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(54) DOUBLE ACTING PNEUMATICALLY DRIVEN ROLLING DIAPHRAGM PUMP

DOPPELWIRKENDE PNEUMATISCH ANGETRIEBENE ROLLMEMBRANPUMPE

POMPE A PISTON A COMMANDE PNEUMATIQUE ET MEMBRANE A ENROULEMENT

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- **PATENT ABSTRACTS OF JAPAN vol. 1997, no. 06, 30 June 1997 (1997-06-30) & JP 09 053566 A (KOGANEI CORP), 25 February 1997 (1997-02-25)**

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Description

FIELD OF THE INVENTION

[0001] The present invention relates generally to reciprocating pumps and, more particularly, to reciprocating pumps having chemically inert wetted areas that use rolling diaphragm pressurizing members, and to pump systems comprising a number of such pumps that are operated to produce a relatively flat overall discharge pressure.

BACKGROUND OF THE INVENTION

[0002] Pumps that are useful in the semi-conductor manufacturing industry must be capable of transferring high purity process fluids that are oftentimes corrosive and/or caustic. These high purity process fluids are oftentimes heated to temperatures near their boiling point to increase their efficiency in performing the particular semiconductor manufacturing process. Accordingly, it is important that pumps placed into service with such process fluids be capable of transferring such corrosive and/or caustic process fluids under high-temperature conditions without failing. It is also important that pumps placed into such service do not introduce contaminant matter that can be transferred downstream, which could eventually damage or contaminate the high-purity finished product, e.g., semiconductors and the like.

[0003] Conventional pumps that are well known for their application in other less demanding applications are not well suited for use in applications where maintaining the high purity of the process fluid is important. For example, rotary or centrifugal pumps, that rely on the use of a rotating impeller to increase the output pressure of fluid entering the pump, are not well suited for use in high-purity systems because of the potential for the process fluid to come into contact with the impeller bearings upon failure of the bearing packing or pump seal. Exposing the process fluid to the bearings introduces contamination leaving the pump in the form of metal particles, into the process fluid resulting in contamination of the final product. Also, reciprocating piston-type pumps that use dynamic seals around the piston circumference are similarly unsuited for high-purity applications because of the abrasion and wear that occurs at the dynamic piston seal, which results in particulate matter from the worn and abraded seal entering and contaminating the process fluid.

[0004] Pumps that have been used in such high-purity service with some degree of success include both diaphragm- and bellows-type pumps. Diaphragm pumps rely on the reciprocating movement of a flexible diaphragm within a chamber to both receive and discharge at pressure the process fluid. The diaphragm for such service can be made from a chemically inert material and is usually fixed about a circumferential edge along the pressure chamber wall. The pressure chamber is configured having inlet and outlet ports that are fitted with one-way check valves so that moving the center portion of the diaphragm in one direction causes fluid to enter the chamber via the inlet port, and moving the diaphragm in the opposite direction causes fluid to exit the chamber via the outlet port.

[0005] The resulting pressure output produced by the diaphragm pump fluctuates from zero to some desired level, and is not flat. The diaphragm in a diaphragm pump is attached to the pump housing about a peripheral edge, and is attached to an actuating piston by a hole disposed through a center portion of the diaphragm body. This hole serves as an additional leak path, other than that provided at the peripheral seal, for the migration of process fluid past the diaphragm and into the inner workings of the pump where it can be exposed to particulate or other contaminate matter. Fluid passing back through the leak path from the housing can thereby contaminate the remaining process fluid.

[0006] Further, the reciprocating movement of the diaphragm is known to place large stresses both upon unsupported areas of the diaphragm and at the point of attachment with the chamber, causing the diaphragm to ultimately fail by rupture or collapse after a relatively short service time. Diaphragm failure not only terminates process fluid transfer but also exposes the process fluid to metallic surfaces and metal particles from parts used to move the diaphragm, e.g., the piston rod, rod bearing and the like, contaminating the high-purity process and possibly contaminating the final product.

[0007] Bellows-type pumps rely on the reciprocating movement of a piston-shaped bellows within a closed chamber to both receive process fluid into a pressure chamber and discharge it under pressure. The bellows can be formed from a chemically inert material and is attached along a circumferential skirt to the chamber wall. The advantage of a bellows pressurizing member over a diaphragm is that in theory the bellows is not stressed to the same degree as a diaphragm during reciprocating movement. Rather, the bellows moves within the chamber by the expansion and contraction of its accordion-like cylindrical wall. However, the bellows pump, like the diaphragm pump, also does not have a relatively flat or constant output pressure.

[0008] It is also known that the accordion-like cylindrical wall of the bellows is prone to fatigue and failure due to wall thickness nonuniformities that are inherent in the bellows manufacturing process. Such wall thickness nonuniformities cause the thinnest portion of the accordion-like cylindrical wall to flex the most during reciprocating movement, and ultimately fail due to fatigue stress, thereby limiting the service life of the pump.

[0009] To ensure accordion-like expansion and contraction movement, and to prevent collapse of the cylindrical wall, the bellows can be supported along the inside wall surface by metal windings. The metal windings prevent the cylindrical wall from collapsing during reciprocating movement. However, upon failure of the accor-

dion-like cylindrical wall, process fluid is free to contact the metal windings, thereby contaminating the process.

[0010] Examples of prior art pumps of the above type are disclosed in US-A-5,063,770, US-A-2,711,134, US-A-4,773,035 and EP-A-0 625 639.

[0011] It is desirable that a pump be constructed that is capable of pressurizing both high and low temperature high-purity process fluid without the possibility of fluid contamination. It is desirable that the pump be constructed in a manner that both minimizes the possibility of internal leakage and is capable of providing an indication of internal leakage.

[0012] It is also desired that a pump system be constructed of a plurality of such pumps that is capable of providing a relatively constant overall pressure output and be fault tolerant, i.e., capable of adjusting system operation to maintain a relatively constant discharge pressure when internal pump leakage is detected.

SUMMARY OF THE INVENTION

[0013] According to the present invention there is provided a pump for pressurizing process fluid comprising: a housing having an annular passage that extends therethrough between opposed open ends; a piston disposed within the annular passage; a piston gland disposed within the annular passage at each open end for guiding slidiable displacement of the piston therethrough; a pressurizing chamber assembly disposed at each housing end and sealed off from remaining housing portions, each pressurizing chamber assembly comprising: a chamber head attached to a respective housing end, the chamber head being adapted to sequential receive and discharge process fluid; and a pressurizing member displaced within the chamber head and connected to an end of the piston, the pressurizing member and inside surface of a respective chamber head forming a pressurizing chamber therebetween, the pressurizing member having a one-piece cylindrical construction formed from a fluoropolymeric material and including a solid nose portion and a skirt extending axially therefrom, the skirt having a flanged end that is interposed between the chamber head and the housing end to form an air- and liquid-tight seal therebetween, the skirt having a thin-walled construction that is rolled upon itself to permit reciprocating movement of the pressurizing member within the chamber head; means for actuating the piston to produce reciprocating slidable displacement of the piston within the passageway, wherein slidable displacement of the piston in one direction effects a simultaneous fluid intake in one pressurizing chamber and a fluid discharge from the other pressurizing chamber.

[0014] A pump system, constructed according to principles of this invention may comprise a number of pumps that are operated by a controller. The pumps in the system may be actuated to produce a relatively constant overall discharge pressure. The cam includes means for detecting leakage from any one of the pumps, and be fault tolerant by allowing continued operation of the system while shutting down operation of a leakage or otherwise malfunctioning pump.

DESCRIPTION OF THE DRAWINGS

[0015] These and other features and advantages of the present invention will become appreciated as the same becomes better understood with reference to the specification, claims and drawings wherein:

FIG. 1 is a cross-sectional side elevational view of a reciprocating pump constructed according to principles of this invention;
FIG. 2 is an enlarged cross-sectional side elevational view of the reciprocating pump of FIG. 1; and
FIG. 3 is a schematic view of a pump system constructed according to principles of this invention comprising a controller and a number of reciprocating pumps.

DETAILED DESCRIPTION

[0016] This invention relates to reciprocating pumps useful for transferring process fluids, and more specifically, to pumps useful for transferring high-purity process fluids such as those used in the semiconductor manufacturing industry. The pumps include internal wetted elements that are made from chemically inert materials that are resistant to corrosive and caustic process fluids, and are not formed from metal. The pumps are of a reciprocating design, comprising symmetrically opposed pressurizing chambers. In a preferred embodiment, the pump provided in accordance with practice of the present invention comprises a pair of opposed reciprocating pressurizing chambers that are pneumatically actuated in an opposed sequence so that at any instant one pressurizing chamber is pressurizing the process fluid and the other is receiving the process fluid. A pump system, constructed according to principles of this invention comprises a number of such pumps that are each actuated at different sequencing intervals so that the overall combined pressure output from the pumps is relatively constant.

[0017] Referring to FIG. 1, an exemplary embodiment of a pump 10 constructed according to principles of this invention is shown. The pump 10 comprises a housing 12, chamber heads 14 and 16 at opposite ends of the housing 12, pressurizing members 18 and 20 disposed within each respective chamber head 14 and 16, and an actuating piston 22 disposed within the housing and connected at opposite ends to the pressurizing members 18 and 20. Generally speaking, the pump 10 is symmetrically configured along a line 23 extending through the midpoint of the housing 12.

[0018] The housing 12 is generally cylindrical in shape, having an annular passage 24 that extends

therethrough from a first open end 26 to an opposed second open end 28. The housing can be formed from any type of structurally rigid material of construction such as plastic, polymeric material, composites, metal and metal alloys, and the like. In low-temperature operations, e.g., below about 40°C, the housing can be made from a molded or machined polymeric material, such as polypropylene and the like. However, in high-temperature operations, above about 40°C, it is desired that the housing be made from metal or metal alloy such as stainless steel and the like to avoid any temperature induced structural weakness or deformation.

[0019] Moving across FIG. 1 from the right-hand side to the left-hand side, the annular passage 24 adjacent the first open end 26 has a first diameter section 30 that extends axially into the passage 24 a distance from the first end 26 to accommodate placement of a first piston gland 32 therein. Moving axially from the first diameter section 30, the annular passage 24 includes a reduced diameter section 34 that extends axially across the middle of the passageway 24 to a second diameter section 36 that extends to the second open end 28. Like the first diameter section 30, the second diameter section 36 is sized to accommodate placement of a second piston gland 38 therein. As discussed in greater detail below, the first and second diameter sections are sized having a diameter larger than the reduced diameter section 34 to limit the maximum inwardly directed axial travel of respective first and second piston glands 32 and 38 within the annular passage by seated placement against axial edges of the reduced diameter section.

[0020] The first and second diameter sections 30 and 36 each include at least one respective leak port 40 and 42 that extends through the housing wall. The reduced diameter section 34 includes two air inlets 44 and 46 that each extend through the housing wall and that are each positioned adjacent the respective passageway first and second diameter sections 30 and 36. In a preferred embodiment, the annular passage 24 also includes a piston indicator port 48 that extends through the housing wall at a middle position of the housing. The piston indicator port 48 is adapted to accommodate placement of a sensor (not shown) therein to monitor the position of the actuating piston 22 within the annular passage, and to control reciprocating actuation of the piston. The piston 22 includes placement monitoring means 49 in the form of black perfluoroalkoxy fluorocarbon resin shrink tubing disposed around the piston. The black surface of the piston is picked up by a sensor mounted in the indicator port 48 to provide an indication of piston position within the housing.

[0021] The actuating piston 22 is disposed within the enlarged diameter section 34 of the annular passage and is symmetrically constructed comprising, moving from right to left in FIG. 1, a first diameter section 50 extending axially a distance from a first piston end 52, and a second diameter section 54 that extends axially a distance from the first diameter section 50. The actuating piston 22 has a generally cylindrical shape and can be formed from any type of structurally rigid material, such as those materials previously described above for the housing, and in addition fluoropolymeric compounds selected from the group consisting of tetrafluoroethylene (TFE), polytetrafluoroethylene (PTFE), fluorinated ethylene-propylene (FEP), perfluoroalkoxy fluorocarbon resin (PFA), polychlorotrifluoroethylene (PCTFE), ethylene-chlorotrifluoroethylene copolymer (ECTFE), ethylene-tetrafluoroethylene copolymer (ETFE), polyvinylidene fluoride (PVDF), polyvinyl fluoride (PVF) and the like. In a preferred embodiment, the piston is formed from a non-metallic material, preferably polypropylene, to avoid possible process fluid contamination from the introduction of metal particles.

[0022] The first diameter section 50 is configured to accommodate attachment with a pressurizing member plug 56 that is attached to the pressurizing member 18. In a preferred embodiment, the first diameter section 50 is threaded to permit threaded attachment with the plug 56. The second diameter section 54 has a diameter that is greater than the first diameter section 50, and that is sized to accommodate axial displacement within a passageway 58 that extends through the first piston gland 32.

[0023] The piston 22 includes an enlarged diameter section 60 that extends axially from the second diameter section 54 and defines a central portion of the piston. The piston 50 is symmetrically constructed about a midpoint running diametrically across the enlarged diameter sections. Thus, the left hand portion of the piston comprises third and forth diameter sections 62 and 64 that extend from the enlarged diameter section to a second piston end 66. The third and fourth diameter sections have a size and configuration that is identical to the respective second and first piston diameter sections 54 and 50.

[0024] The enlarged diameter section 60 is larger in diameter than the second and third diameter sections 54 and 62 and includes at least one sealing flange 68 that extends circumferentially therearound. The sealing flange 68 includes a groove 70 positioned radially therein and has a diameter that is slightly smaller than the diameter of the enlarged diameter section 34 of the annular passage 24. In a preferred embodiment, a dual seal arrangement is used with the groove 70 to provide an air-tight seal between the annular passage 24 and the piston 22. The dual seal arrangement comprises an O-ring seal 71 that is disposed within the groove 70, and a ring-seal 72 that is disposed within the groove 70 over the O-ring seal. The O-ring seal 71 is used as an energizer to force the ring-seal 72 into contact against the adjacent wall of the annular passage 24. Alternatively, it is to be understood that a single seal arrangement can be used.

[0025] The seal can be formed from well known sealing materials such as elastomeric materials and the like. In a preferred embodiment, the O-ring seal 71 is made

from fluoroelastomers such as Viton, for low-temperature operations, or Kalrez, for high-temperature operations, both of which are available from DuPont of Wilmington Delaware. A preferred ring-seal 72 material is a filled PTFE.

[0026] In the event that the piston comprises only one sealing flange 68, the sealing flange is axially positioned at the center of the enlarged diameter section 60. In the event that two sealing flanges are used, each is positioned adjacent opposing axial ends of the piston enlarged diameter section 60. In a preferred embodiment, the piston 22 comprises two sealing flanges 68. A piston construction having dual sealing flange is desired because it both allows for piston centerline sensing and provides an unpressurized area for the piston indicator port 48 and piston sensor.

[0027] The first and second piston glands 32 and 38 are each identically sized and configured, so it is understood that the following description applies equally to each. The piston glands are formed from a suitable structurally rigid material, such as those previously described for forming the housing and the piston. In low-temperature applications of less than about 40°C, the piston glands may be made from non-metallic materials, and are preferably made from PTFE. In high-temperature applications above about 40°C, the pistons glands are preferably made from metal or metal alloy, such as stainless steel and the like.

[0028] Each piston gland 32 and 38 has a cylindrical construction and is disposed axially within the respective first and second diameter sections 30 and 36 of the housing passageway 24. The piston glands 32 and 38 each have an outside diameter that is both slightly smaller than the respective first and second diameter sections 30 and 36 to permit slidable placement therein, and that is slightly larger than the reduced diameter sections 34 of the passageway 24 to limit axial displacement into reduced diameter section of the passageway. The piston glands each have an axial length that is similar to the length of the respective first and second diameter sections of the housing passageway so that open ends 74 of each piston gland are coterminous with the respective housing first and second open ends 26 and 28.

[0029] Referring to FIG. 2, which is only the right hand side of the pump 10, in addition to FIG. 1, the piston glands each include an annular plug chamber 76 that extends axially within each gland from its open end 74 to a gland shoulder 78 that encloses each gland opening 58. The plug chamber 76 is cylindrical in shape and is sized to accommodate placement of a respective pressurizing member plug 56 and 57 therein. Each plug chamber 76 includes one or more leak ports 80 that extends through a respective gland wall. A leak channel 81 is disposed circumferentially around the outside surface of each gland and is in communication with each leak port 80. The leak channel of each gland is sized and positioned to communicate with respective leak ports 40 and 42 that extend through the housing wall to permit fluid passage from each respective plug chamber 78 through the housing. The outside wall surface of each piston gland 32 and 38 includes a number of grooves 82 that each extend circumferentially therearound, and that are each configured to accommodate a ring-shaped seal 84 therein for providing a liquid- and air-tight seal between the housing passage 24 and each piston gland 32 and 38. The seals 84 are each preferably formed from a chemically resistant elastomeric material such as Viton, Kalrez and the like. In a preferred embodiment, the seals are in the shape of an O-ring formed from Viton. Alternatively, each piston gland seal can be provided by a dual seal arrangement, like that previously described for the piston sealing flange 68.

[0030] In a preferred embodiment, each piston gland comprises three grooves 82 and respective ring-shaped seals 84. A first circumferential groove is positioned adjacent each gland open end 74, a second groove is positioned adjacent one side of the leak channel 81, and a third groove is positioned adjacent an opposite side of the leak channel 81. Arranging the grooves 82 and seals 84 in this manner, at each axial end of the leak channel in each gland, is designed to contain any leaking process fluid to the housing first and second diameter sections and direct it from the leak channel 81 to the leak ports 40 and 42, and thereby prevent its migration to other parts of the housing.

[0031] Referring particularly to FIG. 2, the gland opening 58 through the gland shoulder 78 of each piston gland 32 and 38 preferably comprises a seal groove 86 disposed circumferentially therearound adjacent the plug chamber 76, with a piston seal 88 disposed therein. A bushing channel 90 is further disposed circumferentially around each opening 58 adjacent the seal groove 86, and a piston bushing 92 is disposed therein. Each piston seal 88 is formed from the same material described above for forming the gland seals 84. The piston bushing 92 can be formed from well know bearing materials, such as elastomeric materials that have been impregnated with friction and wear reducing agents. In a preferred embodiment, each piston bushing 92 is formed from filled PTFE.

[0032] The seal groove 86 and piston seal 88 are designed to provide a liquid- and air-tight seal between each piston gland 32 and 38 and each respective piston second and third diameter section 54 and 62 within the piston glands. Each piston bushing 92 is designed to minimize radial movement of each respective second and third piston diameter section 54 and 62 within the piston glands, thereby optimizing accurate piston centering and eliminating potential piston binding within the housing passage.

[0033] The actuating piston 22 is disposed within the housing passage 24 between the first and second piston glands 32 and 38, so that the piston second and third diameter sections 54 and 62 extend through respective gland openings 58, and so that the piston first and fourth diameter sections 50 and 64 extend into respective plug

chambers 76. Each piston first and forth diameter section 50 and 64 is attached to respective pressurizing member plugs 56 and 57. The plugs can be formed from the same materials previously described above for the piston and have a cylindrical configuration with a diameter less than that of the respective plug chamber to facilitate placement therein.

[0034] To accommodate attachment with the piston, each plug 56 and 57 includes a threaded female connection 93 at one end. Each plug has a threaded male connection 94 at an opposite end to facilitate attachment with respective pressurizing members 18 and 20. As will be described in greater detail below, the plugs are designed to support side wall portions of the pressurizing member during reciprocating movement.

[0035] Referring again to FIG. 1, in addition to FIG. 2, pressurizing members 18 and 20 are in the form of rolling diaphragms and each have a generally cylindrical configuration and are formed from chemically inert non-metallic materials, such as those previously described for the piston 22. In a preferred embodiment, the pressurizing members are a one-piece construction formed from a solid billet of PTFE. Each pressurizing member includes a threaded female connection 98 to accommodate attachment with the threaded male connection 94 of a respective plug. Each pressurizing member has a substantially solid nose portion 100, opposite the female connection 98, that extends a distance from a tip 101 of the nose to about one-half of the axial length.

[0036] Configuring each pressurizing member as a one-piece construction, comprising the solid nose portion and a bore formed at one end of the member for attachment to a respective plug, eliminates having to form a hole through the member to facilitate attachment with the piston, thereby avoiding the creation of a possible leak path and source of pump failure.

[0037] In a preferred embodiment, the nose portion 100 has a tapered outside surface 102 of increasing diameter moving axially away from its tip 101. If desired, the nose portion can be configured differently, e.g., having a constant diameter outside surface. A tapered outside surface is preferred, when used with a similarly tapered pressurizing chamber, to maximize the flow velocity effect of process fluid pressurized in each pressurizing chamber 118 by the pressurizing member.

[0038] Each pressurizing member 18 and 20 includes a thin-walled skirt 104 that extends away from the nose portion. In a preferred embodiment, the skirt 104 has an outside surface of increasing diameter that complements the taper of the nose portion. The skirt is of a thin-wall construction to allow it to flex and roll upon itself during reciprocating movement of the pressurizing member nose portion 100; specifically, when the pressurizing member is being retracted into a respective plug chamber. To facilitate such rolling action, it is desired that the skirt 104 have a wall thickness in the range of from about 0.01 to 1 millimeter. It is to be understood that the wall thickness of the skirt can vary depending on the particular pump application and process fluid parameters. For example, in high-temperature conditions above about 40°C, it may be desired to use a pressurizing member having a skirt wall that is thicker than that used in low-temperature conditions to help avoid unwanted temperature induced softening and/or deformation.

[0039] As is best shown in FIG. 2, each skirt 104 includes a flange 108 that extends radially outwardly away from a circumferential edge of the skirt. The flange 108 has an outside diameter sized approximately the same as an outside diameter of a respective piston gland 32 and 38. A tongue 110 extends axially away from the flange 108 in a direction pointed toward the chamber head, and is designed to provide an air- and liquid-tight seal with the chamber head. In a preferred embodiment, the tongue 110 has a two-step configuration comprising, moving radially outwardly, a first relatively short stepped portion 111, and a second relatively taller stepped portion 113.

[0040] The flange 108 of each pressurizing member 18 and 20 is interposed between the open ends 74 of respective piston glands 32 and 38 and chamber heads 14 and 16. As is shown in FIG. 1, each chamber head 14 and 16 is configured having a frusto conical 112 that extends axially from a nose portion 114 at one end of the body to a flange 116 at an opposite end of the body. The flange 116 extends radially outwardly away from the body and defines the body peripheral edge. The body 112 includes a pressurizing chamber 118 that extends between the nose portion and the flange 116. In a preferred embodiment, the body has a tapered shape of increasing diameter, moving from the nose portion to the flange, that complements the taper of the pressurizing member. Each chamber head 14 and 16 is formed from chemically inert non-metallic materials such as those previously described above for use in forming the pressurizing members. In a preferred embodiment, each chamber head is formed from PTFE.

[0041] Referring to FIG. 2, the Flange 116 includes a groove 120 that extends circumferentially therearound along the inwardly facing a radial edge 122 of the flange. The groove is configured to accommodate the pressurizing member tongue 110 therein. In a preferred embodiment, the groove 120 is stepped to accommodate placement of the first and second stepped tongue portions therein to provide an air- and liquid-tight seal therebetween.

[0042] Each chamber head 14 and 16 is attached to the housing 12 after: (1) each pressurizing member plug 56 and 57 has been attached to a respective pressurizing member 18 and 20 at one end; (2) each pressurizing plug 56 and 57 has been attached to a respective piston first and forth diameter section 50 and 64 at an opposite end; and after (3) each pressurizing member tongue 110 has been inserted into each chamber head groove 120 by placing the chamber head flange 116 adjacent a respective housing first and second open end 26 and 28.

Use of a static tongue and groove seal between each pressurizing member and respective chamber head for forming a seal therebetween is advantageous because it avoids a the use of a dynamic sealing mechanism and, thereby avoids both the potential for process fluid contamination by generation of particulate matter from worn seals, and eliminates a possible process fluid leak path.

[0043] Each chamber head can be secured to the housing by conventional means, such as by threaded attachment therebetween or by use of external flanges and bolt connection. In a preferred embodiment, a coupling nut 124 is used to secure each chamber head to the housing. The coupling nut 124 includes an annular passageway 126 that extends therethrough from a shouldered end 128 to an opposite open end 130. The coupling nut can be made from the same materials described above for the housing. In a preferred embodiment, for low-temperature operation below about 40°C the coupling nut is made from polypropylene, and for high-temperature operation above about 40°C the coupling nut is made from stainless steel.

[0044] The passageway 126 adjacent the open end 130 is threaded to complement threads disposed around the outer surface of the housing 12 adjacent the respective first and second open ends 26 and 28. Tightening the coupling nut 124 to each respective housing open end traps each respective chamber head flange 116 between the housing and an inside surface of the shouldered end 128 of the coupling nut.

[0045] Referring to FIG. 1, each chamber head 14 and 16 includes means 132 for receiving fluid therein and means 134 for dispensing fluid therefrom. The means for receiving and dispensing fluid can be in the form of separate inlet and outlet ports disposed adjacent the nose portion 114 of each chamber head body. In such an embodiment, it is desired to place a check valve 135 in each inlet and outlet flow path outside of the chamber head, to prevent undesired reverse flow of fluid through each port. In a preferred embodiment, each chamber head has a single fluid port 136 disposed through the nose portion 114. The single fluid port 136 is designed to accommodate sequential fluid intake into and fluid dispensement from the chamber head during reciprocating movement of the pressurizing member. Alternatively, each chamber head may have separate inlet and outlet ports disposed through the nose portion, rather than a single fluid port.

[0046] A fluid manifold 138 is in fluid flow communication with the fluid port 136 and is disposed outside of each respective chamber head. In a preferred embodiment, the fluid manifold 138 is an integral member of the chamber head and includes the fluid inlet port 132 and a separate fluid outlet port 134. Check valves 135 are positioned in the fluid flow path of both the fluid inlet and outlet ports 132 and 134 to ensure that fluid both enters the manifold 138 via only the fluid inlet port 132, and that fluid exits the manifold via only the fluid outlet port 134. Check valves suitable for use in such application include those compatible with use in such process fluid system, such as flapper-type check valves that include no metal parts and that are formed from chemically inert materials.

[0047] Each manifold 138 can additionally include an isolation valve 144 that is positioned adjacent the chamber housing fluid port 136 to prevent fluid from entering or exiting the chamber head when actuated. The isolation valve 144 can be actuated by conventional means, such as by electrical, hydraulic, or pneumatic means, and can be configured to provide fail open or fail close service. In a preferred embodiment, the manifold 138 comprises an isolation valve 144 that is disposed both between the fluid inlet and outlet ports 132 and 134, and opposite from the chamber housing fluid port 136. The isolation valve 144 can be of conventional design, formed from non-metallic chemically inert materials, is pneumatically actuated, and is designed to fail in the closed position. As will be disclosed in greater detail below, the isolation valve is intended to be used to isolate the chamber head from the process fluid in the event that fluid leakage within the chamber head is detected.

[0048] The pump 10 is pneumatically operated by injecting pressurized air into one housing air inlet 44 or 46 while simultaneously venting air from the other housing air inlet. Referring still to FIG. 1, pressurized air that is injected into air inlet 46 and into the housing passage reduced diameter section 34, imposes a pressure force between the second piston gland 38 and the actuating piston 22, causing the piston to be slidably displaced within the housing to the right. The rightward movement of the piston 22 both causes pressurizing member 20 to be retracted away from respective chamber head 16, and causes pressurizing member 18 to be inserted into respective chamber head 14. The retraction of pressurizing member 20 causes fluid to be drawn into the chamber head 16 via respective chamber housing fluid port 136 and fluid inlet port 132. The insertion of pressurizing member 18 causes fluid to be pressurized and dispensed from the chamber head 14 through respective chamber fluid port 136 and outlet port 134.

[0049] After air has been injected into air inlet 46, and vented from the other air inlet, the input of injected air is terminated and rightward travel of the piston 22 is terminated. The injection of pressurized air into the air inlet is terminated once the desired piston travel within the housing is sensed by operation of a sensor within the piston indicator port 48. After air injection in one air inlet is terminated, air is injected into the other air inlet until the desired piston travel is again detected. Pressurized air is sequentially injected through each air inlet, causing the piston to reciprocate back and forth within the housing, and causing pressurizing members 18 and 20 to sequentially produce a pressurized fluid output. The pump is designed to be actuated by using an air supply pressure in the range of from about 30 to 150 psig.

[0050] It is desired that the pump be designed so that the amount of pressurized air needed to move the piston

in each direction be less than the desired amount of discharge pressure to be produced by each pressurizing member, i.e., it is desired that the ratio of discharge pressure to actuation pressure be positive. In a preferred embodiment, the desired positive ratio is achieved by sizing the portion of the piston in contact with the pressurized air to have a larger surface area than that of the pressurizing member.

[0051] The pump can be used in conjunction with a leak detection system or device to monitor whether process fluid has migrated past the pressurizing member due to pressurizing member failure. In an example embodiment, the leak detection system may comprise sensors that are adapted to attach to leak ports 40 and 42 through the housing, and that are capable of relaying an appropriate sensor signal to a controller. Alternatively, the tubing may be routed from the leak ports to a central leak detection device to facilitate transmission of the leaking liquid to the device where it can be detected. As discussed in greater detail below, in a preferred embodiment the leak detection system is used in conjunction with a pump system to monitor the operation of the system.

[0052] A cycle sensor or the like can be connected to the piston indicator port 48 to provide a means of monitoring the cycles of the actuating piston 22. As discussed in more detail below, such cycle sensor is used in conjunction with a controller to track the performance of each pump used in a pump system.

[0053] Pumps constructed according to principles of this invention can be operated with fluids at a low temperature, e.g., below about 40°C, or with high-temperature fluids, e.g., above about 40°C and to a maximum temperature of about 200°C. As mentioned above, the primary difference between low- and high-temperature embodiments of the pump is the materials of construction that are used for the housing and the coupling nuts. The pump capacity depends on the size of each chamber head and the cycle speed of the piston and can vary depending on the particular pump application. In a preferred embodiment, the pump has a capacity of approximately 10 to 80 liters per minute. The pump discharge pressure can be adjusted depending on the process fluid temperature, and may be as high 130 psig. It is to be understood that, to account for softening of the pressurizing members, it may be desired that the discharge pressure of the pump be decreased as the process fluid temperature increases to prevent damage to the pressurizing members. The output pressure of the pump is adjusted by reducing or increasing the pressure of the air injected in to the air inlets. It is also desired that the wall thickness of the pressurizing member skirt be increased where elevated discharge pressures are desired in high-temperature applications.

[0054] A pump system, constructed according to principles of this invention, comprises a number of the pumps previously described above. For purposes of describing the pump system each pump will be referred to hereafter as a module, each module comprising two horizontally opposed pressurizing members. Referring to FIG. 3, a preferred embodiment of a pump system 145 includes four modules 146, comprising a total of eight pressurizing members. The fluid inlets 147 of each module are connected to a fluid inlet manifold 148 that is connected to a process fluid source. The fluid outlets 150 of each module are connected to a fluid outlet manifold 152 that is connected to a desired process fluid handling device.

[0055] Pressurized air is routed to the air inlets 154 of each module via air tubing 156 and the like. Pressurized air is also routed to the isolation valves 157 of each module via air tubing 158 and the like. It is desired that the modules of the pump system be actuated in a manner that produces a relatively constant pulseless fluid discharge pressure to avoid problems with downstream fluid handling devices, e.g., to avoid filter pulsation and the generation of resulting filter particulates. A controller 159 is configured to regulate the actuation of each module to provide a relatively constant discharge pressure by controlling the sequence of routing pressurized air to each module. For example, in a four module system where each module is configured to provide one cycle per second, it is desired that the controller 159 be programmed to provide pressurized air to each module air inlet 154 in one-eighth second sequencing.

[0056] In an exemplary embodiment, the controller is additionally configured to produce electric signals that actuate solenoids 160, which solenoids operate to regulate the supply of pressurized air supply to the air inlets 154 of the modules, and operate to provide pressurized air to the isolation values 157. It is to be understood that this is but one embodiment of how the pump system can be configured and operated to provide a relatively constant fluid discharge pressure, and that other embodiments are intended to be within the scope of this invention. For example, instead of four modules the pump system can comprise any number of modules that is capable of being actuated to provide a relative flat discharge pressure. Additionally, rather than using separate solenoids, the controller can be configured to having internal means for dispensing pressurized air to the air inlets 154 and isolation valves 157.

[0057] Referring still to FIG. 3, the pump system comprises a number of leak detection sensors 162 that are connected to the leak ports 164 of each module. The leak detection sensors 162 are connected to the controller 159 and are adapted to provide an indication of whether process fluid has migrated past a pressurizing member within the modules. Upon detecting any such leakage in a particular module, the controller is configured to both discontinue routing pressurized air to the module air inlets 154, and to discontinue routing pressurized air to the module isolation valves 157. Configured in this manner, the controller both terminates operation of a leaking module and isolates the leaking module from fluid inlet or outlet flow, thereby both pre-

venting the possible introduction of contaminates from the leaking module into the process fluid, and allowing the module to be serviced.

[0058] In a preferred embodiment, the controller 159 is also configured to compensate for a non-operating or isolated module by resequencing the operation of the remaining modules to provide the most constant discharge pressure, thereby making the pump system fault tolerant. A fault tolerant pump system is desired as it allows the pump system to continuously operate while the isolated module is being serviced, thereby avoiding costly downtime associated with taking the entire pump system offline.

[0059] In a preferred embodiment, the controller is also configured to monitor the number of cycles that each module has been operated by use of a cycle sensor 166 connected to each module piston indicator port 168 so that a performance history for each module in the pump system can be maintained and downloaded for evaluation of performance history. The controller 159 can also be configured to monitor the temperature of the process fluid and the discharge pressure from the pump system, or from each module, and regulate the operation of the modules to correspond to a desired temperature and pressure curve, thereby preventing the modules from exceeding a desired maximum discharge pressure at a given pressure. Configuring the controller in this manner is desired to extend the service life of the pump system.

[0060] A feature of the pump constructed according to principles of this invention is that the wetted area of the pump are formed entirely from a chemically inert non-metallic material, such as PTFE, thereby eliminating the possibility of process fluid contamination that may occur from deteriorating or corroding materials.

[0061] Another feature of the pump is the design of the pressurizing member in the form of a rolling diaphragm, whereby the pressurizing member is permitted to move in a reciprocating manner within a respective chamber head by the rolling action of the thin-walled skirt. The use of such rolling diaphragm minimizes the possibility of pressurizing member failure due to overstressed and/or unsupported flexible portions.

[0062] Still other features of the pump are that the wetted area has only one leak path, which is across the tongue and groove seal between the pressurizing member and the chamber head. The design of the pump having a single leak path is possible due to the use of a static pressurizing member seal and because the pressurizing member is formed from a solid billet of PTFE, thereby avoiding the need to place a hole therethrough to facilitate attachment with the piston.

[0063] Although limited embodiments of the pump and pump system have been specifically described and illustrated herein, and specific dimensions have been disclosed, many modifications and variations will be apparent to those skilled in the art. Accordingly, it is to be understood that, within the scope of the appended claims, the pump and pump system according to principles of this invention may be embodied other than as specifically described herein.

Claims

1. A pump (10) for pressurizing process fluid comprising:

a housing (12) having an annular passage (24) that extends therethrough between opposed open ends (26 and 28);
a piston (22) disposed within the annular passage;
a piston gland (32) disposed within the annular passage at each open end for guiding slidable displacement of the piston therethrough;
a pressurizing chamber assembly disposed at each housing end and sealed off from remaining housing portions, each pressurizing chamber assembly comprising:

a chamber head (14) attached to a respective housing end, the chamber head being adapted to sequentially receive and discharge process fluid; and
a pressurizing member (18) disposed within the chamber head and connected to an end of the piston, the pressurizing member and inside surface of a respective chamber head forming a pressurizing chamber therebetween, the pressurizing member having a one-piece cylindrical construction formed from a fluoropolymeric material and including a solid nose portion (100) and a skirt (104) extending axially therefrom, the skirt having a flanged end (108) that is interposed between the chamber head and the housing end to form an air- and liquid-tight seal therebetween, the skirt having a thin-walled construction that is rolled upon itself to permit reciprocating movement of the pressurizing member within the chamber head;

means for actuating the piston to produce reciprocating slidable displacement of the piston within the passageway, wherein slidable displacement of the piston in one direction effects a simultaneous fluid intake in one pressurizing chamber and a fluid discharge from the other pressurizing chamber.

2. The pump as recited in claim 1 further comprising a pressurizing member plug (56) interposed between the pressurizing member and the end of the piston, the plug extending axially from the pressurizing member and having an outside surface in

contact with an inside surface of the skirt to support the pressurizing member skirt when the pressurizing member is slidably displaced within the pressurizing chamber assembly;

3. The pump as recited in claim 1 wherein the housing includes a leak port (40) that extends through a housing wall, wherein each piston gland includes at least one leak port (80) that extends therethrough at a position outside of the pressurizing chamber, and wherein respective piston gland and housing leak ports are in communication with each other to facilitate detecting process fluid leakage from the pressurizing chamber.

4. The pump as recited in claim 1 wherein the housing annular passage includes a reduced diameter section (34) disposed between the piston glands for limiting inward axial movement of each piston gland within the housing, the piston including at least one sealing flange (68) that extends circumferentially around the piston to form an air-tight seal between the piston and reduced diameter section, the reduced diameter section including air inlets (44) through a housing wall adjacent opposite ends of the reduced diameter section, whereby the means for actuating the piston comprises introducing pressurized air sequentially into each air inlet.

5. The pump as recited in claim 1 wherein each pressurizing chamber is in fluid flow communication with a fluid inlet port and a fluid outlet port, and wherein a check valve (135) is disposed within each fluid inlet and fluid outlet flow path.

6. The pump as recited in claim 5 comprising an isolation valve (144) connected to each chamber head that is actuated to isolate each chamber head from the process fluid.

7. The pump as recited in claim 1 wherein each pressurizing chamber comprises a single predetermined leak path from each pressurizing chamber to the annular passage of the pump housing.

8. The pump as recited in claim 1 wherein an inside surface of the pressurizing chamber and an outside surface of the pressurizing member are formed from a non-metallic chemically inert material.

9. The pump as recited in claim 1 further comprising means for detecting for detecting process fluid leakage within the pump the detecting means comprising:

at least one leak port (80) extending through a wall portion of each piston gland; and
at least one leak port extending through a wall portion of the housing (40), the leak port for the housing and each piston gland being positioned to communicate with each other to permit leaking fluid transfer outside of the housing.

10. The pump as recited in Claim 1 wherein: each pressurising chamber is in fluid flow communication with a fluid inlet port and a fluid outlet port; a check vale is disposed within each fluid inlet and fluid outlet flow path; each pressurising member (18) has a skirt flange; and wherein each chamber head (14) has a complimentary tapered inside surface.

Patentansprüche

1. Eine Pumpe (10) zur Druckbeaufschlagung von Prozessflüssigkeit, umfassend:

ein Gehäuse (12) mit einem Ringspalt (24), der sich durch dieses zwischen gegenüberliegenden offenen Enden (26 und 28) erstreckt;
einen im Ringspalt angeordneten Kolben (22);
eine im Ringspalt am jeweiligen offenen Ende angeordnete Kolbenstopfbuchse (32 für geführte, verschiebbare Verdrängung des Kolbens durch diese;
eine Druckbeaufschlagungskammerbaugruppe , die an jedem Gehäuseende angeordnet ist und von den restlichen Gehäuseteilen abgedichtet ist, jede Druckbeaufschlagungsbaugruppe umfassend: einen Kammerkopf (14), der an ein jeweiliges Gehäuseende angebracht ist, wobei der Kammerkopf adaptiert ist, Prozessflüssigkeit sequentiell zu empfangen und auszutragen, und
eine Druckbeaufschlagungskammer (18), die im Kammerkopf angeordnet und an ein Ende des Kolbens angeschlossen ist, wobei das Druckbeaufschlagungselement und die Innenfläche eines jeweiligen Kammerkopfes eine Druckbeaufschlagungskammer dazwischen formen, das Druckbeaufschlagungselement eine einteilige zylindrische Konstruktion aufweist, die aus einem fluoropolymerischen Material geformt ist und ein massives Nasenteil (100) und eine Schürze (104) einschließt, die sich axial daraus erstreckt, die Schürze ein Flanschende (108) hat, das zwischen dem Kammerkopf und dem Gehäuseende angeordnet ist, um eine luft- und flüssigkeitsdichte Dichtung dazwischen zu formen, die Schürze eine dünnwandige Konstruktion aufweist, die auf sich selbst aufgrollt wird, um hin- und hergehende Bewegung des Druckbeaufschlagungselements im Kammerkopf zu erlauben;
Mittel zur Betätigung des Kolbens, um hin- und

hergehende, verschiebbare Verdrängung des Kolbens im Durchgang zu produzieren, worin gleitende Verdrängung des Kolbens in einer Richtung eine simultane Flüssigkeitsansaugung in eine Druckbeaufschlagungskammer und eine Flüssigkeitsaustragung aus der anderen Druckbeaufschlagungskammer bewirkt.

2. Die Pumpe wie in Anspruch 1 rezitiert, die weiter einen Druckbeaufschlagungselementstopfen (56) umfasst, der zwischen dem Druckbeaufschlagungselement und dem Ende des Kolbens eingeschaltet ist, wobei sich der Stopfen axial aus dem Druckbeaufschlagungselement erstreckt und eine Außenflache in Kontakt mit einer Innenfläche der Schürze hat, um die Druckbeaufschlagungselementschürze zu stützen, wenn das Druckbeaufschlagungselement in der Druckbeaufschlagungskammerbaugruppe verschiebbar verdrängt wird.

3. Die Pumpe wie in Anspruch 1 rezitiert, worin das Gehäuse einen Leckanschluss (40) einschließt, der sich durch eine Gehäusewand erstreckt, worin jede Kolbenstopfbuchse wenigstens einen Leckanschluss (80) einschließt, der sich durch diese an einer Stelle außerhalb der Druckbeaufschlagungskammer erstreckt, und worin jeweilige Kolbenstopfbuchsen- und Gehäuseleckanschlüsse in Kommunikation miteinander sind, um das Feststellen von Prozessflüssigkeitsleckage ab der Druckbeaufschlagungskammer zu erleichtern.

4. Die Pumpe wie in Anspruch 1 rezitiert, worin der Gehäuseringspalt einen Abschnitt mit reduziertem Durchmesser (34) einschließt, der zwischen den Kolbenstopfbuchsen angeordnet ist, um axiale nach innen gerichtete Bewegung jeder Kolbenstopfbuchse im Gehäuse zu beschränken, der Kolben wenigstens einen Dichtflansch (68) einschließt, der sich umfangsbezogen um den Kolben erstreckt, um eine luftdichte Dichtung zwischen dem Kolben und dem Abschnitt mit reduziertem Durchmessers zu formen, wobei der Abschnitt mit reduziertem Durchmesser Lufteinlässe (44) durch eine Gehäusewand angrenzend an gegenüberliegende Enden des Abschnitts mit reduziertem Durchmesser einschließt, wodurch das Mittel zum Betätigen des Kolbens die Einführung druckbeaufschlagter Luft sequentiell in jeden Lufteinlass umfasst.

5. Die Pumpe wie in Anspruch 1 rezitiert, worin jede Druckbeaufschlagungskammer in Flüssigkeitsströmungskommunikation mit einem Flüssigkeitseinlassanschluss und einem Flüssigkeitsauslassanschluss steht, und worin ein Rückschlagventil (135) in jedem Flüssigkeitseinlass- und Flüssigkeitsauslassfließweg angeordnet ist.

6. Die Pumpe wie in Anspruch 5 rezitiert, die ein an jeder Kammerkopf angeschlossenes Absperrventil (144) umfasst, das betätigt wird, um jeden Kammerkopf von der Prozessflüssigkeit zu isolieren.

7. Die Pumpe wie in Anspruch 1 rezitiert, worin jede Druckbeaufschlagungskammer einen einzelnen, vorbestimmten Leckweg ab jeder Druckbeaufschlagungskammer zum Ringspalt des Pumpengehäuses umfasst.

8. Die Pumpe wie in Anspruch 1 rezitiert, worin eine Innenfläche der Druckbeaufschlagungskammer und eine Außenfläche des Druckbeaufschlagungselements aus einem nichtmetallischen, chemisch inerten Material geformt sind.

9. Die Pumpe wie ein Anspruch 1 rezitiert, die weiter Mittel zur Feststellung von Prozessflüssigkeitslekkage in der Pumpe umfasst, wobei die Mittel umfassen:

wenigstens einen Leckanschluss (80), der sich durch einen Wandteil jeder Kolbenstopfbuchse erstreckt, und
wenigstens einen Leckanschluss, der sich durch einen Wandteil des Gehäuses (40) erstreckt, wobei der Leckanschluss für das Gehäuse und jede Kolbenstopfbuchse positioniert sind miteinander zu kommunizieren, um Transfer leckender Flüssigkeit außerhalb des Gehäuses zuzulassen.

10. Die Pumpe wie in Anspruch 1 rezitiert, worin jede Druckbeaufschlagungskammer in Flüssigkeitskommunikation mit einem Flüssigkeitseinlassanschluss und einem Flüssigkeitsauslassanschluss steht; ein Rückschlagventil in jedem Flüssigkeitseinlass- und Flüssigkeitsauslassfließweg angeordnet ist; jedes Druckbeaufschlagungselement (18) einen Schürzenflansch aufweist; und worin jeder Kammerkopf (14) eine komplementäre konische Innenfläche hat.

Revendications

1. Une pompe (10) pour pressuriser un fluide de traitement comprenant:

un boîtier (12) ayant un passage annulaire (24) qui fait tout le long du boîtier et qui présente deux extrémités opposées ouvertes (26 et 28):

un piston (22) disposé dans le passage annulaire;
une bague de piston (32) disposée à l'intérieurdu passage annulaire à chacune des

extrémités ouvertes pour guider le glissement du piston passant dedans;
un ensemble de chambre de pressurisation disposé à chaque extrémité du boîtier et scellé par rapport aux autres portions du boîtier, chaque chambre de pressurisation comprenant:

une tête (14) de chambre attachée à une extrémité correspondante du boîtier, la tête de chambre étant adaptée pour recevoir et décharger séquentiellement le fluide de traitement; et
un membre de pressurisation (18) disposé à l'intérieur de la tête de pressurisation et connecté à une extrémité du piston, le membre de pressurisation et la surface intérieure de chaque tête de chambre formant une chambre de pressurisation, le membre de pressurisation ayant une construction cylindrique en une pièce formée à partir d'une matière fluoropolymérique et comprenant une portion solide formant un bec (100) et une jupe (104) partant du bec et s'étendant axialement, la jupe comportant une extrémité (108) à collerette qui s'interpose entre la tête de chambre et l'extrémité du boîtier pour former entre les deux un joint étanche à l'air et au liquide, la jupe étant construite avec une paroi mince qui s'enroule sur elle-même pour permettre un mouvement alternatif du membre pressurisant à l'intérieur de la tête de chambre;
un moyen pour mettre en marche le piston pour produire un glissement alternatif à l'intérieur de la voie de passage, dans lequel le glissement du piston en une direction produit simultanément une entrée de fluide dans une chambre de pressurisation, et une décharge de fluide de l'autre chambre de pressurisation.

2. Une pompe selon la revendication 1, comprenant de surcroît un obturateur (56) de membre de pressurisation interposé entre le membre de pressurisation et l'extrémité du piston, l'obturateur s'étendant axialement en partant du membre de pressurisation et ayant une surface extérieure en contact avec une surface intérieure de la jupe pour supporter la jupe du membre de pressurisation quand le membre de pressurisation glisse dans la chambre de pressurisation.

3. Une pompe selon la revendication 1, dans laquelle le boîtier comprend un orifice de fuite (40) qui passe à travers la paroi du boîtier, et chaque bague de piston comprend au moins un orifice de fuite (80) qui passe dedans à une position à l'extérieur de la chambre de pression et les orifices de fuite respectifs de la bague de piston et du boîtier communiquent entre eux pour faciliter la détection des fuites de fluide de traitement dans la chambre de pressurisation.

4. Une pompe selon la revendication 1, dans laquelle le passage annulaire dans le boîtier comprend une section de diamètre réduit (34), disposée entre les bagues de piston pour limiter le mouvement axial intérieur de chaque bague de piston à l'intérieur de boîtier, le piston comprenant au moins une collerette d'étanchéité (68) qui s'étend en circonférence autour du piston pour former un joint étanche entre le piston et la section de diamètre réduit, la section à diamètre réduit comprenant des entrées d'air (44) passant par une paroi du boîtier adjacente aux extrémités opposées de la section à diamètre réduit, et le moyen pour mettre en marche le piston permet également d'introduire de l'air pressurisé séquentiellement dans chaque orifice d'entrée d'air.

5. Une pompe selon la revendication 1, dans laquelle chaque chambre de pressurisation est en communication fluide avec un orifice d'entrée de fluide et un orifice de sortie de fluide, et dans laquelle une soupape d'arrêt (135) est disposée sur le chemin de chaque entrée de fluide et sortie de fluide.

6. Une pompe selon la revendication 5, comprenant une soupape d'isolement (144) connectée avec chaque tête de chambre, qui sera mise en marche pour isoler chaque tête de chambre du fluide de traitement.

7. Une pompe selon la revendication 1, dans laquelle chaque chambre de pressurisation comprend un seul chemin de fuite prédéterminé allant de la chambre de pressurisation au passage annulaire du boîtier de la pompe.

8. Une pompe selon la revendication 1, dans laquelle une surface intérieure de la chambre de pressurisation, ainsi qu'une surface extérieure du membre pressurisant, est formé d'une matière non-métallique et chimiquement inerte.

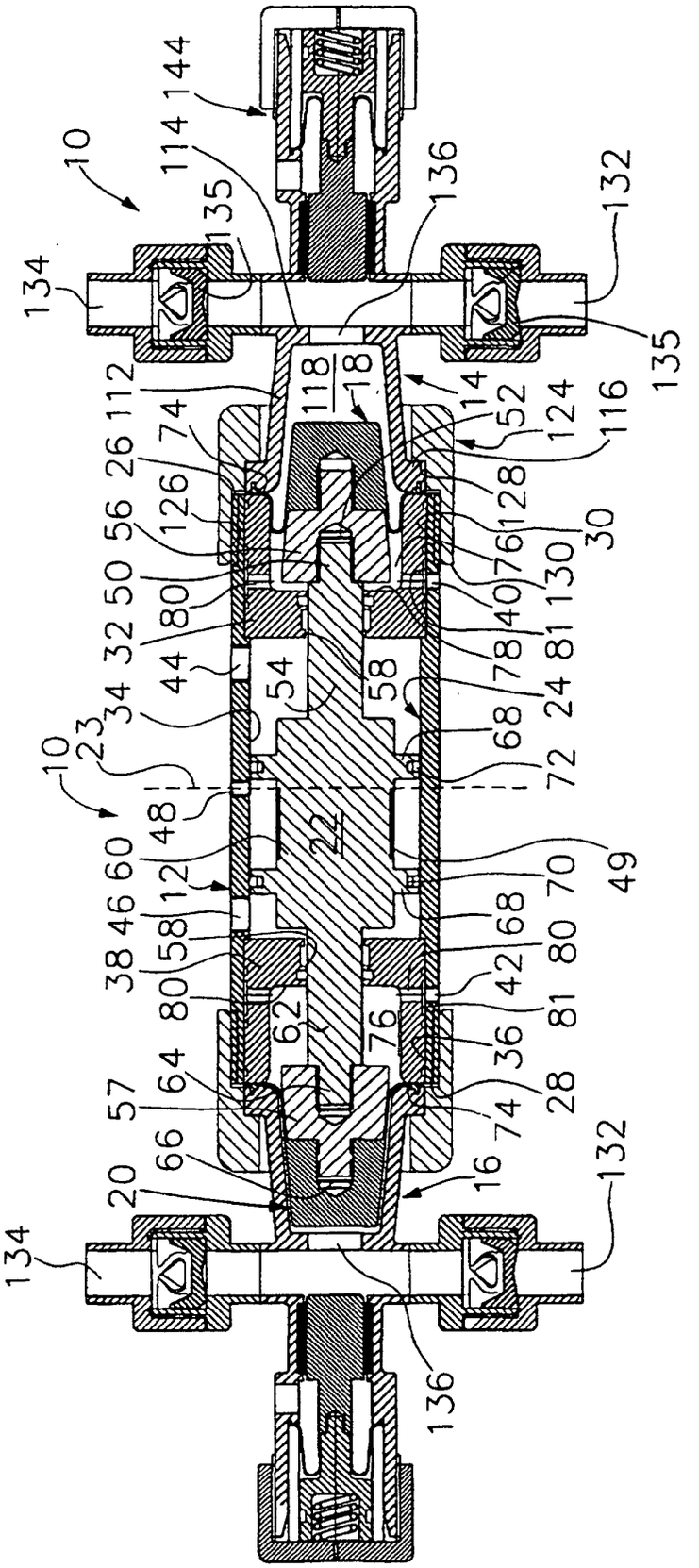
9. Une pompe selon la revendication 1, comprenant de surcroît un moyen de détection de fuite de fluide de traitement à l'intérieur de la pompe, ce moyen de détection comprenant:

au moins un orifice de fuite (80) passant par une portion de paroi de chaque bague de pis-

ton; et
au moins un orifice de fuite passant par une portion de la paroi du boîtier (40), l'orifice de fuite pour le boîtier, ainsi que chaque bague de piston étant placés de façon à communiquer l'un avec l'autre pour permettre aux fuites de fluide de passer en dehors du boîtier.

10. Une pompe selon la revendication 1, dans laquelle chaque chambre de pressurisation sera en communication fluide avec un orifice d'entrée de fluide et un orifice de sortie de fluide; une soupape d'arrêt étant disposée à l'intérieur de chaque chemin d'entrée de fluide et de sortie de fluide; chaque membre de pressurisation (18) a une collerette de jupe; et chaque tête de chambre (14) est complétée par une surface intérieure fuselée.

FIG. 1


138
10
144
114
135
136
132
134
112
118
18
14
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124
116
74
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126
56
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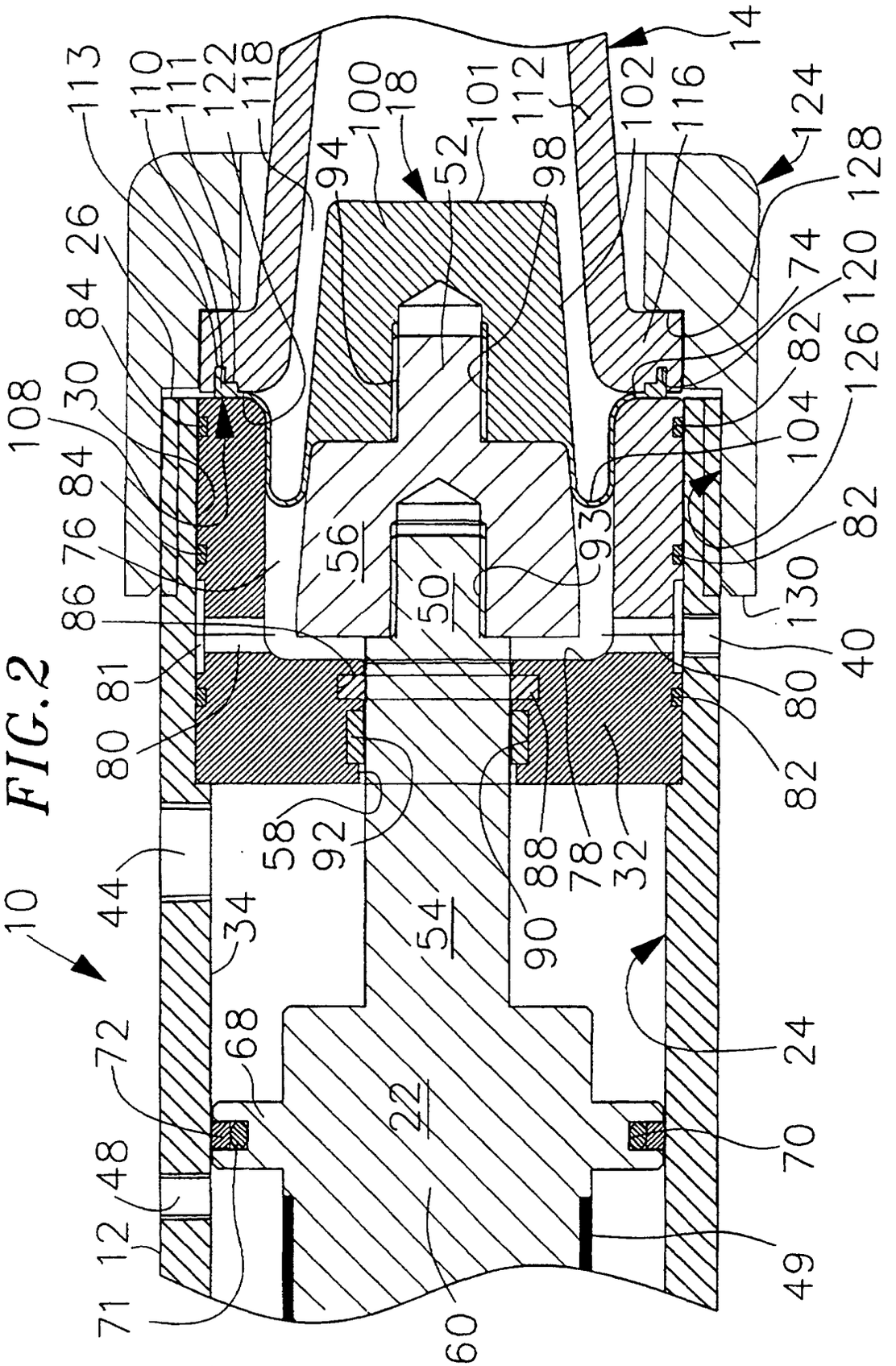

10
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FIG.2

FIG.3

