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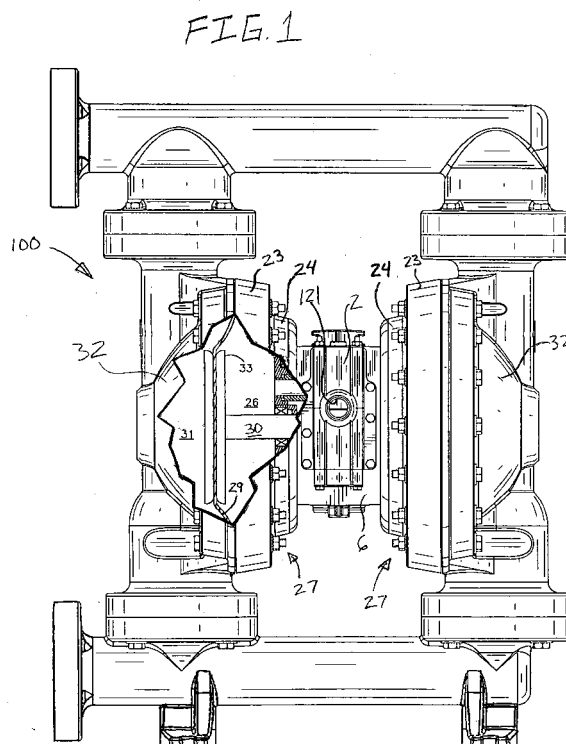
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(54) **Non-metallic diaphragm pump housing**

(57) A non-metallic pressure cap equivalent for a metallic pressure cap of a diaphragm pump, is provided the non-metallic pressure cap having a plate portion, a flange portion, and a wall portion located between and connecting the plate and the flange portions. The thickness of the flange portion of the non-metallic pressure cap is greater than the thickness of a flange portion of the metallic pressure cap. Also provided is a non-metallic pressure cap for a diaphragm pump, the non-metallic pressure cap having a plate portion, a flange portion, and a wall portion located between and connecting the plate and the flange portions. The wall portion has a thickness, t_w , and defines a radius, r , on an outer surface transition between the wall and flange portions, the ratio between the radius and the thickness of the wall portion being defined according to the following equation $r > 1/3 (t_w)$. A diaphragm pump having a non-metallic pressure cap equivalent is also provided having a plate portion, a flange portion, and a wall portion located between and connecting the plate and the flange portions. The thickness of the flange portion of the non-metallic pressure cap is greater than the thickness of a flange portion of the metallic pressure cap. The wall portion includes a radius, r , defined on an outer surface transition between the wall and flange portions, the ratio between the radius and the thickness of the wall portion being defined according to the following equation: $r > 1/3 (t_w)$.



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Description

[0001] This invention relates to an improved fluid operated, double diaphragm pump, and, more particularly, to the housing construction for such a pump.

[0002] Air operated double diaphragm pumps are known for pumping a wide variety of substances. Typically such a pump comprises a pair of pumping chambers with a pressure chamber arranged in parallel with each pumping chamber in a housing. Each pressure chamber is separated from its associated pumping chamber by a flexible diaphragm. As one pressure chamber is pressurised, it forces the diaphragm to compress fluid in the associated pumping chamber. The fluid is thus forced from the pumping chamber. Simultaneously, the diaphragm associated with the second pumping chamber is flexed so as to draw fluid material into the second pumping chamber. The diaphragms are reciprocated in unison in order to alternately fill and evacuate the pumping chambers. In practice, the chambers are all aligned so that the diaphragms can reciprocate axially in unison. In this manner the diaphragms may also be mechanically interconnected to ensure uniform operation and performance by the double acting diaphragm pump.

[0003] In some applications, double diaphragm pumps are utilised to pump caustic chemicals such as acids, in other applications, comestible substances such as flowable foods and beverages can be pumped. In such applications, the component pump parts that are to contact the material to be pumped are often constructed using materials that resist corrosion and are chemically compatible with the material being pumped. In this regard, polymeric materials are often used for various pump components such as the fluid caps of the pumping chambers and the diaphragms and/or their liners. However, polymer materials have not been readily incorporated into the pressure caps of such diaphragm pumps due to the high stresses generated in the pressure chambers of these pumps.

[0004] According to one aspect of the present invention, there is provided a non-metallic pressure cap equivalent for a metallic pressure cap of a diaphragm pump, the non-metallic pressure cap comprising a plate portion, a flange portion, and a wall portion located between and connecting said plate and said flange portions; said flange portion having a thickness, t_f , wherein said thickness of said flange portion of said non-metallic pressure cap is greater than the thickness of a flange portion of said metallic pressure cap.

[0005] According to a second aspect of the present invention, there is provided a non-metallic pressure cap for a diaphragm pump, the non-metallic pressure cap comprising a plate portion, a flange portion, and a wall portion located between and connecting said plate and said flange portions; said wall portion having a thickness, t_w , and defining a radius, r , on an outer surface transition between said wall and flange portions, the ratio between the radius and the thickness of the wall portion being defined according to the following equation $r > 1/3 (t_w)$.

[0006] According to a third aspect of the present invention, there is provided a diaphragm pump having a non-metallic pressure cap equivalent for a metallic pressure cap, comprising a non-metallic pressure cap having a plate portion, a flange portion, and a wall portion located between and connecting said plate and said flange portions; said flange portion having a thickness, t_f , and said wall portion having a thickness, t_w , and defining a radius, r , on an outer surface transition between said wall and flange portions; wherein said thickness of said flange portion of said non-metallic pressure cap is greater than the thickness of a flange portion of said metallic pressure cap and the ratio between the radius and the thickness of the wall portion being defined according to the following equation $r > 1/3 (t_w)$.

[0007] For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Fig. 1 is an elevational view of a diaphragm pump housing and showing a housing chamber in partial section;
 Fig. 2 is a part-sectional schematic view illustrating a pressure cap; and
 Fig. 3 is a sectional schematic view illustrating the pressure cap shown in Fig. 2.

[0008] The present invention provides improvements to the diaphragm pumps and components shown and described in US-A-4,854,832 and US-A-5,584,666, the specifications of which are incorporated herein by reference.

[0009] As used herein, the term "modulus of elasticity," commonly referred to in the art as "Young's modulus," is defined as the ratio of an applied unit tensile stress to the unit strain that results when the stress is applied to a material within the elastic limit and without fracture of the material.

[0010] The drawings illustrate a typical double diaphragm pump incorporating a housing construction. Like numbers refer to like parts in each of the figures. Shown in Fig. 1 is a partial sectional view of a double diaphragm pump incorporating a main housing 100 that defines first and second opposed and axially spaced housing chambers. Each housing chamber includes a pressure chamber 26 defined by a pressure cap 27 and a fluid chamber 31 defined by a fluid cap 32 that are separated by a flexible diaphragm 29 as depicted by the partial sectional view of the left housing chamber in Fig. 1. The pressure cap 27 includes a flat, plate portion 25 having a flange portion 23 with a wall portion 24 located between and connecting the plate and flange portions as shown. The pressure chamber, fluid chamber, and diaphragm in the right housing chamber are similarly arranged and form a mirror image of those components in the left housing chamber. Located between the left and right housing chambers and attached to each of their plate portions is a centre

body housing 6. A valve block or body 2 having an air inlet 121 is attached to centre body housing 6 as shown.

[0011] Each of the diaphragms 29 is fashioned from an elastomeric material as is known to those skilled in the art. The diaphragms 29 are connected mechanically by means of a shaft 30 that extends axially through the midpoint of each of the diaphragms. The shaft 30 is attached to the diaphragm 29 by means of opposed plates 33 on opposite sides thereof. Thus, the diaphragms 29 will move axially in unison as the pump operates by the alternate supply and exhaust of air to the pressure chambers of the pump as discussed in greater detail in the abovementioned U.S. patents. In brief, upon reciprocating the diaphragms of the pump, fluid that passes into each fluid chamber from associated inlet check valves is alternately compressed within and forced outwardly through associated outlet check valves. Operation of the fluid check valves controls movement of fluid in and out of the pump chambers causing them to function as a single acting pump. By connecting the two chambers through external manifolds, output flow from the pump becomes relatively constant.

[0012] Although unfilled (i.e., unreinforced) polymers such as polypropylene have been used in fluid caps of diaphragm pumps, typically, such polymers are not well-suited for use in the pressure caps of these pumps. Without reinforcement, these low rigidity materials can be subject to creep failure at room temperature that can result in deformation, leakage, and eventually cracking in highly stressed areas of the pressure cap. Moreover, although these polymers may be reinforced with glass fibres, such glass-filled polymers are not well-suited for use in pressure caps due to their propensity for cracking and, thus, leaking. Furthermore, in certain applications, glass-filled polymers may also be prone to attack by caustic fumes that may be emitted from a material to be pumped.

[0013] The specific structure of the present invention relates to the construction of the pressure chamber 26 and, more specifically, to the geometry of the pressure cap 27 that defines the pressure chamber. Through the use of finite element analysis, a technique known in the art, and empirical testing it has been determined that a pressure cap may be provided with a geometry that reduces stress in highly loaded areas such that conventional metal pressure caps, including those made of aluminium, aluminium alloys, cast iron, or steel, may be replaced by pressure caps made of a non-metallic material such as a polymeric material. Examples of polymer materials in this regard are thermoplastic polymers such as polypropylene polymers and thermoset polymers such as vinyl ester polymers. Although these polymers may be glass-filled for reinforcement, the stress reduction in the present pressure caps may also be unfilled, i.e., unreinforced, thereby permitting their use in caustic environments. The flange portion of the non-metallic pressure cap is provided in a thickness that is greater than the thickness of a flange portion of a conventional metallic pressure cap which is to be replaced. More specifically, the features that describe the geometric aspects for minimising stress and deformation relate to the relationship between the moduli of elasticity of the pressure cap metallic material to be replaced with that of the non-metallic replacement material, according to Eqn. 1 below, the parameters for which are described below and shown in Fig. 3:

EQUIVALENT NON-METALLIC FLANGE THICKNESS

$$t_{f(\text{nonmetallic})} = \left(\frac{E_m}{E_{nm}} \right)^{1/3} \times t_{f(\text{metallic})} \quad [\text{Eqn. 1}]$$

where:

$t_{f(\text{metallic})}$ = metallic flange thickness

$t_{f(\text{nonmetallic})}$ = equivalent non-metallic flange thickness

E_m = modulus of elasticity of metal

E_{nm} = modulus of elasticity of non-metal

[0014] Although $t_{f(\text{nonmetallic})}$ is shown above as being approximately equal to $t_{f(\text{metallic})}$ by the cube root of the ratio of their moduli of elasticity according to Eqn. 1, it is to be understood that it is preferred that this relationship be equal. Other design details in the pressure cap, however, may require $t_{f(\text{nonmetallic})}$ to be slightly smaller or greater, hence the approximate expression of the relationship with $t_{f(\text{metallic})}$. Such design details include any thickness variations of the periphery of the flange or the use of an outer rim or other stiffening feature that may be employed in a particular design.

[0015] Additionally, the dimensional relationship between the flange portion 23 and wall portion 24 of pressure cap 27 according to Eqn. 2 below, also minimises stress and deformation of the pressure cap, the parameters for which are described below and shown in Fig. 3:

WALL THICKNESS TO RADIUS RATIO

$$r > 1/3 (t_w) \quad [\text{Eqn. 2}]$$

where:

r = radius of the outer surface transition between pressure cap flange and wall portion

t_w = wall thickness of the pressure chamber

[0016] Although the observance of one or the other of the criteria above in manufacturing a non-metallic pressure cap will improve the resistance to stress and deformation in a non-metallic pressure cap, it is preferred that the present non-metallic pressure cap meet both of the criteria expressed by Eqns. 1 and 2 above.

[0017] In the following claims, reference is made to a metallic pressure cap, with which the present non-metallic pressure cap is compared. For the purposes of introduction to this specification, an example of a metallic pressure cap is shown in the un-numbered component adjoining the housing 6 and abutting the diaphragm 19 in Fig. 1 of US-A-5,584,666.

Claims

1. A non-metallic pressure cap (27) equivalent for a metallic pressure cap of a diaphragm pump, the non-metallic pressure cap comprising:

a plate portion (25), a flange portion (23), and a wall portion (24) located between and connecting said plate and said flange portions,
said flange portion (23) having a thickness, t_f ,

wherein said thickness of said flange portion of said non-metallic pressure cap (27) is greater than the thickness of a flange portion of said metallic pressure cap.

2. A non-metallic pressure cap according to claim 1 wherein the relationship between the non-metallic flange thickness and the metallic flange thickness is defined according to the following equation:

$$t_{f(\text{nonmetallic})} = \left(\frac{E_m}{E_{nm}} \right)^{1/3} \times t_{f(\text{metallic})}$$

where:

$t_{f(\text{metallic})}$ = metallic flange thickness

$t_{f(\text{nonmetallic})}$ = equivalent non-metallic flange thickness

E_m = modulus of elasticity of metal

E_{nm} = modulus of elasticity of non-metal

3. A non-metallic pressure cap according to claim 1 or 2, wherein said wall portion (24) further comprises a thickness, t_w , and a radius, r , defined on an outer surface transition between said wall (24) and flange portions (23), the ratio between the radius and the thickness of the wall portion being defined according to the following equation:

$$r > 1/3 (t_w)$$

4. A non-metallic pressure cap (27) for a diaphragm pump, the non-metallic pressure cap comprising:

a plate portion (25), a flange portion (23), and a wall portion (24) located between and connecting said plate and said flange portions,
said wall portion (24) having a thickness, t_w , and defining a radius, r , on an outer surface transition between said wall and flange portions, the ratio between the radius and the thickness of the wall portion being defined according to the following equation:

$$r > 1/3 (t_w)$$

5. A non-metallic pressure cap according to any one of the preceding claims, wherein said non-metallic pressure cap

is made of a polymer material.

6. A non-metallic pressure cap according to claim 5, wherein said polymer is selected from the group consisting of vinyl ester and polypropylene.

7. A diaphragm pump having a non-metallic pressure cap equivalent for a metallic pressure cap, comprising:

a non-metallic pressure cap (27) having a plate portion (25), a flange portion (23), and a wall portion (24) located between and connecting said plate and said flange portions, said flange portion having a thickness, t_f , and said wall portion having a thickness, t_w , and defining a radius, r , on an outer surface transition between said wall and flange portions,

wherein said thickness of said flange portion (23) of said non-metallic pressure cap (27) is greater than the thickness of a flange portion of said metallic pressure cap and the ratio between the radius and the thickness of the wall portion being defined according to the following equation:

$$r > 1/3 (t_w)$$

8. A diaphragm pump according to claim 7, wherein the relationship between the non-metallic flange thickness and the metallic flange thickness is defined according to the following equation:

$$t_{f(\text{nonmetallic})} = \left(\frac{E_m}{E_{nm}} \right)^{1/3} \times t_{f(\text{metallic})}$$

where:

$t_{f(\text{metallic})}$ = metallic flange thickness
 $t_{f(\text{nonmetallic})}$ = equivalent non-metallic flange thickness
 E_m = modulus of elasticity of metal
 E_{nm} = modulus of elasticity of non-metal

9. A diaphragm pump according to claim 7 or 8, wherein said non-metallic pressure cap is made of a polymer material.

10. A diaphragm pump according to claim 9, wherein said polymer is selected from the group consisting of vinyl ester and polypropylene. (Figs. 1 and 2)

FIG. 1

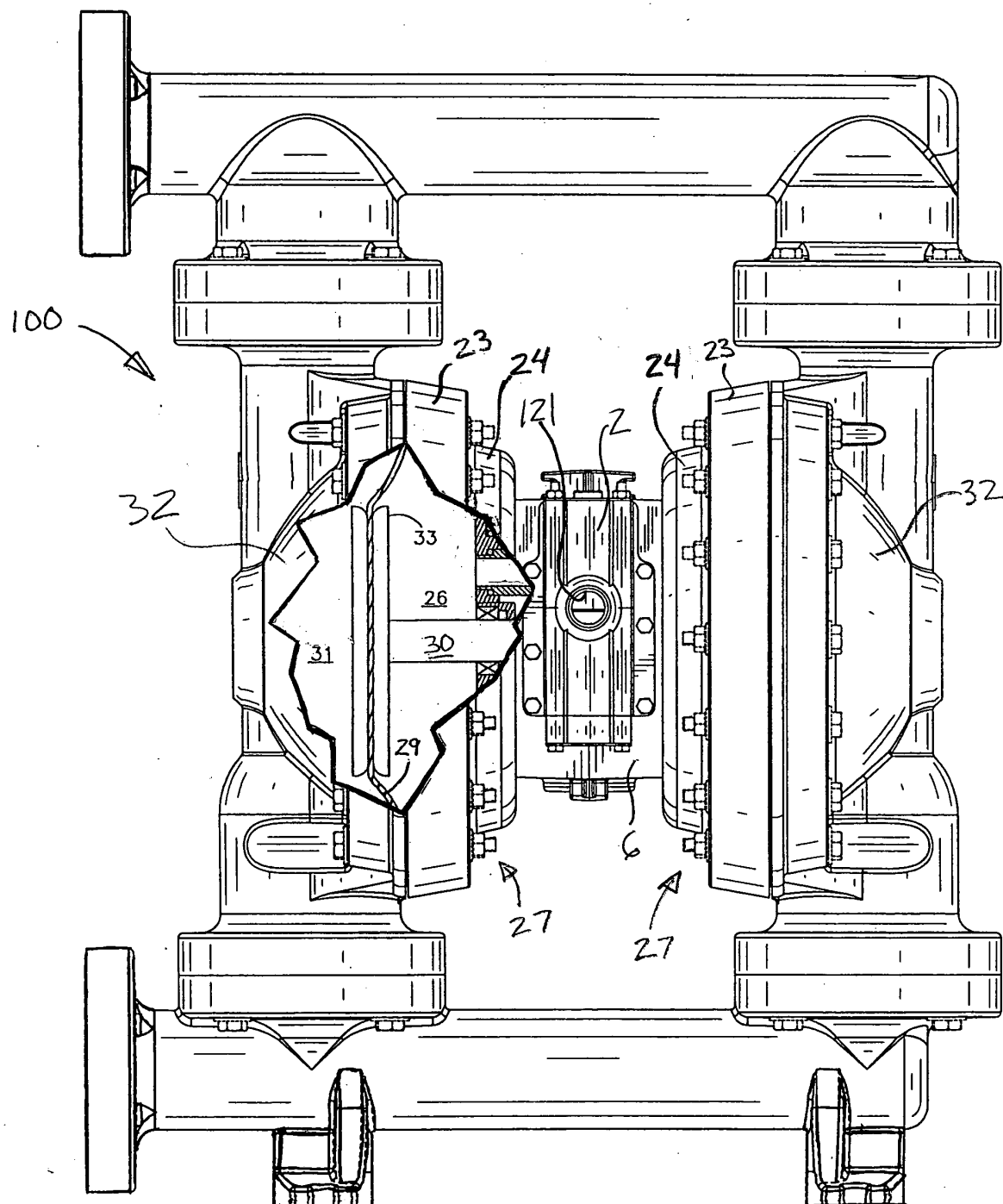


FIG. 2

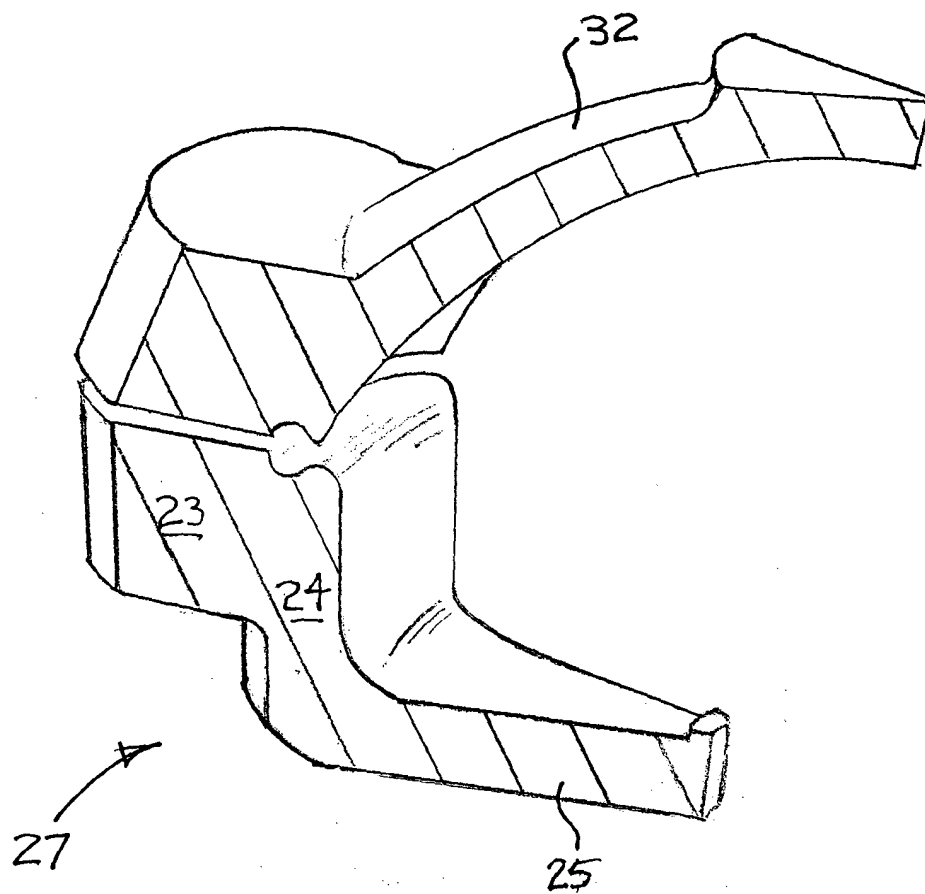


FIG. 3

