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(54) **Title**: DISPENSING VALVE

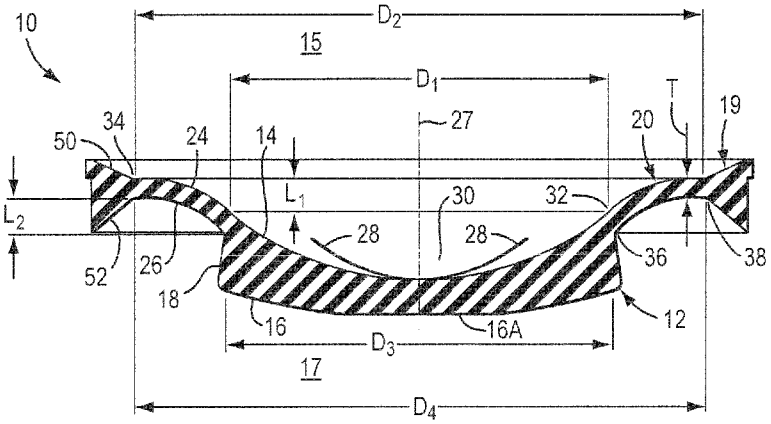

FIG. 2

(57) **Abstract**: A flexible, resilient, slit valve (10) including a flexible, resilient head (12) centered on a central axis (27) and extending laterally therefrom, an annular, peripheral attachment portion (19) centered on the central axis, and an annular, flexible, resilient, intermediate portion (20). The head has a convex interior surface (16) and a concave exterior surface (14). The intermediate portion (20) has an interior surface (26) an exterior surface (24). The exterior surfaces (14, 24) intersect at a circular line of intersection (32) having a diameter D_1. The exterior surface (24) and the peripheral attachment portion (19) intersect at a circular line of intersection (34) having a diameter D_2. The lines of intersection (32, 34) lie in parallel planes extending transverse to the central axis (27) and spaced from each other along the central axis by a distance L_1. The ratio of D_1/D_2 is in the range of 0.600 to 0.900 and the ratio of D_2/L_1 is in the range of 14.000 to 19.000 in an as-molded condition of the valve (10).

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DISPENSING VALVE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable.

MICROFICHE/COPYRIGHT REFERENCE

[0003] Not Applicable.

FIELD OF THE INVENTION

[0004] The present invention relates generally to dispensing valves and systems, and more particularly relates to valves for dispensing a product from a container or other source, and in more particular applications, to such valves suitable for use in a dispensing closure for a flexible container which is squeezable to create a pressure differential across the valve.

BACKGROUND OF THE INVENTION

[0005] One type of flexible, resilient, dispensing valve is a self-closing, slit-type valve mounted by a closure in a port of a fluent container or other

source of fluent product. Such valves have a slit or slits which define a normally closed orifice that opens to permit flow therethrough in response to an increased pressure differential across the valve (e.g., resulting from an increased pressure within the container when the container is squeezed, or from a reduced external ambient pressure compared to the pressure within the container). Such valves are typically designed so that they automatically close to shut off flow therethrough upon a reduction of the pressure differential across the valve.

[0006] Designs of such valves and of closures using such valves are illustrated in the U. S. Patent No. 5,271,531, No. 5,927,566, No. 5,934,512 and No. 6,405,901. Typically, the closure includes a body or base mounted on the container neck to define a seat for receiving the valve and includes a retaining ring or other structure for holding the valve on the seat in the base. See, for example, U.S. Patent No. 6,269,986 and No. 6,616,016. The valve is normally closed and can withstand the weight of the fluid product when the container is completely inverted so that the liquid will not leak out unless the container is squeezed. With such a system, the lid or cap need not be re-closed (although it is typically re-closed if the package is to be transported to another location, packed in a suitcase, etc.).

[0007] While such valves and valve systems have significant advantages and function well, there is always room for improvement. For example, in some applications it is desirable for such valves to open in a "gentle" or non-abrupt manner with reduced splatter and more control of a fluent product when dispensing than is achieved with currently available valves.

SUMMARY OF THE INVENTION

[0008] In accordance with one feature of the invention, a flexible, resilient slit valve is provided to allow selective dispensing of a fluent product from an interior environment to an exterior environment. The valve includes a flexible, resilient head centered on a central axis and extending laterally therefrom, an annular, peripheral attachment portion centered on the central axis and spaced laterally from the head, and an annular, flexible resilient, intermediate portion centered on the central axis and extending laterally from the head to the peripheral attachment portion. The head has a convex interior surface to face an interior environment; a concave exterior surface to face an exterior environment; at least one self-sealing slit through the head; confronting, openable portions along the at least one slit to define a normally closed orifice in an unconstrained condition wherein the openable portions can move in a first direction toward the exterior environment to an open orifice configuration and return in an opposite direction to a closed configuration; and a laterally outwardly facing peripheral surface extending from the interior surface toward the exterior surface, the peripheral surface being centered on the central axis. The intermediate portion has an interior surface to face an interior environment, and an exterior surface to face an exterior environment. The exterior surfaces of the head and the intermediate portion intersect at a first circular line of intersection having a diameter D_1. The exterior surface of the intermediate portion and the peripheral attachment portion intersect at a second interior circular line of intersection having a diameter D_2. The second circular line of intersection is spaced in the first direction from the first circular line of intersection. The first and second circular lines of intersection lie in parallel planes extending transverse

to the central axis and are spaced from each other along the central axis by a distance L_1. The ratio of D_1/D_2 is in the range of 0.600 to 0.900 in an as-molded condition of the valve, and the ratio of D_2/L_1 is in the range of 14.000 to 19.000 in said as-molded condition of the valve.

[0009] In one feature, the exterior surface of the intermediate portion is convex and the exterior surface of the head is concave and the first circular line of intersection is defined at an inflection point between the convex exterior surface of the intermediate portion and the concave exterior surface of the head.

[0010] As one feature, the ratio of D_2/L_1 is in the range of 15.500 to 16.000 in the as-molded condition of the valve.

[0011] According to one feature, the ratio of D_2/L_1 is 15.750 in the as-molded condition of the valve.

[0012] In one feature, the ratio of D_2/L_1 is in the range of 18.500 to 19.000 in the as-molded condition of the valve.

[0013] According to one feature, the ratio of D_2/L_1 is 18.750 in the as-molded condition of the valve.

[0014] As one feature, the ratio of D_1/D_2 is in the range of .625 to .675 in the as-molded condition of the valve.

[0015] In one feature, the ratio of D1/D2 is .653 in the as-molded condition of the valve.

[0016] As one feature, the ratio of D_1/D_2 is in the range of .800 to .850 in the as-molded condition of the valve.

[0017] According to one feature, the ratio of D_1/D_2 is .827 in the as-molded condition of the valve.

[0018] In one feature, the ratio of D_2/L_1 is in the range of 15.500 to 16.000, and the ratio of D_1/D_2 is in the range of .625 to .675 in the as-molded condition of the valve.

[0019] As one feature, the ratio of D_2/L_1 is in the range of 18.500 to 19.000, and the ratio of D_1/D_2 is in the range of .800 to .850 in the as-molded condition of the valve.

[0020] In one feature, the intermediate portion has a uniform material thickness separating the exterior and interior surfaces.

[0021] As one feature, the interior surface of the intermediate portion is concave, and the peripheral surface of the head is frustoconical.

[0022] According to one feature, at least one of the interior and exterior surfaces of the head has a planar portion adjacent the central axis, extending transverse to the central axis.

[0023] In accordance with another feature of the invention, a flexible, resilient slit valve is provided to allow selective dispensing of a fluent product from an interior environment to an exterior environment. The valve includes a flexible, resilient head centered on a central axis and extending laterally therefrom, an annular, peripheral attachment portion centered on the central axis and spaced laterally from the head, and an annular, flexible resilient, intermediate portion centered on the central axis and extending laterally from the head to the peripheral attachment portion. The head has a convex interior surface to face an interior environment, a concave exterior surface to face an exterior environment, at least one self-sealing slit through the head,

confronting, openable portions along the at least one slit to define a normally closed orifice in an unconstrained condition wherein the openable portions can move in a first direction toward the exterior environment to an open orifice configuration and return in an opposite direction to a closed configuration, and a laterally outwardly facing peripheral surface extending from the interior surface toward the exterior surface, the peripheral surface centered on the central axis. The intermediate portion has an interior surface to face an interior environment, and an exterior surface to face an exterior environment. The interior surface of the intermediate portion and the peripheral surface of the head intersect at a third circular line of intersection having a diameter D_3. The interior surface of the intermediate portion and the peripheral attachment portion intersect at a fourth circular line of intersection having a diameter D_4. The fourth circular line of intersection is spaced in the first direction from the third circular line of intersection. The third and fourth circular lines of intersection lie in parallel planes extending transverse to the central axis and are spaced from each other along the central axis by a distance L_2. The ratio of D_3/D_4 is in the range of 0.600 to 0.900 in an as-molded condition of the valve, and the ratio of D_4/L_2 is in the range 14.00 to 30.00 in an as-molded condition of the valve.

[0024] In one feature, the ratio of D_3/D_4 is in the range of .650 to .700 in an as-molded condition of the valve.

[0025] In one feature, the ratio D_3/D_4 is .681 in an as-molded condition of the valve.

[0026] In one feature, the ratio of D_4/L_2 is in the range of 14.5 to 15.5 in an as-molded condition of the valve.

[0027] As one feature, the ratio of D_4/L_2 is 14.921 in an as-molded condition of the valve.

[0028] As one feature, the ratio of D_3/D_4 is in the range of .850 to .950 in an as-molded condition of the valve.

[0029] According to one feature, the ratio D_3/D_4 is .867 in an as-molded condition of the valve.

[0030] In one feature, the ratio of D_4/L_2 is in the range of 29 to 31 in an as-molded condition of the valve.

[0031] As one feature, the ratio of D_4/L_2 is 30.

[0032] Numerous other advantages and features of the present invention will become readily apparent from the following detailed description of the invention, from the claims, and from the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] In the accompanying drawings forming part of the specification, in which like numerals are employed to designate like parts throughout the same.

[0034] FIG. 1 is a top plan view of a valve embodying the present invention;

[0035] FIG. 2 is a cross-sectional view taken from line 2-2- in FIG. 1;

[0036] FIG. 3 is an isometric view from above of the valve of FIGS. 1 and 2;

[0037] FIG. 4 is a fragmentary, cross-sectional view of the valve of FIGS. 1-3 installed in a closure and showing the valve in a closed condition;

[0038] FIG. 5 is a view similar to FIG. 4, but showing the valve in an open condition;

[0039] FIG. 6 is a greatly enlarged fragmentary, cross-sectional view of a portion of the valve shown in FIG. 2; and

[0040] FIG. 7 is a graphical representation showing the test results of a Control of Dispense test comparing valves made according to the invention to conventional valves.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0041] While this invention is susceptible of embodiment in many different forms, this specification and the accompanying drawings disclose only one specific form as an example of the invention. The invention is not intended to be limited to the embodiment so described, however. The scope of the invention is pointed out in the appended claims.

[0042] For ease of description, the valve of this invention may be described, along with a closure, in a typical (upright) position, and terms such as upper, lower, horizontal, etc., are used with reference to this position. It will be understood, however, that the valve embodying this invention may be manufactured, stored, transported, used, and sold in an orientation other than the position described.

[0043] Figures illustrating the valve of this invention and the associated closure show some conventional mechanical elements that are

known and that will be recognized by one skilled in the art. The detailed descriptions of such elements are not necessary to an understanding of the invention, and accordingly, are herein presented only to the degree necessary to facilitate an understanding of the novel features of the present invention.

[0044] A presently preferred embodiment of a valve according the invention is illustrated in FIGS. 1-6 and is designated generally by the number 10. The valve 10 is a self-closing, slit-type valve and is preferably molded as a unitary structure from material which is flexible, pliable, elastic, and resilient. This can include elastomers, such as a synthetic, thermosetting polymer, including silicone rubber, such as the silicone rubber sold by Dow Corning Corp. in the United States of America under the trade designations DC-99-595 and RBL-9595-40. Both of these materials have a hardness rating of 40 Shore A. The valve 10 can also be molded from other thermosetting materials or from other elastomeric materials, or from thermoplastic polymers or thermoplastic elastomers, including those based upon materials such as thermoplastic propylene, ethylene, urethane, and styrene, including their halogenated counterparts.

[0045] The valve 10 includes a flexible, resilient central portion or head 12 having a first or exterior surface 14 facing an exterior environment (shown generally at 15 in FIGS. 2, 4, and 5) and a second or interior surface 16 (FIGS. 2, 4, and 6) facing an interior environment (shown generally at 17 in FIGS. 2, 4, and 5). The head 12 also has a laterally outwardly facing peripheral surface 18 (FIGS. 2, 4, and 6) extending from the interior surface 16 toward the exterior surface 14, and in the illustrated and preferred embodiment the peripheral surface 18 is frustoconical.

[0046] The valve 10 further includes a peripheral attachment portion or flange 19, and a flexible, resilient intermediate portion or sleeve 20 that extends laterally outwardly from the head 12 to the flange 19. Hereinafter, the term "sleeve" 20 is used in this specification, but in the claims the term "intermediate portion" 20 is used. The sleeve 20 has an exterior surface 24 (FIGS. 1-4, and 6) and interior surface 26 (FIGS. 2, 4, and 6) that, in the illustrated and preferred embodiment, are separated by a uniform material thickness T (FIG. 1) of the sleeve 20.

[0047] The head 12, peripheral attachment portion 19, and sleeve 20 are preferably all symmetrical bodies of revolution centered on a central axis 27. Preferably and as illustrated, the exterior surface 14 of the head 12 is concave, the interior surface 16 of the head 12 is convex, the exterior surface 24 of the sleeve 20 is convex, and the interior surface 26 of the sleeve 20 is concave. In the illustrated embodiment, the convex, interior surface 16 of the head 12 includes a planar portion 16A (FIGS. 2 and 6) extending transversely from the central axis 27 over a limited area adjacent the axis 27.

[0048] As best seen in FIGS. 1 and 3, the head 12 has planar, intersecting, self-sealing slits 28 which together define a closed orifice when the valve 10 is in the closed condition. For purposs of illustration, the slits 28 are each shown in FIGS. 1, 2, 3 and 6 as defining an open slot. However, it will be understood that in the as-molded, closed condition of the valve 10, each slit 28 is closed and does not define an open slot. Preferably, the slits 28 are normal to each other and equal in length. In the illustrated form of the valve 10, the slits 28 define four, generally sector-shaped, equally sized flaps or petals 30 in the head 12. The flaps or petals 30 may also be characterized as "openable regions" or "openable portions" of the valve head

12. Each flap or petal 30 has a pair of diverging transverse faces 31 defined by the slits 28, and each transverse face seals against a confronting transverse face 31 of an adjacent petal 30 when the valve 16 is closed (faces 31 shown spaced from each other in some of the figures for purposes of illustration only). The valve 10 can be molded with the slits 28, or alternatively, the slits 28 can be subsequently cut into the head 12 of the valve 10 by suitable conventional techniques. As another alternative, the slits 28 could be partially molded into the head 12, with the remainder being cut after molding.

[0049] The valve 10 has a normally closed, rest position or configuration shown in FIGS. 1-4 and 6. The valve 10 is typically designed to remain closed when the pressure differential across the valve head 12 is below a predetermined amount, with the petals 30 defining a normally closed orifice configuration. The valve 10 can be forced to one or more open positions or configurations, as shown in FIG. 5, when a sufficiently high dispensing pressure differential is applied across the valve 12 thereby moving the petals 30 in a first or opening direction toward the exterior environment to an open orifice configuration. When the pressure differential across the valve I10 is decreased sufficiently, the inherent resiliency of the valve 10 allows the valve 10 to return to the normally closed condition (by action of the force generated from the resilient valve's deformational stresses).

[0050] The exterior surfaces 14 and 24, respectively, of the head 12 and sleeve 20 intersect at a first circular line of intersection, shown diagrammatically at 32 in FIGS. 1-4 and 6, having a diameter D_1 (FIG. 1) and which is defined at an inflection point between the convex exterior surface 24

and the concave exterior surface 14 in the illustrated and preferred embodiment. The exterior surface 24 of the sleeve 20 intersects the peripheral attachment portion 19 at a second circular line of intersection, shown diagrammatically at 34 in FIGS. 1-4 and 6, having a diameter D_2 (FIG. 1). The peripheral surface 18 of the head 12 and the interior surface 26 of the sleeve 20 intersect at a third circular line of intersection 36 (FIGS. 2, 4, and 6) having a diameter D_3 (FIG. 1), and the interior surfaces 26 of the sleeve 20 intersects the peripheral attachment portion 19 at a fourth circular line of intersection 38 (FIGS. 2, 4, and 6) having a diameter D_4 (FIG. 1).

[0051] The second circular line of intersection 34 is spaced in the first direction (toward the exterior environment 15) from the first circular line of intersection 32. The fourth circular line 38 of intersection is spaced in the first direction from the third circular line of intersection 36. The first, second, third, and fourth circular lines of intersection 32, 34, 36, and 38 lie in parallel planes extending transverse to the central axis 27, with the first and second circular lines of intersection 32 and 34 being spaced from each other along the central axis 27 by a distance L_1, (FIG. 1) and the third and fourth circular lines of intersection 36 and 38 begin spaced from each other along the central axis 27 by a distance L_2 (FIG. 1).

[0052] The inventors of the present invention have discovered that a "gentle" or non-abrupt opening of the valve 10 with reduced splatter and more control of a fluent product can be achieved by controlling the distance L_1 with respect to the diameters D_1 and D_2, and/or by controlling the distance L_2 with respect to the diameters D_3 and D_4, with all of the distances and diameters being controlled in the as-molded condition or state of the valve 10 (e.g. the condition or state of the valve 10 as defined by the mold and without

external forces being applied to the valve 10). More specifically, it has been discovered that controlling the ratio of D_2/L_1 and/or the ratio of D_1/L_1 with respect to the ratio of D_1/D_2, and/or controlling the ratio D_4/L_2 and/or the ratio of D_3/L_2 with respect to the ratio D_3/D_4, produces the desirable result of a "gentle" opening of the valve 10 with reduced spatter and more control of a fluent product during dispensing.

[0053] In preferred embodiments of the valve 10, the ratio of D_2/L_1 is in the range of 14.000 to 19.000 in the as-molded condition of the valve 10 with respect to ratios of D_1/D_2 in the range of 0.600 to 0.900 in the as-molded condition of the valve 10. In some more preferred embodiments of the valve 10, the ratio of D_2/L_1 is in the range of 18.500 to 19.000 in the as-molded condition of the valve 10 with respect to ratios of D_1/D_2 in the range of 0.600 to 0.900 in the as-molded condition of the valve 10, and even more preferably, with respect to ratios of D_1/D_2 in the range of 0.800 to 0.850 in the as-molded condition of the valve 10, especially when molded from the previously identified silicone rubber material. In some highly preferred embodiments of the valve 10, the ratio of D_2/L_1 is in the range of 15.500 to 16.000 in the as-molded condition of the valve 10 with respect to ratios of D_1/D_2 in the range of 0.600 to 0.900 in the as-molded condition of the valve 10, and even more preferably, with respect to ratios of D_1/D_2 in the range of 0.625 to 0.675 in the as-molded condition of the valve 10, especially when molded from the previously identified silicone rubber material.

[0054] Furthermore, in preferred embodiments of the valve 10, the ratio of D_1/L_1 is in the range of 10.000 to 16.000 in the as-molded condition of the valve 10 with respect to ratios of D_1/D_2 in the range of 0.600 to 0.900 in the as-molded condition of the valve 10. In some more preferred

embodiments of the valve 10, the ratio of D_1/L_1 is in the range of 15.000 to 16.000 in the as-molded condition of the valve 10 with respect to ratios of D_1/D_2 in the range of 0.600 to 0.900 in the as-molded condition of the valve 10, and even more preferably, with respect to ratios of D_1/D_2 in the range of 0.800 to 0.850 in the as-molded condition of the valve 10, especially when molded from the previously identified silicone rubber material. In some highly preferred embodiments of the valve 10, the ratio of D_1/L_1 is in the range of 10.000 to 10.500 in the as-molded condition of the valve 10 with respect to ratios of D_1/D_2 in the range of 0.600 to 0.900 in the as-molded condition of the valve 10, and even more preferably, with respect to ratios of D_1/D_2 in the range of 0.625 to 0.675 in the as-molded condition of the valve 10, especially when molded from the previously identified silicone rubber material.

[0055] Turning to other previously mentioned ratios, in preferred embodiments of the valve 10, the ratio of D_4/L_2 is in the range of 14.500 to 30.500 in the as-molded condition of the valve 10 with respect to ratios of D_3/D_4 in the range of 0.625 to 0.925 in the as-molded condition of the valve 10. In some more preferred embodiments of the valve 10, the ratio of D_4/L_2 is in the range of 29.500 to 30.500 in the as-molded condition of the valve 10 with respect to ratios of D_3/D_4 in the range of 0.625 to 0.925 in the as-molded condition of the valve 10, and even more preferably, with respect to ratios of D_3/D_4 in the range of 0.825 to 0.900 in the as-molded condition of the valve 10, especially when molded from the previously identified silicone rubber material. In some highly preferred embodiments of the valve 10, the ratio of D_4/L_2 is in the range of 14.500 to 15.500 in the as-molded condition of the valve 10 with respect to ratios of D_3/D_4 in the range of 0.625 to 0.925 in the as-molded condition of the valve 10, and even more preferably, with respect to ratios of D_3/D_4 in the range of 0.650 to 0.750 in the as-molded condition of

the valve 10, especially when molded from the previously identified silicone rubber material.

[0056] Furthermore, in preferred embodiments of the valve 10, the ratio of D_3/L_2 is in the range of 9.500 to 26.500 in the as-molded condition of the valve 10 with respect to ratios of D_3/D_4 in the range of 0.625 to 0.925 in the as-molded condition of the valve 10. In some more preferred embodiments of the valve 10, the ratio of D_3/L_2 is in the range of 25.500 to 26.500 in the as-molded condition of the valve 10 with respect to ratios of D_3/D_4 in the range of 0.625 to 0.925 in the as-molded condition of the valve 10, and even more preferably, with respect to ratios of D_3/D_4 in the range of 0.825 to 0.900 in the as-molded condition of the valve 10, especially when molded from the previously identified silicone rubber material. In some highly preferred embodiments of the valve 10, the ratio of D_3/L_2 is in the range of 9.500 to 10.500 in the as-molded condition of the valve 10 with respect to ratios of D_3/D_4 in the range of 0.625 to 0.925 in the as-molded condition of the valve 10, and even more preferably, with respect to ratios of D_3/D_4 in the range of 0.650 to 0.750 in the as-molded condition of the valve 10, especially when molded from the previously identified silicone rubber material.

[0057] By design, the intermediate portion or sleeve 20 is more flexible than the peripheral portion of the head 12 from which the intermediate portion or sleeve 20 extends. This flexibility allows some axial translation of the head 12 along the central axis 27 and further allows the intersection of the sleeve 20 with the head 12 to act somewhat like a hinge for each of the pedals 30 of the head 12 as the pedals 30 move between the closed and open positions. In this regard, the material thickness T of the sleeve 20 is less than the material thickness of the peripheral portion of the head 12 from

which the intermediate portion or sleeve 20 extends, and in the preferred embodiments described above the ratio of D_1/T and/or D_3/T is in the range of 15.000 to 55.000 in the as-molded condition of the valve 10, and in more preferred embodiments the ratio of D_1/T and/or D_3/T is in the range of 28.000 to 48.000 in the as-molded condition of the valve 10, and in highly preferred embodiments the of D_1/T and/or D_3/T is in the range of 17.000 to 23.000 in the as-molded condition of the valve 10, especially when molded from the previously identified silicone rubber material. Alternatively, in the preferred embodiments described above the ratio of D_2/T and/or D_4/T is in the range of 25.000 to 65.000 in the as-molded condition of the valve 10, and in more preferred embodiments the ratio of D_2/T and/or D_4/T is in the range of 35.000 to 47.000 in the as-molded condition of the valve 10, and in highly preferred embodiments the of D_2/T and/or D_4/T is in the range of 25.000 to 40.000 in the as-molded condition of the valve 10, especially when molded from the previously identified silicone rubber material.

[0058] Testing of valves made according to the invention has shown significant improvement in achieving the desired "gentle" dispensing in comparison to conventional, currently available valves. For example, a Splatter Evaluation Test was performed to compare valves made according to the invention to conventional valves. This testing showed that the valves made according to the invention produced a splatter area that was 52% to 28% the size of the splatter area produced by conventional valves, with the percent improvement varying from greater (52%) to smaller (28%) as the rate of dispense increases. Additionally, FIG. 7 illustrates the results of a Control of Dispense test wherein the amount of fluent product dispensed are measured with respect to time for a fixed rate of squeeze of a squeezable container on which the valves are mounted by a closure during testing. As

seen in FIG. 7, the valves made according to the invention provide a more gradual increase in dispense rate with no initial "burst" of fluent product, as shown by the gentle curve upwards of the dispense amount for the valves made according to the invention in comparison to the initial steep slope of the dispense amount for the conventional valves.

[0059] In one specific preferred embodiment of the valve 10, especially when molded from the previously identified silicone rubber material, D_2/L_1 = 18.750, D_1/L_1 = 15.500, D_1/D_2 = .827, D_4/L_2 = 30.000, D_3/L_2 = 26.000, D_3/D_4 = .867, D_1/T = 35.420, D_2/T = 42.857, D_3/T = 37.143, D_4/T = 42.857, and in one preferred form of this embodiment D_1 = .238 inch, D_2 = .300 inch, D_3 = .260 inch, D_4 = .300 inch, L_1 = .016 inch, L_2 = 0.10 inch, and T = .007 inch.

[0060] In one highly preferred embodiment of the valve 10 which is molded from the previously identified silicone rubber material, and whose ratios match those in the FIGS., D_2/L_1 = 15.750, D_1/L_1 = 10.278, D_1/D_2 = .653, D_4/L_2 = 14.921, D_3/L_2 = 10.158, D_3/D_4 = .681, D_1/T = 20.556, D_2/T = 31.500, D_3/T = 21.500, D_4/T = 31.500, and in one preferred form of this embodiment D_1 = .370 inch, D_2 = .567 inch, D_3 = .387 inch, D_4 = .567 inch, L_1 = .036 inch, L_2 = .038 inch, and T = .018 inch.

[0061] It should be understood the valve 10 may find use with many different types and constructions of closures, containers, and other sources of fluent product, that a closure 40 is shown in FIGS. 4 and 5 for purposes of illustration, and that the particular form or construction of the closure 40 forms no part of the invention unless expressly recited in an appended claim. For purposes of illustration, the closure 40 comprises a base 41 and a retainer 42. The base 41 includes a deck 43 having a dispensing port 44

defined therein, and a skirt 45 extending downwardly from the deck 43 and having retention and sealing features for engagement with a neck of a suitable container (not shown). The retainer 42 includes a laterally outwardly extending annular lip or bead 46 that forms a snap fit engagement with a laterally inwardly extending bead(s) or rib(s) 47 on an interior side 48 of the deck 43. To accommodate mounting and retention of the valve 10, the peripheral attachment portion 19 preferably has a generally dovetail-shaped, transverse cross section which defines a pair of frustoconical surfaces 50 and 52, as best seen in FIGS. 2, 4, and 6. As best seen in FIG. 4, the deck 43 includes a frustoconical surface 54 surrounding the port 44 for matingly engaging the axially outwardly (e.g., exterior environment) facing frustoconical surface 50 of the attachment portion 19, and the retainer 42 includes a frustoconical surface 56 for matingly engaging the axially inwardly (e.g., interior environment) facing frustoconical surface 52.

[0062] While a preferred form of mounting has been shown, the attachment portion 19 could have other configurations, many of which are known, that would engage with corresponding configurations on a closure, container, or other source of fluent product. Also, in some other arrangements, the attachment portion 19 could be held by other means, such as, for example, heat bonding, material bonding such as is achieved in bi-injection molding, adhesive, and/or a press fit, etc.

[0063] It is to be understood that the orifice of the valve 10 may be defined by structures other than the illustrated straight slits 28. The slits 28 may have various different shapes, sizes and/or configurations in accordance with the requirements and parameters of each particular application. For

example, the orifice may also include only one slit 28 or three or more intersecting slits 28.

[0064] If it is desired to provide particular performance characteristics, then the valve 10 is preferably configured for use in conjunction with (1) the characteristics of the particular application, which, for example, may establish the maximum anticipated pressure differential across the valve 10; (2) the characteristics of the particular substance or product to be used with the valve 10; and (3) any relevant characteristics of other components, such as a closure or container. For example, the viscosity and density of the fluent substance can be relevant factors in designing the specific configuration of the valve 10. The rigidity and durometer of the valve material, and size and shape of the valve head 10, can also be relevant to achieving some desired characteristics, and can be selected for accommodating the normal range of pressure differential that is expected to be typically applied across the valve head 10, and for accommodating the characteristics of the substance to be used with the valve 10.

[0065] It will be readily observed from the foregoing detailed description of the invention and from the illustrations thereof that numerous other variations and modifications may be effected without departing from the true spirit and scope of the novel concepts or principles of this invention.

CLAIMS

1. A flexible, resilient, slit valve (10) to allow selective dispensing of a fluent product from an interior environment to an exterior environment, the valve comprising:

a flexible, resilient head (12) centered on a central axis (27) and extending laterally therefrom, the head (12) having:

a convex interior surface (16) to face an interior environment (17),

a concave exterior surface (14) to face an exterior environment (15),

at least one self-sealing slit (28) through the head (12),

confronting, openable portions (30) along the at least one slit (28) to define a normally closed orifice in an unconstrained condition wherein the openable portions (30) can move in a first direction toward the exterior environment (15) to an open orifice configuration and return in an opposite direction to a closed configuration, and

a laterally outwardly facing peripheral surface (18) extending from the interior surface (16) toward the exterior surface (14), the peripheral surface (18) centered on the central axis (27);

an annular, peripheral attachment portion (19) centered on the central axis (27) and spaced laterally from the head (12); and

an annular, flexible, resilient, intermediate portion (20) centered on the central axis (27) and extending laterally from the head (12) to the peripheral attachment portion (19), the intermediate portion (20) having:

an interior surface (26) to face said interior environment (17), and

an exterior surface to face said exterior environment (15); and

wherein;

the exterior surfaces (14, 24) of the head (12) and the intermediate portion (20) intersect at a first circular line of intersection (32) having a diameter D_1,

the exterior surface (24) of the intermediate portion and the peripheral attachment portion (19) intersect at a second circular line of intersection (34) having a diameter D_2,

the second circular line of intersection (34) is spaced in the first direction from the first circular line of intersection (32),

the first and second circular lines of intersection (32, 34) lie in parallel planes extending transverse to the central axis (27) and spaced from each other along the central axis (27) by a distance L_1,

the ratio of D_1/D_2 is in the range of 0.600 to 0.900 in an as-molded condition of the valve (10), and

the ratio of D_2/L_1 is in the range of 14.000 to 19.000 in said as-molded condition of the valve (10).

2. The valve (10) of claim 1 wherein the exterior surface (24) of the intermediate portion (20) is convex and the exterior surface (14) of the head is concave and the first circular line of intersection (32) is defined at an inflection point between the convex exterior surface (24) of the intermediate portion (20) and the concave exterior surface (14) of the head (12).

3. The valve (10) of claim 2 wherein the ratio of D_2/L_1 is in the range of 15.500 to 16.000 in the as-molded condition of the valve (10).

4. The valve (10) of claim 3 wherein the ratio of D_2/L_1 is 15.750 in the as-molded condition of the valve (10).

5. The valve (10) of claim 2 wherein the ratio of D_2/L_1 is in the range of 18.500 to 19.000 in the as-molded condition of the valve (10).

6. The valve (10) of claim 5 wherein the ratio of D_2/L_1 is 18.750 in the as-molded condition of the valve (10).

7. The valve (10) of claim 2 wherein the ratio of D_1/D_2 is in the range of .625 to .675 in the as-molded condition of the valve (10).

8. The valve (10) of claim 7 wherein the ratio of D_1/D_2 is .653 in the as-molded condition of the valve (10).

9. The valve (10) of claim 2 wherein the ratio of D_1/D_2 is in the range of .800 to .850 in the as-molded condition of the valve (10).

10. The valve (10) of claim 9 wherein the ratio of D_1/D_2 is .827 in the as-molded condition of the valve (10).

11. The valve (10) of claim 2 wherein the ratio of D_2/L_1 is in the range of 15.500 to 16.000 and the ratio of D_1/D_2 is in the range of .625 to .675 in the as-molded condition of the valve (10).

12. The valve (10) of claim 2 wherein the ratio of D_2/L_1 is in the range of 18.500 to 19.000 and the ratio of D_1/D_2 is in the range of .800 to .850 in the as-molded condition of the valve (10).

13. The valve (10) of claim 2 wherein the intermediate portion (20) has a uniform material thickness separating the exterior and interior surfaces (24, 26).

14. The valve (10) of claim 2 wherein the interior surface (26) of the intermediate portion (20) is concave and the peripheral surface (18) of the head (12) is frustoconical.

15. The valve of claim 1 wherein at least one of the interior and exterior surfaces (14, 16) of the head (12) has a planar portion adjacent the central axis (27), extending transverse to the central axis (27).

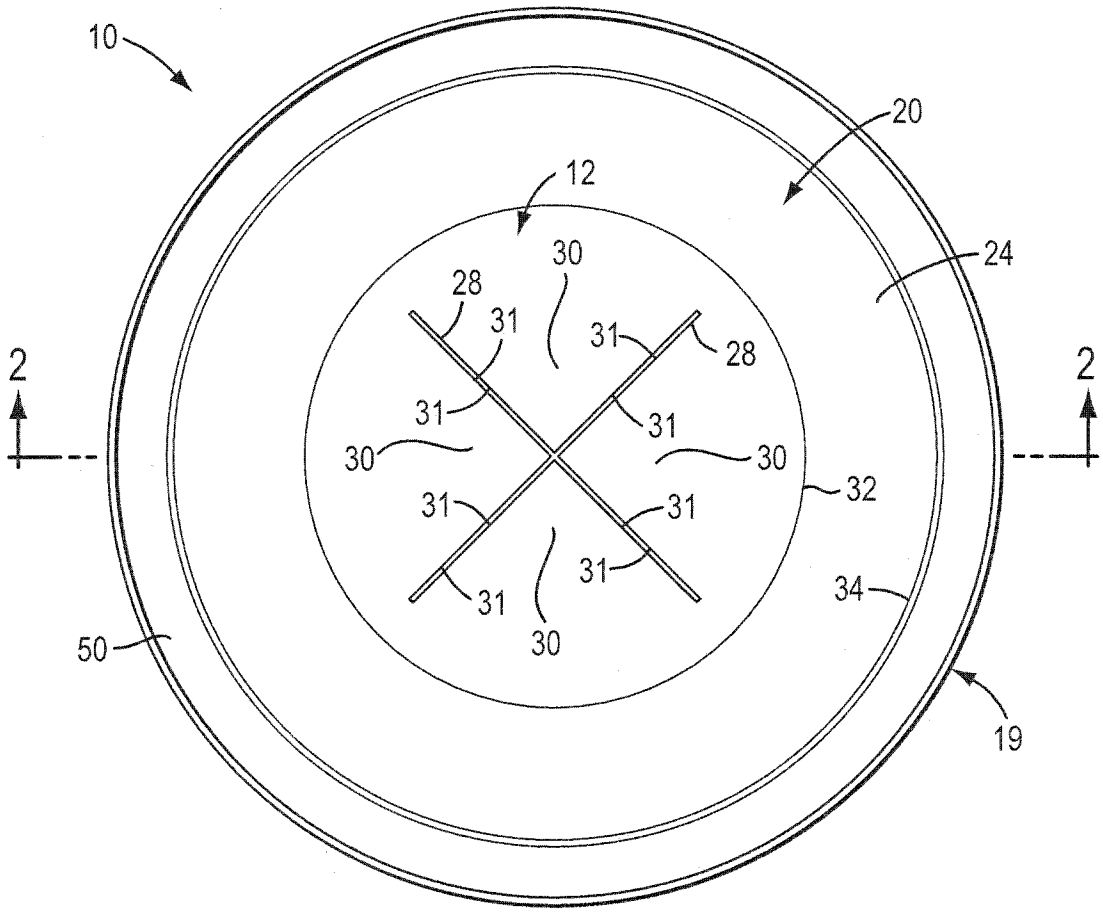
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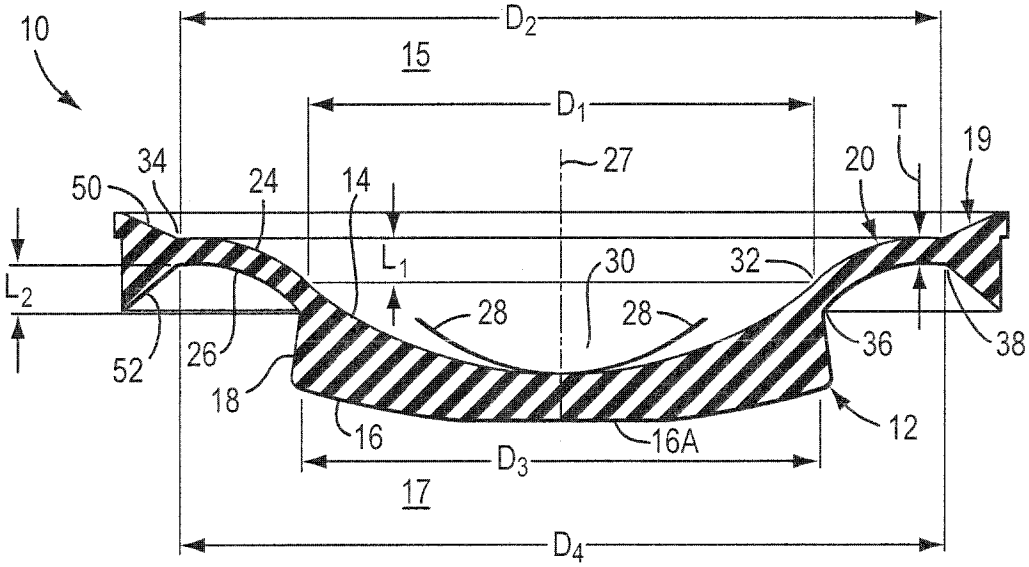
FIG. 1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D_2
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D_1
T
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14
L_1
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16A
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D_3
17
D_4

FIG. 2

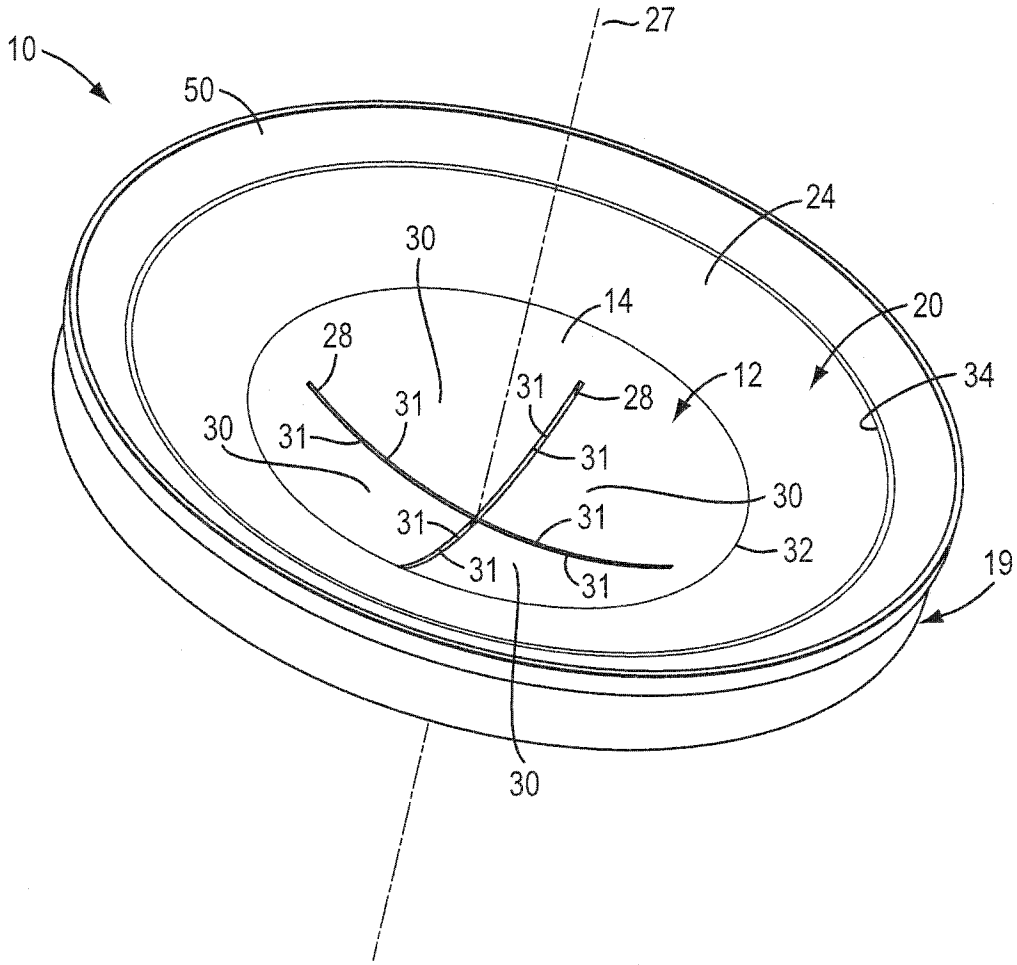

FIG. 3

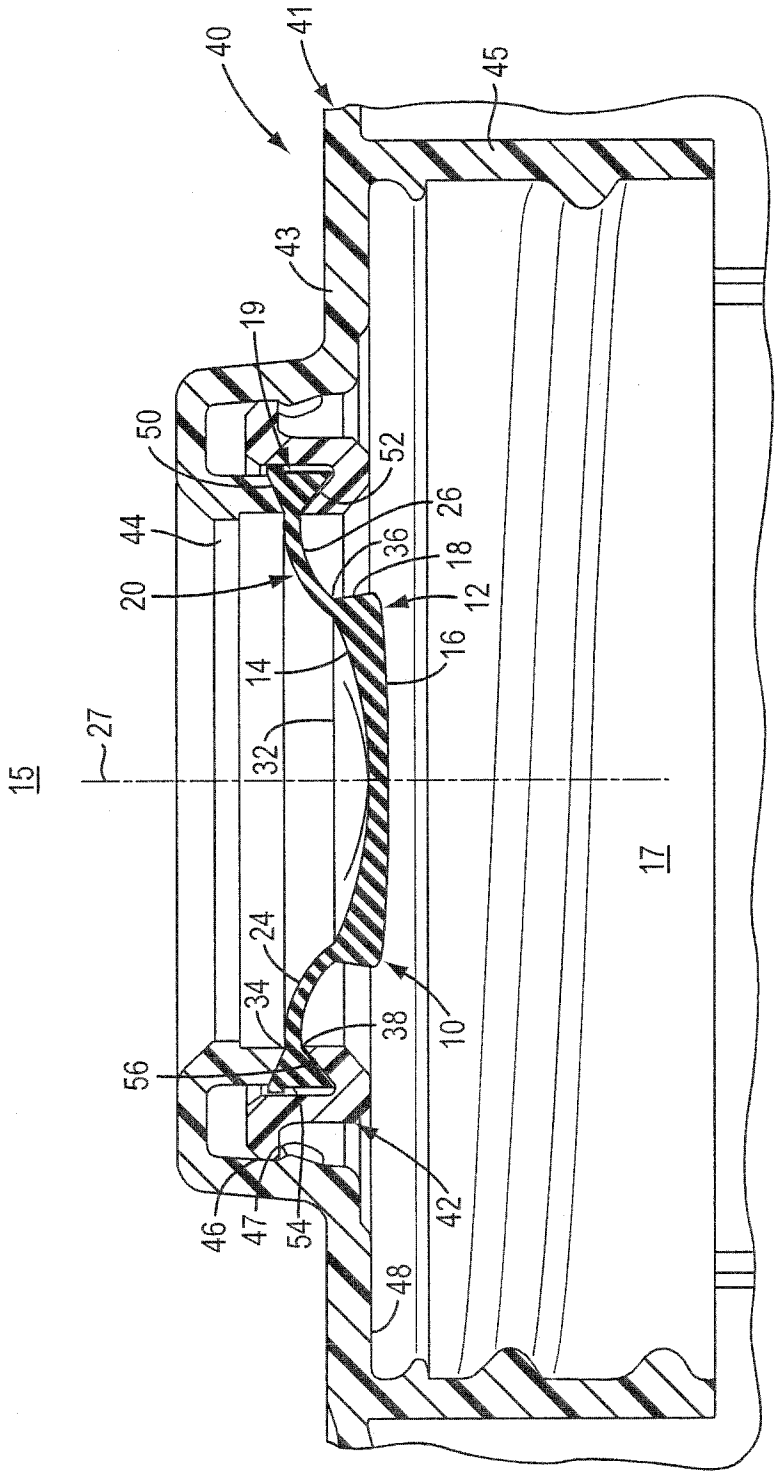
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FIG. 4

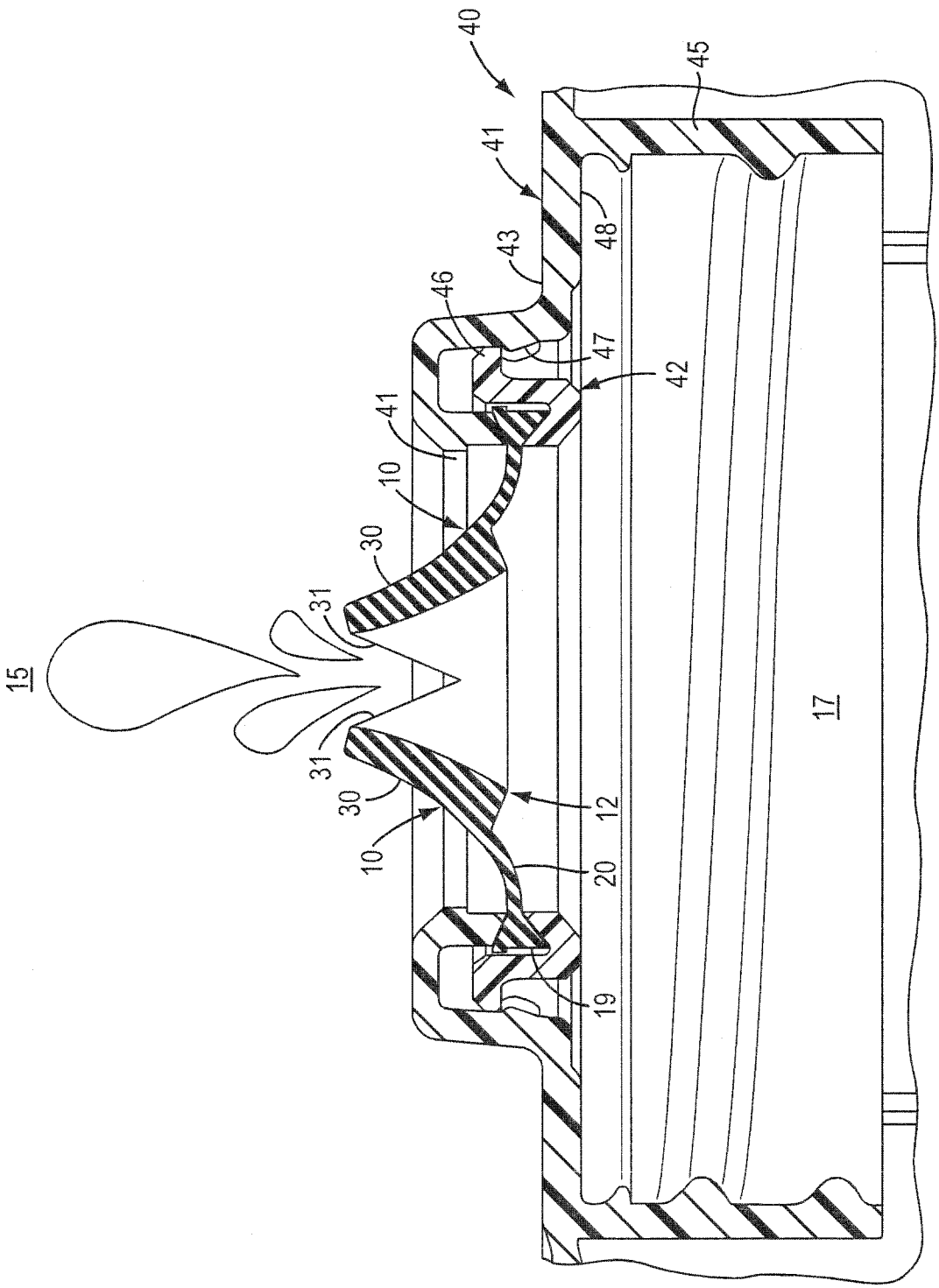


FIG. 5

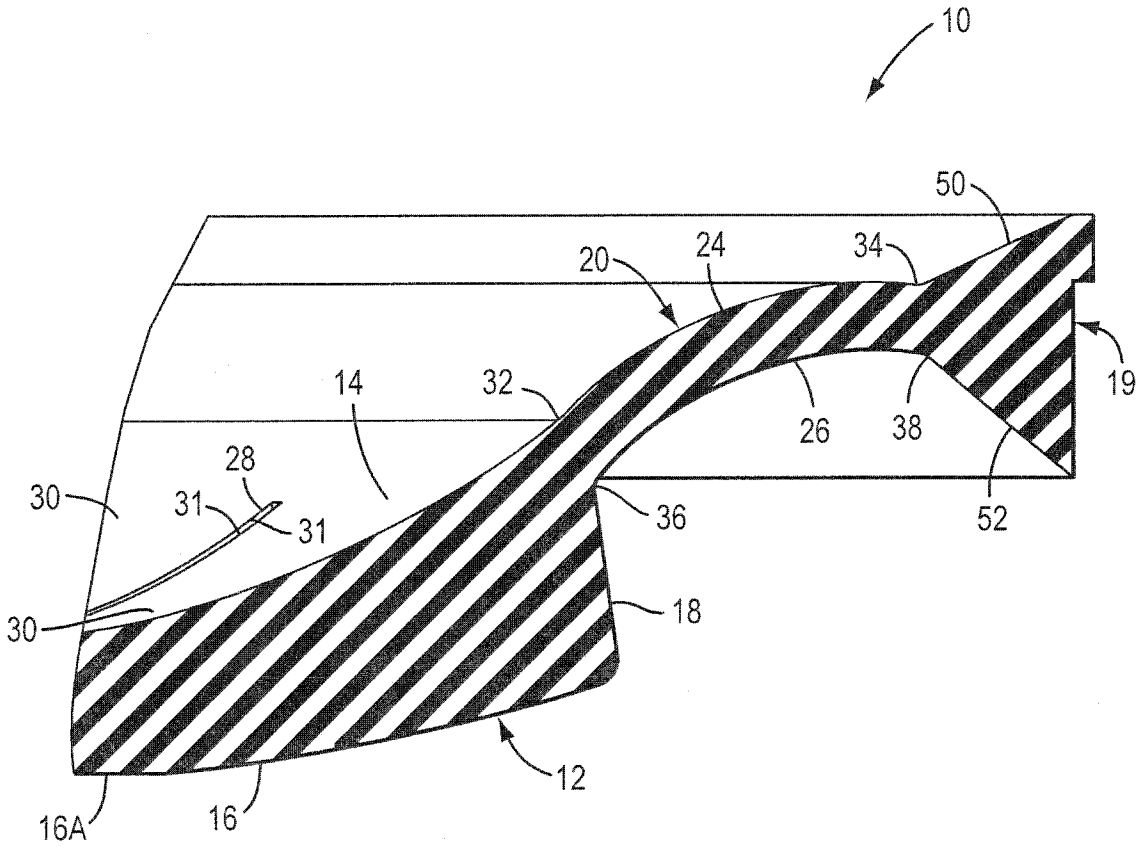
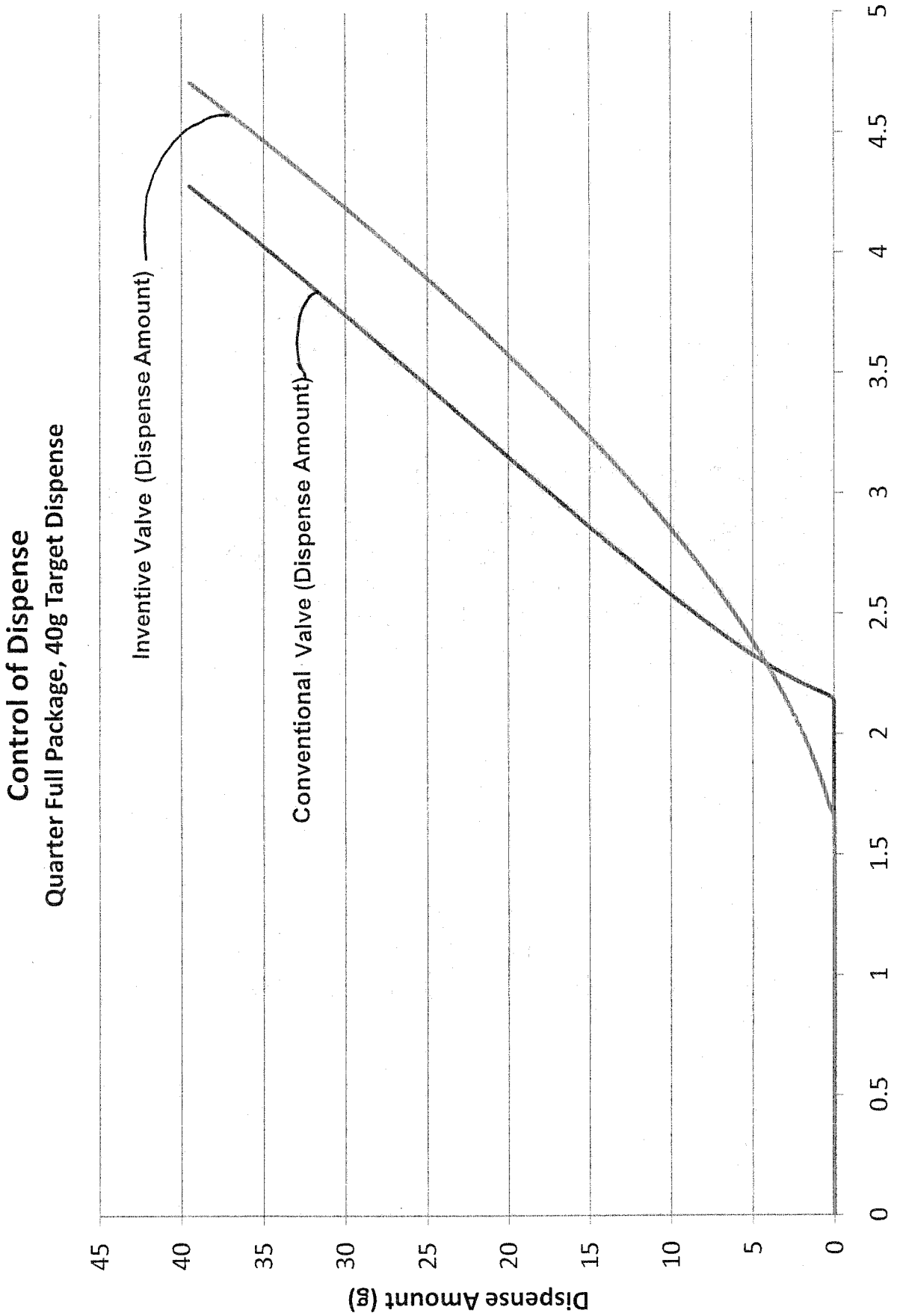


FIG. 6


Control of Dispense
Quarter Full Package, 40g Target Dispense
Inventive Valve (Dispense Amount)
Conventional Valve (Dispense Amount)
Dispense Amount (g)
0
5
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15
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25
30
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40
45
Elapsed Time (sec)
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4.5
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FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/051390

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B65D 47/20 (2012.01)
USPC - 222/212, 494
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B65D 47/20 (2012.01)
USPC - 222/212, 490, 494

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Delphion

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7,784,652 B2 (GAUS et al) 31 August 2010 (31.08.2010) entire document	1-15

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 January 2012	31 JAN 2012
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)