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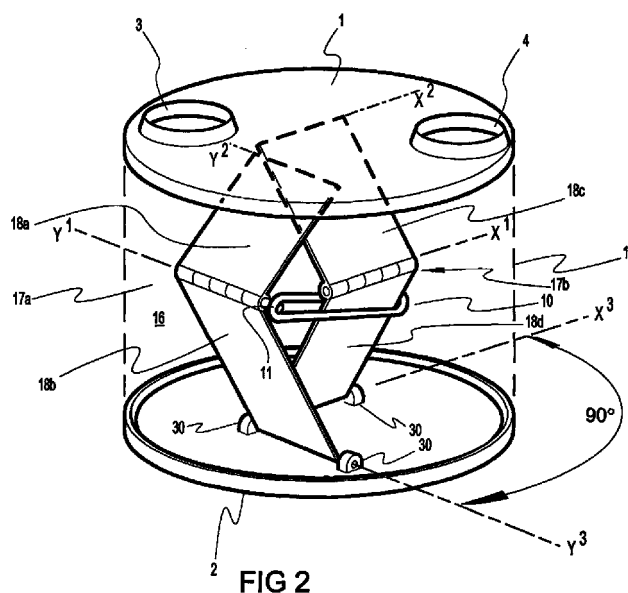
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(54) **Reciprocating foot pump for inflating**

(57) A reciprocating pump having a closed chamber with oppositely orientated unidirectional inlet and outlet valves, the pump being operable by relative separation and approach of two parts of the chamber, in which

there are provided guide means, separate from the wall of the chamber, constraining the relative motion of the said two parts to be substantially rectilinear.



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Description

[0001] The present invention relates generally to a reciprocating pump and particularly to a reciprocating pump used for the inflation with air of inflatable articles such as air beds and inflatable boats.

[0002] Reciprocating pumps for such purposes are known and are commonly designed with two generally flat plates joined by a single hinge about which the plates can be turned in a reciprocating fashion by acting on the ends remote from the hinge. In each case the volume between the plates is enclosed by a flexible membrane to define a chamber, and respective unidirectional valves allow air in and out of the chamber as it is expanded and compressed by the reciprocating motion.

[0003] When considering pumps of this sort it is desirable to produce the largest possible displacement volume for each cycle of the reciprocal motion. Additionally, taking into account the most likely usage, it is advantageous for such a pump to be as easily portable as possible. A further consideration is the ergonomic relationship between the actuating member and that part of the user's anatomy, for example the foot, by which the pump is to be activated. Consideration must be given to the most ergonomically effective positioning of the foot on the pump and the path it follows during actuation.

[0004] With an increase in size to increase the displacement volume the mechanical stresses are also increased requiring a heavier construction, this would make the pump more cumbersome and difficult to operate as well as making it more difficult to carry. It also involves a longer stroke which is inconvenient for the user.

[0005] Although a degree of lateral movement of the point of contact of the foot is acceptable the main point is that a single hinge design, if made large enough to inflate rapidly (say 3 litres per cycle) will need plates to be extended for a mechanical advantage (to achieve the pressure), and the resultant pump is a very clumsy item. The whole leg is always used during pumping and the ball of the foot is applied usually to a raised, non-slip ridge on the top of the pump.

[0006] The present invention seeks, therefore, to provide a reciprocating pump in which the displacement volume is maximised, whilst retaining portability. It is a feature of the present invention that the design is ergonomic and allows a much more agreeable movement by the user in operating the pump.

[0007] According to a first aspect of the invention there is provided a reciprocating pump having a closed chamber with oppositely orientated unidirectional inlet and outlet valves, the pump being operable by relative separation and approach of two parts of the chamber, in which there are provided guide means, separate from the wall of the chamber, constraining the relative motion of the said two parts to be substantially rectilinear.

[0008] In a preferred embodiment the guide means comprise at least two pairs of substantially rigid link members, the link members of each pair being pivotally connected together to turn about respective axes. In such an embodiment the said respective axes may be positioned at or close to right angles to each other. However, other means which prevents unwanted movement of two parts of a chamber with respect to each other could be envisaged and are not beyond the scope of this invention. The links may be made from sheet metal, plastics or extruded metal or they may comprise a strip of flexible material enclosed by metal on one or both sides except at pivot points. Other materials could be used, so long as they confer sufficient strength and torsional rigidity to maintain the path of the part of the pump guided by the linkage to be substantially rectilinear in normal use.

[0009] The guide means may be connected to each other in such a way as to cause their axes to separate upon compression of the chamber.

[0010] The geometry of a linkage with two pivoted elements allows a pump to be produced in which the height is less than 80% of the diameter of the two plates. If a greater height to diameter ratio is required, for example if greater pressure is required, linkages with more link elements may be used. Linkages having a greater number of links may require stabilising, and a stabilising connection between links may be used.

[0011] One advantage of the use of a linkage as described above as a guide mechanism is that it occupies very little space when collapsed and this allows the pump to collapse to a very small volume.

[0012] The two part of the chamber may be plates which are substantially parallel to each other and connected to each other by the guide means. In a preferred embodiment the pump is cylindrical with circular plates, however it is to be understood that other shapes would be suitable, for example rectangular plates, square plates resulting in cuboid chambers, hexagonal plates, or triangular plates resulting in prism chambers may also be used. It is also possible, for example, within the scope of the invention, to form a completely spherical pump with the plates merely marked on the surface as points at which to apply force. The rectilinear guide means allow for such configurations, which for a given distance between two plates allows for an increased displacement volume over known pumps. The rectilinear mechanism results in much reduced stresses in the plates when compared to a single hinge pump. Additionally, such configurations allow the actuating member to follow a rectilinear path, which is more natural for the operator's body, especially in the case of a foot pump. Flat contact between the foot and the pump plate can be achieved easily if this is preferable for a user.

[0013] The inlet and outlet valves may be carried, on or by, together or separately on one or both of the plates.

[0014] There may also be provided means for resil-

iently biasing the pump to urge the chamber towards an expanded condition. The resilient biasing means may act on the guide means. In a preferred embodiment such resilient biasing means may be connected between two links of respective pairs, and may act between two links at a pivot axis of, or at points intermediate, two axes.

[0015] The resilient biasing means may be a coil spring, leaf spring, tension spring or torsion spring.

[0016] The guide means may be connected to the two parts of the chamber internally thereof, however in some embodiments the guide means are connected externally.

[0017] In a preferred embodiment the chamber is defined by a base plate, a foot plate and a flexible membrane which may be made from any flexible sheet material such as woven fabric coated with rubber or plastics, or a plastics film. Embodiments of the invention may be made in which the membrane is corrugated although this is not essential and, indeed, in the preferred embodiment described hereinbelow the membrane is not corrugated.

[0018] In addition to the above when, considering pumps of this sort regard must be had to the join between the plates and the membrane. As the pump is operated the chamber is pressurised and the join between the plates and the membrane is preferably such that air loss is kept to a minimum or eliminated; any air loss reduces the efficiency of the pump.

[0019] Taking into account the most likely usage, it is advantageous for the method of joining the plates to the membrane to be low cost and utilise materials that do not corrode, for example in those conditions present in sea water; additionally whilst the join must be strong and air tight it should also preferably be detachable to allow access to the interior of the pump for maintenance or repair.

[0020] Commonly known reciprocating pumps with flexible membranes use steel clamping beads which, unless they are stainless steel, will corrode over time and this may be accelerated by exposure to certain conditions such as those present in sea water.

[0021] The present invention therefore seeks also to provide a reciprocating pump in which the join between the plates and the membrane fulfils the criteria outlined above.

[0022] According to a second aspect of the present invention there is provided a reciprocating pump having a closed chamber defined at least in part by a plate and a flexible membrane having a perimetral rim, in which the flexible membrane is sealingly attached to the plate using forces provided by the interengagement of the rim and the plate.

[0023] One or both of the rim and the plate may comprise or include a resilient portion whereby to provide the interengagement forces when engaged.

[0024] In some embodiments at least the perimetral portion of the plate is resilient and as such may com-

prise the resilient portion or a part thereof. Alternatively or additionally the resilient portion may comprise or include an elastic cord at the perimetral rim of the flexible membrane.

[0025] In a preferred embodiment the plate has a single resilient strip extending around the perimetral portion thereof which constitutes the resilient portion. The resilient strip may be formed from any suitable material such as rubber or plastics. The resilient strip may be attached to the plate by any suitable means such as adhesion, or by using an elastic material that is stretched around the plate and held in place by its own resilience.

[0026] In such embodiments the perimetral rim of the flexible membrane may include an inelastic cord which forms a continuous enlarged bead. The effective length of such a cord is important so as to secure the perimetral rim of the membrane to a corresponding resilient portion at the perimetral rim of the plate. Suitable materials for the construction of the cord include some man made fibres such as Kevlar RTM or Twaron RTM, or multi-strand wire. The cord may be wrapped once or several times around the perimetral rim of the membrane and may be secured either to itself or to the membrane by any suitable means such as adhesion.

[0027] Where elastic and/or inelastic cords are present the cord may be encased in an envelope portion at or around the perimetral rim. The envelope portion may conveniently be a pocket or hem formed as part of the membrane.

[0028] The plate may have a peripheral collar portion depending therefrom; the resilient portion may be contiguous with the collar portion.

[0029] The plate may further include a substantially rigid peripheral flange portion, which itself may project from the collar portion

[0030] The resilient portion may itself also include a flange portion.

[0031] The plate may have a peripheral groove into which fits an enlarged bead formed at the perimetral rim.

[0032] The periphery of the plate may include a collar portion depending therefrom. The resilient portion may be contiguous with the collar portion.

[0033] In a preferred embodiment the membrane is releasably attached to the plate, however in other embodiments the membrane is fixedly attached to the plate.

[0034] According to a further aspect of the invention there is provided a reciprocating pump having a closed chamber defined at least in part by a flexible membrane and a plate, and having means for releasably sealingly attaching said flexible membrane to said plate.

[0035] Various embodiments of the invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic exterior view of a foot pump

formed as a first embodiment of the invention, shown in the relaxed or expanded state;

Figure 2 is a view showing the interior of the embodiment of Figure 1;

Figure 3 is a view of the pump of Figure 1 shown in a compressed state;

Figure 4 is a view illustrating the interior of an alternative embodiment of the first aspect of the invention;

Figure 5 is an exterior view of a further alternative embodiment of the invention;

Figure 6 is a diagrammatic illustration of a plate formed as an embodiment of the second aspect of the invention;

Figure 7a, b and c show three stages in the incorporation of an inelastic cord into a membrane;

Figure 8 is a diagrammatic illustration of the plate shown in Figure 6 following engagement with the inelastic cord shown in Figure 7c;

Figure 9 is a diagrammatic illustration of an alternative resilient portion, having a flange portion, formed at the perimetral region of a plate; and

Figure 10 is a diagrammatic illustration of an alternative embodiment of the second aspect of the invention in which the plate has a groove portion.

[0036] Referring first to Figures 1 to 3 there is shown a reciprocating pump comprising a cylindrically curved flexible membrane 12 sealingly joined at its ends to respective substantially rigid end plates 1 and 2 which comprise the main movable components of the pump. The membrane 12 and end plates 1 and 2 together enclose a sealed chamber 16 the volume of which varies as the plates 1, 2 are brought together or moved apart as will be described in more detail below.

[0037] One of the plates, in this embodiment the plate 1, carries oppositely orientated inlet and outlet valves 3 and 4. In other embodiments (not shown) the valves could be carried by the plate 2 or by the flexible membrane 12.

[0038] The pump is operable by relative separation and approach of two plates 1 and 2. Relative motion of the two plates 1 and 2 is constrained to be generally rectilinear by guide means 17a, 17b located within the chamber 16. In this embodiment the guide means 17a, 17b comprise two pairs of linkages each in the form of two substantially flat rigid link members 18a, 18b and 18c, 18d. The link members 18a and 18b of one pair are connected to each other to turn about an axis Y^1 , with the link member 18a being pivotally connected to the plate 1 via bags 30 (not shown) for turning movement about an axis Y^2 which is parallel to the axis Y^1 and is in or close to the plane of the plate 1. Similarly the link member 18b is pivotally connected, at its end remote from the pivotal connection to the other link member 18a, to the plate 2 via lugs 30 for turning movement about a further axis Y^3 parallel to and spaced from the axes Y^1 and Y^2 . Similarly, the link members 18c and

18d are pivotally connected to each other at respective proximal ends to turn about an axis X^1 and each is pivotally connected at a respective distal end to a respective plate 1, 2 for turning movement about respective axes X^2 , X^3

[0039] The parallel axes X^1 , X^2 , X^3 lie, in this embodiment, substantially orthogonal to the parallel axes Y^1 , Y^2 , Y^3 such that the two pairs of pivoted link members form, in effect a parallelogram linkage in which the two lateral pairs of links turn about non-parallel axes. The effect of this is that each pair of links acts to guide the relative motion of the distal ends of the other pair, constraining them to follow respective rectilinear paths.

[0040] The two pairs of links 17a, 17b are resiliently biased to a first, extended position by resilient biasing means in the form of a resilient band 10 passing around a projecting pin 11 at the proximal ends of the links 18a, 18b and passing around one of the two links 18c, 18d close to the pivot axis X^1 . As the two plates 1, 2 are caused to approach one another the pin 11 is caused to move away from the links 18c, 18d. Thus, in use, the resilient biasing means 10 is stretched as the axes X^1 and Y^1 move apart, caused by the approach of plate 1 and 2 as force is applied to plate 1. When the force is removed from plate 1 the resilient biasing means 10 contracts, pulling axes X^1 and Y^1 towards each other, which urges the distal ends of the pairs of links 17a, 17b apart and thus moves the chamber 16 towards an expanded condition.

[0041] A delivery hose 5 is also shown, it can be removably attached to either the inlet valve 3 or outlet valve 4 to provide pressure or suction.

[0042] Straps 6 are also provided which can be used to secure the pump in the compressed condition shown in Figure 3, the straps 6 may also serve to hold the delivery hose 5 during storage.

[0043] Figure 4 shows an alternative embodiment. In this and the subsequent drawings those components which are the same as or fulfil the same functions as corresponding components in the embodiment of Figures 1 to 3 have been identified with the same reference numerals. In Figure 4 each of two guide means 25a, 25b comprise three rigid link members each pivotally connected together about respective axes. In other embodiments (not shown) the number of links in each guide means may be greater than three. In this embodiment in each guide means 25a, 25b one link member 20a, 20f is pivotally connected to plate 1 via lugs 30 (not shown) so as to be turnable about respective axes A^1 , or B^1 , and another member 20c, 20d is pivotally connected to plate 2 via lugs 30 so as to be turnable about respective axes A^2 or B^2 . Intermediate link members 20b, 20e then connect pivotally to both the outer link members 20a, 20c and 20d, 20f so as to be turnable about respective axes A^3 and A^4 , B^3 and B^4 .

[0044] As was described in the first embodiment, in this alternative embodiment the parallel axes A^1 , A^2 , A^3 ,

A⁴ lie substantially orthogonal to the parallel axes B¹, B², B³, B⁴ resulting in the aforementioned guidance of the respective relative motion of the pairs of links. The rectilinear relative motion of the pairs of links is further encouraged by a stabilising means 13 which is a resilient c-shape element fixedly connected to intermediate link member 20e at point 13a and to intermediate link member 20b at points 13b and 13c

[0045] In other embodiments (not shown) suitably resilient stabilising means 13 may be fixedly connected between any of the link members of link pairs with connection to each link member at any point, but preferably so that the resulting stabilising means is parallel to the plates 1 and 2. The stabilising means 13 may be pivotally connected to one link member, being fixedly connected to the other or pivotally connected to both link members.

[0046] Where the distance between two points to be connected by a stabilising means does not change during operation of the pump, for example in Figure 4 the proximal ends of link members 20a, b and 20e, f as defined by pivot axes A⁴ and B⁴, the stabilising means may be substantially rigid.

[0047] Although not shown in Figure 4 the resilient biasing means 10 described with respect to the first embodiment could also be used in this embodiment, and other embodiments with a greater number of link members.

[0048] Figure 5 shows a further alternative embodiment in which the positioning of the guide means 17a, 17b is different from that of the first embodiment, both with respect to the plates 1 and 2 and each other. In this embodiment the guide means 17a, 17b are pivotally connected to plates 1 and 2 by lugs 30 located at the periphery of the plates 1 and 2 with the result that the guide means are outside the flexible membrane 12 and thus the chamber 16. This embodiment is designed to produce a greater pressure for a finer stroke (and is of course limited by the maximum force which can be applied by the user). For this reason the diameter of the membrane is reduced to such an extent that the guide linkage cannot be accommodated within it.

[0049] In this embodiment the edges of link members 18b, 18d which lie adjacent plate 2 together form an L-shape, the same is true for the corresponding link members 18b, 18d in the first embodiment. However, in this embodiment axes X¹ and Y¹ both lie outside the included angle, and in the first embodiment axis X¹ lies within the included angle.

[0050] A resilient biasing means 10 is also provided as previously described for the first embodiment, in this embodiment the resilient biasing means 10 is connected to projecting hooks 40 which are located at the proximal ends of links 18a, 18b and 18c, 18d. In another embodiment (not shown) the resilient biasing means may be a torsion spring, a leaf spring or a compression spring, fitted so that the plates separate when foot pressure is removed.

[0051] In this embodiment the inlet valve 3 is carried by the plate 1 and the outlet valve 4 (not shown) is carried by the plate 2. The delivery hose is releasably connected to the outlet valve 4.

5 **[0052]** Referring now to Figure 6 there is shown a plate 1 formed as an embodiment of the second aspect of the invention. At the edge of the plate 1 a collar 43 projects downwardly from a rounded shoulder 7, being orthogonal to the plate 1. The collar 43 has a flange 44 that projects outwardly from the lower end of the collar as shown in the drawing so as to be orthogonal to the collar 43 and parallel to the plate 1. A resilient strip 45 is fixedly attached to the collar 43 and the flange 44. The resilient strip 45 is generally rectangular in section and has a rounded edge 46.

10 **[0053]** Figure 7a shows an end 13 of a membrane 12 and an inelastic fibrous thread in this embodiment formed as an encircling cord 42. The cord 42 is incorporated into the structure of the membrane 12 by folding the end 13 over onto itself in the direction shown by the arrow X, resulting in the formation of a hem 14 as shown in Figure 7b. Figure 7b shows the encircling cord 42 in phantom, being retained in the hem 14 at the end 13 of the membrane 12.

15 **[0054]** Figure 8 shows the plate 1 of Figure 6 with the end 13 of membrane 12 (as shown in Figure 7c) attached. The length of the cord 42 is such that when the membrane is fitted to the plate the cord 42 will pass around the collar 43 but not the flange 44. The resilience of the strip 45 allows the cord 42 to pass over the strip 45 and embed therein as shown in the figure. The passage of the cord 46 over the plate 1 and the resilient strip 45 is helped by the presence of the rounded shoulder 7 and the rounded edge 46. The interengagement of the cord 43 with the strip 45 seals the membrane 12 to the plate 1.

20 **[0055]** To fit the membrane to the plate in practice, two diametrically opposed points of the perimetral rim are first brought into proximity with the opening in the membrane which will be wide enough for the plate 1 to be manoeuvred into its interior. The cord 42 may then be placed in contact with part of the resilient strip 43 before working the cord 42 around the remainder of the strip 43.

25 **[0056]** Figure 9 shows an alternative embodiment, in which the resilient strip 45 itself also includes a flange 47 projecting orthogonally therefrom, being parallel to the flange 44. The flange 47 serves further to help prevent the cord from sliding off the strip 45.

30 **[0057]** Figure 10 shows a further alternative embodiment in which the collar 43 includes a semi-circular peripheral groove 50 that is filled with a resilient strip 51 which in this embodiment is therefore also semi-circular. The inelastic cord 42 again interengages with the resilient strip 45.

35

Claims

interengagement forces when engaged.

1. A reciprocating pump having a closed chamber with oppositely orientated unidirectional inlet and outlet valves, the pump being operable by relative separation and approach of two parts of the chamber, in which there are provided guide means, separate from the wall of the chamber, constraining the relative motion of the said two parts to be substantially rectilinear. 5 10
2. A reciprocating pump as claimed in Claim 1, in which the said guide means comprise at least two pairs of substantially rigid link members, the link members of each pair being pivotally connected together to turn about respective axes. 15
3. A reciprocating pump as claimed in Claim 2, wherein the said respective axes are orientated substantially at right angles to each other. 20
4. A reciprocating pump as claimed in any preceding claim in which the said two parts are plates which are substantially parallel to each other and connected to each other by said guide means. 25
5. A reciprocating pump as claimed in any preceding claim, wherein said chamber is defined by a flexible membrane. 30
6. A reciprocating pump as claimed in any preceding claim, wherein said guide means are connected to said two parts externally of the said chamber.
7. A reciprocating pump as claimed in any preceding claim, wherein the guide means are connected to each other in such a way as to cause their axes to separate upon compression of the chamber. 35
8. A reciprocating pump as claimed in any preceding claim, wherein there are provided resilient biasing means for urging the chamber towards an expanded condition. 40
9. A reciprocating pump as claimed in Claim 10, in which the said resilient biasing means acts on the said guide means. 45
10. A reciprocating pump having a closed chamber defined at least in part by a plate and a flexible membrane having a perimetral rim, in which the flexible membrane is sealingly attached to the plate using forces provided by the interengagement of the rim and the plate. 50 55
11. A reciprocating pump as claimed in Claim 1, in which one or both of the rim and the plate comprise or include a resilient portion whereby to provide the
12. A reciprocating pump having a closed chamber defined at least in part by a flexible membrane and a plate, and having means for releasably sealingly attaching said flexible membrane to said plate.

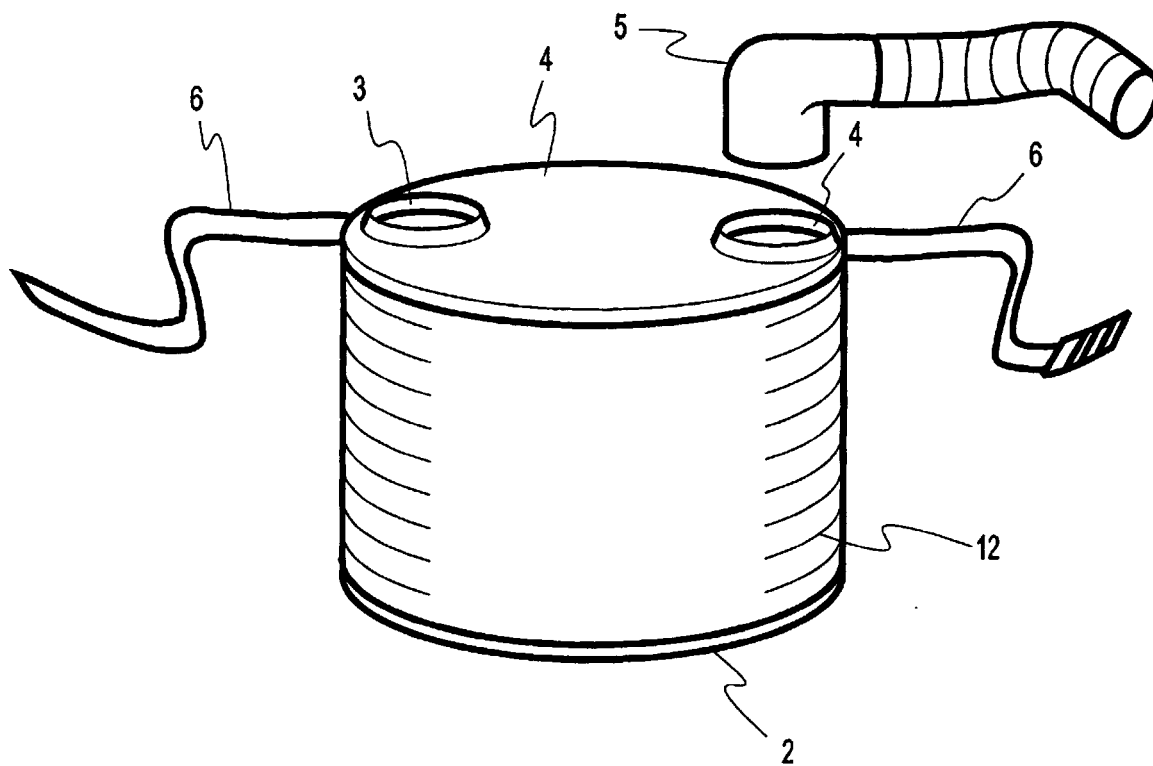


FIG 1

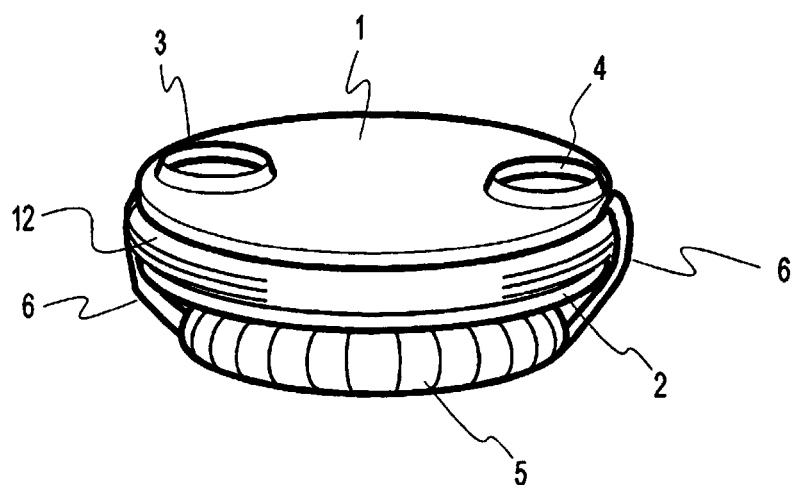
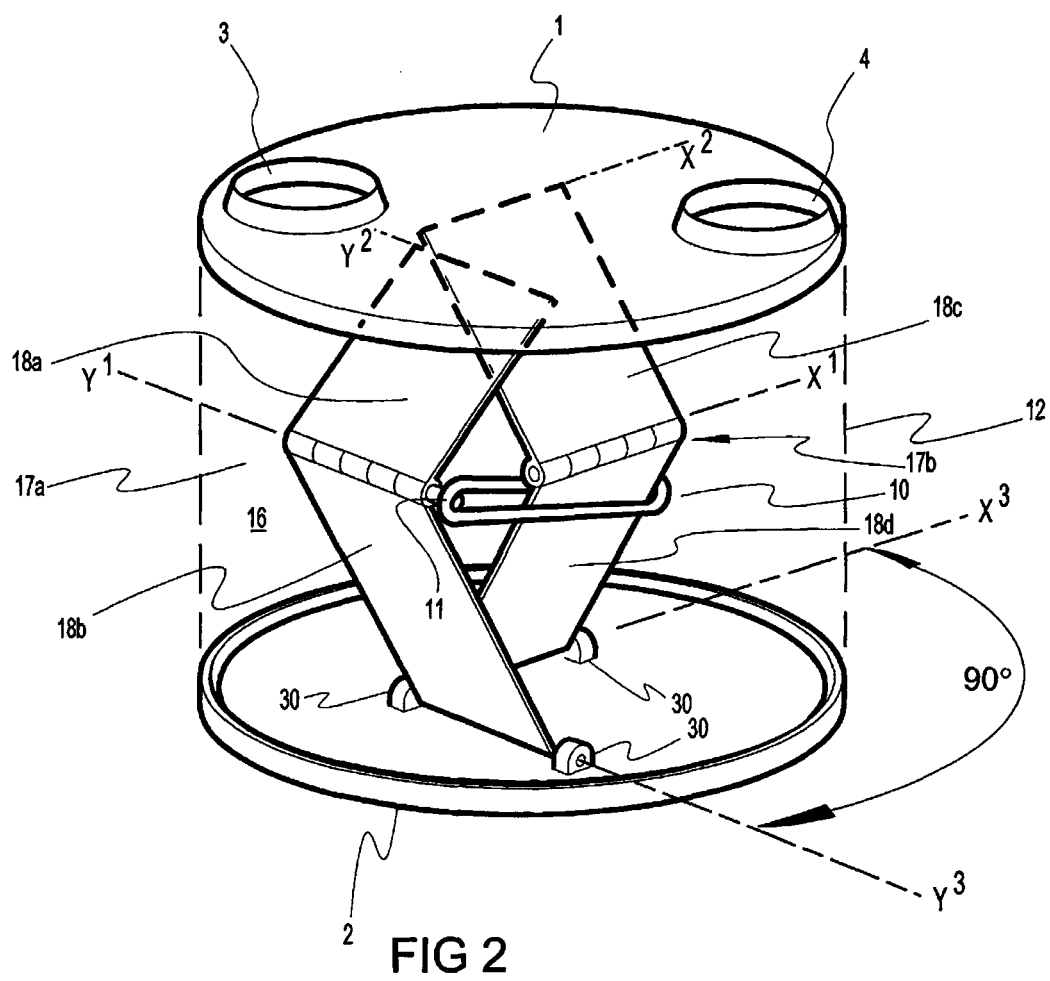


FIG 3



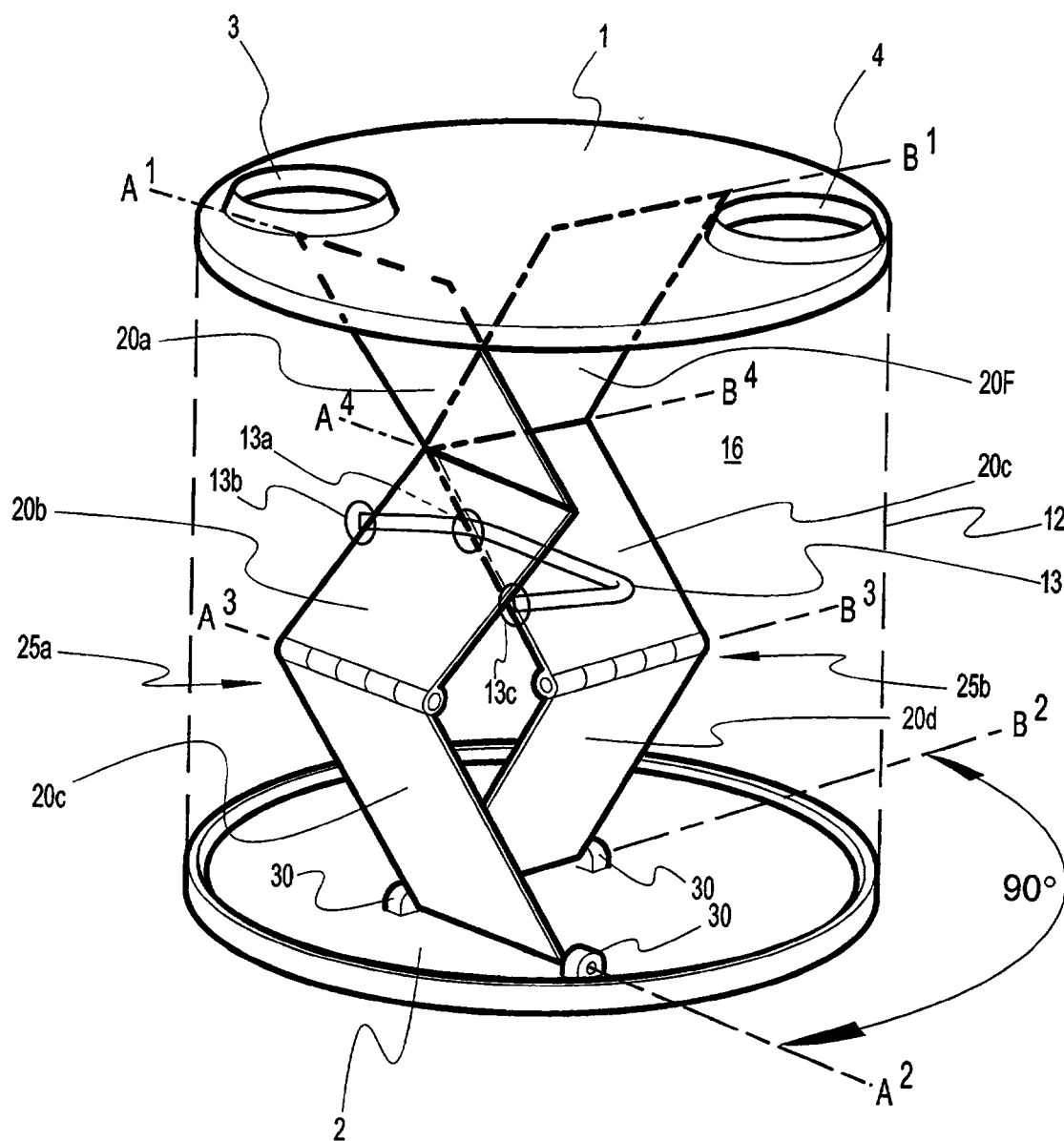


FIG 4

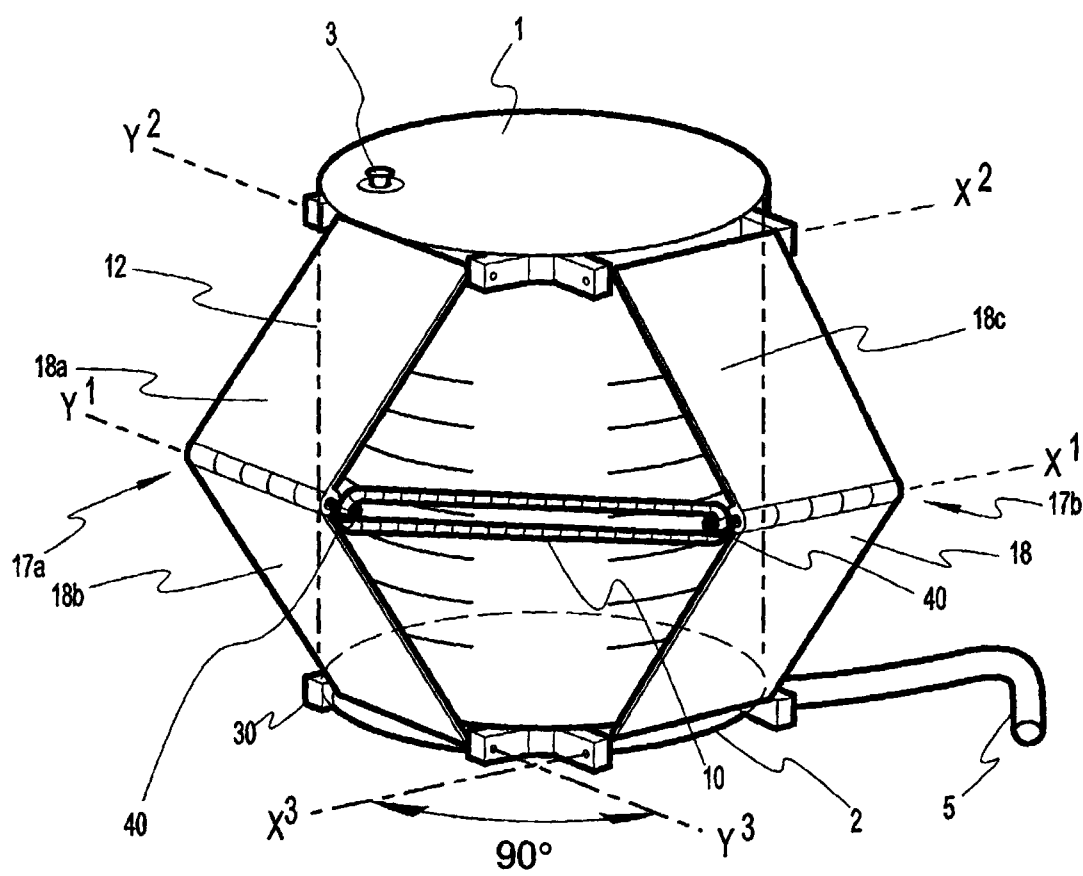
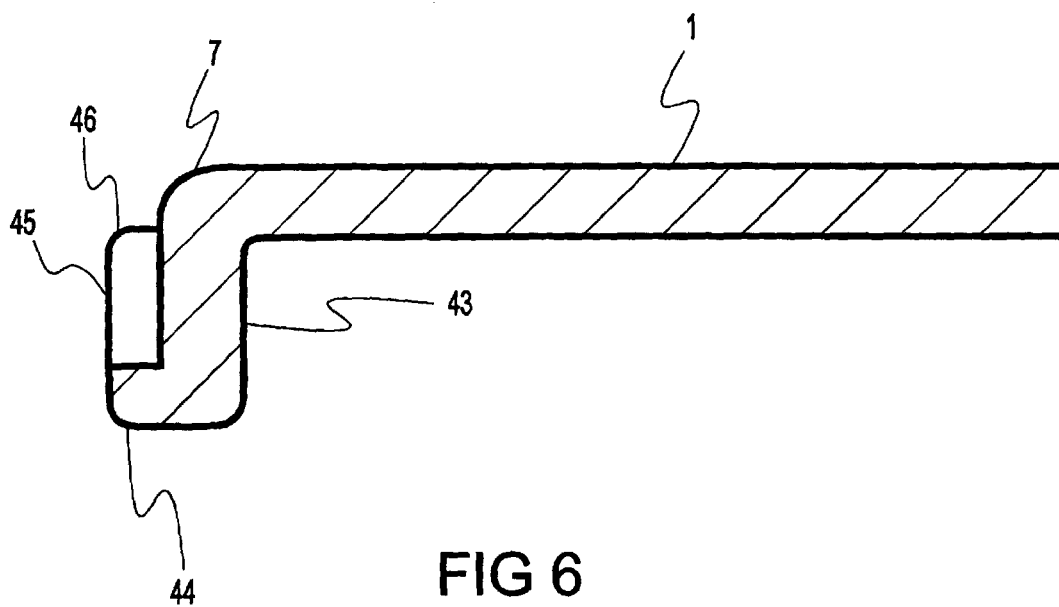


FIG 5



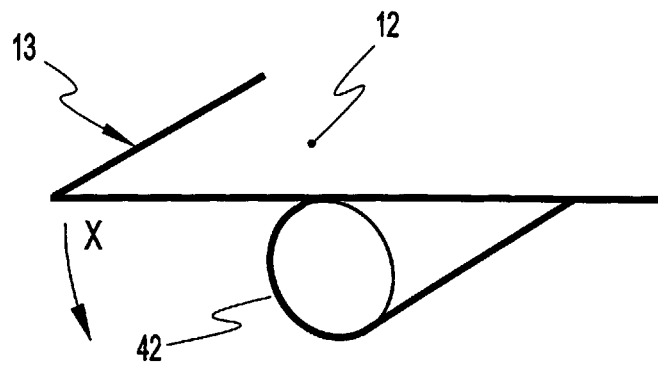


FIG 7a

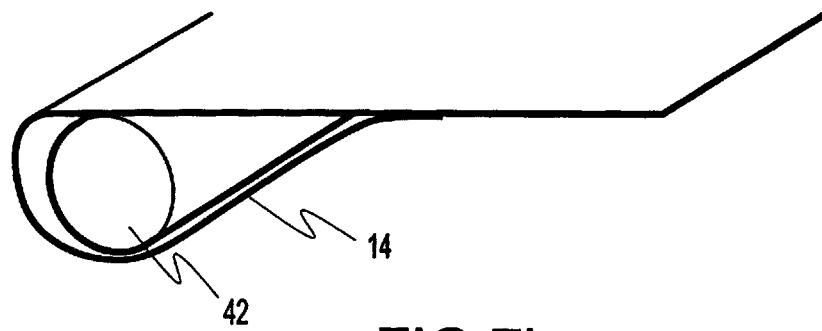


FIG 7b

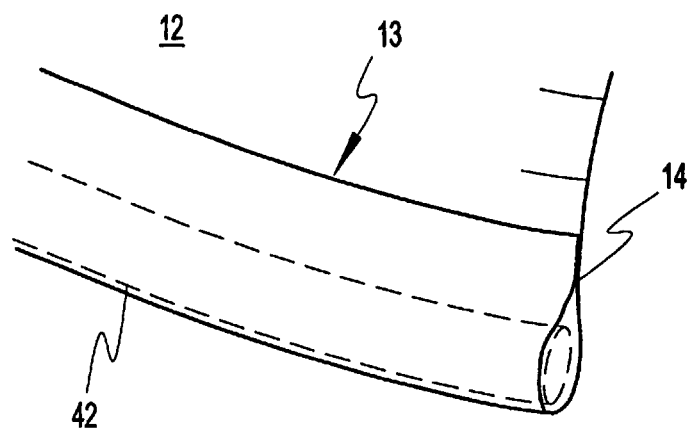


FIG 7c

