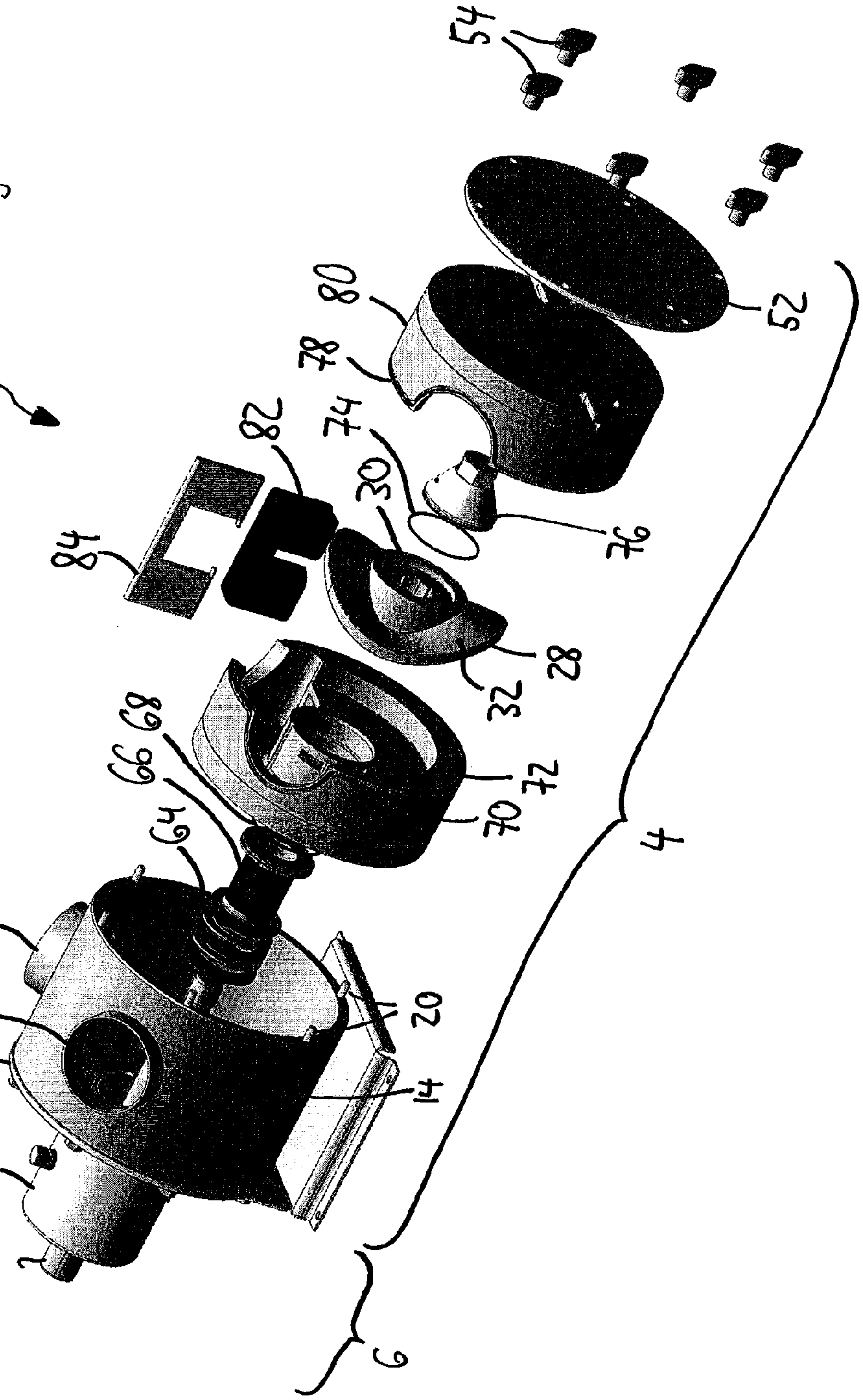

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 11 17 9881

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	16 January 2012	Sbresny, Heiko

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 17 9881

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