Dec. 30, 1969 F. H. HUMPHREY 3,486,663

ELASTOMERIC PUMP AND CHECK-VALVE

Filed July 17, 1968 2 Sheets-Sheet 1

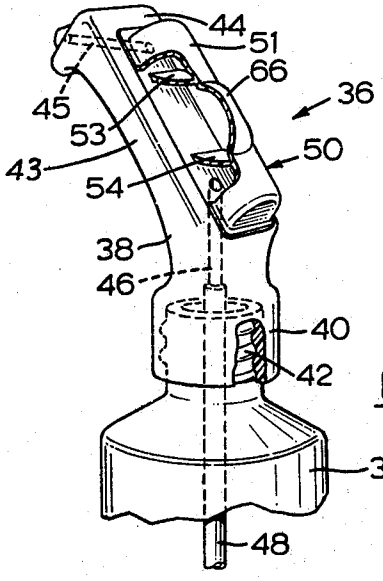


FIG. 3

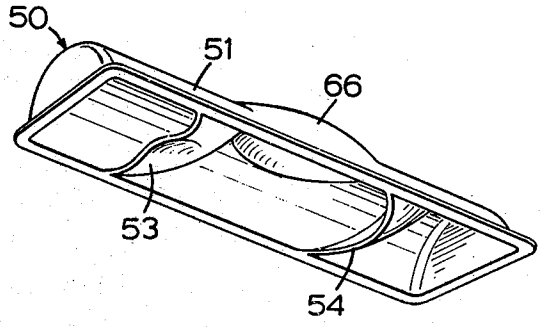


FIG. 7

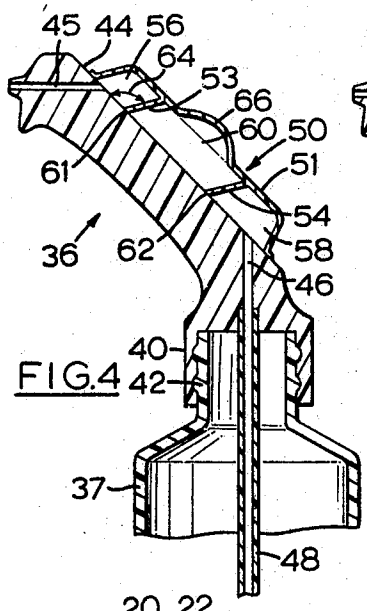


FIG. 4

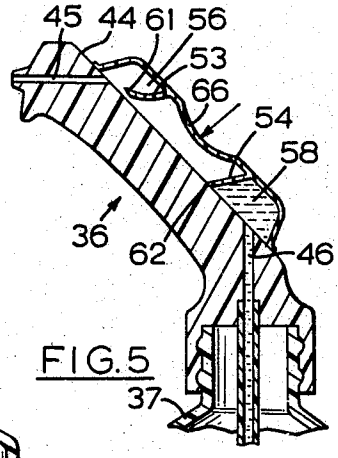


FIG. 5

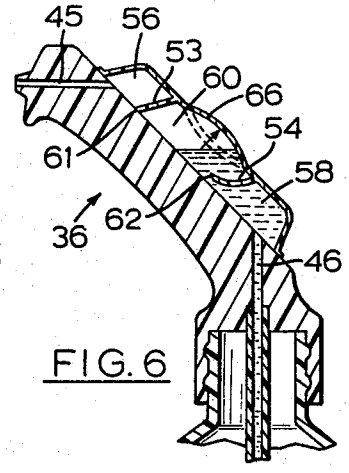


FIG. 6

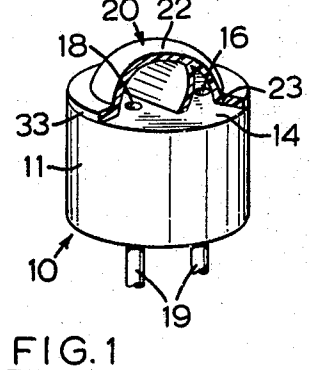


FIG. 1

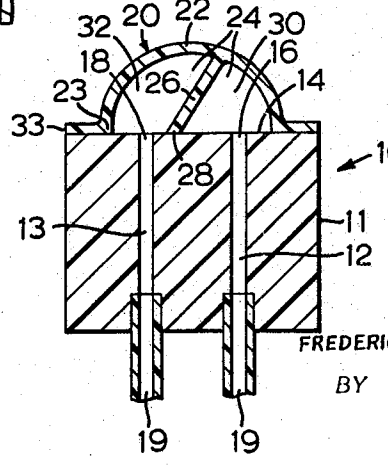


FIG. 2

INVENTOR.
FREDERICK HAROLD HUMPHREY
BY
PATENT AGENT

Dec. 30, 1969 F. H. HUMPHREY 3,486,663

ELASTOMERIC PUMP AND CHECK-VALVE

Filed July 17, 1968 2 Sheets-Sheet 2

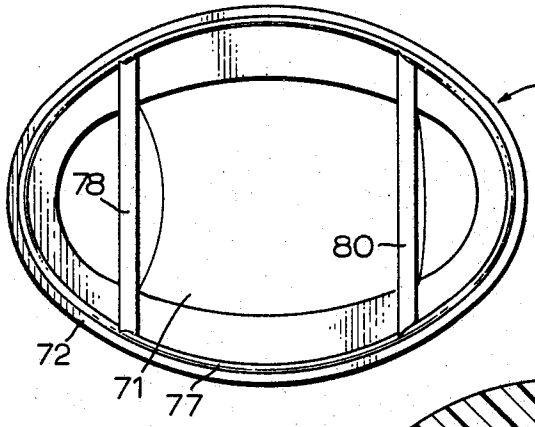


FIG. 8

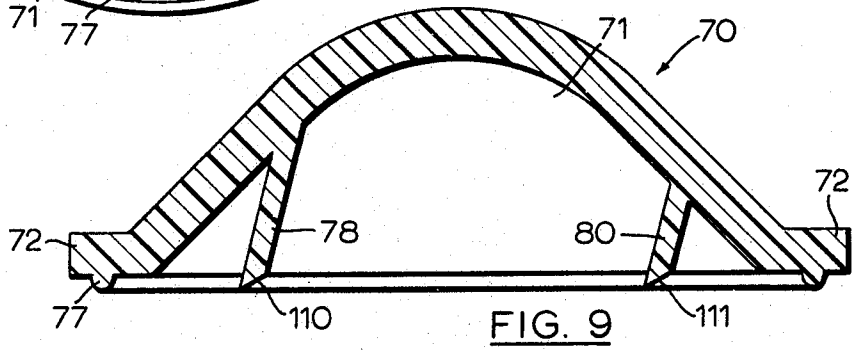


FIG. 9

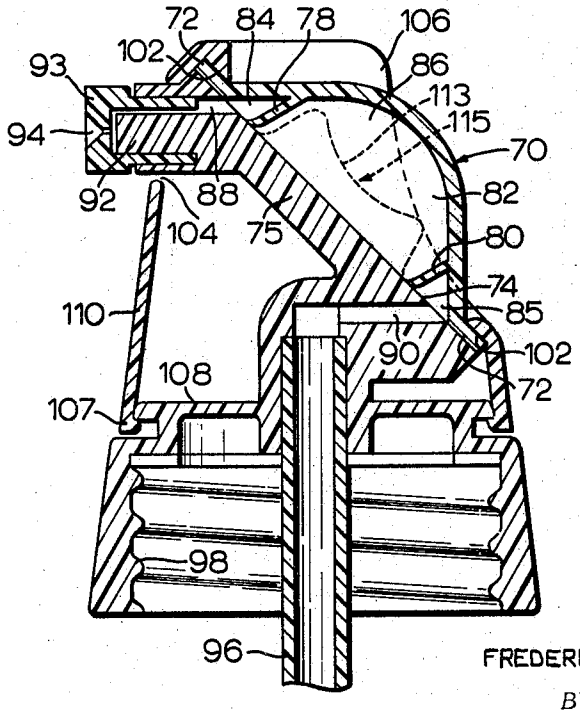


FIG. 10

INVENTOR.
FREDERICK HAROLD HUMPHREY
BY

Agent

United States Patent Office 3,486,663 Patented Dec. 30, 1969

3,486,663

ELASTOMERIC PUMP AND CHECK-VALVE

Frederick Harold Humphrey, 7 Orchard St., Markham, Ontario, Canada

Continuation-in-part of application Ser. No. 683,731, Nov. 16, 1967. This application July 17, 1968, Ser. No. 764,685

Int. Cl. B65d *37/00*; F04b *43/02*

U.S. Cl. 222—207 36 Claims

ABSTRACT OF THE DISCLOSURE

A pump or check-valve consisting of an elastomeric member having a recessed portion adapted for sealing engagement with a supporting surface to define therewith a closed chamber. The supporting surface has two ports opening into the chamber, and the elastomeric member has one or two partitions dividing the chamber into two or three compartments, each of two of which communicates with one of the ports. The partition or partitions are in sloping relation to the surface.

This invention relates generally to check-valves and pumps, and has to do specifically with integrally moulded items intended for use with supporting surfaces to form there with either a check-valve or a pump which is at the same time a check-valve.

This application is a continuation-in-part of U.S. patent application Ser. No. 683,731, "Elastomeric Pump and Check-valve," F. Harold Humphrey, filed Nov. 16, 1967, now abandoned.

Many liquids, such as window sprays, can presently be purchased on the market in containers which are equipped with a small pumping device adapted to dispense the liquid in small quantities in the form of a spray or a jet. Most such pumping mechanisms involve the use of one-way ball valves, springs, sliding pistons, sealing elements, etc., and suffer from some or all of the following disadvantages.

The first disadvantage of conventional pumping mechanisms is an economic one. Because of the large number of parts that are required for the pumping mechanism, they are comparatively expensive to manufacture.

A disadvantage of those conventional pumping mechanisms which involve a rectilinearly reciprocable piston is the fact that the user must depress the plunger along a given direction. Any lateral pressure could cause binding. For this reason, some spray mechanisms of this type are awkward to use.

All of the conventional pumping mechanisms in which the valve openings are defined by rigid material, such that the cross-sectional area of the open valve is unchangeable, are susceptible of being clogged by solid particles that find their way into the pumping mechanism.

Many of the conventional pump mechanisms include parts which are made from materials, often metals, which are susceptible to corrosion.

Many of the pumping mechanisms of the conventional type are constructed in such a way that it is difficult to gain access to the inner components for cleaning or inspection.

Some of the conventional pumping mechanisms require a particular orientation with respect to the force of gravity in order to function properly.

Certain conventional pumping mechanisms are capable of pumping liquids, but not gases.

In view of the above disadvantages of the conventional pumping mechanisms currently available, it is an object of this invention to provide an inexpensive pressure-operated pump consisting of a single, intergrally-moulded

item adapted to cooperate with a supporting surface, thereby appreciably reducing the number of pump components and effecting a cost saving.

It is a further object of this invention to provide a pressure-operated pump, in which the application of pressure to operate the pump is not restricted to a single direction.

Yet a further object of this invention is to provide a pressure-operated pump in which the risk of clogging by solid particles is substantially reduced, and in which most instances of valve blockage by foreign material can be overcome by an increase in operating pressure.

It is a further object of this invention to provide a pressure-operated pump of which the parts can be constructed of material which resists corrosion by the media being pumped.

It is a further object of this invention to provide a pressure-operated pump design which is suitable for pumping any kind of fluid, either liquid or gaseous.

It is a further object of this invention to provide a pressure-operated pump design in which considerable size versatility and design latitude are achieved, in order to permit miniaturization or very large designs while maintaining leak-free characteristics.

Yet another object of this invention is to provide a pressure-operated pump which can be designed for easy opening to permit cleaning or inspection access to the valve surfaces.

A further object of this invention is to provide a pressure-operated pump which can function in any position relative to the force of gravity.

Yet a further object of this invention is to provide an entirely glandless construction for a pressure-operated pump.

Although the pressure-operated pump of this invention also is capable of functioning as a check-valve, it is a separate object of this invention to provide a check-valve construction alone, which is not capable of acting as a pressure-operated pump. All but the second of the objects listed above for the pressure-operated pump apply equally well, mutatis mutandis, to the check-valve construction.

The pump and check-valve of this invention are capable of use with either liquids or gases, with substantially leak-free characteristics, and for this reason the term "fluid" will be generally used in the remainder of this specification to describe the medium passing through the pump or check-valve.

Although the pump of this invention is particularly suitable for dispensing small quantities of fluid, its use is not restricted to small applications. It will be apparent from the description that follows that the pump of this invention can be built to any size requirement, limited only by the physical characteristics of the material from which the pump is made.

In view of the above objects, this invention provides a check-valve comprising: a base member having a surface through which two ports open, and an integral elastomeric member which includes a recessed portion having a peripheral rim seated against said surface to define therewith a closed chamber communicating with said two ports, a partition in said recessed portion and integral therewith, said partition having an edge resting resiliently against the surface of said base member between said ports, thereby dividing said chamber into two compartments, each communicating with one port, said partition being in sloping relationship with every line which is (a) tangent to said surface where the latter contacts said edge, and (b) normal to said edge.

This invention further provides an integral elastomeric member for use in combination with a base member having a surface through which two ports open, the elas-

tomeric member comprising: a recessed portion having a peripheral rim adapted to seal said recessed portion against said surface to define therewith a closed chamber communicating with said two ports, said recessed portion having a first partition and a second partition, each partition having an edge adapted to rest resiliently against the surface of said base member between said ports, thereby to divide said chamber into: a first compartment containing one port and defined by said first partition, a second compartment containing the other port and defined by said second partition, and a third compartment defined between said first partition and said second partition, said first partition defining an acute angle with every line in said third compartment which is (a) tangent to said surface where the latter contact the edge of the first partition, and (b) normal to the edge of the first partition, said second partition defining an acute angle with every line in said second compartment which is (a) tangent to said surface where the latter contacts the edge of the second partition, and (b) normal to the edge of the second partition.

Four embodiments of this invention are shown in the accompanying drawings, in which like numerals denote like parts throughout the several views, and in which:

FIGURE 1 is a perspective view of a check-valve incorporating the first embodiment of this invention;

FIGURE 2 is an axial sectional view of the check-valve of FIGURE 1;

FIGURE 3 is a perspective view of a pump incorporating the second embodiment of this invention;

FIGURE 4 is a sectional view of the pump of FIGURE 3;

FIGURES 5 and 6 are sectional views similar to FIGURE 4, showing two phases in the operation of the pump;

FIGURE 7 is a perspective view, from underneath, of a pump incorporating the third embodiment of this invention;

FIGURE 8 is a view from beneath of a fourth embodiment of this invention;

FIGURE 9 is a vertical, longitudinal sectional view of the fourth embodiment; and

FIGURE 10 is a vertical sectional view of a container cap assembly incorporating the fourth embodiment of this invention.

Turning first to FIGURES 1 and 2, a check-valve indicated generally at **10** consists of a cylindrical base **11** having an inlet passage **12** and an outlet passage **13**, both parallel with the axis of the cylindrical base **11**. The upper surface **14** of the cylindrical base **11** thus has two ports, a first port **16** communicating with the inlet passage **12**, and a second port **18** communicating with the outlet passage **13**. Tubes **19** can be provided for passages **12** and **13** as shown.

An integral elastomeric member **20** includes a recessed portion **22** having a peripheral rim **23** which seals the recessed portion **22** against the surface **14** to define therewith a closed chamber **24** communicating with the two ports **16** and **18**. The recessed portion **22** has a partition **26** of which the edge **28** is adapted to rest resiliently against the surface **14** between the two ports **16** and **18**, thereby to divide the chamber **24** into two compartments, a first compartment **30** communicating with the port **16**, and a second compartment **32** communicating with the port **18**. It will be observed that the partition **26** is substantially planar, and is in sloping relation to the surface **14**.

It should be noted here that it is not essential that the surface **14** be flat. To begin with, the contour of the surface **14** is only important in the immediate area where it contacts the edge **28** of the partition **26**. The contour of the surface **14** within the two compartments **30** and **32** has no effect on the function of the check-valve **10**. However, should the surface **14** adjacent the edge **28** be other than a plane surface, proper functioning of the check-valve requires that the partition be in sloping relationship with every line which is (a) tangent to the surface **14** where the latter contacts the edge **28**, and (b) normal to the edge **28**. To state this criterion another way, all dihedral angles between the partition **26** and the hypothetical surface which is tangent to the surface **14** along the line of contact between the partition **26** and the surface **14** must be acute on one side of the partition.

Although the partition **26** shown in FIGURES 1 and 2 is substantially planar, this is not essential to the proper functioning of the check-valve. Some departure from the planar characteristic is permissible without impeding function, and it will be shown presently in connection with the pump embodiment that a particular curvature in the partition may have special advantages.

It will be seen that an integral outward flange **33** extends from the peripheral rim **23**, the outer diameter of the flange **33** being the same as the diameter of the cylindrical base **11**. The flange **33**, although not essential to this invention, is useful for the securing of the elastomeric member **20** to the surface **14**, as for example by means of glue.

The term "elastomeric" used throughout this specification, is intended to include polymeric substances which exhibit suitable elastic resilience, and thus covers within its ambit natural and synthetic rubbers, and a large number of plastic materials having elastic properties. From the wide field of suitable elastomers, the following materials have been tested and found satisfactory as the material forming the integral elastomeric member for all four embodiments of this invention:

Plasticized PVC
Ethyl vinyl acetate
Styrene-butadiene rubber
Butyl rubber
Natural rubber
Silicone rubber

The choice of a material for any given application would of course be governed by economic considerations, as well as by the performance criteria of the particular application and the solvent characteristics of the fluid being valved or pumped.

As can best be seen in FIGURE 2, the elastomeric member **20** cooperates with the surface **14** to form a check-valve between the ports **16** and **18**. Fluid can flow in the direction from port **16** to port **18**, but cannot flow in the reverse direction. The reason for this is the slope of the partition **26**. If the fluid pressure in compartment **30** rises above that in compartment **32**, the fluid pressure will be exerted perpendicularly to the partition **26**, and this pressure will be so directed as to lift the lower edge of the partition **26** upwardly away from the surface **14**, thereby allowing the fluid to pass from compartment **30** into compartment **32** beneath the edge **28**. If, however, the fluid pressure in compartment **32** exceeds the fluid pressure in compartment **30**, the resulting pressure acting perpendicularly against the partition **26** will urge the latter downwardly, and as a result the edge **28** will be pushed more firmly against the surface **14**, thereby preventing transference of fluid from the compartment **32** to the compartment **30**.

Although in the embodiment shown in FIGURES 1 and 2 the recessed portion **22** is substantially hemispherical, it will be appreciated that the proper functioning of the check-valve is not dependent upon a hemispherical shape, provided the outer wall is thick enough to resist "ballooning" deformation caused by high fluid pressure in compartment **32**. With this proviso, the recessed portion **22** could have an elliptical or rectangular horizontal section, a rectangular vertical section, etc. However, if the hemisphere walls are thin enough to be deformed by fluid pressure, any shape other than a substantially hemispherical one may tend to deform in the direction of a hemisphere under high fluid pressure, due to the "ballooning" effect. This deformation could have the result

of lifting the partition **26** upwardly away from the surface **14**, thereby breaking the back-pressure seal.

Attention is now directed to FIGURE 3, which shows a pump attachment **36** for use with a container **37**. The pump attachment **36** includes a base member **38** which has a threaded female coupling **40** for engagement with the neck **42** of the container **37**. The base member **38** extends upwardly at an angle from the coupling **40**, and the upwardly extending portion will hereinafter be called a tabular member **43**. In the embodiment shown, the tabular member **43** has an upper, flat, oblique surface **44** from which an aperture **45** extends through the tabular member **43**. The base member also has a passage **46** communicating the surface **44** with the interior of the coupling **40**. A tube **48** communicates with the passage **46** and extends downwardly therefrom into the container **37**.

An integral elastomeric member **50** is provided, having a recessed portion **51** in sealed engagement with the surface **44** to define therewith a closed chamber communicating with the aperture **45** and the passage **46**.

As best seen in FIGURE 4, the recessed portion **51** contains two partitions **53** and **54** which divide the chamber defined by the recessed portion **51** into a first compartment **56** communicating with the aperture **45**, a second compartment **58** communicating with the passage **46**, and a third compartment **60** between the partitions **53** and **54** and intermediate the first and second compartments **56** and **58**. Each partition **53** and **54** has an edge **61** and **62**, respectively, adapted to rest resiliently against the surface **44**. Both partitions **53** and **54** slope in the same direction with respect to the surface **44**, the slope being such that the surface **44** within the first compartment **56** defines an obtuse angle **64** with the partition **53** defining the first compartment **56**. The partitions **53** and **54** shown in FIGURES 3, 4, 5 and 6 are substantially flat partitions.

The third compartment **60** has an upwardly protruding bubble **66**, the purpose of which will now be explained with reference to FIGURES 5 and 6.

FIGURES 5 and 6 show two phases of the pumping action of the pump **36** when the latter is used with liquid. It will be appreciated from what follows that the pump shown in FIGURES 3–6 is also useful for pumping gases. In FIGURE 5 it is assumed that liquid has already been drawn up into the second compartment **58**, but that it has not yet entered the third compartment **60**. In FIGURE 5, inward pressure has been applied to the bubble **66** as shown by the arrow. As a result, the bubble **66** is inverted into the third compartment **60**, thereby decreasing the volume of the latter, and increasing the pressure of the air contained in the compartment. The increased air pressure in compartment **60** urges the edge **62** of the partition **54** tightly against the surface **44**, and causes the edge **61** of the partition **53** to be raised away from the surface **44**, permitting air to pass from the compartment **60** into the compartment **56**, and thence out the aperture **45**. When inward pressure on the bubble **66** is released, it returns to its outward position as shown by the arrow in FIGURE 6. The outward movement of the bubble **66** causes the volume of the compartment **60** to increase, thereby lowering the pressure in compartment **60** with respect to the compartments **56** and **58**, and this causes the edge **62** of the partition **54** to be raised away from the surface **44** to allow liquid to pass from compartment **58** into compartment **60**, and causes the edge **61** of the partition **53** to be urged firmly against the surface **44**.

It will now be obvious that the next succeeding inward stroke on the bubble **66** will close partition **54** and open partition **53**, with substantially the same quantity of liquid remaining in the third compartment **60** as is shown in FIGURE 6. Release of inward pressure on the bubble **66** will then cause the partition **53** to close and the partition **54** to open and permit more liquid to pass from the second compartment **58** into the third compartment **60**. This process continues until the third compartment **60** is full, whereupon liquid will be pumped into the first compartment **56** and thence out the aperture **45**

Attention is now directed to FIGURE 7, in which is illustrated the third embodiment of this invention, incorporating a different shape for partitions **53** and **54**. The partitions **53** and **54** in FIGURE 7 are sloped to the same degree as those in FIGURE 3, but instead of being substantially flat, they are curved, preferably in a substantially cylindrical shape. Put more specifically, the intersections between the partitions in FIGURE 7 and hypothetical planes normal to the surface **44** and parallel with the long dimension of the elastomeric member **50** are sloped and substantially rectilinear, while the intersections between the partitions and hypothetical planes parallel with the surface **44** are curved, the centres of curvature of the last-mentioned intersections lying on the same side of each partition as the compartment in which the angle between that partition and the surface **44** is obtuse.

The reason for the curved shape of the partitions shown in FIGURE 7 is as follows. When the partitions are planar, the passage of fluid therebeneath requires that the partitions be stretched as well as flexed, since the partitions are integral with the sides of the recessed portion **51**, and the lower edges of the latter are secured to the surface **44**. By curving the partitions in the manner shown in FIGURE 7, however, passage of fluid from one compartment to another beneath a partition requires only flexing of the partition. The flexed shape of a curved partition is shown in partition **53** in FIGURE 7. It will be observed that the central portion of the partition adjacent the edge is, in a sense, inverted, allowing the edge to be displaced a considerable distance from the surface **44** without the restraint which would arise from stretching if the partition were planar as in FIGURE 3.

It will be appreciated that a curved partition could also be used in the check-valve of FIGURES 1 and 2, with the same advantage.

It should be emphasized, in connection with the second and third embodiments of this invention, that the bubble **66** is not essential to the operation of the pump. The pump shown in FIGURES 3–6 would work if the integral elastomeric member **51** had a constant cross-sectional profile without the bubble **66**, provided that inward pressure above the compartment **60** would cause the volume of the latter to decrease. Provision of the bubble, however, permits a considerable volume change in compartment **60**, and therefore permits a greater pumping rate.

Although in the second and third embodiments of this invention, shown in FIGURES 3–7, it is preferred that the surface **44** be substantially flat, this is not an essential characteristic of the invention. Firstly, the contour of the surface **44** is only important in the immediate area where it contacts the edges **61** and **62** of the partitions **53** and **54**. Secondly, the contour in these immediate areas may depart from a plane to some extent without disrupting the function of the pump. For example, the surface **44** may be spherical or cylindrical, concave or convex, in the immediate areas where it contacts the edges **61** and **62**. The contour of the surface **44** within compartments **56**, **58** and **60** has no effect on the operation of the partitions **53** and **54**. Regardless of whether the surface **44** in the areas immediately adjacent the edges **61** and **62** is a plane surface or a curved surface, it is considered that the proper functioning of the pump shown in FIGURES 3–7 requires that the first partition **53** define an acute angle with every line in the third compartment **60** which is (a) tangent to the surface **44** where the latter contacts the edge **61** of the first partition **53**, and (b) normal to the edge **61** of the first partition **53**, and also requires that the second partition **54** define an acute angle with every line in the second compartment **58** which is (a) tangent to the surface **44** where the latter contacts the edge **62** of the second partition **54**, and (b) normal to the edge **62** of the second par-

tition **54**. This criterion can be stated another way, as it was above with reference to the check-valve **10** shown in FIGURES 1 and 2: all dihedral angles between each partion and the hypothetical surface which is tangent to the surface **44** along the line of contact between the particular partition and the surface **44** must be acute on one side of the partition.

FIGURES 8, 9 and 10 show the fourth embodiment of this invention, which differs in minor ways from the second embodiment shown in FIGURES 3–6. FIGURE 9 is a sectional view, while FIGURE 8 is a view from underneath, of an elastomeric member **70** which is roughly eliptical in plan, and humped, or blister-like, in profile and in vertical section. As in the other embodiments, a recessed portion **71** has a peripheral rim **72** which is adapted to seal the recessed portion **71** against a surface **74** of a tabular member **75** (FIGURE 10). To improve the seal between the rim **72** and the surface **74**, an integral bead **77** protrudes from the lower surface of the rim **72** as best seen in FIGURE 9. A first partition **78** and a second partition **80** are provided to fill the same functions as their counterparts **53** and **54** in the second embodiment shown in FIGURES 3–6. Looking at FIGURE 10, the closed chamber **82** defined between the surface **74** and the recessed portion **70** is divided by the partitions **78** and **80** into a first compartment **84**, a second compartment **85**, and a third compartment **86**. The tabular member **75** has a first port **88** adapted to open into the first compartment **84**, and a second port **90** adapted to open into the second compartment **85**. The tabular member **75** has a protruding portion **92** upon which is fitted a nozzle cap **93** having a nozzle **94**. The nozzle **94** communicates with the port **88** as shown in FIGURE 10. The port **90** communicates with a vertical tube **96** adapted to extend downwardly into a container having a threaded neck to which a screw-cap **98** can be screwed. The screw-cap **98** is integral with the tabular member **75**.

A frusto-conical cap **100** is adapted to fit tightly over the entire assembly and has ledge surfaces **102** adapted to urge the rim **72** of the elastomeric member **70** against the surface **74**. The cap **100** also has an opening **104** to allow passage therethrough of the protruding portion **92** of the tabular member **75**, and a roughly circular opening **106** through which a portion of the elastomeric member **70** protrudes, as shown in FIGURE 10. Around the base of the cap **100** is a rim **107** which is adapted for a snap-fit around the periphery of an integral disc-like, horizontal plate portion **108** forming a part of the tabular member **75**.

The major differences between the second embodiment and the fourth embodiment of this invention are as follows. Firstly, the partitions **78** and **80** define a large acute angle with the surface **74**. Trials have shown that, provided the angle between a given partition and the surface remains acute, the actual value of the angle can be varied within wide limits. Secondly, the lower edges **110** and **111** of the partitions **78** and **80** respectively have a slope of approximately 30° in the same direction as the slope of each partition **78** and **80** (FIGURE 9). The knife-edge seal thereby obtained between each partition and the surface **74** is believed to improve the efficiency and the resistance to leakage of the fourth embodiment. It will be noted in FIGURE 9 that the sloping bottom edges **110** and **111** of the partitions extend downwardly a distance equal to the depth of the bead **77**. When the elastomeric member **70** is clamped in position as shown in FIGURE 10, the bead **77** is flattened to some degree and compressed upwardly into the material of the rim **72**, which is why the bead **77** is not visible in FIGURE 10. Because of the upward compression of the bead **77**, the lower edges **110** and **111** of the partitions **78** and **80** are urged positively against the surface **74**, resulting in the slight curvature at the edges which is visible in FIGURE 10. The first and second differences detailed above can also be incorporated into the check-valve taught by this invention. Also, the check-valve could be provided with a bead similar to the bead **77** in FIGURE 9, and for the same purpose. Lastely, an optional variation is shown in FIGURE 10, whereby the surface of the tabular member **75** is designed in such a way that it extends upwardly into the third compartment **86**, as shown by the dotted-line profile **133** in FIGURE 10. The profile **113** has a concave or dished central portion **115** which conforms approximately to the shape of the inverted wall of the elastomeric member **70** when thumb or finger pressure has been applied from the outside. The reason for the provision of the upstanding profile **113** is to avoid the necessity of repeated pumping depressions of the elastomeric member **70** in order to fill the third compartment **86** and begin spraying the liquid. By providing the concavity **115**, the pumping contour is not disturbed, and a volume reduction in the third compartment **86** can be achieved.

It was found that satisfactory pumping operation was obtained with a blister-like elastomeric member shaped as shown in FIGURES 8, 9 and 10, and made from ethyl vinyl acetate. The dimensions of the tested elastomeric member were as follows:

Total length along major axis, including rim	inches	1.14
Total width along minor axis, including rim	do	.820
Thickness of partitions	do	0.030
Thickness of main "blister" wall	do	0.060
Depth of bead **77**	do	.020
Width of top surface of rim **72**	do	.100
Thickness of rim **72**	do	.060
Acute angle between partitions and surfaces	deg	75
Acute angle between bottom edges **110** and **111** and the surface	deg	30

The advantages of a construction wherein each partition defines a large as opposed to a small acute angle with the surface are (a) the conservation of longitudinal space required for the partition and for the entire elastomeric member, and (b) the obvious case of moulding. When the acute angle is small, the partition is more difficult to mould, but there is the advantage of requiring a smaller pressure differential to open the partition to permit fluid to flow. By the same token, a smaller acute angle provides a tighter seal against back-pressure, and permits a larger opening cross-section for a given material deflection as compared to a larger acute angle.

With regard to the thickness of the partition, it will be obvious that the less the thickness, the less stiff is the partition, hence a smaller presure differential is required to open the partition. Also, by reducing the thickness of the partitions, an economy of material is effected. If the partitions are made thicker, a larger pressure difference is required to activate or open them. Thicker partitions can be of adavntage in applications where it is desired completely to eliminate trickling in either direction when the partition is intended to be closed. The provision of thicker, more rigid partitions permits constructions wherein a "threshold" opening pressure differential is required. In other words, the pressure differential in the forward or "opening" direction must rise above a certain minimum or "threshold" pressure before the partition will be lifted away from the surface to permit fluid to flow.

It should also be pointed out that it is advantageous to locate the partitions as far as possible away from the location where pressure is to be applied to the outside wall of the third or central compartment. If the partition is integral with the outside wall at a location too close to the point of pressure application, there is a risk that the partition will be distorted and possibly be raised away from the surface when it should not be.

It will be appreciated to those skilled in the art to which this invention pertains that it is not essential for

the two partitions of the pump embodiments to be either identical or parallel. Firstly, the acute angles defined between each partition and the surface need not be identical for the two partitions. Secondly, it is possible for the two partitions to have different contours: for example, one could be curved as in FIGURE 7, and the other could be flat as in FIGURE 3. Thirdly, the lines along which the bottom edges of the partitions contact the surface need not be parallel or congruent. For example, the lines of contact for the edges of two flat partitions could be angled to one another, e.g. at right angles.

While preferred embodiments of this invention have been disclosed herein, those skilled in the art will appreciate that changes and modifications may be made therein without departing from the spirit and scope of this invention.

What I claim as my invention is:

1. A fluid-handling device including a check-valve comprising:

a base member having a surface through which two ports open,

and an integral elastomeric member which includes a recessed portion having a peripheral rim seated against said surface to define therewith a closed chamber communicating with said two ports,

a partition in said recessed portion and integral therewith, said partition having an edge resting resiliently across and against the surface of said base member between said ports, thereby dividing said chamber into a first compartment and a second compartment, each compartment communicating with one port, said partition defining an acute angle with every line in said second compartment which is (a) tangent to said surface where the latter contacts said edge, and (b) normal to said edge, said partition being attached throughout its periphery except said edge to the elastomeric member, whereby the inherent resistance to stretching in the material of the partition will cause the edge to resist being moved toward said second compartment.

2. A fluid-handling device as claimed in claim **1**, in which the partition is substantially planar.

3. A fluid-handling device as claimed in claim **1**, in which said peripheral rim has an integral outward flange by which the elastomeric member is secured against said base member.

4. A fluid-handling device as claimed in claim **1**, in which the recessed portion is substantially hemispherical.

5. A fluid-handling device is claimed in claim **1**, in which the surface of said base member is a substantially flat surface.

6. A fluid-handling device as claimed in claim **5**, in which the partition is substantially planar.

7. A fluid-handling device as claimed in claim **1**, in which the partition is curved away from the compartment in which said sloping relationship is acute, the curvature being in planes parallel to said surface.

8. A fluid-handling device as claimed in claim **5**, in which the hypothetical intersections between the partition and hypothetical planes parallel with said surface are curved, the centres of curvature of said intersections lying on the same side of said partition as the compartment in which the angle between the partition and said surface is obtuse.

9. A fluid-handling device as claimed in claim **1**, in which the edge of said partition is sloped in the same direction as the partition itself, thereby to provide a knife-edge seal between the two compartments.

10. A fluid-handling device as claimed in claim **3**, in which the outward flange has an integral bead protruding downwardly from beneath the flange.

11. An integral elastomeric member for use in combination with a base member having a surface through which two ports open, the elastomeric member comprising:

a recessed portion having a peripheral rim adapted to seal said recessed portion against said surface to define therewith a closed chamber communicating with said two ports,

said recessed portion having a partition which has an edge adapted to rest resiliently across and against the surface of the base member between the ports, thereby to divide said chamber into a first compartment and a second compartment, each compartment communicating with one port, said partition defining an acute angle with every line in said second compartment which is (a) tangent to said surface where the latter contacts said edge, and (b) normal to said edge, said partition being attached throughout its periphery except said edge to the elastomeric member, whereby the inherent resistance to stretching in the material of the partition will cause the edge to resist being moved toward said second compartment.

12. An integral elastomeric member as claimed in claim **11**, in which the partition is substantially planar.

13. An integral elastomeric member for use in combination with a base member having a surface through which two ports open, the elastomeric member comprising:

a recessed portion having a peripheral rim adapted to seal said recessed portion against said surface to define therewith a closed chamber communicating with said two ports;

said recessed portion having a first partition and a second partition; each partition having an edge adapted to rest resiliently across and against the surface of said base member between said ports, thereby to divide said chamber into: a first compartment containing one port and defined by said first partition, a second compartment containing the other port and defined by said second partition, and a third compartment defined between said first partition and said second partition said first partition defining an acute angle with every line in said third compartment which is (a) tangent to said surface where the latter contacts the edge of the first partition, and (b) normal to the edge of the first partition; said second partition defining an acute angle with every line in said second compartment which is (a) tangent to said surface where the latter contacts the edge of the second partition, and (b) normal to the edge of the second partition, each partition being attached throughout its periphery except its edge to the elastomeric member, whereby the inherent resistance to stretching in the material of the partitions will cause each edge to resist being moved toward the compartment in which its respective partition defines an acute angle with the surface.

14. An integral elastomeric member as claimed in claim **13**, in which the edges of said first and second partitions are parallel straight lines.

15. An integral elastomeric member as claimed in claim **13**, in which said first and second partitions are in parallel planes.

16. An integral elastomeric member as claimed in claim **13**, in which the edges of said first and second partitions are congruent curvilinear lines.

17. An integral elastomeric member as claimed in claim **13**, in which said surface is a substantially flat surface, and in which said first and second partitions are in parallel planes.

18. An integral elastomeric member as claimed in claim **13**, in which the first partition is curved away from said third compartment and in which the second partition is curved away from said second compartment.

19. An integral elastomeric member as claimed in claim **13**, in which said surface is a substantially flat surface, and in which the hypothetical intersections between each partition and hypothetical planes parallel with said surface are curved, the centres of curvature of the intersections

for the first partition lying on the same side of the first partition as the first compartment, the centres of curvature of the intersections for the second partition lying on the same side of the second partition as the third compartment.

20. An integral elastomeric member as claimed in claim **13**, in which said peripheral rim has an integral outward flange by which the elastomeric member is secured against said base member.

21. An integral elastomeric member as claimed in claim **20**, in which said outward flange has an integral bead protruding downwardly from beneath the flange.

22. An integral elastomeric member as claimed in claim **13**, in which the edges of said partitions are sloped in the same direction as the partitions themselves, thereby to provide knife-edge seals between adjacent compartments.

23. An integral elastomeric member as claimed in claim **13**, in which the first-mentioned acute angle and the second-mentioned acute angle are each substantially 75°.

24. An integral elastomeric member as claimed in claim **1**, in which the elastomeric member is made of a material chosen from the group: plasticized PVC, ethyl vinyl acetate, styrenebutadiene rubber, butyl rubber, natural rubber, and silicone rubber.

25. An integral elastomeric member as claimed in claim **6**, in which the elastomeric member is made of a material chosen from the group: plasticized PVC, ethyl vinyl acetate, styrene-butadiene rubber, butyl rubber, natural rubber, and silicone rubber.

26. An integral elastomeric member as claimed in claim **9**, in which the elastomeric member is made of a material chosen from the group: plasticized PVC, ethyl vinyl acetate, styrene-butadiene rubber, butyl rubber, natural rubber, and silicone rubber.

27. An integral elastomeric member as claimed in claim **13**, in which the elastomeric member is made of a material chosen from the group: plasticized PVC, ethyl vinyl acetate, styrene-butadiene rubber, butyl rubber, natural rubber, and silicone rubber.

28. An integral elastomeric member as claimed in claim **18**, in which the elastomeric member is made of a material chosen from the group: plasticized PVC, ethyl vinyl acetate, styrene-butadiene rubber, butyl rubber, natural rubber, and silicone rubber.

29. An integral elastomeric member as claimed in claim **19**, in which the elastomeric member is made of a material chosen from the group: plasticized PVC, ethyl vinyl acetate, styrene-butadiene rubber, butyl rubber, natural rubber, and silicone rubber.

30. An integral elastomeric member as claimed in claim **13**, in which both partitions are planar, and in which the acute angle for each partition is substantially 75°.

31. For use with a container having an open top, a finger pump comprising:

a base member having a coupling for engagement with the open top of the container, and a tabular member extending from said coupling, the tabular member having a surface through which open a first port and a second port, a first passage communicating said first port with a nozzle, a second passage communicating said second port with a nozzle, a second passage communicating said second port with a tube adapted to extend into said container;

and an integral elastomeric member having a recessed portion which has a peripheral rim in sealed engagement with said surface to define therewith a closed chamber communicating with said first and said second port;

said recessed portion having a first partition and a second partition; each partition having an edge adapted to rest resiliently across and against said surface between said ports, thereby to divide said chamber into: a first compartment containing one port and defined by said first partition, a second compartment containing the other port and defined by said second partition, and a third compartment defined between said first partition and said second partition; said first partition defining an acute angle with every line in said third compartment which is (a) tangent to said surface where the latter contacts the edge of the first partition, and (b) normal to the edge of the first partition; said second partition defining an acute angle with every line in said second compartment which is (a) tangent to said surface where the latter contacts the edge of the second partition, and (b) normal to the edge of the second partition, each partition being attached throughout its periphery except its edge to the elastomeric member, whereby the inherent resistance to stretching in the material of the partitions will cause each edge to resist being moved toward the compartment in which its respective partition defines an acute angle with the surface.

32. A finger pump as claimed in claim **31**, in which the elastomeric member is made of a material chosen from the group: plasticized PVC, ethyl vinyl acetate, styrene-butadiene rubber, butyl rubber, natural rubber, and silicone rubber.

33. A finger pump as claimed in claim **31**, in which said partitions are in parallel planes.

34. A finger pump as claimed in claim **33**, in which said acute angles are substantially 75°.

35. A finger pump as claimed in claim **31**, in which the said surface protrudes partly into said third compartment, to reduce the volume thereof.

36. A finger pump as claimed in claim **31**, in which said peripheral rim has an integral outward flange by which the elastomeric member is secured against said surface, said outward flange having an integral bead protruding downwardly from beneath the flange.

References Cited

UNITED STATES PATENTS

2,219,604	10/1940	Trotter	222—207
2,715,236	7/1955	Tereno	222—207
3,013,502	12/1961	Fay	103—150 X

ROBERT B. REEVES, Primary Examiner

H. S. LANE, Assistant Examiner

U.S. Cl. X.R.

103—150