

DEVICE AND SYSTEM FOR DISPENSING A LIQUID

The invention relates to a device for dispensing a liquid from a container as a spray or as a foam. In particular, the invention relates to a liquid dispensing device which allows a liquid to be
5 dispensed at a precisely controlled output pressure, and thus allows droplet sizes to be maintained within a narrowly defined range.

More specifically, the invention relates to a liquid dispensing device comprising an inlet channel configured to be brought in fluid communication with the container, a pump in fluid communication with the inlet channel, the pump including a pump chamber and a piston
10 reciprocally movable in the pump chamber, an inlet valve arranged between the inlet channel and the pump, a buffer in fluid communication with the pump, a nozzle for dispensing the liquid, the nozzle in fluid communication with the pump and/or the buffer, an outlet valve arranged between the pump and/or buffer and the nozzle, and means for connecting the dispensing device to the container. Such a liquid dispensing device is known, e.g. from WO 2013/043938 A2.

15 This prior art document by the present applicant discloses a liquid dispensing device having a buffer arranged opposite the pump, which extends downwardly from the device into the neck of a container. This buffer includes a buffer chamber in which a spring-loaded buffer piston is arranged. When liquid is moved from the pump into the buffer, the piston is forced downward, thus loading the spring. Once pumping has stopped, the spring relaxes, thus forcing liquid from the
20 buffer towards the nozzle. This prior art buffer design takes up a relatively large amount of space and includes an assembly of individual parts which complicates manufacture of the liquid dispensing device.

Document WO 2018/202645 A1, also by the present applicant, discloses a similar liquid dispensing device in which the buffer includes a gas-filled buffer bag, rather than a spring-loaded
25 buffer piston, arranged in the buffer chamber. In this device, the gas-filled buffer bag is compressed when liquid is pumped into the buffer chamber, thus defining an external volume between the deformable outside of the buffer bag and the stiff inner wall of the buffer chamber.

Document WO 2014/074654 A1, also by the present applicant, discloses yet another liquid dispensing device including a gas-filled buffer bag arranged in a buffer chamber. In this document
30 the buffer chamber is open at the bottom and open at the top. This allows liquid to enter the buffer chamber from one side, which is in fluid communication with the pump, and exit the buffer chamber at the other side, which leads to the nozzle.

US 11 498 089 B2 discloses a manually operated trigger sprayer that stores a quantity of pressurized liquid during the charge stroke of the trigger for subsequent release during the return
35 stroke. The trigger sprayer is configured such that an appreciable volume of liquid is dispensed during both the charge and the return strokes of the trigger, creating a continuous discharge stream,

for so long as the trigger is actuated. The pressurized liquid is stored in an elastic tube that is attached to a nipple extending rearwardly from the back of the housing of the trigger sprayer.

The invention has for its object to provide a liquid dispensing device of the type discussed above which is structurally simple, which is relatively easy to assemble, and which may be
5 manufactured at relatively low cost.

In accordance with the invention, this is achieved in a liquid dispensing device of the type described above, wherein the buffer comprises an elastic buffer bag defining an expansible volume and extending at least partially past the connecting means towards an interior of the container. An elastic buffer bag does not require moving parts and a separate spring, and as such is easier to
10 manufacture than prior art buffers. Moreover, it allows the entire dispensing device to be made of plastics material, which facilitates recycling at the end of the life cycle. As the return force exerted by the buffer bag results from the elasticity of the material of the bag, rather than from compression of a gas held in the bag, gas-tightness is no issue, thus providing a greater freedom of choice of the bag material. And by at least partially arranging the buffer bag in the interior of the
15 container, efficient use is made of the available head space, thus resulting in a compact design.

In an embodiment, the elastic buffer bag may be arranged in a buffer housing which extends at least partially past the connecting means towards an interior of the container. In this way the buffer bag is shielded from external influences.

In another embodiment, the elastic buffer bag may define an internal volume and may have
20 an opening in fluid communication with the pump. Although the expansible volume could be an external volume defined between the buffer bag and the buffer housing, an internal volume is more efficient and structurally simpler.

In an embodiment, the elastic buffer bag and/or the buffer housing may extend substantially parallel to the inlet channel. In this way a head space in the container may be
25 efficiently used for the buffer.

In a further embodiment, the buffer housing may be fixed to the inlet channel. In this way a structurally simple dispensing device is obtained.

In a further embodiment, the opening of the elastic buffer bag may be enclosed by a neck which is sealingly connected to an inner peripheral edge of the buffer housing. In this way, no
30 liquid can escape past the buffer bag. The neck may have an enlarged diameter, and may engage a reduced diameter part of the buffer housing in order to fix the buffer bag in the buffer housing.

In another embodiment, the elastic buffer bag and the buffer housing may be integrally made. This reduces the number of assembling steps, as well as the number of separate parts to be manufactured and stocked.

The buffer housing may define an internal volume that is larger than an external volume of the elastic buffer bag when empty. In this way there is room within the buffer housing for the buffer bag to expand when it is filled with liquid from the pump.

5 The necessary room may be provided around the buffer bag if the buffer housing has an internal diameter that is larger than an external diameter of a cylindrical part of the elastic buffer bag. This allows for radial expansion of the buffer bag. The buffer housing may be substantially cylindrical, but other cross-sectional shapes may be envisioned as well.

10 In a further embodiment, the buffer housing may have openings on two opposite sides. In this case the opening on the side facing the pump chamber accommodates the open side of the buffer bag, while the opening on the opposite side allows the buffer bag to expand in lengthwise direction, in addition to the radial expansion.

In an embodiment, the liquid dispensing device may further comprise a core element arranged in the elastic buffer bag. Such a core element prevents the buffer bag from collapsing when it is emptied, which would complicate refilling the buffer bag in a next pump stroke.

15 In a further embodiment the neck of the elastic buffer bag may be clamped between the inner peripheral edge of the buffer housing and the core element. In this way the core element serves a double purpose.

In such an embodiment, the core element may substantially fill the internal volume of the elastic buffer bag. In this way the amount of “dead” volume in the device at the end of a pump stroke may be reduced, thus facilitating priming of the device. By varying the size of the core element in relation to the internal volume of the elastic buffer bag when relaxed, an amount of stretching of the buffer bag when introducing the core element may be adjusted. Stretching occurs when the size of the core element is larger than the internal volume of the elastic buffer bag in its state of relaxation. The amount of stretching in turn defines a minimum pressure at which the liquid enters the buffer bag.

25 On the other hand, the core element may leave free a substantial part of the internal volume, thus increasing the storage capacity of the buffer bag. Thus, the core element may take up e.g. 10%, 25%, 50%, 75% or approximately 100% of the internal volume of the elastic buffer bag in its state of relaxation.

30 In an embodiment, the core element may include at least one recess in fluid communication with the pump chamber. This recess may be filled with liquid, so as to maintain a minimal space between the core element and the buffer bag which will allow liquid to enter.

In order to allow liquid to fill the entire interior volume of the buffer bag, the at least one recess may be a groove extending over substantially an entire length of the core element.

35 Alternatively, a channel could be arranged within the core element which could fluidically connect to another channel leading to the exterior surface of the core element. The core element might also

have a cross section which is oval shaped, triangular shaped, cross shaped or any other shape which would leave a recess between the outside of the core element and the inside wall of the buffer bag.

In an embodiment, the elastic buffer bag may be made of a thermoplastic elastomer (TPE) or a natural or synthetic rubber, in particular a silicone rubber. Thermoplastic elastomers have the ability to be stretched to moderate elongations and, upon the removal of stress, return to something close to their original shape. Moreover, they are processable as a melt at elevated temperature, and are free from significant creep. The thermoplastic elastomer for the buffer bag may be selected from styrene block copolymers (TPS or TPE-S), thermoplastic polyolefin elastomers (TPO or TPE-O), thermoplastic vulcanizates (TPV or TPE-V), thermoplastic polyurethanes (TPU or TPE-U), thermoplastic copolyesters (TPC or TPE-E), thermoplastic polyamides (TPA or TPE-A), and unclassified thermoplastic elastomers (TPZ).

In an embodiment, the elastic buffer bag may be made of a recyclable material, in particular a styrene block copolymer (TPS or TPE-S). This allows the entire dispensing device to be recycled as a whole, without having to disassemble the various parts.

In a further embodiment, the styrene block copolymer may comprise Thermolast® K from Kraiburg TPE (www.kraiburg-tpe.com), which is a low-cost and durable material that is easy to process and easy to recycle.

In case the elastic buffer bag and the buffer housing are integrally made, the buffer housing may be made of a polyolefin, such as PP or PE, in particular HDPE, and the elastic buffer bag and the buffer housing may be made by 2C injection molding.

In an embodiment of the liquid dispensing device, the internal volume of the elastic buffer bag may be in open communication with the pump chamber. In this way dispensing of the liquid will be interrupted as soon as the pump is no longer actuated, since the liquid stored in the buffer bag will simply flow back into the pump chamber. This concept is identified as “direct stop”.

In a further embodiment, a difference in volume between a fully expanded state and a relaxed state of the elastic buffer bag may be at least 30 % of a displacement volume of the pump, in particular at least 40 %, more in particular at least 50 %, even more in particular at least 60 %, most in particular at least 70%, preferably at least 80 %, more preferably at least 90 % of the displacement volume, and most preferably substantially equal to the displacement volume. In this case the amount of buffer capacity that is needed, i.e. the difference in volume between the elastic buffer bag in relaxation and the buffer bag when fully expanded, is determined by the swept volume or displacement volume of the pump. The displacement volume is defined as the volume that is displaced during a full stroke of the piston, i.e. the cross-sectional area of the piston chamber multiplied by the distance which the piston can travel.

Since the buffer is in open communication with the pump chamber, the maximum amount of liquid that has to be stored in the buffer equals the volume that is displaced during a single pump stroke. The volume of the elastic buffer bag in its fully expanded state is limited only by the interior volume of the buffer housing. The dimensions of the elastic buffer bag are selected such
5 that when it is expanded to the point where it is restricted by the buffer housing, its fully expanded state in the sense of the present disclosure, the material of the bag is still (well) within its elastic range. In that way liquid may be buffered at a relatively lower pressure.

It is also conceivable that the bag is dimensioned such that its internal volume, when restricted by the buffer housing, is greater than the displacement volume of the pump. In that case
10 the bag would never reach its fully expanded state, and the liquid pressure in the buffer bag would be even lower. The internal volume of the bag when expanded to come into contact with the buffer housing could be two times, four times, seven times or even ten times the displacement volume of the pump. For instance, the internal volume of the bag when expanded to come into contact with the buffer housing could be 1, 2, 3, 4 or even 5 ccm, while the displacement volume of the pump
15 could be 0.5 ccm. An oversized buffer bag that may potentially be expanded to such dimensions will lead to a very gradual pressure build-up when it is partially filled during a pump stroke.

In another embodiment the liquid dispensing device may further comprise a pump outlet valve arranged between the pump and the buffer. This allows dispensing of the liquid to continue even when the pump is no longer actuated, since the pump outlet valve, which is a one-way valve,
20 prevents the liquid stored in the buffer bag from flowing back into the pump chamber. Consequently, the liquid stored in the buffer can only flow past the outlet valve and through the nozzle. This concept is identified as “continuous dispensing” or “continuous spray”.

In a liquid dispensing device which is configured for continuous spray, a displacement volume of the pump may be between 0.15 and 3.0 ccm, preferably between 0.2 and 2.5 ccm and
25 more preferably between 0.3 and 2.0 ccm, and a difference in volume between a fully expanded state and a relaxed state of the elastic buffer bag may be between 0.5 and 15 times of the displacement volume of the pump, preferably between 0.7 and 12 times the displacement volume and more preferably between 1 and 10 times the displacement volume.

In such a continuous liquid dispensing device it is important that buffer capacity is
30 sufficient to accommodate the amount of liquid that is displaced during consecutive pump strokes at a certain frequency. This is because part of the total volume displaced by the pump will be dispensed via the nozzle, while another part will be stored in the buffer, since the nozzle flow rate is lower than the total flow rate offered by the pump.

The buffer volume that is required is also dependent on a number of completed strokes at a
35 set trigger stroke frequency and flow. When this frequency is high, not all liquid stored in the

buffer will be dispensed before additional liquid is added by the consecutive trigger stroke. The more trigger strokes are made, the more liquid will accumulate in the buffer.

When the pump displacement volume, buffer volume, nozzle flow rate and trigger stroke rate are not suitably balanced, the buffer bag may become damaged, overstretched, or full, so that it will no longer be able to accommodate the amount of liquid displaced by the pump. As a result, the system pressure will increase, thus impacting the overall performance and operating convenience of the liquid dispensing device.

It is believed that pumps having a lower pump displacement volume support a higher frequency of trigger strokes without resulting in fatigue. This is because such pumps have a piston which is relatively smaller in diameter resulting in a lower force to actuate, while the travel or stroke is also relatively shorter.

When operated at convenient or manageable trigger stroke frequencies, and when fitted with the same nozzles and operating at the same pressure, and therefore having the same flow rate, pumps having a larger pump displacement volume require a different, smaller, pump volume-to-buffer volume ratio than pumps having a smaller pump displacement volume. Pumps having a larger pump displacement volume require a lower trigger frequency than pumps having a smaller pump displacement volume to maintain a continuous spray when having the same flow rate.

In regular use of a continuous liquid dispensing device it is assumed that a maximum of 10 to about 20 consecutive trigger or pump strokes are made to complete a targeted job such as wetting a surface or dispensing air freshener - although continuous strokes could theoretically be made until a container connected to the liquid dispensing device is empty. The trigger frequency can be anywhere between 10 and 180 strokes per minute, preferably between 30 and 160 strokes per minute and more preferably between 60 and 120 strokes per minute. To keep an operating force that is exerted on the trigger within acceptable limits, the buffer needs sufficient capacity in order to avoid an excessive pressure build up. These considerations lead to the selection of buffer-to-pump volume ratios and maximum pump displacement volumes as defined above.

In a further embodiment the outlet valve may be a pre-compression valve. Such a pre-compression valve opens and closes at a well-defined and somewhat elevated pressure, thus providing a clear cut-off when dispensing liquid, and preventing any dripping of liquid.

The invention further provides a system for dispensing a liquid, which comprises a container and a liquid dispensing device of the type described above connected to the container.

The invention will now be illustrated by way of a number of exemplary embodiments, with reference being made to the annexed drawings, in which like elements are identified by reference numerals increased by 100, and in which:

Fig. 1 is a side view of a system for dispensing a liquid which comprises a container and a first embodiment of a liquid dispensing device connected thereto;

Fig. 2 is a front view of the system of Fig. 1;

Fig. 3 is an enlarged scale cross-sectional view along the lines III-III in Fig. 2, showing the liquid dispensing device at rest, when the buffer bag is empty;

Fig. 4 is a view corresponding to Fig. 3, showing the dispensing device in use, when the piston is at the end of its stroke and the buffer bag is completely filled;

Fig. 5 is a view corresponding to Fig. 3, showing a second embodiment of the dispensing device of the invention in its position of rest with an empty buffer bag;

Fig. 6 is a view corresponding to Fig. 5, showing the dispensing device with the piston in its lowermost position and the buffer bag completely filled;

Fig. 7 is a view corresponding to Figs. 3 and 5, showing a third embodiment of the dispensing device of the invention in its position of rest;

Fig. 8 is a view corresponding to Fig. 7, showing the dispensing device with the piston at the end of its stroke and the buffer bag completely filled;

Fig. 9 is a view corresponding to Figs. 3, 5 and 7, showing a fourth embodiment of the dispensing device of the invention in its position of rest;

Fig. 10 is a view corresponding to Fig. 9, showing the dispensing device with the piston at the end of its stroke and the buffer bag completely filled;

Fig. 11 is a view corresponding to Figs. 3, 5, 7 and 9, showing a fifth embodiment of the dispensing device of the invention in its position of rest; and

Fig. 12 is a view corresponding to Fig. 11, showing the dispensing device with the piston at the end of its stroke and the buffer bag completely filled.

A system 1 for dispensing a liquid comprises a container 2 which is at least partially filled with the liquid to be dispensed and which has a neck (not shown). The system 1 further comprises a liquid dispensing device 3 connected to the neck of the container 2 by an annular connector 4 (Figs. 1, 2).

The liquid dispensing device 3 comprises a pump 5 which includes a pump chamber 6 and a piston 7 that is reciprocally movable in the pump chamber 6 as indicated by arrow R (Figs. 3, 4). The device 3 further comprises a movable actuator 8, in the illustrated embodiment a trigger, which is operatively coupled to the piston 7. The actuator 8 may be pivotable or slidable as indicated by arrow T. It may be moved inward to urge the piston 7 towards an end wall 53 of the pump chamber 6 by a user exerting force to initiate a pump stroke, and may be moved outward in a return stroke by means of e.g. a return spring (not shown).

The piston 7 is conventional and includes an end face 60 and two annular seals 44, 46 for sealing the pump chamber 6 and for sealing a vent opening 47 which can be brought into fluid communication with the interior of the container 2. The piston further includes two mounting

openings (not shown) for receiving mounting pins protruding from a connector 48 of the actuator or trigger 8.

The liquid dispensing device 3 further comprises an inlet channel 14 which is configured to be brought in fluid communication with the container 2. In the illustrated embodiment the inlet
5 channel 14 accommodates a top end of a dip tube 15 which extends into the container 2. The inlet channel 14 leads to an inlet opening 16 of the pump 5, which may be closed by an inlet valve 17 sealingly abutting a valve seat 33.

The liquid dispensing device 3 also comprises a buffer 9 which is in fluid communication with the pump 5, as will be described in more detail below.

10 The liquid dispensing device 3 further comprises a nozzle 12 having a dispensing orifice 25 for dispensing the liquid. In the illustrated embodiment the nozzle 12 is in fluid communication with the pump 5 and with the buffer 9 as well. The fluid communication between the nozzle 12 and the buffer 9 runs through the pump chamber 6, while the fluid communication between the pump chamber 6 and the nozzle 12 is established through an outlet channel 24. The outlet channel 24 is
15 in communication with the pump chamber 6 through a pump outlet opening 19, a valve chamber 20 and an outlet opening 22. In the illustrated embodiment the pump inlet opening 16 and pump outlet opening 19 are formed by a single aperture in the end wall 53 of the pump chamber 6.

An outlet valve 13 is arranged between the pump 5 and buffer 9 on the one hand and the nozzle 12 on the other. In the illustrated embodiment, the outlet valve 13 is a pre-compression
20 valve, more in particular a dome valve which is arranged in the valve chamber 20 that communicates with the pump chamber 6 through the pump outlet opening 19. The dome valve 13 is locked in the valve chamber 20 by an end wall 21. The dome valve 13 comprises a substantially cylindrical sleeve 26 extending from the end wall 21 towards the pump outlet opening 19 and carrying the actual dome 27. This dome 27 sealingly abuts a valve seat 23 surrounding the outlet
25 opening 22 to interrupt the fluid communication between the pump 5 and elastic buffer 9 and the nozzle 12. An end part of the sleeve 26 carrying the dome 27 is sealingly received in an annular flange 28.

In the illustrated embodiment, the valve chamber 20 is shown to be offset from but parallel to the pump chamber 6. The inlet valve 17 is shown to be formed by a peripheral lip of the sleeve
30 26, which is flexible and may be urged away from a peripheral wall of the valve chamber 20 which forms the valve seat 33 into a recess in the annular flange 28 to allow fluid flow through the inlet opening 16, as shown in dotted lines 17' in Fig. 3.

In this embodiment, the connector 4 connecting the liquid dispensing device 3 to the container 2 comprises a ring having inner threading 29 which cooperates with outer threading on
35 the container neck (not shown).

In the illustrated embodiment, the various parts of the liquid dispensing device 3 are covered by a shroud 31 extending between the annular connector 4 and the nozzle 12.

The pump chamber 6 is shown to have an axis P defining the direction R of the reciprocal movement of the piston 7 which is substantially perpendicular to an axis I of the inlet channel 14.

5 In other words, during normal use of the liquid dispensing system 1, when the container 2 and the inlet channel 14 will be substantially vertically oriented, the pump chamber 6 will be substantially horizontal. This arrangement allows for a compact construction having a relatively limited amount of “dead” volume.

10 In accordance with the invention, the buffer 9 comprises an elastic buffer bag 10 which defines an expansible volume V_b . The elastic buffer bag 10 extends at least partially past the connecting means - here the annular connector 4 - towards an interior of the container 2. In the shown embodiment the elastic buffer bag 10 is arranged in a buffer housing 54. The elastic buffer bag 10 has an opening 11 which is in fluid communication with the pump 5. In the illustrated embodiment the elastic buffer bag 10 has a substantially cylindrical (or slightly conical) part 18
15 extending from the opening 11 towards a closed end part 32. In the illustrated embodiment, the opening 11 of the elastic buffer bag 10 is arranged in an open end 35 of the buffer housing 54 which is connected with the pump chamber 6 by a channel 55 and an opening 56 in the end wall 53 of the pump chamber 6. The opening 11 is enclosed by a neck 36 which is sealingly connected to an inner peripheral edge 37 of the buffer housing 54.

20 In this embodiment the neck 36 has an enlarged diameter and is clamped between a part of the buffer housing 54 having a reduced diameter in the form of an inwardly extending flange 38 and an intermediate structure 57. This clamping ensures that the elastic buffer bag 10 is fixed in the buffer housing 54 and may withstand the pressures that are generated when fluid is stored in the bag 10 during pumping. As shown in Fig. 3, the buffer housing 54 has an internal volume V_h that
25 is larger than an external volume of the elastic buffer bag 10 when this is empty. The buffer housing 54 is shown to be cylindrical and its internal diameter D_i is shown to be larger than an external diameter d_o of the cylindrical part 18 of the buffer bag 10, thus creating an annular space 39 around the buffer bag 10 in its empty state. Buffer housing 54 has a closed end 42 opposite its open end 35.

30 The bottom 41 of the intermediate structure 57 extends over the entire internal diameter D_i of the buffer housing 54 and covers the open end 35. The intermediate structure 57 has a downwardly protruding ridge 58 surrounding the open end 35 and fixing the buffer housing 54.

The elastic buffer bag 10 can be made of a thermoplastic elastomer (TPE) or a natural or synthetic rubber, in particular a silicone rubber. In order to allow the liquid dispensing device 3 to
35 be recycled, the elastic buffer bag 10 can be made of a recyclable material, in particular a styrene

block copolymer (TPS or TPE-S). A suitable material for the elastic buffer bag 10 is Thermolast® K from Kraiburg TPE (www.kraiburg-tpe.com).

In the illustrated embodiment a core element 40 is arranged in the buffer bag 10. This core element 40 substantially fills the internal volume V_b of the buffer bag 10 when this is empty, thus minimizing the amount of “dead” volume in the dispensing device 3 at the end of a pump stroke, which makes it easier to prime the device, i.e. remove any air before first use. The core element 40, which is made from a relatively stiff material, e.g. a plastic like polypropylene or polyethylene, is shown to protrude from the intermediate structure 57. In the illustrated embodiment, the core element 40 has a tip 59 which is spaced from the closed end 42 of the buffer housing 54, thus allowing for longitudinal expansion of the elastic buffer bag 10. In order to allow liquid to enter the buffer bag 10, the core element 40 is shown to include a recess 45, in this case a groove in an outer surface 34 which extends all the way to its end 30. This groove 45 is in fluid communication with the channel 55 leading to the pump chamber 6 through a bore 43 in a bottom of the intermediate structure 57. Although the core element 40 is shown here to extend all the way to the closed end part 32 of the buffer bag 10, it may be shorter, as indicated by dashed lines 40' and dotted lines 40'', respectively, in Fig. 4. In this way the effective volume of the elastic buffer bag 10 can be increased.

It should be noted that the ridge 58 surrounding the open end 35 is only an exemplary way of connecting the core element 40 with the buffer housing 54 and buffer bag 10. Alternatively, this connection might also be formed by a peripheral edge of the bottom 41 being received in a peripheral groove near an upward facing end of the buffer housing 54. This would require a part of the buffer housing wall to extend past the bottom 41.

As can be seen from Figs. 3 and 4, when the dispensing device 3 is in its position of rest, the elastic buffer bag 10 is arranged around the core element 40 and the internal volume V_b of the buffer bag 10 corresponds substantially with the external volume of the core element 40. On the other hand, when the dispensing device 3 is operated and liquid is stored in the elastic buffer bag 10, its internal volume will increase until it substantially corresponds with the internal volume V_h of the buffer housing 54 – minus the volume taken up by the elastic material of the wall of the buffer bag 10. The difference in volume between the expanded state of the elastic buffer bag 10 shown in Fig. 4 and the relaxed state shown in Fig. 3 may be at least 30 % of a displacement volume of the pump, in particular at least 40 %, more in particular at least 50 %, even more in particular at least 60 %, most in particular at least 70%, preferably at least 80 %, more preferably at least 90 % of the displacement volume, and may even be substantially equal to the displacement volume.

During use of the liquid dispensing system 1, the pump 5 will first be primed by operating the trigger 8 one or more times. The “dead” volume at the end of a stroke, i.e. the volume bordered

by the end wall 53 of the piston chamber 6, the end face 60 and annular seal 44 of the piston 7 and the intermediate structure 57 and core element 40, is relatively small and will contain only a limited amount of air. Consequently, priming does not require many pump strokes. After priming, whenever the piston 7 is moved outward by the return spring after a pump stroke, to the position
5 shown in Fig. 3, liquid will be drawn from the container 2 through the dip tube 15, the inlet channel 14, and the inlet opening 16 into the pump chamber 6. During such a return stroke or suction stroke, the inlet valve 17 will be lifted from its valve seat 33 as a result of the suction applied by the piston 7 moving outward, thus allowing the liquid to flow through the inlet opening 16.

10 During a subsequent pump stroke, as the piston 7 is moved inward by the trigger 8, the inlet valve 17 will be closed by the pressure created by the piston 7 moving inward, and the liquid in the pump chamber 6 will be forced through the pump outlet opening 19 into the valve chamber 20. There the liquid pressure will act on the dome-shaped part 27 of the pre-compression outlet valve 13. When the pressure of the liquid in the pump chamber 6 exceeds a cracking pressure of
15 the pre-compression valve 13, the pre-compression valve 13 will be moved from its valve seat 23 by deformation of the dome 27 (Fig. 4), allowing the liquid to flow through the outlet opening 22 and the outlet channel 24 towards the nozzle 12 to be dispensed through the orifice 25.

The dimensions of the various parts of the liquid dispensing device 3 are such that the orifice 25 cannot dispense the liquid at the same rate as it is pressurized and forced past the pre-
20 compression valve 13 by actuation of the pump 5. Pressurized liquid that cannot be dispensed through the orifice 25 flows through the opening 56, the channel 55 and the bore 43 in the bottom 41 into the groove 45 of the core element 40. The liquid in the groove 45 then forces the cylindrical part 18 of the elastic buffer bag 10 outwards, away from the outer surface 34 of the core element 40, thus creating more room for accommodating liquid (Fig. 4). This expansion of the elastic buffer
25 bag 10 is controlled by the buffer housing 54, which limits the extent to which the buffer bag 10 can be stretched.

If the piston 7, after having reached the inner end of its stroke, is held in that position by a user continuing to exert force on the trigger 8, the pressurized liquid that has accumulated in the buffer bag 10 is forced out by contraction of the elastic buffer bag 10, which returns to its initial
30 shape as indicated by the dashed lines 10' in Fig. 4. As long as the pressure stored in the elastic buffer bag 10 exceeds the cracking pressure of the pre-compression valve 13, this liquid will be forced past the pre-compression valve 13 towards the nozzle 12, to be dispensed through the orifice 25. In this way liquid is dispensed from the nozzle 12 for a prolonged period.

When the user stops actuating the pump 5, the trigger 8 will be returned to its initial
35 position by the return spring, thus also causing the piston 7 to be returned. This will cause the liquid flow to be interrupted immediately, regardless of the amount of liquid that may still remain

in the buffer. This is because the remaining liquid in the device 3 will be distributed over the volume of the pump chamber 6 and the internal volume V_b of the elastic buffer bag 10, so that its pressure will fall below the cracking pressure of the pre-compression valve 13 (Fig. 3). The abrupt closure of the pre-compression valve 13 will prevent any dripping.

5 In an alternative embodiment of the liquid dispensing device 103, pump chamber 106 has an axis P which is parallel to the axis I of inlet channel 114 (Figs. 5, 6). Piston 107 is connected to actuator 108 by a pin 148 in an oblong aperture 162, which transforms the pivoting movement of the actuator 108 in the direction of arrow T into vertical reciprocating movement of the piston 107 as indicated by arrow R. An inlet channel 149 runs from inlet opening 116 to pump chamber 106.

10 In this embodiment the inlet valve 117 is shown to comprise a disk that is movable with respect to an annular valve seat 133 surrounding the inlet opening 116.

Buffer 109 is again arranged in buffer housing 154 and comprises an elastic buffer bag 110 and a core element 140.

15 In this embodiment, pump outlet opening 119 leads to channel 155 which directs liquid into both the bore 143 and a vertical intermediate channel 151. Bore 143 again leads to groove 145 of core element 140, while vertical intermediate channel 151 leads to valve chamber 120. In valve chamber 120, dome valve 113 once again sealingly abuts valve seat 123 surrounding outlet channel 124. The outlet channel 124 guides the liquid to the orifice 125 of the nozzle 112.

20 In this embodiment connector 104 is integrally formed with liquid dispensing device 103 and includes inwardly protruding cams 129 which are configured for cooperation with bayonet provisions on the container neck (not shown).

Further structural features, as well as the operation of this embodiment of the liquid dispensing device 103 are the same as those of the first embodiment, discussed in connection with Figs. 3 and 4. Here again, any liquid that cannot be dispensed through nozzle 112 at the rate at which it is moved by pump 105 being operated by a user, will be stored in buffer 109 by elastic deformation of buffer bag 110, as shown in Fig. 6. The liquid is then released from buffer 109 to vertical intermediate channel 151 and onwards to nozzle 112 when the user maintains piston 107 in its lowermost position by keeping actuator 108 depressed.

30 Instead of being perpendicular or parallel to the axis I of the inlet channel 214, in a further embodiment of the liquid dispensing device 203 the pump chamber 206 has an axis P which is arranged at an acute or obtuse angle α with respect to the axis I of the inlet channel 214 (Figs. 7, 8). Here again, buffer 209 is arranged in buffer housing 254 and comprises an elastic buffer bag 210 and a core element 240.

35 Like in the first embodiment, outlet valve 213 is a dome valve which is arranged in valve chamber 220 that communicates with pump chamber 206 through pump outlet opening 219 and through a short intermediate channel 251. Inlet valve 217 is again shown to be formed by a

peripheral lip of sleeve 226, which is flexible and may be urged away from a peripheral wall of valve chamber 220 that forms valve seat 233.

In this embodiment, a vent channel 252 connects vent opening 247 in the pump chamber wall with the interior of annular connector 204. Inlet channel 214 and buffer 209 are shown to be
5 vertical, while outlet channel 224 is shown to be horizontal and pump 205 is arranged at an angle α in between the inlet and outlet channels 214, 224.

The shown embodiment resembles the first embodiment of Figs. 3 and 4 in all further aspects. Further structural features, as well as the operation of this embodiment of the liquid dispensing device 203 are the same as those of the first and second embodiments, discussed in
10 connection with Figs. 3-6.

Although the buffer bag and buffer housing have been shown and described above as separate parts that can be assembled, it is also conceivable that elastic buffer bag 310 and buffer housing 354 will be integrally made, as shown in the embodiment of Figs. 9 and 10. The elastic buffer bag 310 and the buffer housing 354 may for example be made by a process of injection
15 molding. Integrally forming these two parts reduces the number of assembling steps, as well as the number of separate parts to be made and stocked.

Since the requirements for elastic buffer bag 310 are different from those for buffer housing 354, e.g. when it comes to structural strength and stiffness or flexibility, or when it comes to suitability for contact with the liquid to be dispensed, the elastic buffer bag 310 and the buffer
20 housing 354 may be made from different materials. For instance, buffer housing 354 may be made of a polyolefin, such as PP or PE, in particular HDPE, while elastic buffer bag 310 may be made of a thermoplastic elastomer (TPE) or a synthetic rubber, in particular a silicone rubber. These different materials may be integrated with each other in a bi-injection molding process or 2C injection molding process. In such a process one of the two parts may be injection molded first,
25 and then the second material may be injected into the same mold so as to bond with the first material while still at least partially in a molten state.

A transition 361 between the material forming buffer housing 354 and the material forming elastic buffer bag 310 may be arranged at substantially the same location where the enlarged diameter part of the neck is clamped between a reduced diameter part of the buffer housing and the
30 intermediate structure in the other embodiments discussed above. In this way the transition area 361 of the integrally molded buffer bag and housing surrounds opening 311 of the elastic buffer bag 310.

In the illustrated embodiment, transition area 361 is clamped between downwardly protruding ridge 358 of intermediate structure 357 and a base part of core element 340. Since the
35 buffer housing 354 is integrally formed with the elastic buffer bag 310, transition area 361 now effectively forms a closed end 342 of buffer housing 354. On the other hand, the opposite end 335

of buffer housing 354, which faces the interior of the container, is open in this embodiment, thus providing additional room for expansion of the buffer bag 310. This open end 335 may be closed off by a cap (not shown) to protect the buffer bag 310 from contact with the contents of the container.

5 Further structural features, as well as the operation of this embodiment of the liquid dispensing device 303 are the same as those of the other embodiments, discussed in connection with Figs. 3-8.

In all embodiments discussed above, the internal volume of the buffer bag has been shown to be in open communication with the pump chamber, resulting in dispensing of liquid being
10 interrupted as soon as a user stops operating the pump. However, in a fifth embodiment a pump outlet valve 463 is arranged between pump 405 and the buffer 409 (Figs. 11 and 12). The pump outlet valve 463 closes off the pump outlet opening 419 and isolates the pump chamber 406 from the channel 455 leading to both the buffer 409 and the intermediate channel 451. In the illustrated embodiment the pump outlet valve 463 comprises a disk, like the pump inlet valve 417. The disk-
15 shaped pump outlet valve 463 is movable with respect to an annular valve seat 464 surrounding the pump outlet opening 419.

Like the inlet valve 417, the pump outlet valve 463 is a one-way valve that opens and closes as a result of pressure differentials acting on the valve. The pump outlet valve 463 opens when pressure is built up in the pump chamber 406 during a downward pump stroke of the piston
20 407, allowing liquid to flow into the channel 455 and from there into the intermediate channel 451 and into the buffer 409. The pump outlet valve 463 closes when the pressure in the pump chamber 406 drops during an upward suction stroke of the piston 407. The pump outlet valve 463 remains closed as long as the liquid pressure in the channel 455, the buffer 409 and the intermediate channel 451 leading to the outlet valve 413 is higher than the pressure in the pump chamber 406.
25 This allows dispensing of the liquid through the nozzle 412 to continue as long as the pressure in the buffer 409 is higher than the cracking pressure of the outlet valve 413. Such continuous dispensing resembles the function of an aerosol, without the need for a propellant.

In order to allow dispensing to continue for some time after the user has stopped operating the trigger 408, the useful internal volume of the expansible buffer bag 410, i.e. the difference in
30 volume between its expanded state and its relaxed state, must be balanced with the displacement volume of the pump 405. As can be seen by comparing the second embodiment of Figs. 5 and 6 with the fifth embodiment of Figs. 11 and 12, both the elastic buffer bag 410 and the buffer housing 454 of the “continuous dispensing” embodiment are larger than the corresponding elements of the “direct stop” embodiment. In the illustrated embodiment the diameter D_i of the
35 buffer housing 454 has been maintained, but its length has been increased. However, it is also conceivable that the diameter is increased instead of or in addition to lengthening the buffer

housing 454. The ratio between the effective internal volume of the elastic buffer bag 410 and the displacement volume of the pump may vary between 0.5 and 15, and preferably between 0.7 and 12. Most preferable, this ratio varies between 1 and 10.

5 The shown embodiment resembles the second embodiment of Figs. 5 and 6 in all further aspects.

The invention as disclosed herein provides a relatively simple yet effective liquid dispensing device which allows the pressure at which liquid is dispensed, and therefore the bandwidth of the liquid droplets, to be optimally controlled. Optimum control of the dispensing pressure may involve selecting the volume of the elastic buffer bag in both relaxed and expanded
10 state, the material of the buffer bag, the size of a potential core element, the cracking pressure of the outlet valve, in particular the pre-compression valve and the throughput of the nozzle orifice. Due to the presence of a buffer, dispensing may be prolonged when the piston is held at the end of a pump stroke. Since all parts of the dispensing device, including the buffer, are made of plastic materials, the device may be recycled after use, thus reducing the carbon footprint and the amount
15 of waste material.

Although the invention has been described by reference to various exemplary embodiments, it is not limited thereto, and may be varied within the scope of the appended claims.

Claims

1. Device for dispensing a liquid from a container, comprising:
- an inlet channel configured to be brought in fluid communication with the container;
 - 5 - a pump in fluid communication with the inlet channel, the pump including a pump chamber and a piston reciprocally movable in the pump chamber;
 - an inlet valve arranged between the inlet channel and the pump;
 - a buffer in fluid communication with the pump;
 - a nozzle for dispensing the liquid, the nozzle in fluid communication with the pump
 - 10 and/or the buffer;
 - an outlet valve arranged between the pump and/or buffer and the nozzle; and
 - means for connecting the dispensing device to the container;
 - wherein the buffer comprises an elastic buffer bag defining an expansible volume and extending at least partially past the connecting means towards an interior of the container.
 - 15
2. Liquid dispensing device as claimed in claim 1, wherein the elastic buffer bag is arranged in a buffer housing which extends at least partially past the connecting means towards an interior of the container.
- 20 3. Liquid dispensing device as claimed in claim 1 or 2, wherein the elastic buffer bag defines an internal volume and has an opening in fluid communication with the pump.
4. Liquid dispensing device as claimed in any one of the preceding claims, wherein the elastic buffer bag and/or the buffer housing extends substantially parallel to the inlet channel.
- 25
5. Liquid dispensing device as claimed in claim 4 when dependent on claim 2, wherein the buffer housing is fixed to the inlet channel.
6. Liquid dispensing device as claimed in any one of claims 3-5, wherein the opening of the elastic buffer bag is enclosed by a neck which is sealingly connected to an inner peripheral edge of the buffer housing.
- 30
7. Liquid dispensing device as claimed in any one of claims 2-5, wherein the elastic buffer bag and the buffer housing are integrally made.
- 35

8. Liquid dispensing device as claimed in any one of claims 2-7, wherein the buffer housing is open on two opposite ends.

9. Liquid dispensing device as claimed in any one of the preceding claims, further comprising a
5 core element arranged in the elastic buffer bag.

10. Liquid dispensing device as claimed in claim 9 when dependent on claim 6, wherein the neck of the elastic buffer bag is clamped between the inner peripheral edge of the buffer housing and the core element.
10

11. Liquid dispensing device as claimed in claim 9 or 10, wherein the core element substantially fills the internal volume of the elastic buffer bag.

12. Liquid dispensing device as claimed in any one of claims 9-11, wherein the core element
15 includes at least one recess in fluid communication with the pump chamber.

13. Liquid dispensing device as claimed in claim 12, wherein the at least one recess is a groove extending over substantially an entire length of the core element.

20 14. Liquid dispensing device as claimed in any one of the preceding claims, wherein the elastic buffer bag is made of a thermoplastic elastomer (TPE) or a natural or synthetic rubber, in particular a silicone rubber.

15. Liquid dispensing device as claimed in claim 14, wherein the elastic buffer bag is made of a
25 recyclable material, in particular a styrene block copolymer (TPS or TPE-S).

16. Liquid dispensing device as claimed in claim 14 or 15 when dependent on claim 7, wherein the buffer housing is made of a polyolefin, such as PE or PP, and wherein the elastic buffer bag and the buffer housing are made by 2C injection molding.
30

17. Liquid dispensing device as claimed in any one of the preceding claims, wherein the expandable volume of the elastic buffer bag is in open communication with the pump chamber.

18. Liquid dispensing device as claimed in claim 17, wherein a difference in volume between a
35 fully expanded state and a relaxed state of the elastic buffer bag is at least 30 % of a displacement volume of the pump, in particular at least 40 %, more in particular at least 50 %, even more in

particular at least 60 %, most in particular at least 70%, preferably at least 80 %, more preferably at least 90 % of the displacement volume, and most preferably substantially equal to the displacement volume.

- 5 19. Liquid dispensing device as claimed in any one of claims 1-16, further comprising a pump outlet valve arranged between the pump and the buffer.

20. Liquid dispensing device as claimed in claim 19, wherein a displacement volume of the pump is between 0.15 and 3.0 ccm, preferably between 0.2 and 2.5 ccm and more preferably between 0.3 and 2.0 ccm, and wherein a difference in volume between a fully expanded state and a relaxed state of the elastic buffer bag is between 0.5 and 15 times of the displacement volume of the pump, preferably between 0.7 and 12 times the displacement volume and more preferably between 1 and 10 times the displacement volume.
- 10

- 15 21. Liquid dispensing device as claimed in any one of the preceding claims, wherein the outlet valve is a pre-compression valve.

22. System for dispensing a liquid, comprising a container and a liquid dispensing device as claimed in any one of the preceding claims connected thereto.