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[54] **DIAPHRAGM PUMPS FOR DELIVERING LIQUID OR GASEOUS MEDIA**

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[51] **Int. Cl.**... **F04b 9/08**

[58] **Field of Search**........... 417/389, 394, 395, 383, 417/390; 92/93, 97, 98, 29, 91, 92, 103

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[57] **ABSTRACT**

A diaphragm pump having a substantially spherical or at least partially spherical diaphragm element. The element is enclosed between an inner and an outer casing to define two cavities as pump spaces for a primary and a secondary fluid medium. It may comprise two substantially concentric individual diaphragm elements with a cavity therebetween filled with a fluid medium adapted to serve as a warning signal.

2 Claims, 4 Drawing Figures

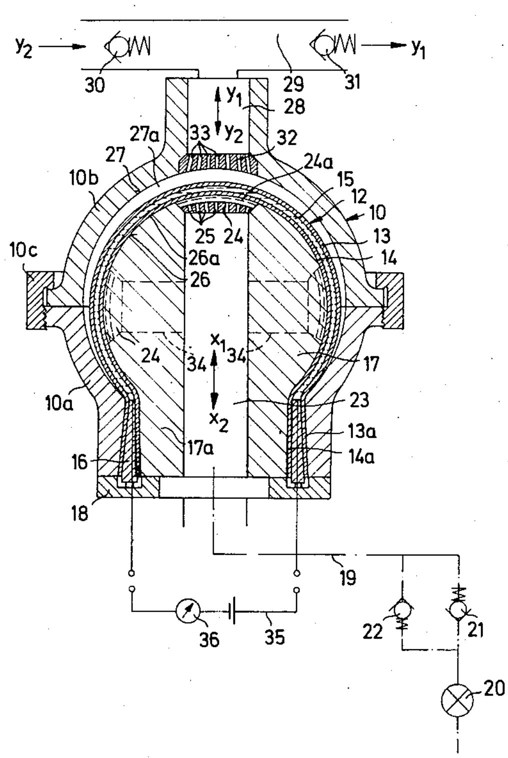


Fig. 1

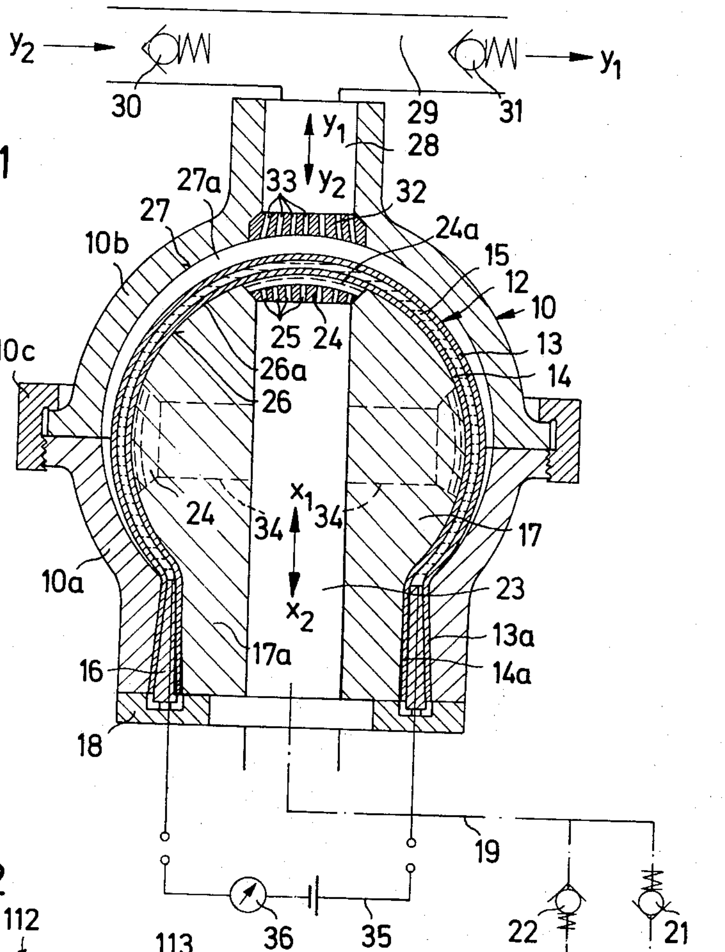
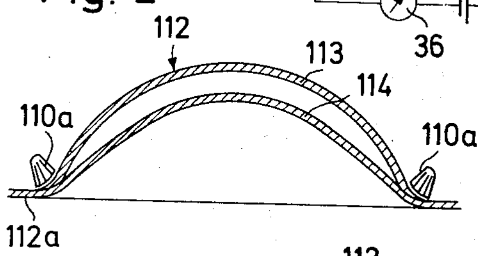


Fig. 2



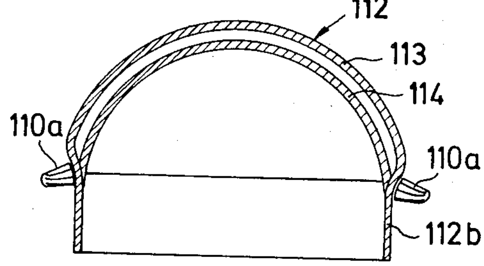
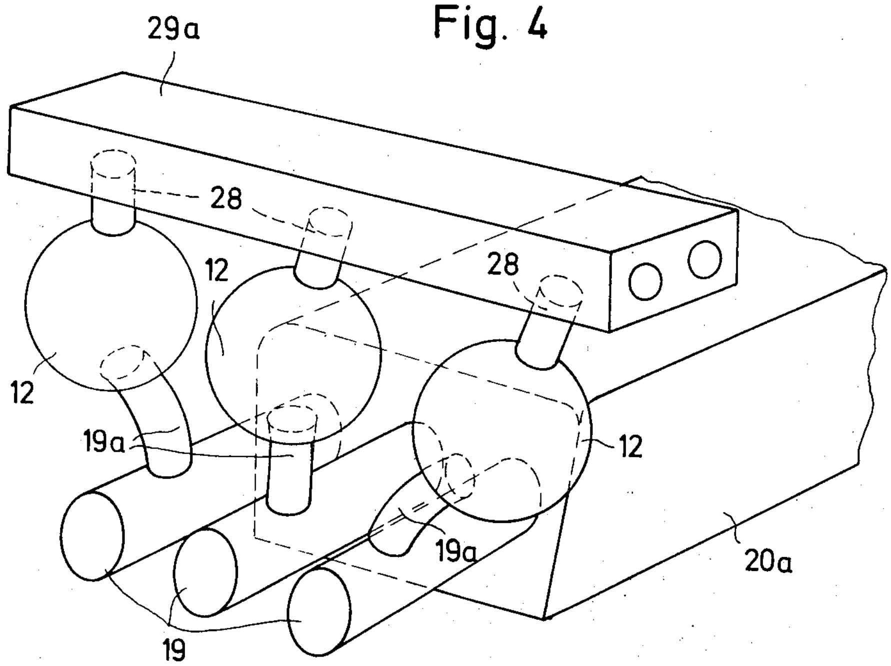


Fig. 3

Fig. 4



DIAPHRAGM PUMPS FOR DELIVERING LIQUID OR GASEOUS MEDIA

Invention concerning a diaphragm pump for delivering liquid or gaseous media, particularly with a connected pump as an auxiliary medium (installed ahead of the diaphragm pump).

Diaphragm pumps have the advantage that the reciprocating diaphragm providing the delivery action can have a perfect seal at the pump housing, as delivery merely depends on the change in shape of the diaphragm. These sort of pumps are mainly designed for delivering such media where any possibility of loss through leakage must be virtually excluded, whether for chemical or health reasons or because it concerns the delivery of expensive media as for example heavy water for reactors.

Standard diaphragm pumps fitted with a flat diaphragm have however the disadvantage that they require a large area for a specific delivery volume and are therefore of very wide design. Moreover, since in many cases they are assembled together with a connected pump for the auxiliary medium which actuates the membrane, extreme difficulties arise with regard to space requirement and assembly, if it deals with multi-cylinder pumps, and a membrane pump has to be allocated to each cylinder or to each of several cylinder groups.

A point of the invention is that these disadvantages attributed to normal membrane pumps are avoided and result in relatively smaller dimensions, and even more so if several membrane pumps have to be set up in a row next to each other.

A further point of the invention is that with a minimum surface area a maximum pumping volume is attained with a membrane pump of this design.

In addition with a specific capacity, a minimum very uniform material stress with low potential drop and long service life of the pump is striven for. Bending or pressure stresses of the diaphragm should whereever possible be completely avoided.

A further point of the invention is that fact that these advantages can be achieved in conjunction with a leak-free delivery, requiring no dynamic seals, of a chemically agressive e.g. corrosive delivery medium in which only the walls contacting this medium need be of high quality material, while those walls e.g. of the inner pump chamber of the spherical diaphragm pump, which contact the auxiliary medium need only be of a relatively inexpensive low quality material. Preferably plain water or a suitable oil should be used as an auxiliary fluid.

A further point is the reliable protection of the diaphragm from any undesired deformation under the pressure of the fluid media impinging against it.

Another advantage is the stable clamping and support of the diaphragm.

Another important contribution of the invention lies mainly in the fact that the pump is designed as a spherical diaphragm pump or spherical-like diaphragm pump, with regard to which pumps are also included which are partly spherical, or also such types of spheres whose sector angle is equal, smaller or larger than 180°.

Such a spherically shaped or similar unit e.g. a diaphragm pump also designed in the form of an ellipsoid or parabaloid, has an inner (radial) and an outer (radial) pump chamber. The inner pump chamber is normally contacted by the auxiliary medium while the outer pump chamber serves to deliver the main medium. However in certain circumstances a reversed action of the diaphragm can be provided.

In this case, because of the suction pressure arising, a very reliable bracing of the diaphragm must be undertaken so that the danger of cavitation arising with the vacuum is eliminated.

Preferably, according to a further feature of the invention, the outer and inner pump chamber should be designed as a sickle-shaped gap at their greatest volume in cross section. On the inside, the diaphragm, according to a further feature of the invention is supported by a supporting unit provided with various ducts for allowing entry of the inner medium to the diaphragm, so that the diaphragm, when the pump is not working or is under a vacuum created on the inner side, contacts the spherical-shaped or similar designed support, corresponding to the diaphragm over its whole area as far as possible.

Further characteristics of the invention concern the bridging of the duct mouths by lattice or sieve type walls and the arranging of the restrictor or baffle elements in front of the pump chambers, which prevent the in or outflowing medium deflecting the diaphragm locally and causing buckling. Accordingly provision is made as well for the outer pump body and the passage of the outer medium to the outer pump chamber, even if here, owing to purely tensile stress, the danger of the diaphragm bending or buckling outwards is less.

The spherical diaphragm pump can be used with a single or double diaphragm. Rubber, or preferably another flexible non-metallic material can be used. With a double diaphragm the individual diaphragms are for preference fitted inside one another forming a dish shape, in which the spherical shaped intermediate gap between the two diaphragms is filled with an intermediate medium e.g. a fluid such as oil or similar. The intermediate medium can, using a known method, be connected to an electric circuit so that if a diaphragm should become ruptured, this rupture is indicated by an alteration in the strength of the current.

Spherical diaphragm pumps can be directly assembled with the pump connected in front of them into one unit. However they can also be completely separate from it so that for example the latter can be accommodated in an insulated room somewhere inside a structure for a reactor etc., which is shielded against radiation to the outside.

The construction of the invention is represented schematically in the drawing as follows:

FIG. 1 an axial cross section drawing of a spherical diaphragm pump,

FIG. 2 and 3 further types of a spherical diaphragm pump of part spherical or similar design, and

FIG. 4 a perspective drawing for the layout of a group of spherical diaphragm pumps possibly for connection to a multi-cylinder pump situated in front for the auxiliary medium.

In FIG. 1 the double diaphragm or diaphragm means (12) is inserted in the spherical housing (10) of the spherical diaphragm pump comprising the two sections (10*a*) and (10*b*) connected together by means of screw connection (10*c*), the double diaphragm consisting of the outer diaphragm (13) and the inner diaphragm (14) with the cavity (15) between them. Both the individual diaphragms (**13**) and (**14**) each have a slight cylindrical or conical shoulder or tubular portion (**13***a*) and (**14***a*), which are clamped in the outer casing section (**10***a*) by a clamping ring (**16**) and an inner spherical shaped support (**17**). A connector ring (**18**) holds the clamp ring (**16**) in position and is firmly connected e.g. by flanging, to the casing (**10**) and/or the support (**17**) and to a feed line (**19**) shown by a dash-dot line for a working or primary medium. The working medium or primary medium, e.g. a fluid, is delivered by pump (**20**), which feeds the medium as a reciprocating medium column possibly via a pressure valve (**21**) and a suction valve (**22**), e.g. to a duct (**23**) in the shape of a bore, in support (**17**). The bore penetrates support (**17**) diagonally in the symmetrical axis of the support from connector piece (**17***a*). Support (**17**) is so designed and its spherical diameter so dimensioned, that inner diaphragm (**14**) in the unloaded state or more or less preloaded state or under suction in duct (**23**), contacts the face of support (**17**). Duct (**23**) is screened at its end opposite to the intake end from diaphragm (**12**) and/or the inner individual diaphragm **14** by a perforated plate (**24**) with bores (**25**), behind which another sieve type grid (**24***a*) is positioned in such a way that the inner diaphragm (**14**) is not drawn in to the duct when vacuum exists in duct (**23**) and is subjected to bulging, but its spherical shape is retained corresponding to the outer surface (**26**) of the inner support (**17**).

Section (**10***b*) of the casing is also so designed that its inner spherical surface (**27**) has a somewhat offset spherical centre point in relation to spherical surface (**26**), so that a sickle shaped pump chamber (**27***a*) is formed between diaphragm (**14**), contacting the inner support (**17**), and the inner spherical surface (**27**), which with expansion or contraction of the membrane reduces or increases in size alternately with pump chamber (**26***a*) (reduced to nil in FIG. **1**).

Pump chamber (**27***a*) is connected via a feed duct (**28**) to a line (**29**), which serves to channel and deliver the actual delivery medium, e.g. heavy water, and has for example a suction valve (**30**) and a pressure valve (**31**). As on the working or primary side, pump chamber (**27***a*) is screened from the feed duct (**28**) by plate (**32**), which is fitted with bores or other apertures and serves to support outer diaphragm (**13**) at maximum expansion, to avoid bulging of the diaphragm into feed duct (**28**). As however, owing to the strong tensile stress of the diaphragm, the danger of such bulging is relatively small, plate (**32**) can if necessary be discarded.

Plates (**24**) and (particularly) (**32**), which for example are made of metal or a sintered material, can also be replaced by plates, ball valves or similar devices.

In addition to longitudinal duct (**23**), transverse duct (**34**) can be fitted which permits an additional passage of the primary medium to the inner side of spherical diaphragm (**12**). The baffle or screening plates (**24**) and sieve grid (**24***a*) can also be installed in this case.

The transition between the spherically shaped section of individual diaphragms (**13**) and (**14**) to the supporting shoulder sections (**13***a*) or (**14***a*) is achieved by as smooth a curvature as possible so that any bending stresses at these points have as little effect as possible. In any case spherical diaphragm (**13**) which consists of individual diaphragms (**13**) and (**14**) is practically only subjected to tensile stress.

Gap **15** between the two individual diaphragms (**14**) and (**15**) is filled with a fluid, e.g. oil, which is connected in to the electrical circuit (**35**) which has a galvanometer, which serves as a warning device and can actuate a warning signal if the current passing through the circuit alters owing to a rupture of the inner or outer diaphragm.

If pump (**20**) transmits a pressure impulse in the direction of arrow x_1, so that the working or primary fluid is forced through duct (**23**) or the bores (**34**) against diaphragm (**14**), spherical diaphragm (**12**) expands bodily whereby it lifts away from the spherical surface (**26**) of support (**17**) and in its other end position contacts the inner spherical surface (**27**) of the casing (**10**). The cross section sickle shaped pump space (**27***a*) is then reduced in size and the displaced delivery fluid is fed via feed duct (**28**) and pressure valve (**31**) in the direction of arrow y_1.

If the medium previously forced into the then sickle shaped working chamber (**26***a*) of the spherical diaphragm pump is now sucked back in the direction of arrow x_2, spherical diaphragm (**12**) contracts again, so that the delivery fluid is again fed in the direction of arrow y_2 into pump chamber (**27***a*). Plates (**24**) and (**32**) which are fitted with apertures ensure in this case that diaphragm (**12**) is not subjected at the feed points to too strong a pressure impulse which could cause indentations or bulges, and that the primary or secondary medium in question is distributed as evenly as possible to pump chambers (**26***a*) and/or (**27***a*).

The designs shown in FIGS. **2** and **3** show types of spherical diaphragms in part spherical form with a smaller sector angle. So for example individual diaphragms (**113**) and (**114**) form part-spherical units with a sector angle of around less than 180°. (**110***a*) shows the clamping of diaphragm (**112**) to the casing in schematic form. The clamping flanges (**112***a*) in this case run in a transverse plane as per FIG. **2**, while in the example in FIG. **3**, the clamping section (**112***b*) of the diaphragm is arranged axially and tubular. Clamping section (**112***b*) which forms a shoulder, can in this case pass tangentially or nearly tangentially into spherical diaphragm (**114**).

Versions with a sector angle of up to 180° offer the possibility if required of joining together two identical individual diaphragms.

It is also possible to interchange the primary and secondary side of the diaphragm pump whereby the working or primary medium is admitted to outer pump chamber (**27***a*) and the delivery medium to inner pump chamber (**26***a*).

FIG. **4** shows schematically the use of spherical diaphragm pumps at a multi-cylinder work pump, which for example is indicated by (**20***a*). The medium pulsating from the pump is led through the feed lines (**19**) and the branch lines (**19***a*) to the individual spherical diaphragm pumps (**12**), which on their side are connected via individual feed lines (**28**) to the line aggregate (**29***a*) for the delivery medium. The invention is not limited to the examples shown.

What I claim is:

1. A diaphragm pump comprising diaphragm means comprising an outer diaphragm and an inner diaphragm spaced from said outer diaphragm, each of said diaphragms having a spherical portion and a cylindrical portion joined to the respective spherical portion by a curved connecting portion, and a fluid filling the space between said two diaphragms; support means within said diaphragm means and having a spherical portion of a shape corresponding to the spherical portion of said inner diaphragm in substantially unstressed condition of the latter for supporting the same in said substantially unstressed condition; first passage means extending through said support means for feeding fluid against that surface of said diaphragm means which faces said support means to expand said diaphragm means, and for discharging fluid from the thus formed space between said diaphragm means and said support means; an outer housing surrounding said diaphragm means, said outer housing having an inner spherical surface having a center of curvature offset with respect to the center of curvature of said spherical portion of said support means so as to form between said inner surface and said diaphragm means, when the latter abuts said support means, a space of sickle-shaped cross-section in which said diaphragm may expand and contract; clamping means comprising a clamping ring of wedge-shaped cross-section located between the tubular portions of said diaphragms for clamping said tubular portions respectively against said outer housing and said support means; and second passage means communicating with said last-mentioned space for feeding fluid into and out of the same.

2. A diaphragm pump as defined in claim **1**, wherein said diaphragm means comprises an outer diaphragm and an inner diaphragm spaced from said outer diaphragm, each diaphragm having a spherical portion and a cylindrical tubular portion integrally joined to the respective spherical portion by a curved connecting portion, and fluid filling the space between the two diaphragms.

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