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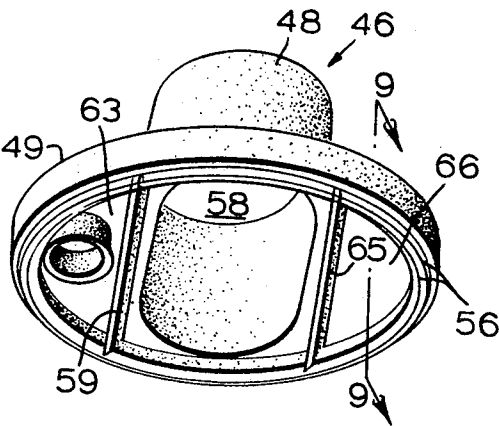
[54] **RESILIENT INTEGRAL BODIES INCORPORATING  
POPPET-VALVES**  
12 Claims, 9 Drawing Figs.

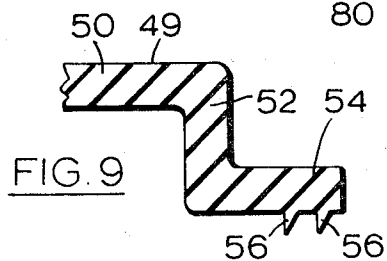
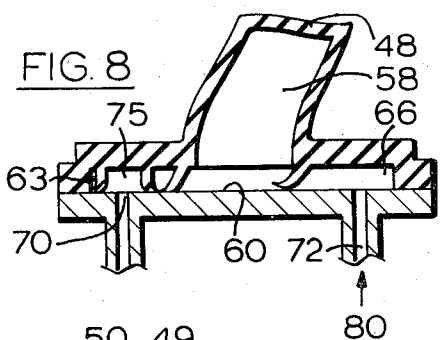
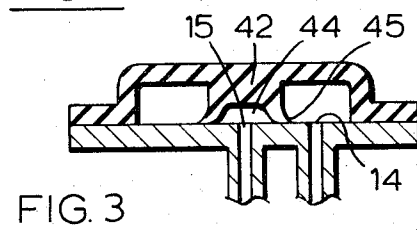
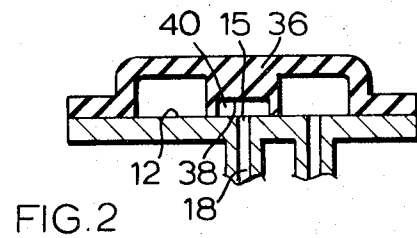
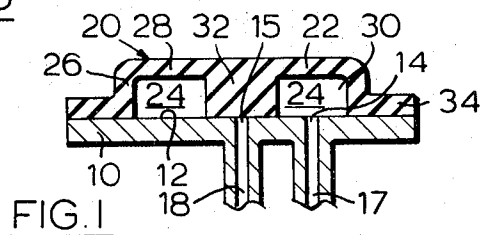
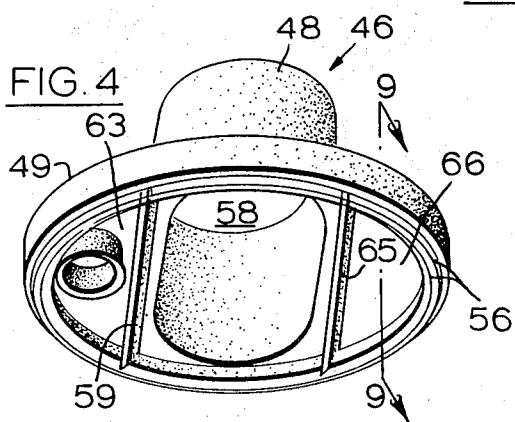
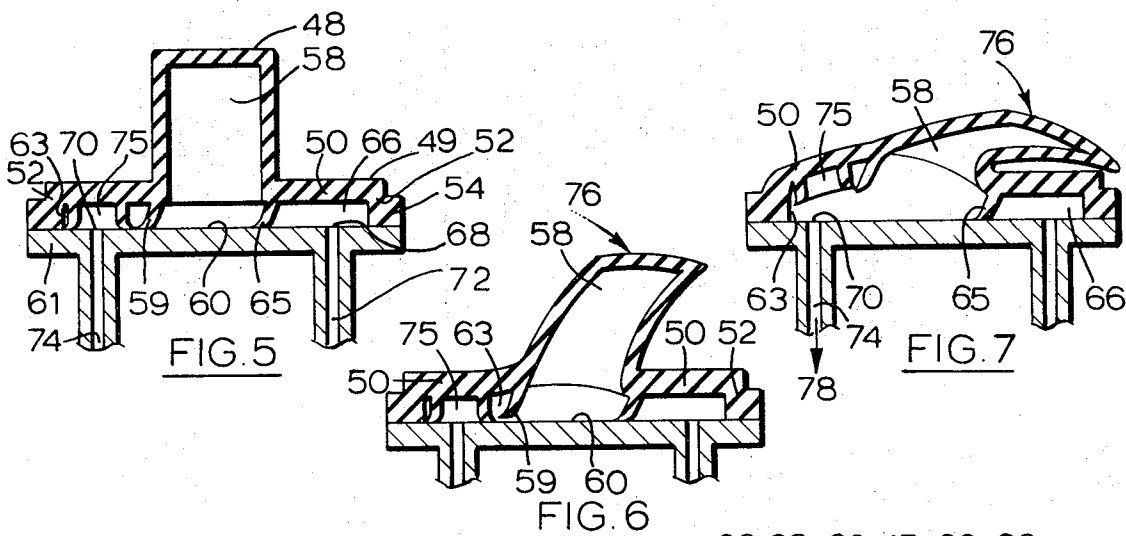
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**ABSTRACT:** The combination of a supporting surface having two ports, and an integral body which includes a recess-defining resilient portion secured against the surface to define therewith a chamber into which the two ports open. A poppet-valve integral with the body extends toward the surface and closes one port with mechanical interference, thereby to establish one pressure threshold above which fluid flows from one port to the other port, and a second pressure threshold above which fluid flows in the opposite direction.





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# RESILIENT INTEGRAL BODIES INCORPORATING POPPET-VALVES

This invention relates to resilient, elastomeric members which incorporate a poppet-valve construction capable of establishing certain pressure thresholds which determine fluid flow.

An object of a particular embodiment of this invention is to provide an elastomeric pump which incorporates a poppet-valve construction in such a way that, on the pumping stroke, the poppet-valve permits fluid to be pumped only after a particular pressure threshold has been surpassed. With such a construction, the poppet-valve pump can be used with liquid dispensers incorporating spray nozzles, with the advantage that the spray characteristic during the pumping stroke is substantially constant. Conventional spraying mechanisms which do not have such a pressure threshold feature often have the disadvantage, overcome by this invention, that the spray pattern deteriorates towards the end of the pumping stroke due to a dropping off of the pressure behind the fluid, often with the result that the spray coalesces at the end of the stroke to form individual droplets which drip from the spray nozzle. The formation of droplets also sometimes occurs at the beginning of the pumping stroke as the pressure gradually builds up.

Accordingly, this invention provides an integral body for use with a supporting surface through which two apertures open, the body comprising: a resilient portion defining a recess having sidewalls and a top wall, the resilient portion being adapted to be placed against the supporting surface such that the recess defines with the supporting surface a main chamber into which the two apertures open, and an integral poppet-valve extending from the top wall toward the supporting surface and being adapted to close one aperture with mechanical interference, whereby the pressure threshold above which fluid flows from said one aperture to the other aperture is at least partly a function of the amount of said mechanical interference, and whereby the pressure threshold above which fluid flows from said other aperture to said one aperture is at least partly a function of the area of the top wall surrounding the poppet-valve.

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:

FIG. 1 is a cross-sectional view through a first embodiment of this invention;

FIG. 2 is a cross-sectional view through a second embodiment of this invention;

FIG. 3 is a cross-sectional view through a third embodiment of this invention;

FIG. 4 is a perspective view, taken from beneath, of a fourth embodiment of this invention; and

FIGS. 5, 6, 7 and 8 are cross-sectional views taken at four stages in the operation of the fourth embodiment; and

FIG. 9 is a section taken at the line 9-9 in FIG. 4.

Turning first to FIG. 1, there is shown a base 10 exhibiting a supporting surface 12 through which a first aperture 14 and a second aperture 15 open. The first and second apertures 14 and 15 communicate with a first and a second tubular passageway 17 and 18 respectively.

Also shown in FIG. 1 is a generally circular integral body 20 which comprises a resilient portion 22 defining a recess 24 having a generally cylindrical sidewall 26 and a generally circular top wall 28. Thus, the recess 24 defines, with the supporting surface 12, a main chamber 30 into which the two apertures 14 and 15 open. An integral rim 34 is provided for securing the resilient portion 22 against the supporting surface 12.

Extending from the center of the top wall 28 toward the supporting surface 12 is an integral poppet-valve 32 which is adapted to close the second aperture 15 with mechanical interference, in such a way as to establish a pressure threshold for the fluid at the aperture 15 above which fluid is permitted to flow from the second aperture 15 to the first aperture 14. Such a pressure threshold for the fluid at the second aperture

15 presupposes that the fluid at the first aperture 14 is atmospheric. If this is not the case, then a more complicated "threshold" condition will have to be exceeded before fluid flow takes place. Suppose that the pressure at aperture 15 is greater than that at aperture 14 but that neither is atmospheric. Then, the resultant force tending to lift the poppet-valve 32 off the aperture 15 will equal the upward force due to the pressure in the main chamber 30 acting upwardly on the top wall 28, plus the upward force due to the fluid pressure in the passageway 18, minus the downward force due to the pressure of the atmosphere on the top wall 28. Given a constant atmospheric pressure and a constant fluid pressure at aperture 14 (even though different from atmospheric), the threshold condition for fluid flow from aperture 15 to aperture 14 can again be given in terms of a pressure at the aperture 15. In the appended claims, the expression "pressure threshold" is intended to embrace both the simple and the complex determination of the threshold conditions discussed immediately above. It will further be appreciated that, regardless of pressure conditions, the "pressure threshold" will always be at least partly a function of (i.e., at least partly depend upon) the amount of the mechanical interference between the poppet-valve 32 and the supporting surface 12.

A further pressure threshold is also established, and this one governs the point at which fluid is permitted to flow from the first aperture 14 to the second aperture 15 when the pressure in the former is greater than that in the latter. Again, the complex expression for this further pressure threshold would be given as the upward force due to the pressure in the main chamber 30 acting upwardly on the top wall 28, plus the upward force due to the fluid pressure in the passageway 18, minus the downward force due to the pressure of the atmosphere on the top wall 28. When the resultant force upwardly is great enough to overcome the mechanical interference between the supporting surface 12 and the poppet-valve 32, the latter will be lifted away from the former, and fluid will flow from the first aperture 14 to the second aperture 15. As with the first threshold condition discussed above, given a constant atmospheric pressure and a constant fluid pressure at the aperture 15 (even though different from atmospheric), the threshold condition for fluid flow from aperture 14 to aperture 15 can be expressed in terms of a pressure at the aperture 14, which determines the pressure acting upwardly against the top wall 28 adjacent the poppet-valve 32.

Thus, this further pressure threshold, above which fluid flows from the aperture 14 to the aperture 15 through the main chamber 30, is at least partly a function of the area of the top wall 28 surrounding the poppet-valve 32 within the main chamber 30, since this area determines the upward force transmitted to the poppet-valve 32.

Of course, the upward force tending to lift the poppet-valve 32 off the supporting surface 12 as a result of the pressure in the main chamber 30 cannot be computed merely by multiplying the pressure within the main chamber 30 by the area of the top wall 28 within the main chamber 30, because the sidewalls 26 are held in position against the supporting surface 12 through the agency of the integral rim 34 which is clamped, glued, welded or otherwise fastened against the base plate 10. Nonetheless, the lifting force on the poppet-valve 32 will be a function of the pressure within the main chamber 30.

Referring now to FIG. 2, it will be seen that the second embodiment differs from the first only in that the poppet-valve 36 has a central recess 38 which defines a subchamber 40 in communication with the second aperture 15. All of the remaining parts of the assembly of FIG. 2 are identical with those in FIG. 1. These parts have not been numbered, in order to avoid cluttering the FIG. with numerals. It will be realized that, with the provision of the subchamber 40, the threshold described first above, i.e. the one governing fluid flow from the aperture 15 to the aperture 14, is at least partly a function of the area of the supporting surface 12 within the subchamber 40, since upward force against the poppet-valve 36 due to the pressure of fluid in the passageway 18 will be equal to the fluid pressure

times the effective area within the subchamber 40, the latter being the same as the area of the supporting surface 12 within the subchamber 40.

In the third embodiment shown in FIG. 3, the poppet-valve 42 has a central recess 44, and is outwardly flared at 45, as shown. The outward flaring tends to increase the suddenness with which the poppet-valve 42 moves from the closed to the open position when the fluid pressure in the aperture 14 is above that in the aperture 15. In most cases, an additional effect of the flare at 45 will likely be to slightly raise the second of the two thresholds discussed above, as well as increasing the suddenness of poppet-valve opening. Again in FIG. 3, the remaining unnumbered portions of the FIG. are identical with the like portions in FIGS. 1 and 2.

Although the integral bodies shown in FIGS. 1, 2 and 3 have been assumed above to be circular in configuration, i.e. radially symmetrical about a central axis, this configuration of course is not essential. The poppet-valve, for example, need not be centrally placed within the main chamber 30, nor does the main chamber 30 itself have to be circular in cross section. It should be pointed out, however, that the position of the integral poppet-valve with respect to the sidewall 26 will have some effect upon the two thresholds described above. For example, if the poppet-valve is immediately adjacent the sidewall 26, it is likely to require a greater pressure differential across the top wall 28 to open the valve, given the same mechanical interference between the valve and the supporting surface 12.

Attention is now directed to FIGS. 4, 5, 6, 7, 8 and 9, all of which depict the fourth embodiment of this invention. The fourth embodiment is essentially a pump which incorporates a poppet-valve such that, on the pumping stroke, the pressure must climb above a particular threshold, determined by the poppet-valve, before fluid actually is expelled through the outlet port.

Looking at FIGS. 4 to 9, an integral body 46 consists essentially of a hollow, upstanding portion 48 and an elliptical surrounding skirt 49. The skirt 49 consists of a top wall 50 and a sidewall 52. At the bottom of the sidewall 52 is an integral peripheral rim 54, which is adapted to be glued, clamped, or otherwise fastened against a supporting surface 60 analogous to the supporting surface 12 shown in FIG. 1. To improve the seal between the rim 54 and the supporting surface 12, the rim 54 is provided with two downwardly protruding circumferential ribs 56 which, as can be seen in FIG. 9, slope inwardly and are adapted to be compressed against the supporting surface so that a "knife-edge" seal can be obtained thereagainst.

Attention is now directed to FIG. 5, which is a vertical sectional view taken on the major axis of the elliptical skirt 49 of the integral body 46. The upstanding hollow portion 48 defines the major part of a compartment 58. A first integral partition 59 extends from the top wall 50 of the skirt 49 toward the supporting surface 60 of a base plate 61. As can be seen in FIG. 4, the integral partition 59 extends across the width of the elliptical skirt 49 and thus, when it is in contact with the supporting surface 60, completely seals off the compartment 58 from a poppet-valve compartment 63 on the other side of the integral partition 59.

A further integral partition 65 extends from the top wall 50 on the other side of the portion 48, and as can be seen in FIG. 4, the further partition 65 also extends across the width of the elliptical skirt 49. The further partition 65 thus divides the compartment 58 from an intake compartment 66 on the side of the partition 65 remote from the compartment 58.

As can be seen in FIG. 5, the base plate 61 has a first port 68 in communication with the intake compartment 66, and a second port 70 in communication with the poppet-valve compartment 63. The ports 68 and 70 communicate with, respectively, tubular passageways 72 and 74.

As can be seen particularly in FIG. 5, both of the partitions 59 and 65 are in sloping relationship with the supporting surface 60, such that they both slope toward the poppet-valve

compartment 63. As shown, the partitions 59 and 65 terminate in a knife-edge which is adapted to rest resiliently against the supporting surface 60, whereby fluid is capable of passing, for example, from compartment 58 into compartment 63 beneath the partition 59 provided that the pressure in the compartment 58 exceeds that in the compartment 63 by a given amount determined by the force with which the partition 59 rests resiliently against the supporting surface 60. Fluid cannot, however, flow from the compartment 63 to the compartment 59 beneath the partition 59 under ordinary circumstances, because the pressure differential across the partition 59 (i.e. an excess of pressure in compartment 63 over that in compartment 58) has the effect of forcing the partition 59 more strongly against the supporting surface 60, and therefore producing an even tighter seal between the two compartments.

In the poppet-valve compartment 63 is a poppet-valve 75 which is essentially the same shape as the poppet-valve 42 shown in FIG. 4. As can be seen in FIG. 5, the poppet-valve 75 has a central recess and flared edges. The central recess in the poppet-valve 75 is in communication with the port 70.

Attention is now directed to FIGS. 6 and 7 which show an intermediate stage and the final stage, respectively, in the pumping stroke. The pumping stroke is carried out by deforming the portion 48 in such a way as to reduce the volume of the compartment 58. Although this deformation can be carried out in several ways, the method shown in the FIGS. is to press downwardly and sidewardly against the top of the portion 48 as shown by the heavy arrows 76 in FIGS. 6 and 7. At the intermediate stage shown in FIG. 6, the volume of the compartment 58 has decreased sufficiently to raise the pressure differential across the partition 59 to the point where the partition 59 is lifted away from the supporting surface 60 and fluid begins to flow into the compartment 63. When the stage shown in FIG. 7 is reached, the volume of the compartment 58 has decreased still further, and the pressure in the compartment 63, now in full communication with the compartment 58, has risen to the point where the resultant force exerted upwardly on the top wall 50 adjacent the poppet-valve 75 is enough to lift the poppet-valve off the port 70. Once the poppet-valve 75 has been lifted away from the port 70, the fluid in the compartment 58 flows outwardly along the tubular passageway 74 as shown by the arrow 78.

During the pumping stroke shown in FIGS. 6 and 7, the pressure differential across the partition 65 is in the direction which forces the edge of the partition 65 more firmly against the supporting surface 60, and therefore no transference of fluid occurs from compartment 58 to compartment 66.

Attention is now directed to FIG. 8, which shows an intermediate stage in the restoration of the portion 48 resiliently to its normal position (which is that shown in FIG. 5). It is to be understood that the portion 48 is restored automatically once the downward pressure (the arrow 76) is removed. As the portion 48 is springing back to its FIG. 5 position, the natural tendency of the poppet-valve 75 will be to close once again over the port 70 and it is shown in this position in FIG. 8. As well, the partition 59 again comes down to rest against the supporting surface 60, and effectively seals the compartment 58 from the compartment 63. The enlargement of the volume of the compartment 58, however, brings about a pressure differential across the partition 65 which acts to raise the partition 65 from the supporting surface 60, and permit fluid to flow into the intake compartment 66 through the tubular passageway 72, and thence into the compartment 58. In other words, the pressure differential arises due to a lowering of the pressure in compartment 58 below that in compartment 66. The arrow 80 shows the ingress of fluid through the tubular passageway 72.

It is to be pointed out that, although the word "fluid" is used above to describe the material pumped, thus including both gas and liquid, the latter is the preferred substance to be pumped, because of the superior seal created along the edges of the partitions 59 and 65. The pump is nevertheless capable of pumping a gas, such as air, although perhaps with less effi-

ciency, and in fact at the beginning of a pumping sequence, with the compartments originally filled with air, it will be necessary to perform several pumping strokes to rid the compartments of air, and to draw through the tubular passageway 72 sufficient liquid to fill up the compartments 58, 63 and 66.

It will further be appreciated that the partition 59 is not strictly necessary for the adequate operation of the pump shown in FIGS. 4 to 7. Because the poppet-valve 75 acts, in effect, like a one-way valve, it will be possible to do away with the partition 59. Partition 59 has been here provided merely for the purpose of increasing the efficiency of the one-way valve provided by the poppet-valve 75.

It will further be appreciated that the precise positioning of the poppet-valve 75 will have some effect on the forces which cause the poppet-valve 75 to lift off the port 70. These forces are two in number: the first of these is the force, described above which arises due to the increased pressure in the compartment 63, and which has the effect of lifting upwardly against the top wall 50 in the compartment 63; the second of these forces relates to the contortion of the resilient material of the integral body 46 itself, caused by the deformation of the portion 48. When the portion 48 is pressed sideways and downwardly as shown in FIGS. 6 and 7, there naturally arises an upward force on the top wall 50 in the compartment 63, and a corresponding downward force against the top wall 50 in the compartment 66. This latter force could be altered, of course, by deforming the portion 48 in a different way. For example, should the portion 48 be pressed straight downwardly toward the supporting surface 60, the forces on the top walls 50 of the compartments 63 and 66 would likely be similar, but would depend on the actual mode of deformation of the walls of the portion 48. It will thus be appreciated that the force tending to lift the poppet-valve 75 can be made less dependent upon a deformation of the portion 58 and more dependent upon a pressure buildup simply by moving the poppet-valve closer to the sidewall 52 and further away from the compartment 58. Also it is possible to isolate the lifting force on the poppet-valve 75 entirely from the forces arising through the deformation of the portion 48 simply by redesigning the shape of the skirt 49 such that the compartment 63 is effectively isolated from the compartment 58, and such that deformation of the portion 48 does not produce any forces of significance in the top wall 50 of the compartment 63.

A number of materials are suitable for manufacturing the integral body 20 of this invention. Generally speaking, most polymeric substances which exhibit suitable elastic resilience, including both natural and synthetic rubbers, would be satisfactory, barring adverse reactions with the fluids passing through the integral body. Specifically, from the wide field of suitable polymeric materials exhibiting elastic resilience, the following have been tested and found satisfactory as the material forming the integral body 20:

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

Naturally, the choice of a material for any given application would be governed not only by the solvent characteristics of the fluid passing through the integral body 20, but also by economic considerations and the performance criteria of the particular application.

I claim:

1. An integral body for use with a supporting surface through which two apertures open, the body comprising:

a resilient portion defining a recess having sidewalls and a top wall, the resilient portion being adapted to be placed against the supporting surface such that the recess defines with the supporting surface a main chamber into which the two apertures open;

and an integral poppet-valve extending from the top wall toward the supporting surface and being adapted to close one aperture with mechanical interference, the poppet-valve being centrally recessed to define a subchamber in communication with said one aperture and being outwardly flared where it contacts the supporting surface, thereby to provide a first pressure threshold above which fluid flows from said one aperture to the other aperture and a second pressure threshold above which fluid flows from said other aperture to said one aperture, said first pressure threshold being at least partly a function of the amount of said mechanical interference and at least partly a function of the area of the supporting surface within said subchamber, said second pressure threshold being at least partly a function of the area of the top wall surrounding the poppet-valve.

2. The combination of a supporting surface through which two apertures open, and an integral body, the integral body comprising:

a resilient portion defining a recess having sidewalls and a top wall, the resilient portion being secured against the supporting surface such that the recess defines with the supporting surface a main chamber into which the two apertures open;

an integral poppet-valve extending from the top wall toward the supporting surface and adapted to close one aperture with mechanical interference, the poppet-valve being centrally recessed to define a subchamber in communication with said one aperture and being outwardly flared where it contacts the supporting surface, thereby to provide a first pressure threshold above which fluid flows from said one aperture to the other aperture and a second pressure threshold above which fluid flows from said other aperture to said one aperture, said first pressure threshold being at least partly a function of the amount of said mechanical interference and at least partly a function of the area of the supporting surface within said subchamber, said second pressure threshold being at least partly a function of the area of the top wall surrounding the poppet-valve.

3. An integral body as claimed in claim 1, in which an integral partition extends from the top wall of the recess to terminate in an edge adapted to rest resiliently against said supporting surface at a location between said two apertures, thereby to divide the main chamber into a first compartment containing said poppet-valve and said one aperture and a second compartment containing said other aperture, said partition being adapted to define an acute angle with the supporting surface in the second compartment adjacent said edge, the top wall within said first compartment having a portion which is resiliently deformable whereby the volume of said first compartment can be changed.

4. An integral body as claimed in claim 3, in which a further integral partition extends from the top wall of the recess to terminate in an edge adapted to rest resiliently against said supporting surface at a location between said poppet-valve and said resiliently deformable portion of the top wall, thereby to divide the first compartment into a first subcompartment defined in part by said resiliently deformable portion of the top wall, and a second subcompartment containing said poppet-valve and said one aperture, said further integral partition being adapted to define an acute angle with the supporting surface in the first subcompartment adjacent the edge of the further integral partition.

5. An integral body as claimed in claim 1, in which the poppet-valve is closer to one sidewall of the recess than to the opposite sidewall, and in which the part of the poppet-valve closest to said one sidewall has less mechanical interference

with the supporting surface than has the part closest to said opposite sidewall.

6. The combination claimed in claim 2, in which an integral partition extends from the top wall of the recess to terminate in an edge adapted to rest resiliently against said supporting surface at a location between said two apertures, thereby to divide the main chamber into a first compartment containing said poppet-valve and said one aperture and a second compartment containing said other aperture, said partition defining an acute angle with the supporting surface in the second compartment adjacent said edge, the top wall within said first compartment having a portion which is resiliently deformable whereby the volume of said first

7. The combination claimed in claim 6, in which a further integral partition extends from the top wall of the recess to terminate in an edge adapted to rest resiliently against said supporting surface at a location between said poppet-valve and said resiliently deformable portion of the top wall, thereby to divide the first compartment into a first subcompartment defined in part by said resiliently deformable portion of the top wall, and a second subcompartment containing said poppet-valve and said one aperture, said further integral partition being adapted to define an acute angle with the supporting surface in the first subcompartment adjacent the edge of the

further integral partition.

8. The combination claimed in claim 2, in which the poppet-valve is closer to one sidewall of the recess than to the opposite sidewall, and in which the part of the poppet-valve closest to said one sidewall has less mechanical interference with the supporting surface than has the part closest to said opposite sidewall.

9. An integral body as claimed in claim 1, in which the integral body is made of a material chosen from the group: plasticized PVC, ethyl vinyl acetate, styrene-butadiene rubber, butyl rubber, natural rubber, and silicone rubber.

10. An integral body as claimed in claim 3, in which the integral body is made of a material chosen from the group: plasticized PVC, ethyl vinyl acetate, styrene-butadiene rubber, butyl rubber, natural rubber, and silicone rubber.

11. The combination claimed in claim 2, in which the integral body is made of a material chosen from the group: plasticized PVC, ethyl vinyl acetate, styrene-butadiene rubber, butyl rubber, natural rubber, and silicone rubber.

12. The combination claimed in claim 6, in which the integral body is made of a material chosen from the group: plasticized PVC, ethyl vinyl acetate, styrene-butadiene rubber, butyl rubber, natural rubber, and silicone rubber.

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