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

(11) EP 0 775 825 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.05.1997 Bulletin 1997/22

(51) Int Cl.[6]: **F04B 43/00**

(21) Application number: **96308482.7**

(22) Date of filing: **25.11.1996**

(84) Designated Contracting States:
DE FR GB IT SE

(30) Priority: **27.11.1995 US 563029**

(71) Applicant: **INGERSOLL-RAND COMPANY**
Woodcliff Lake, NJ 07675 (US)

(72) Inventor: **Able, Stephen D.**
Bryan, Ohio 43506 (US)

(74) Representative: **Feakins, Graham Allan et al**
RAWORTH, MOSS & COOK
RAWORTH HOUSE
36 Sydenham Road
Croydon, Surrey CRO 2EF (GB)

(54) Pump diaphragm

(57) A pump diaphragm has a central portion (16), a peripheral portion (12) and a working portion (20) joining the peripheral and central portions. An outer corner (24) is formed where the peripheral portion (12) joins the working portion (20). A first skirt member (26) extends across the peripheral portion, the outer corner and a portion of the working portion adjacent the peripheral portion. The diaphragm may also include an inner corner (22) formed where the working portion joins the central portion and a second skirt member (28) which substantially extends across the central portion, the inner corner and a portion of the working portion adjacent the central portion.

The thickness of the peripheral portion (12) of the diaphragm may also be increased to about twice the thickness of the central and working portions. Additionally, a notch (42) may be provided in the peripheral portion of the diaphragm where the working portion joins the peripheral portion.

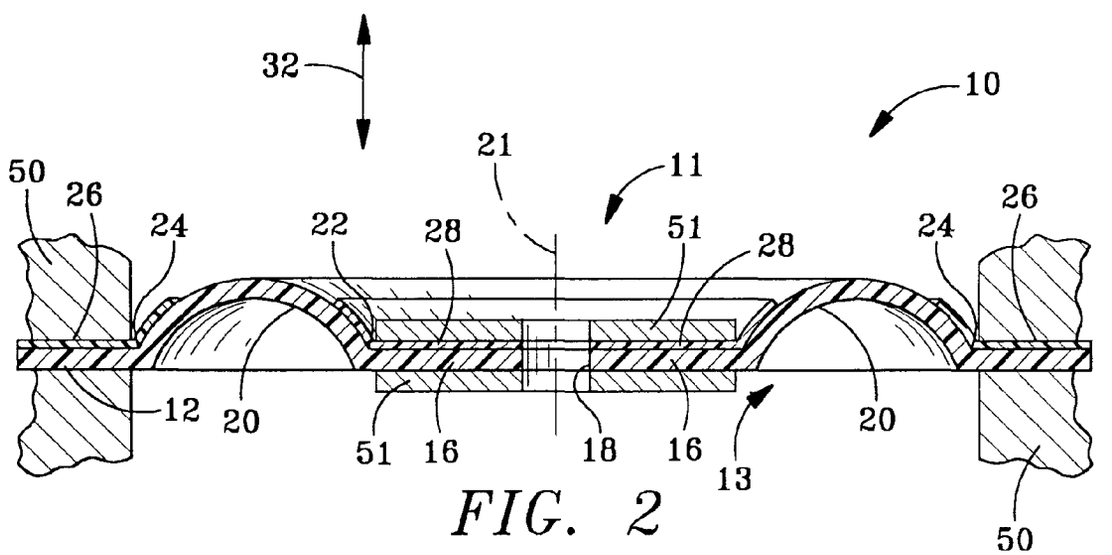

FIG. 2

EP 0 775 825 A2

Description

This invention relates to a pump diaphragm for a fluid operated diaphragm pump and more particularly to a pump diaphragm for an air operated diaphragm pump where the diaphragm includes means for reducing pump diaphragm failure due to fatigue.

Diaphragms are used in air operated diaphragm pumps to pump a liquid at a flow rate that typically does not exceed 250 gal/min. (946.25 ℓ/min.). The diaphragms used in such diaphragm pumps are relatively flexible membranes that have an outer peripheral portion that is clamped or otherwise held in a stationary position against the pump housing. Such diaphragms also include a centrally located portion and a working portion that joins the central and peripheral portions. The central portion is sandwiched between a pair of clamping washers or the like during operation of the pump. The working and central portions of the diaphragm are displaced in a reciprocating manner along an axis to drive liquid out of the pump. Corners are defined where the working portion joins the peripheral portion and the central portion.

A diaphragm rod or other rigid connection member is connected at one end to the washers along the diaphragm central portion, and extends through the diaphragm, and is operatively connected to a mechanical means for cycling the diaphragm in a reciprocating manner. The useful life of a diaphragm can range from 10 - 20 million cycles. Whether the useful life of a diaphragm is maximised or minimised is dependent mainly on the pressure of the liquid pumped, the pressure of the driving fluid, and the volume of abrasives contained in the liquid handled by the pump.

Diaphragm failure is most frequently caused by fatigue. The fatigue is a result of bending stresses which are imparted on the diaphragm as the diaphragm is cycled during pump operation. The bending stresses are highest at the corners that are formed where the working portion joins the peripheral and central portions. Fatigue failure is believed to initiate in the corners and propagate radially toward the centre of the diaphragm.

Another factor which can decrease the useful life of a pump diaphragm is the presence of abrasives in the liquid that is being handled by the pump. Such abrasives can scratch the diaphragm body. Frequently these scratches are produced by abrasives which have accumulated in the corners of the diaphragm. These scratches greatly increase the stress concentration in the corners, accelerate fatigue failure and significantly reduce the useful life of the pump diaphragm.

According to one aspect of the present invention there is provided a diaphragm for a fluid pump, the diaphragm comprising a unitary diaphragm body having a central portion, a peripheral portion and a working portion joining the peripheral and central portions; characterised in that the peripheral portion and central portions each have a thickness that is greater than the thickness of at least part of the working portion.

According to a second aspect of the present invention there is provided a flexible diaphragm for an air operated pump comprising a central portion, a peripheral portion and a working portion joining the central and peripheral portions; characterised by means for limiting the effects of stresses in the working, central and peripheral portions, said means being located substantially where the working portion joins the central and peripheral portions.

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:-

Figure 1 is a plan view of one embodiment of a pump diaphragm;

Figure 2 is a sectional view taken along line 2-2 of Figure 1; and

Figure 3 is an enlarged view of the sectional view of Figure 2 but showing another embodiment.

The pump diaphragm shown in Figures 1 and 2 is indicated generally at 10. During operation of the pump diaphragm 10, the side of the diaphragm generally indicated at 11 in Figure 2 is a liquid receiving side and the diaphragm side generally indicated at 13 is an air pressure receiving side.

The diaphragm includes a peripheral portion 12 that is clamped or otherwise held stationary by a pump housing 50 during operation of the pump. A plurality of apertures 14 are provided in the peripheral portion. The apertures are oriented in a circular array along the portion 12 and are equi-spaced from one another. The apertures are for receiving a conventional connection member such as a bolt, pin or the like.

The diaphragm 10 has a central portion 16 having an opening 18 located at approximately the centre of the diaphragm.

During pump operation, the central portion is sandwiched between a pair of clamping washers 51 each including a centrally positioned opening to be aligned with the diaphragm opening 18. The openings in the clamping washers and central diaphragm portion are adapted to receive an end of a diaphragm rod (not shown) or other member for moving a working portion 20 and the central portion 16 in a reciprocating manner, relative to the fixed peripheral portion 12, along an axis 21 in the direction shown by arrow 32. One end of the diaphragm rod is connected to the clamping washers at the diaphragm central portion and may also be either operatively connected to a mechanical driving means or to a second diaphragm.

The annular working portion 20 joins the central and peripheral portions 16 and 12. As shown in Figure 2, the annular working portion has an arcuate cross section that is directed outwardly away from the peripheral and

central portions and towards the liquid receiving side 11 of the diaphragm 10.

An inner corner 22 is defined by the working and central portions where the working portion joins the central portion. An outer corner area 24 is defined by the working and peripheral portions where the working portion joins the peripheral portion. As shown in dashed font in Figure 1, both the inner and outer corners 22 and 24 form circular paths and extend completely around the body of the diaphragm. During pump operation, bending stresses in the diaphragm are greatest at the corners 22 and 24 and scratches caused by abrasives in the pumped liquid tend to form most frequently in the corners.

In order to reduce the effects of scratches which may be formed in the diaphragm by abrasive particulate matter in the pumped liquid and limit the effects of bending stresses, the diaphragm includes first and second skirt members 26 and 28 along the liquid receiving side 11 of the diaphragm 10.

As shown in the cross-sectional view of Figure 2, the first skirt member 26 extends substantially across the peripheral portion 12, outer corner 24 and a portion of the working portion adjacent the peripheral portion 12. The skirt member 26 may completely cover the peripheral portion 12 or may only cover a portion of the surface area defined by the peripheral portion. Apertures 14 are not covered by the first skirt member 26.

The second skirt member 28 covers substantially all of the central portion 16, the inner corner 22 and a portion of the working portion 20 adjacent the central portion 16. The second skirt does not cover the opening 18, and although the second skirt member is shown as covering substantially all of the central portion, it need only cover a portion of the central portion 16.

The diaphragm may include only one of the skirts members 26 and 28 or may include both of the skirt members as shown in Figures 1 and 2. The skirt members may extend in a full circle along the surface of the diaphragm or may only extend in a partial circle and cover only a portion of the diaphragm surface.

Since the skirt members do not extend completely over the working portion 20, they do not affect the operation of the diaphragm. It is recommended that the skirt members cover about half of the working portion and not a majority of the working portion. The skirt members increase the useful life of the diaphragm by reducing the bending stresses at the diaphragm corners and also by preventing the accumulation of a high concentration of abrasives at both of the corners.

The diaphragm 10 may be made from any suitable material such as the material known and sold under the trade mark "Teflon", a thermoplastic material or rubber. The skirt members 26 and 28 may be made from the same material as the diaphragm body or from a different material. It is recommended that the skirt member be one to two times the thickness of the diaphragm.

Since the skirt members are located on the portions of the diaphragm which experience the largest number of scratches, it is likely any diaphragm scratches will be formed in the skirt members, and will not affect the corners. In this way, it is believed the scratches will not increase the stresses at the corners and accelerate failure of the diaphragm. Therefore, pump diaphragms which include one or both of the skirt members will be able to sustain scratches without increasing stress at the corners and decreasing the useful life of the diaphragm.

Another embodiment of diaphragm 40 is shown in the enlarged sectional view of Figure 3 and includes the peripheral portion 12, central portion 16 and working portion 20 joining the central and peripheral portions. The diaphragm 40 also includes a liquid receiving side 11 and an air pressure side 13. The diaphragm peripheral portion is held in place during pump operation by the pump housing 50 and the central portion is sandwiched between the clamping washers 51, as previously described.

The peripheral and central portions 12 and 16 have a thickness "T", which is greater than the thickness "t" of the working portion 20. The thickness "T" of the peripheral and central portions may be twice the thickness "t". Increasing the thickness of the diaphragm portions 12 and 16 helps to minimise the effects of scratches which may form along the central and peripheral portions near the working portion, and also reduce the effects of diaphragm bending stresses. In the diaphragm 40, both the central and peripheral portions 16 and 12 may have a thickness that is greater than the thickness of the working portion or only one of the portions may be of greater thickness. In this way, at least one of the portions 12 or 16 has a thickness that is greater than the thickness of the working portion.

An inner stress reducing notch 41 is formed where the central portion joins the working portion and an outer stress reducing notch 42 is formed where the peripheral portion joins the working portion. Each notch is U-shaped; however, the notch may have any suitable shape. The notches extend completely around the diaphragm in the same manner that the corners 22 and 24 extend around the diaphragm 10. The notches reduce the stress concentration in the central and peripheral portions, which are the portions of the diaphragm 40 which experience the largest magnitude of bending stresses during pump operation.

The diaphragm 40 may include both notches 41 and 42 or may include only one of the notches.

Therefore, it is believed that by increasing the thickness of the peripheral and central portions relative to the working portion of the diaphragm 40, the effects of scratches and bending stresses will be decreased, thereby increasing the useful life of the diaphragm.

Claims

1. A diaphragm (10) for a fluid pump, the diaphragm

comprising a unitary diaphragm body having a central portion (16), a peripheral portion (12) and a working portion (20) joining the peripheral and central portions; characterised in that the peripheral portion and central portions (12, 16) each have a thickness that is greater than the thickness of at least part of the working portion (20).

2. A diaphragm according to claim 1, wherein the peripheral and central portions (12, 16) are twice as thick as the working portion (20).

3. A diaphragm according to claim 1 or 2, wherein at least one notch (41, 42) is formed in the diaphragm where the working portion (20) joins one of the other diaphragm portions (12, 16).

4. A diaphragm according to claim 3, wherein the or each notch (41, 42) is U-shaped.

5. A diaphragm according to claim 3 or 4, wherein said at least one notch (41) is formed in the diaphragm where the central portion (16) joins the working portion (20).

6. A diaphragm according to claim 3, 4 or 5, wherein said at least one notch (42) is formed where the working portion (20) joins the peripheral portion (12).

7. A diaphragm according to any one of the preceding claims wherein said peripheral and central portions (12, 16) are co-planar and the working portion (20) has a substantially arcuate cross-section, the working portion lying substantially outside the plane of the central and peripheral portions.

8. A diaphragm according to any one of the preceding claims, wherein the greater thickness is provided by a first skirt member (26) extending across and substantially covering the peripheral portion (12), and a portion of the working portion (20) adjacent the peripheral portion.

9. A diaphragm according to claim 8, wherein the diaphragm body has an outer corner (24) formed where the peripheral portion (12) is joined to the working portion (20) and an inner corner (22) formed where the central portion (16) is joined to the working portion (20) and wherein the greater thickness is further provided by a second skirt member (28) extending across and substantially covering the central portion (16), the inner corner (22) and a portion of the working portion (20) adjacent the central portion.

10. A diaphragm according to claim 9, wherein the first and second skirt members (26, 28) are located on a liquid receiving side of the diaphragm.

11. A diaphragm according to claim 9 or 10, wherein the first and second skirt members (26, 28) cover no more than substantially half of the working portion (20).

12. A diaphragm according to any one of the preceding claims, wherein the first and second skirt members (26, 28) and the working, peripheral and central portions are made from the same material.

13. A diaphragm according to any one of the preceding claims, comprising means for clamping a portion of the diaphragm comprising first and second clamping washers (51) clamping the central portion (16).

14. A flexible diaphragm for an air operated pump comprising a central portion (16), a peripheral portion (12) and a working portion (20) joining the central and peripheral portions; characterised by means for limiting the effects of stresses in the working, central and peripheral portions (20, 16, 12), said means being located substantially where the working portion (20) joins the central and peripheral portions (16, 12).

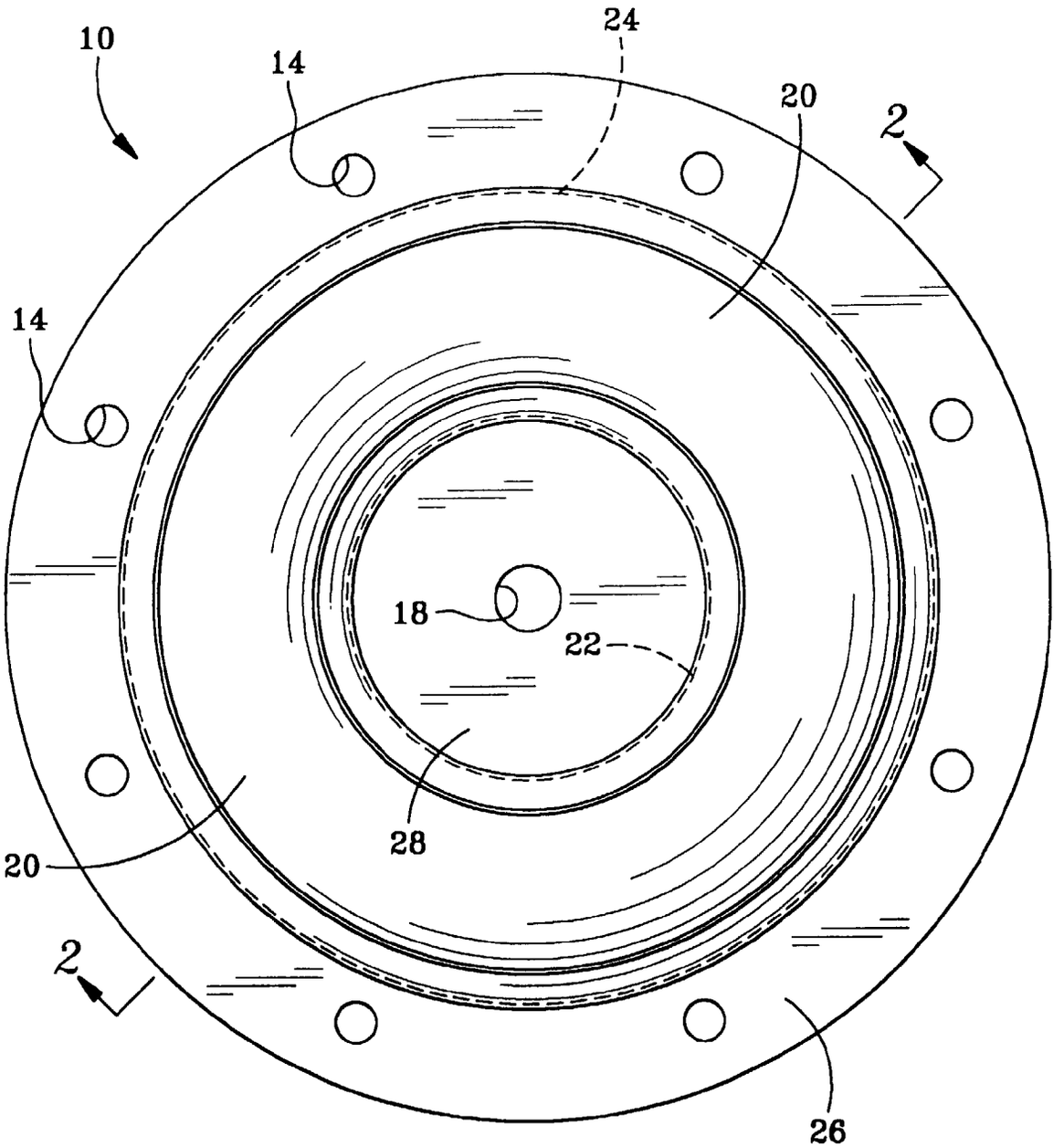

FIG. 1

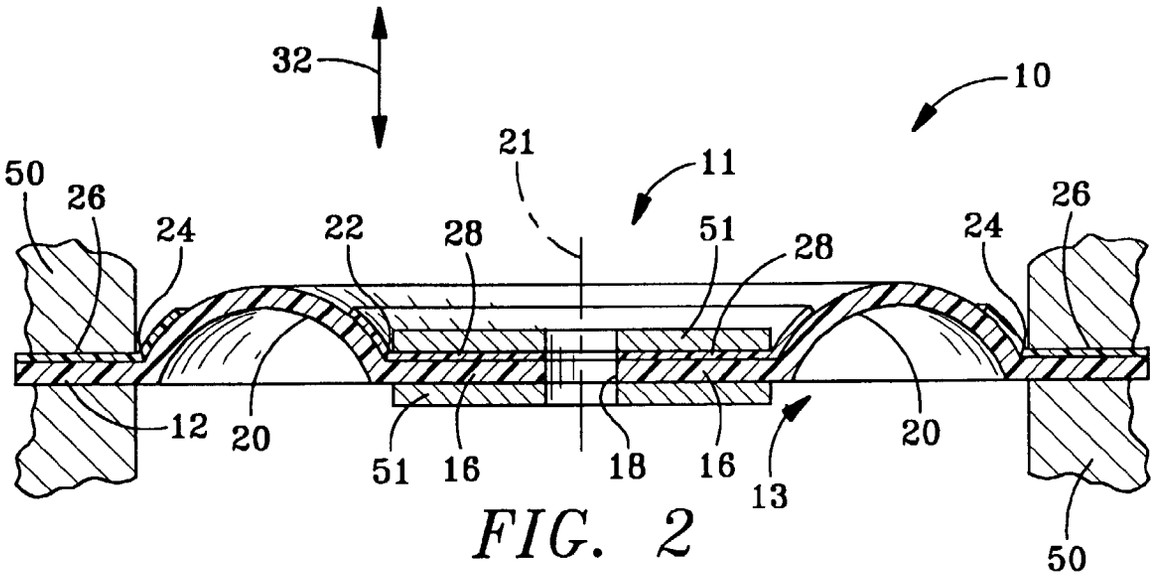
32
10
21
11
50
26
24
22
28
51
28
24
26
12
20
51
16
18
16
13
20
50

FIG. 2

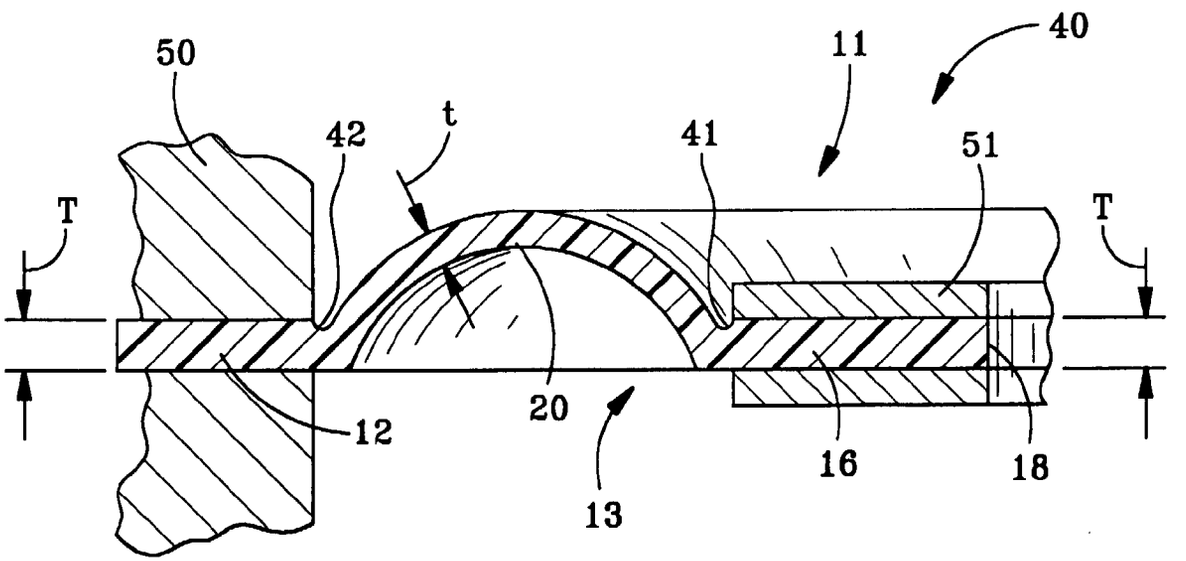
40
11
50
42
t
41
51
T
T
12
20
16
18
13

FIG. 3