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(54) **EXTENDED EMISSION TIME LIQUID SPRAYER**

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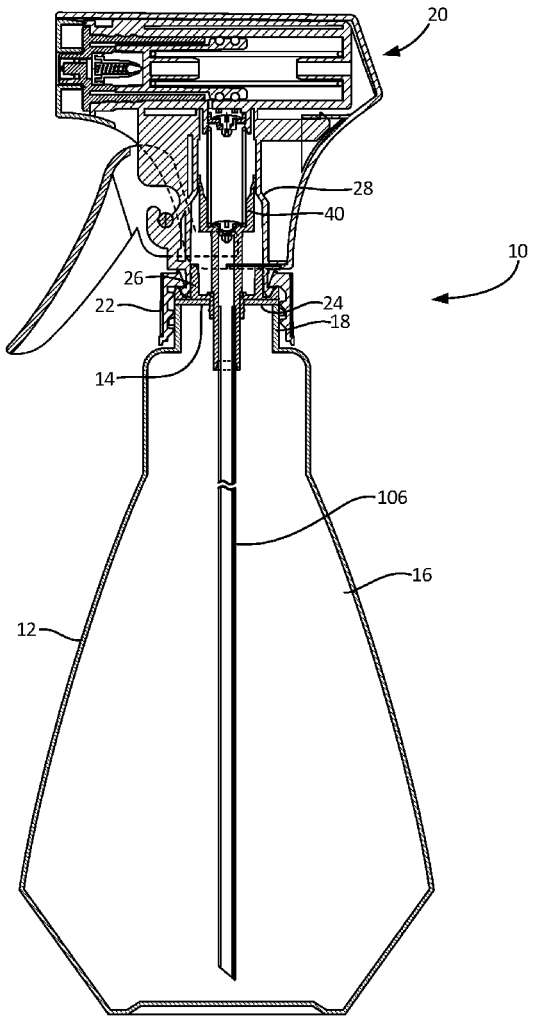
CPC ***B05B 11/3025*** (2013.01); ***B05B 15/005*** (2013.01); ***B05B 11/3011*** (2013.01); ***B05B 11/3014*** (2013.01)

(57) **ABSTRACT**

A liquid sprayer apparatus includes a multi-chamber spray mechanism, with at least one chamber being adapted to accumulate pressurized fluid for dispensation over an extended time period. The liquid sprayer apparatus is capable of emitting a liquid spray over a period of time that is substantially greater than a manual pump action applied to the trigger.



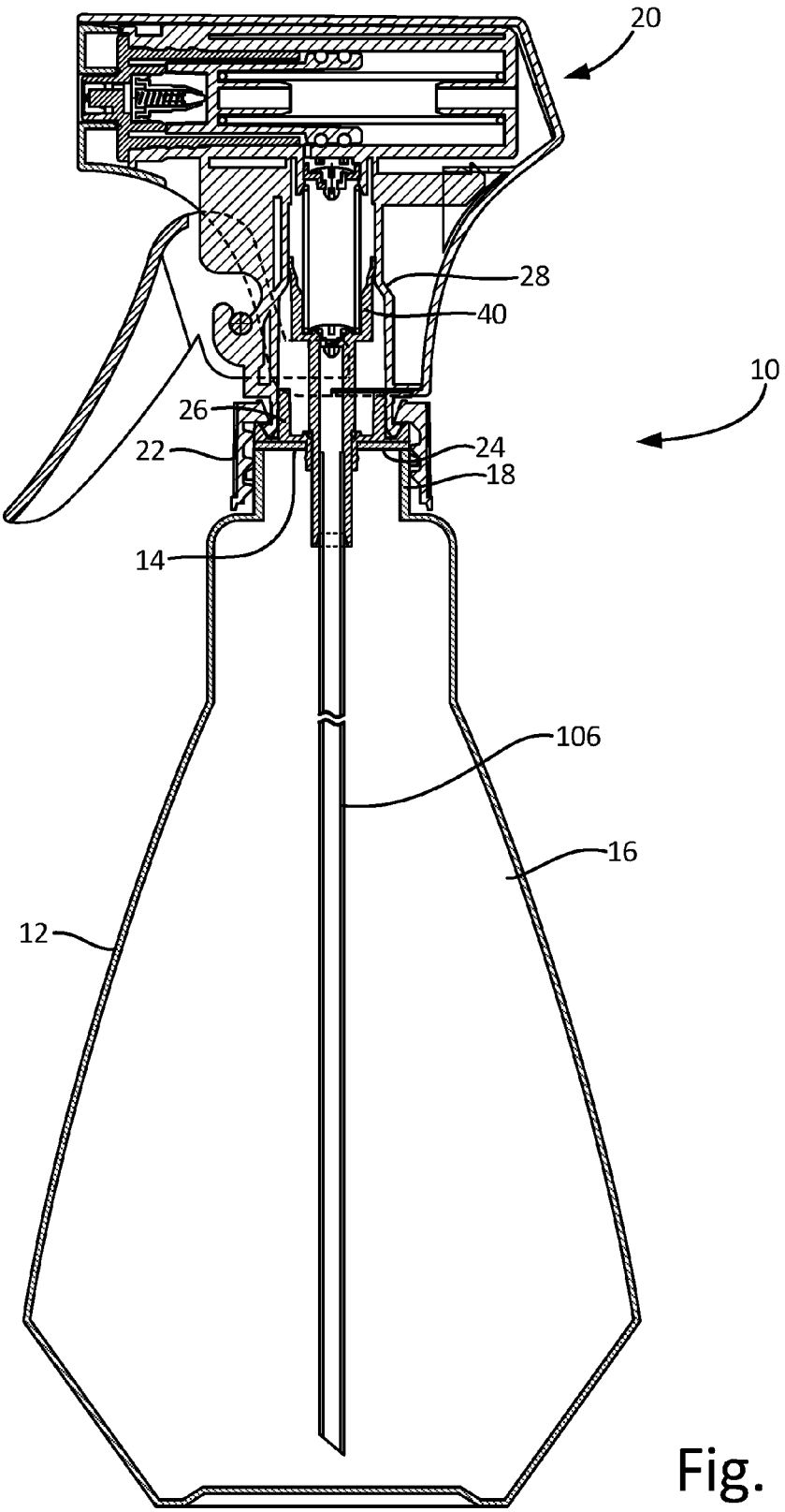


Fig. 1

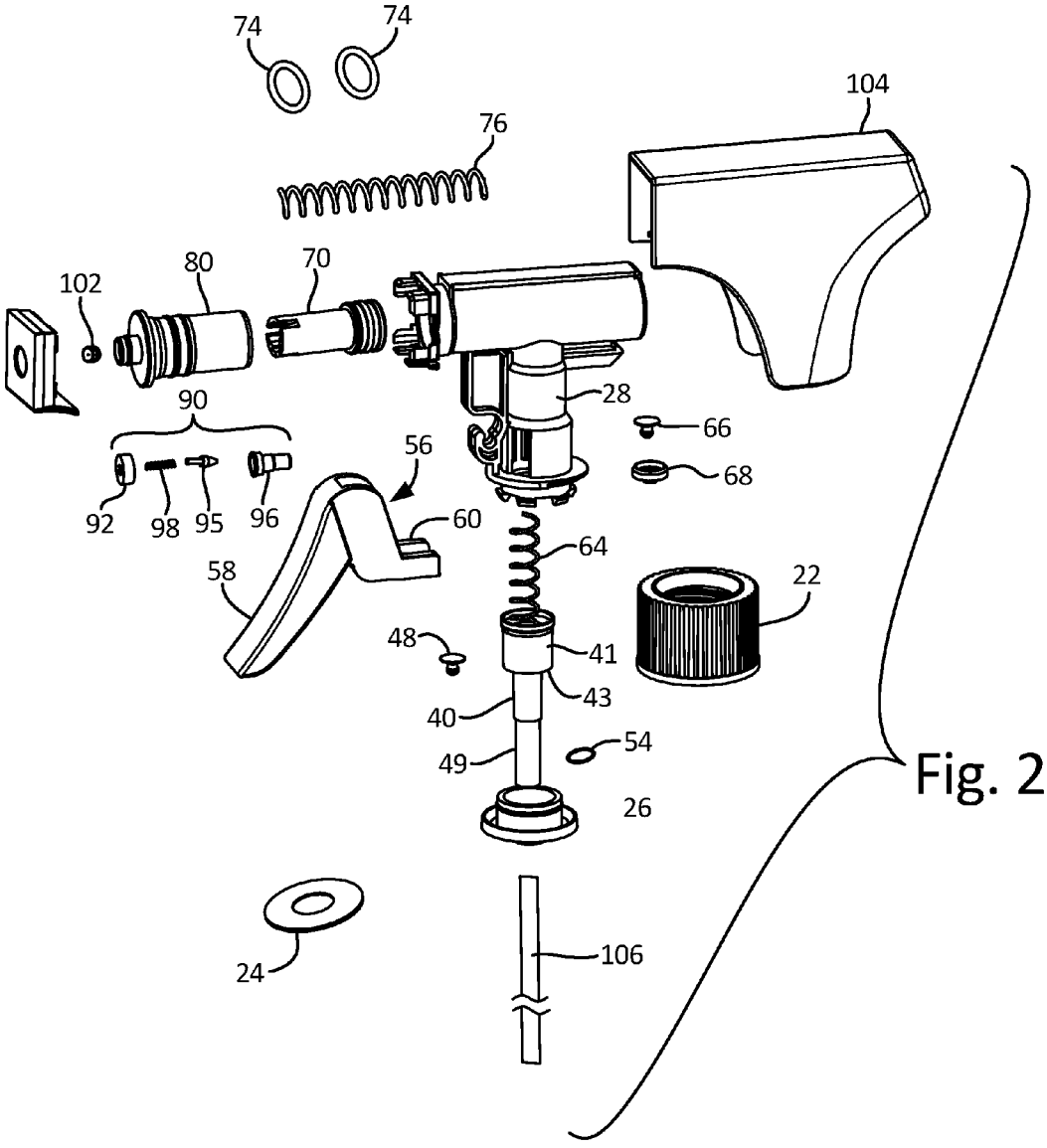

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Fig. 2

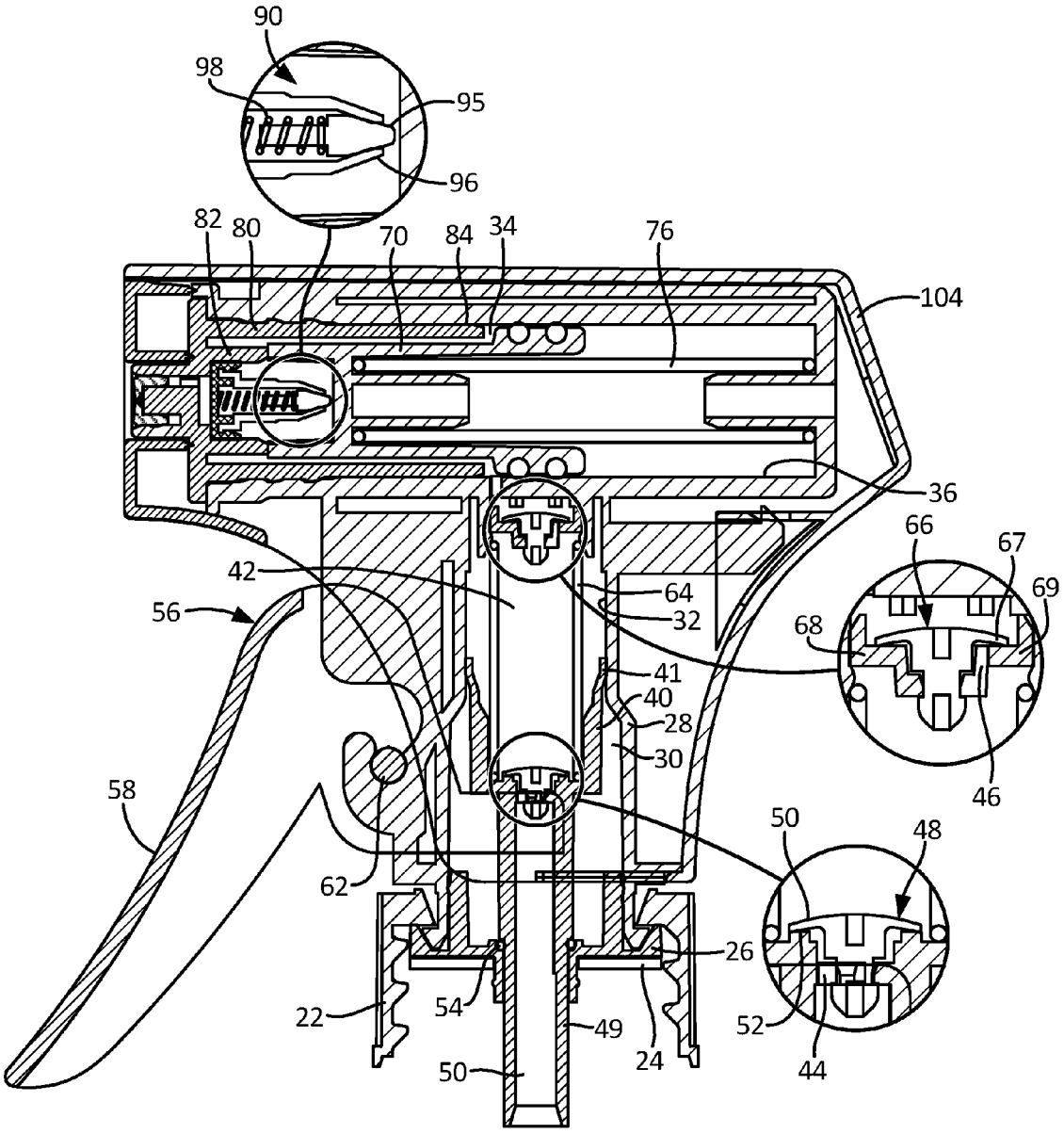
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Fig. 3

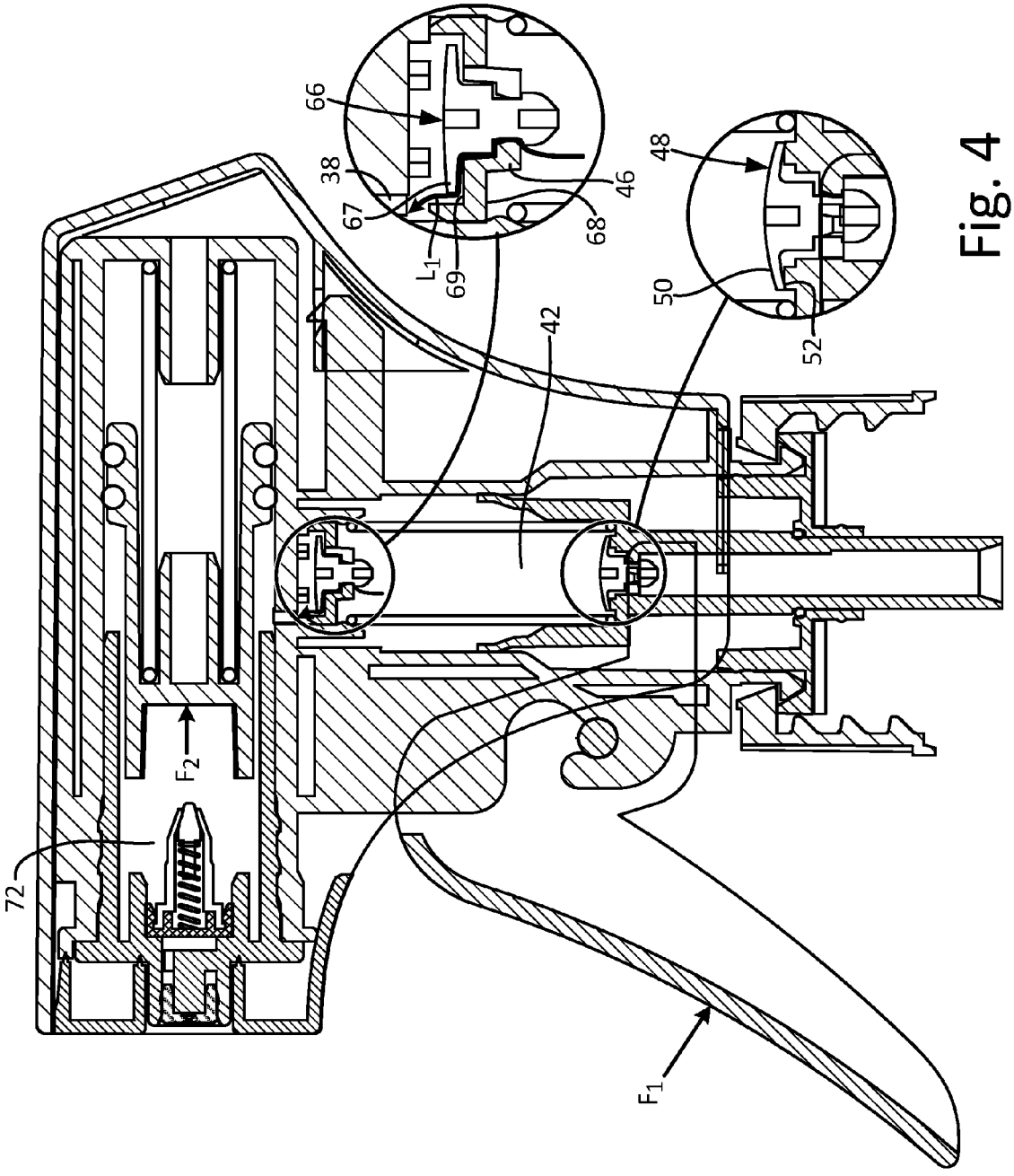

Fig. 4

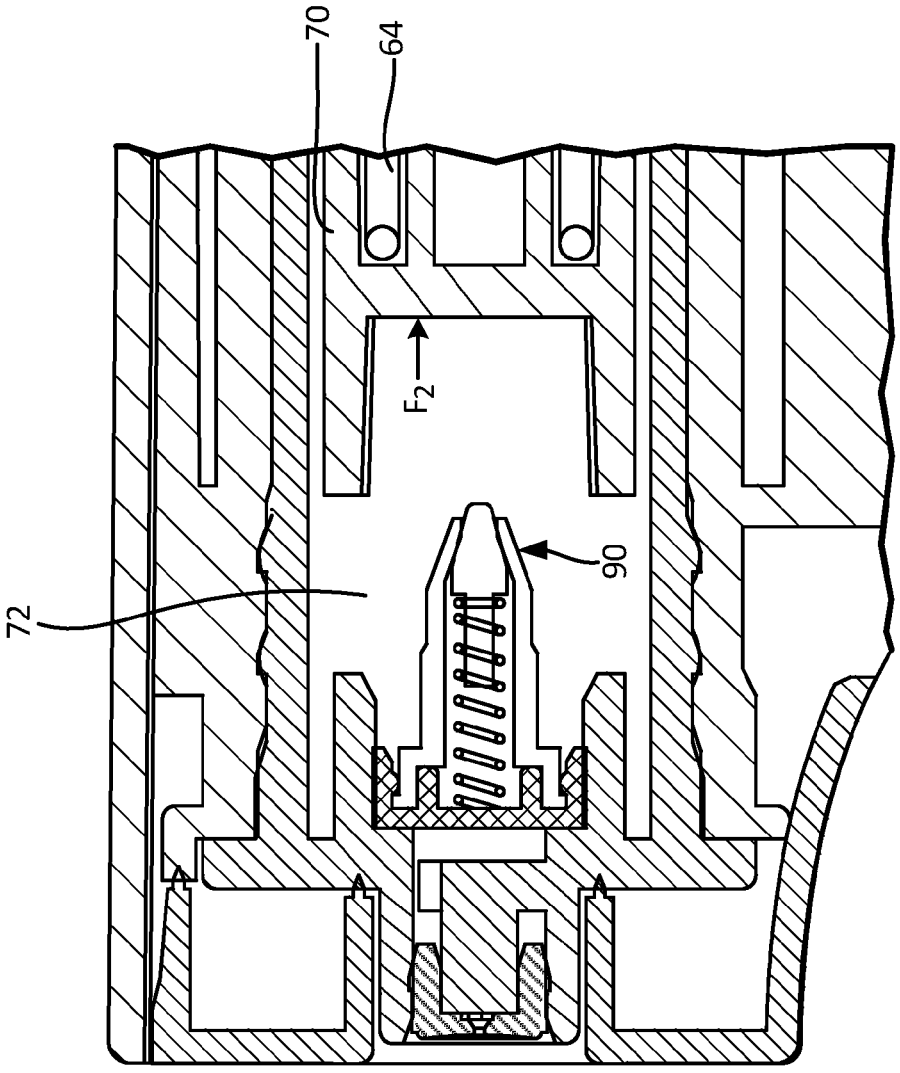

Fig. 5

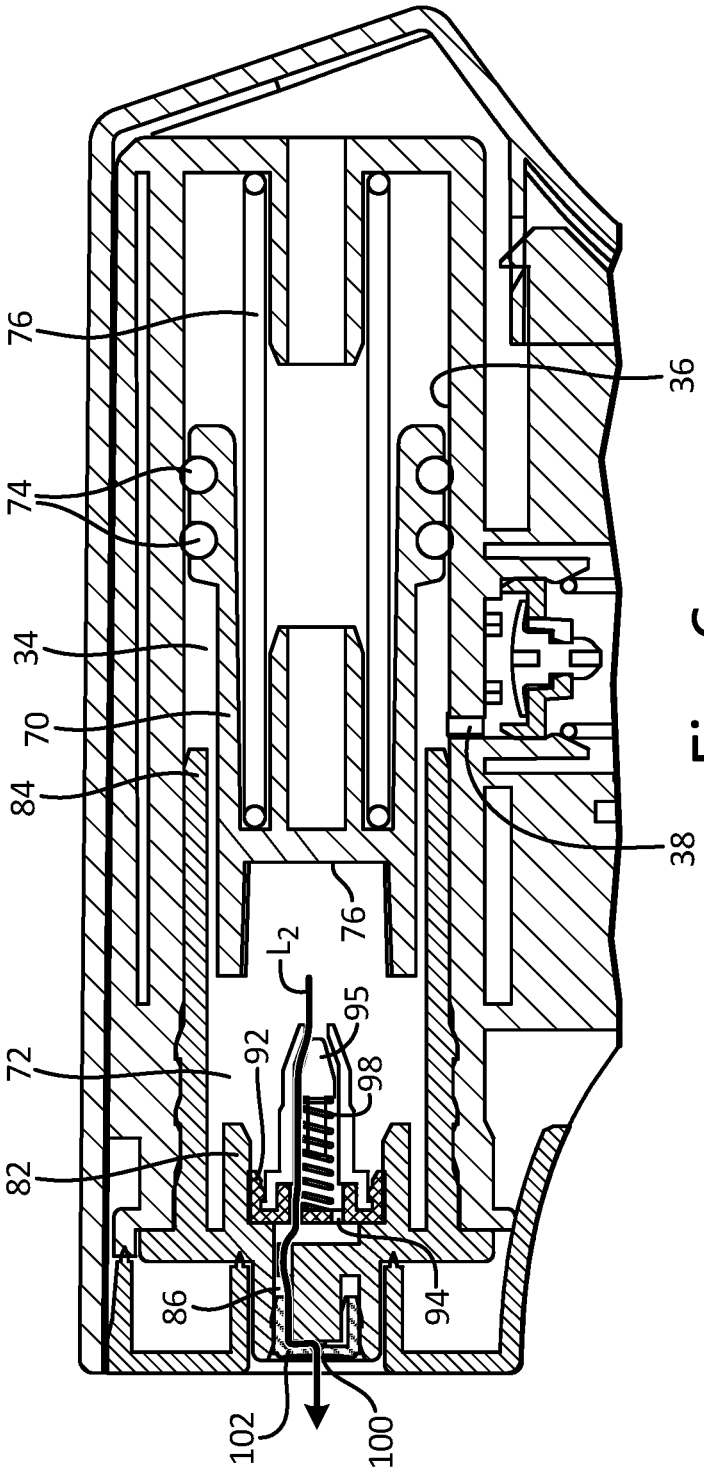

Fig. 6

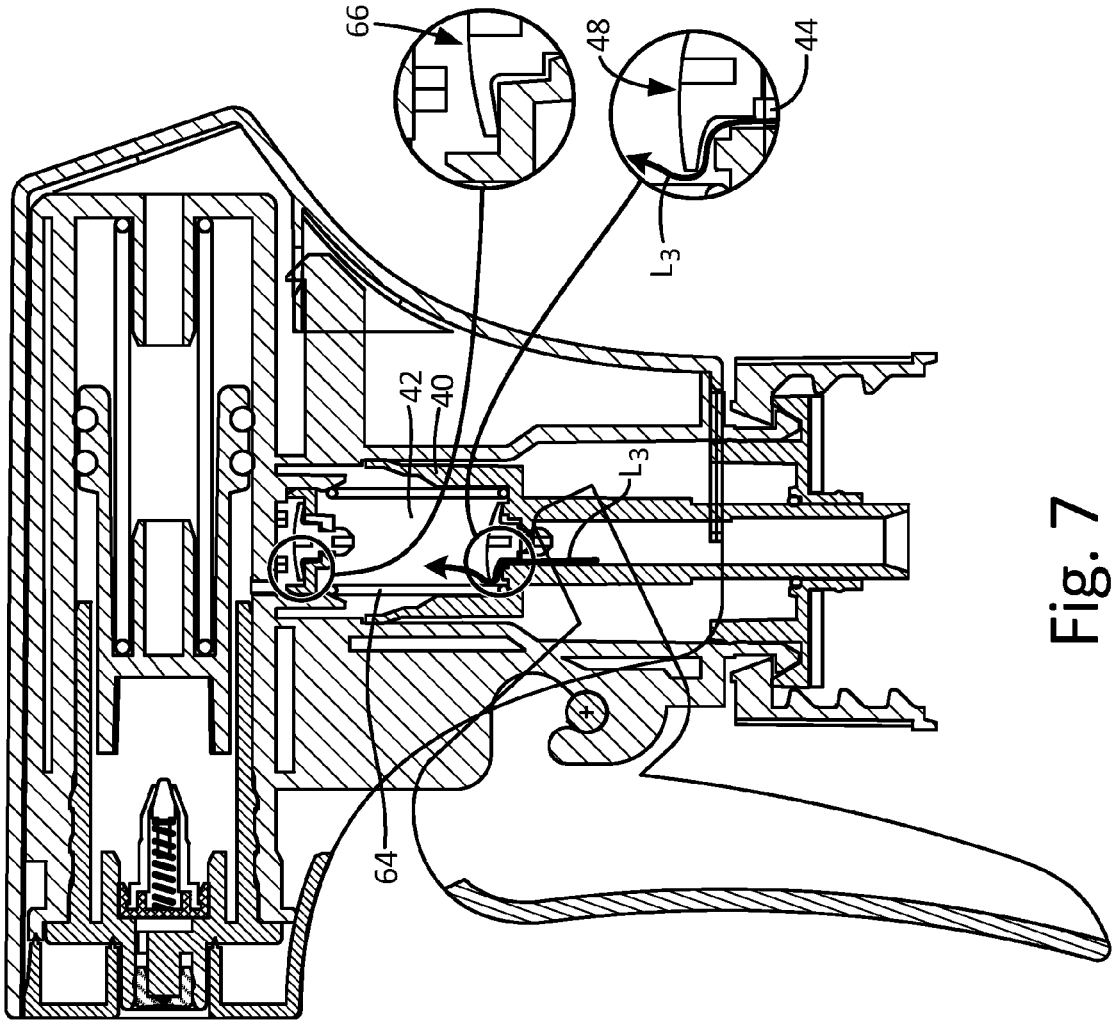

Fig. 7

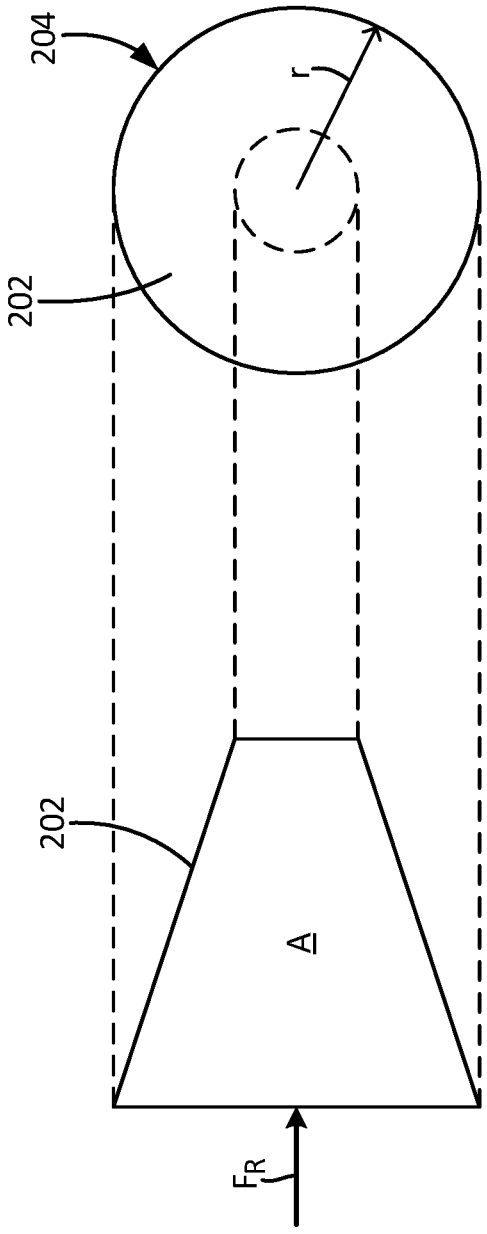

Fig. 8

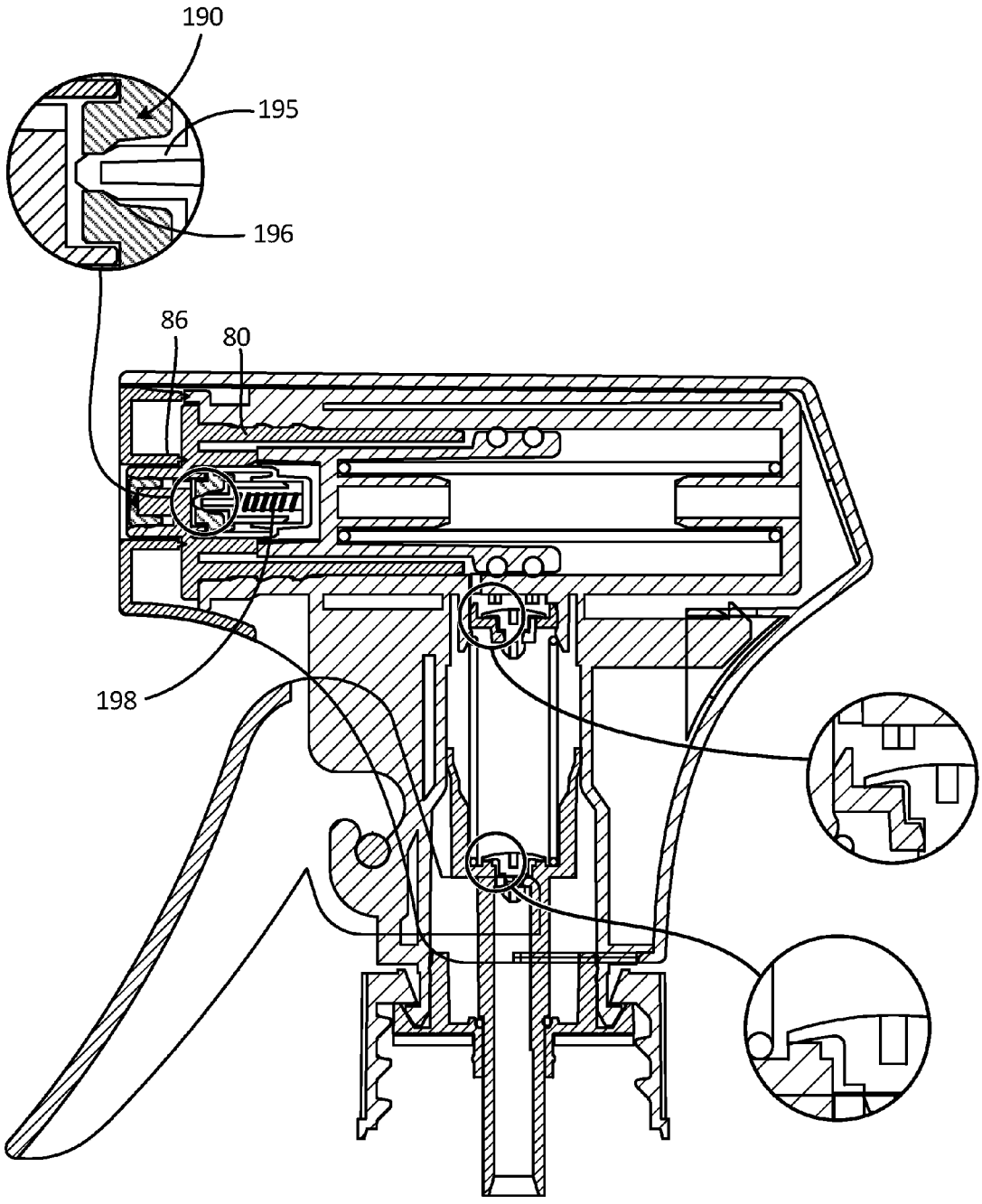

Fig. 9

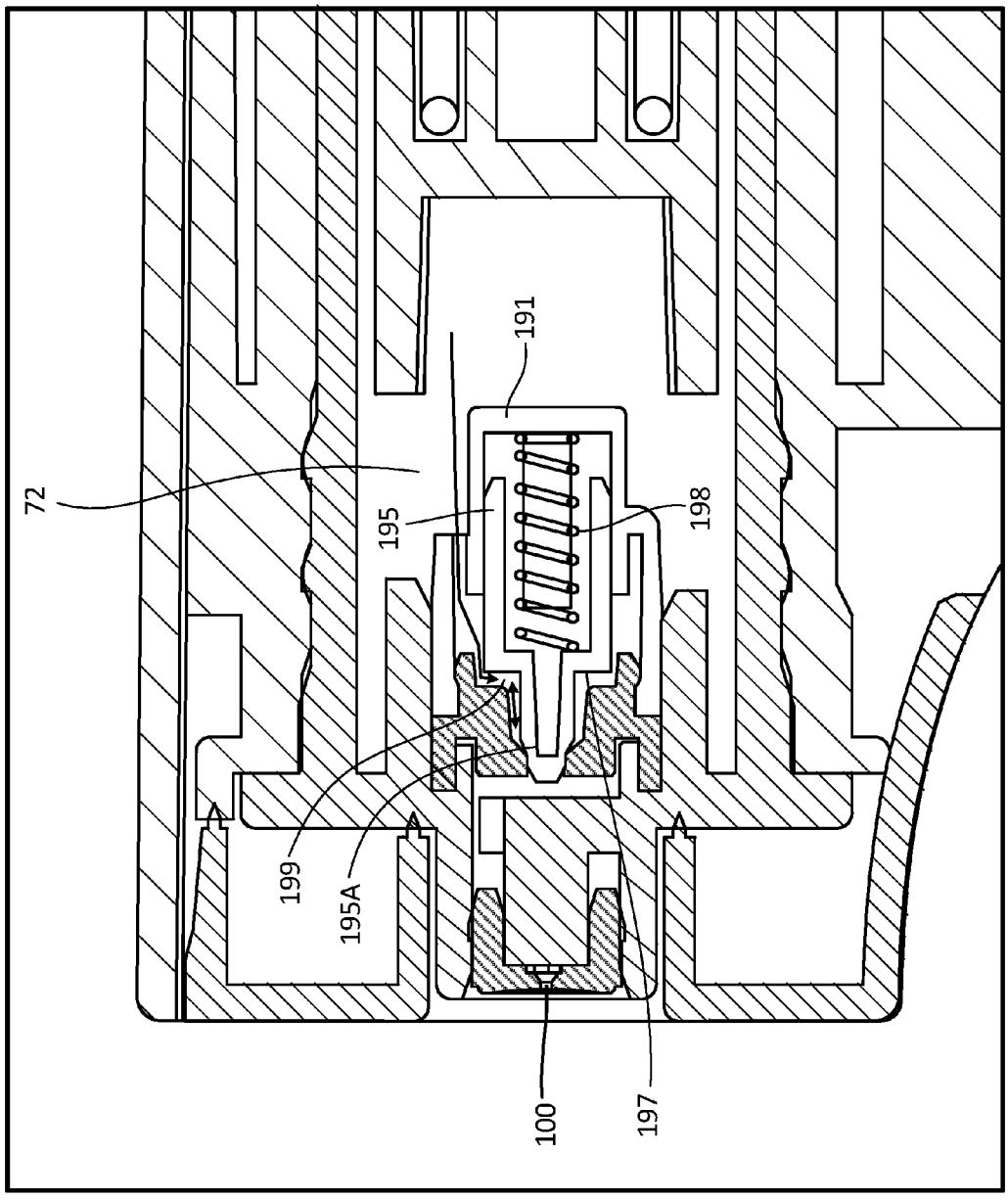

Fig. 10

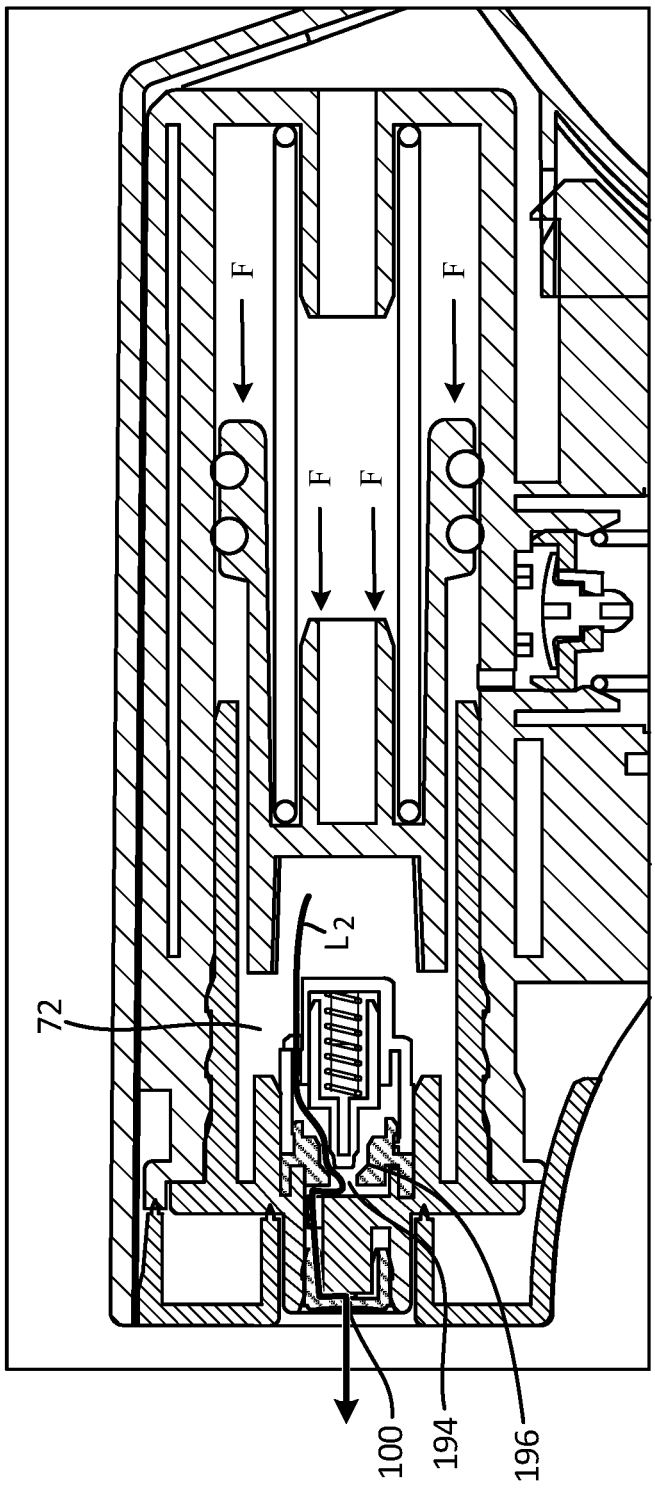

Fig. 11

EXTENDED EMISSION TIME LIQUID SPRAYER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation-in-part of U.S. patent application Ser. No. 15/150,617, filed May 10, 2016, entitled "EXTENDED EMISSION TIME LIQUID SPRAYER", the content of which being incorporated herein in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to manual liquid sprayers generally, and more particularly to a liquid sprayer apparatus that permits semi-continuous emission with discontinuous manual pumping.

BACKGROUND OF THE INVENTION

[0003] Liquid spray apparatus are widely used in a variety of applications. The simplest form of a liquid spray apparatus involves a manual pump mechanically connected to a piston that operates to draw liquid from a container, and also to discharge liquid from a collection chamber. For many apparatus, a manual pump trigger is actuated by the user to move a piston in a collection chamber against a spring force to discharge liquid from the collection chamber out through an orifice. Upon release of force against the actuator, the spring force acts to push the piston back toward an initial position, wherein a reduced pressure is developed in the collection chamber as a motive force to drive liquid from the container into the collection chamber. Typically, one-way valves at the inlet and the outlet of the collection chamber control the collection and discharge of the liquid. In this common arrangement, liquid is dispensed from the sprayer only as the actuator is manipulated to move the piston through the collection chamber during the "discharge" portion of the cycle. In other words, liquid is not dispensed from the sprayer apparatus during the "collection" portion of the pumping cycle.

[0004] Another common type of liquid spray apparatus is a pressure sprayer, in which a pressure, typically pneumatic, is developed in a chamber through either manual or automatic means. Release from the pressure chamber is controlled by a valve that may be selectively operated by the user to introduce an elevated pressure into a liquid chamber, thereby driving liquid out from the liquid chamber through an orifice. Liquid emission will continue for so long as sufficient driving pressure is available in the pressure chamber. While pressure sprayers are useful for continuous spray applications, the mechanisms involved are typically more expensive to produce than the manual individual pump cycle spray apparatus described above, since pressure sprayers require a pressure chamber separate from the liquid chamber, and/or additional valving to accommodate the pressurization mechanism.

[0005] A need therefore exists for a liquid spray apparatus that is capable of continuous or semi-continuous emission in a compact and inexpensive manual pump spray mechanism. With such an apparatus, the user is able to maintain liquid emission for a period of time between pumping actions.

SUMMARY OF THE INVENTION

[0006] By means of the present invention, a liquid spray apparatus may exhibit a spray dispensation time that is substantially greater than a discharge phase of a pump cycle of a manual pump mechanism. The liquid spray dispensation time may be extended through the use of an adjustable volume dispensation chamber, in coordination with an outlet orifice of desired dimension. The adjustable volume dispensation chamber is facilitated by a movable piston acting against fluid pressure developed in the manual pumping action. Liquid spray dispensation initiates upon reaching a threshold fluid pressure in the dispensation chamber, and ceases when the fluid pressure drops below either the same or another threshold.

[0007] In one embodiment, a liquid sprayer apparatus includes a liquid container having an opening, and a spray mechanism sealingly engagable to the liquid container adjacent to the opening in order to fluidically communicate with an interior of the liquid container. The spray mechanism includes a main body defining a first channel with a first channel wall and a second channel with a second channel wall fluidically connected to each other through a first passage. A charge piston coordinates with the first channel wall to define a collection chamber, with the charge piston itself defining a third channel through which liquid may be introduced to the collection chamber. A one-way inlet valve permits liquid flow from the container to the collection chamber. The spray apparatus further includes a dispensation piston and a discharge valve base coordinating with the second channel wall to define a dispensation chamber, wherein the dispensation piston is responsive to a fluid pressure in the dispensation chamber. A one-way outlet valve permits liquid flow from the collection chamber to the dispensation chamber through the first passage. An actuator is provided with the spray apparatus for selectively moving the charge piston with respect to the first channel wall against a first restorative force to reduce a collection chamber volume of the collection chamber. A one-way discharge valve is provided to permit liquid flow from the dispensation chamber through a second passage in the discharge valve base, wherein the discharge valve includes a plunger with a sealing portion sealingly engagable with an aperture in a discharge valve seat structure, wherein the dispensation chamber is fluidly connected to the second passage through the aperture when the discharge valve is open with the sealing portion of the plunger disengaged from the discharge valve seat structure, the plunger being responsive to the fluid pressure in the dispensation chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a cross-sectional view of a liquid sprayer apparatus of the present invention;

[0009] FIG. **2** is an exploded view of a portion of the liquid sprayer apparatus of the present invention;

[0010] FIG. **3** is a cross-sectional view of a portion of the liquid sprayer apparatus of the present invention;

[0011] FIG. **4** is a cross-sectional view of a portion of the liquid sprayer apparatus of the present invention during a discharge phase of a pump cycle;

[0012] FIG. **5** is an enlarged view of a portion of the liquid sprayer apparatus of the present invention during a discharge phase of a pump cycle;

[0013] FIG. **6** is an enlarged cross-sectional view of a portion of the liquid sprayer apparatus of the present invention during liquid dispensation;

[0014] FIG. **7** is a cross-sectional view of a portion of the liquid sprayer apparatus of the present invention during a collection phase of a pump cycle;

[0015] FIG. **8** is a schematic illustration of an effective surface area of a portion of the liquid sprayer apparatus of the present invention;

[0016] FIG. **9** is a cross-sectional view of a portion of the liquid sprayer apparatus of the present invention;

[0017] FIG. **10** is an enlarged cross-sectional view of a portion of the liquid sprayer apparatus of the present invention during a discharge phase of a pump cycle; and

[0018] FIG. **11** is an enlarged cross-sectional view of a portion of the liquid sprayer apparatus of the present invention during liquid dispensation.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] The objects and advantages enumerated above together with other objects, features, and advances represented by the present invention will now be presented in terms of detailed embodiments described with reference to the attached drawing figures which are intended to be representative of various embodiments of the invention. Other embodiments and aspects of the invention are recognized as being within the grasp of those having ordinary skill in the art.

[0020] With reference now to the drawing figures, a liquid sprayer apparatus **10** includes a liquid container **12** and an opening **14** for access to interior **16** of liquid container **12**. A neck **18** may surround opening **14**, and may provide a convenient location for engagement with spray mechanism **20**.

[0021] A skirt closure **22** may engage with neck **18**, such as through a threadable engagement. A gasket **24** is supported by a valve base **26** to create a sealing engagement with neck **18** of liquid container **12** when skirt closure **22** securely engages with neck **18**. Valve base **26** is secured to main body **28**, which defines a first channel **30** with a first channel wall **32** and a second channel **34** with a second channel wall **36**. The first and second channels **30**, **34** of main body **28** may be fluidically connected through a first passage **38**.

[0022] A charge piston **40** coordinates with first channel wall **32** to define a collection chamber **42** having a valve-controlled inlet **44** and a valve controlled outlet **46**. As illustrated in FIG. **3**, a one-way inlet valve **48** may be secured at a position to establish an openable seal with charge piston **40**, and may particularly be positioned adjacent to a third channel **50** of charge piston **40** to control liquid passage from third channel **50** to collection chamber **42**. One-way inlet valve **48** is illustrated in FIG. **3** in a closed condition, with a valve flange **50** contacting a valve seat surface **52** to block transmission of liquid into or out from collection chamber **42**.

[0023] In the illustrated embodiment, charge piston **40** includes a first portion **41** that is in slidable engagement with first channel wall **32** to define at least a portion of collection chamber **42**. Charge piston **40** includes a second portion **49** that defines third channel **50** through which fluid flow may be directed from liquid container **12** to collection chamber **42** (through valve-controlled inlet **44**). Second portion **49** is slidable with respect to valve base **26**, and sealingly engaged thereto with, for example, an O-ring gasket **54**.

[0024] An actuator **56** includes a trigger portion **58** and a lift portion **60**, wherein actuator **56** is secured to main body **28** at a pivot **62**. Operation of actuator **56** occurs through the application and release of force against trigger portion **58**, wherein an applied force against trigger portion **58** causes rotation of actuator **56** about pivot **62**, which, in turn, rotates lift portion **60** about pivot **62**. In the illustrated orientation, application of force against trigger portion **58** results in generally counter-clockwise rotation of lift portion **60** about pivot **62**. Actuator **56** is mounted with lift portion **60** adjacent to bearing surface **43** of charge piston **40**, so that rotational movement of lift portion **60** about pivot **62** moves charge piston **40** with respect to first channel wall **32**. Such movement is applied against a first restorative force that is generated by, for example, a first spring **64**. Other devices, such as elastic or resilient bodies, and the like are also contemplated as being capable of generating the first restorative force against charge piston **40**. The first restorative force exerted upon charge piston **40** is transferred to actuator **56** at lift portion **60**, to thereby act against an operation force applied to trigger portion **58**. In the absence of an operational force upon trigger portion **58**, therefore, actuator **56** is urged by first spring **64** to rotate about pivot **62** to a base condition. Movement of charge piston **40** with respect to first channel wall **32** adjusts a collection volume of collection chamber **42**. In the illustrated embodiment, collection chamber **42** is defined by surfaces of one-way inlet valve **48**, charge piston **40**, first channel wall **32**, one-way outlet valve **66**, and outlet valve base **68** to which outlet valve **66** is secured. Outlet valve base **68** is secured to main body **28**.

[0025] Spray mechanism **20** may further include a dispensation piston **70** that coordinates with second channel wall **36**, as well as with a discharge valve base **80** and a discharge valve **90** to define a dispensation chamber **72** that is fluidically connected to collection chamber **42** through valve-controlled outlet **46** and first passage **38**. In the embodiment illustrated in FIG. **3**, one-way outlet valve **66** may include a flange **67** that contacts a seat portion **69** of outlet valve base **68** to block liquid transmission between collection chamber **42** and dispensation chamber **72** when outlet valve **66** is in a closed condition. Dispensation piston **70** is sealingly and slidably engaged with second channel wall **36**. In some embodiments, one or more gaskets, such as O-ring type gaskets **74** are press-fit or otherwise position between dispensation piston **70** and second channel wall **36**. Dispensation piston **70** is preferably responsive to a fluid pressure in dispensation chamber **72**, wherein dispensation piston **70** is movable against a second restorative force to adjust a dispensation volume of dispensation chamber **72**. Dispensation piston **70** may include a wall **76** that is displaceable in its position relative to countervailing forces acting upon it. In particular, fluid pressure in dispensation chamber **72** exerts a fluid force on dispensation piston **70**, acting against the second restorative force that may be supplied by, for example, a second spring **76**. Mechanisms other than second spring **76**, such as elastic or resilient bodies, however, are contemplated as being useful in generating the second restorative force urging dispensation piston **70**.

[0026] Discharge valve base **80** may be secured to main body **28** to aid in positioning discharge valve **90** and dispensation piston **70** in second channel **34**. In some embodiments, one or more of stop flange **82** and end flange

84 of discharge valve base **80** may act as a stop limiter to arrest movement of dispensation piston **70** at the urging of the second restorative force in the absence or insufficiency of a fluid force exerted by a fluid pressure in dispensation chamber **72**. The illustration of FIG. **3** shows dispensation piston **70** urged against stop flange **82** of discharge valve base **80**. Stop flange **82** may also provide a mount location for discharge valve cap **92**, which includes an aperture **94** for permitting liquid flow passing through discharge valve **90** to transmit to orifice **100** in nozzle **102**.

[0027] Discharge valve **90** is arranged for permitting liquid flow from dispensation chamber **72** through a second passage **86** in discharge valve base **80**, wherein discharge valve **90** opens when the fluid pressure in dispensation chamber **72** exceeds a first threshold pressure. In some embodiments, discharge valve **90** includes a plunger **95** urged into contact with a discharge valve seat structure **96** by a third restorative force when discharge valve **90** is in a closed condition. The third restorative force may, in some embodiments, be provided by a third spring **98**, though other mechanisms are contemplated as providing the third restorative force in discharge valve **90** to permit one-way fluid flow out from dispensation chamber **72**. Each of inlet valve **48**, outlet valve **66**, and discharge valve **90** are illustrated in FIG. **3** in a closed condition. Fluid flow through spray mechanism **20** will be described hereinbelow with reference to the drawings.

[0028] In another embodiment illustrated in FIG. **9**, discharge valve **190** is arranged for permitting liquid flow from dispensation chamber **72** through second passage **86** in discharge valve base **80**, wherein discharge valve **190** opens when the fluid pressure in dispensation chamber **72** exceeds a first threshold pressure. Discharge valve **190** includes a plunger **195** urged into contact with a discharge valve seat structure **196** by a third restorative force when discharge valve **190** is in a closed condition. The third restorative force may, in some embodiments, be provided by a third spring **198**, though other mechanisms are contemplated as providing the third restorative force in discharge valve **190** to permit one-way fluid flow out from dispensation chamber **72**. Discharge valve **190**, as illustrated in FIGS. **9-11**, includes a discharge valve support **191** that may slidably receive plunger **195** under the counteracting forces of spring **198** and fluid pressure within dispensation chamber **72**. As illustrated in FIG. **10**, fluid pressure acts upon plunger **195** against third spring **198** in a pressure chamber **199**, and specifically against a shoulder surface **197** of plunger **195**. The fluid pressure in dispensation chamber **72** is animated by the directional arrows applying force against shoulder portion **197**, which, in turn acts against the third restorative force generated by third spring **198**. As described in greater detail hereinbelow, and as illustrated in FIG. **11**, when the fluid pressure in dispensation chamber **72** exceeds a threshold pressure, plunger **95** moves against third spring **198** to open discharge valve **190** through a separation between plunger **195** and dispensation valve seat **196**. Such separation permits one-way fluid flow out from dispensation chamber **72**, as depicted by the fluid motion arrows L_2 in FIG. **11**.

[0029] A shroud **104** may be removably secured to main body **28** for both aesthetic and functional purposes. Tube **106** may be provided for conveying liquid from container **12** to third channel **50** of charge piston **40**. In at least some embodiments, tube **106** may be connected to second portion **49** of charge piston **40**, wherein tube **106** moves with charge piston **40**, as driven by actuator **56** and first spring **64**. Accordingly, tube **106** may preferably be sufficiently long to maintain submersion in the liquid in container **12** when tube **106** is moved upwardly with charge piston **40** during a pump cycle.

[0030] As described herein, an aspect of the present invention is the continuous or semi-continuous liquid emission from spray mechanism **20** during and between repeated pump cycles to actuator **56**. The relationship among dispensation piston **70** and discharge valve **90**, **190** with the fluid pressure in dispensation chamber **72** permits extended liquid discharge intervals that may continue for a period of time after actuator **56** (and charge piston **40**) have ceased to be moved against the first restorative force. Such extended time liquid discharge may be facilitated by dispensation piston **70**, and the potential energy accumulated by second spring **76** as a result of fluid pressure buildup in dispensation chamber **72**. Conversion of the accumulated potential energy in second spring **76** to kinetic spring expansion energy may arise when a first threshold pressure in dispensation chamber **72** is exceeded, causing discharge valve **90**, **190** to open and permit discharge of liquid from dispensation chamber **72** out through second passage **86**, and ultimately out from spray mechanism **20** at orifice **100** of nozzle **102**. In this manner, liquid discharge from spray mechanism **20** may occur independently from the operational status of actuator **56**, in that liquid discharge may occur even when an operating force has been removed from trigger portion **58** to allow first spring **64** to urge charge piston **40** back to a base position.

[0031] Operation of an example embodiment of the present invention will now be described with reference to FIGS. **3-11**, wherein FIGS. **3** and **9** illustrate a "base" condition for spray mechanism **20**, in which each of inlet valve **48**, outlet valve **66**, and discharge valve **90**, **190** are in a closed condition, and each of charge piston **40** and dispensation piston **70** are in a base position, urged by respective restorative forces against a support structure. In this condition, each of springs **64**, **76**, and **98**, **198** may be in compression with respective restorative forces continuing to act against respective structures.

[0032] FIG. **4** represents a first phase of a pumping cycle in which an operating force "F_1" is applied by a user against trigger portion **58** of actuator **56** to correspondingly move charge piston **40** against the first restorative force developed by first spring **64**. This movement of charge piston **40** reduces the collection volume of collection chamber **42**, to force incompressible fluid out from collection chamber **42** through outlet **46** with outlet valve **66** forced into an open condition wherein outlet valve flange **67** is displaced from valve seat surface **69** of outlet valve base **68**. The pathway of fluid flow out from collection chamber **42** through first passage **38** is demonstrated by arrow "L_1". This fluid flow continues into dispensation chamber **72**, as illustrated in FIG. **4**. During this discharge phase of the pumping cycle, inlet valve **48** remains in a closed condition, with valve flange **50** in contact with valve seat surface **52**, thus preventing liquid from exiting collection chamber **42** through inlet **44**.

[0033] Fluid entering into dispensation chamber **72** exerts a fluid pressure, which acts against all surfaces to which the liquid is exposed, including dispensation piston **70**. The force "F_2" results in displacement of dispensation piston **70**

against the second restorative force, thereby expanding the dispensation volume of dispensation chamber **72**. Each of discharge valve **90**, **190** and dispensation piston **70** represent movable structures exposed to fluid pressure in dispensation chamber **72**. Such movable structures are adapted to yield to pressure, but preferably initially yield at different pressure thresholds, and may also yield at different yield rates. In particular, it is desired that dispensation piston **70** yields with movement against its second restorative force at a lower pressure than that required to cause plunger **95**, **195** of discharge valve **90**, **190** to yield with movement against its third restorative force. In this manner, as fluid pressure builds in dispensation chamber **72**, dispensation piston **70** moves against its second restorative force before discharge valve **90**, **190** opens.

[0034] In order to fulfill a purpose of the present invention, a mechanism is preferably provided to generate a dispensable liquid reservoir through a manual pumping action, wherein the liquid reservoir is released over a period of time that is equal to or greater than a pump cycle time period, which includes a "discharge phase" of operating actuator **56** to reduce volume in collection chamber **42**, and a "collection" phase in which force is removed from actuator **56** to permit collection chamber volume to expand with a new liquid charge. One approach for developing such a liquid reservoir may be to manually pump liquid into a chamber of fixed volume. Once the pressure in the fixed-volume reservoir exceeds a threshold pressure of an outlet valve, the outlet valve may open to dispense the liquid at a metered rate. Such an approach, however, would likely result in operational challenges, in that the manual pumping operation would require inequal and dramatically increasing force on actuator **56** in an effort to continue to fill an already "filled" fixed-volume chamber. In fact, due to the incompressible nature of many liquids, desired pressure buildup in the reservoir would quickly become impossible under typical manual pumping forces. Instead, dispensation chamber **72** of the present invention utilizes an adjustable-volume chamber **72** so that fluid pressure builds only with an increasing restorative force generated by second spring **64** as dispensation piston **72** is displaced against the increasing restorative force of second spring **64**. This approach limits resistance to continued filling of dispensation chamber **72**, while nevertheless generating a reservoir for extended time liquid dispensation from spray mechanism **20**.

[0035] A measure of yield resistance for dispensation piston **70** and discharge valve **90**, **190** may be defined herein as a "pressure resistance", which is determined as follows:

$$R=F/A$$

[0036] Wherein:

[0037] "F" is the respective restorative force applied against a movable structure exposed to fluid pressure in the dispensation chamber; and

[0038] "A" is the effective surface area of movable structure exposed to fluid pressure in the dispensation chamber.

[0039] As described above, the restorative force applicable to dispensation piston **70** is the second restorative force, supplied in the illustrated example by second spring **76**. The restorative force applicable to discharge valve **90**, **190** is the third restorative force, generated in the illustrated example by third spring **98**, **198** applied against plunger **95**, **195**. It should be understood that the applicable restorative force is dependent upon the mechanism employed to urge the movable structures against fluid pressure in dispensation chamber **72**. In some embodiments, the restorative force may be determined or approximated pursuant to Hooke's Law, which is a principle that states that the force needed to extend or compress a spring by some distance is proportional to that distance:

$$F=k*X$$

[0040] Wherein:

[0041] "k" is a constant factor characteristic of the spring (stiffness); and

[0042] "X" is the displacement distance.

[0043] It should also be understood, however, that Hooke's Law is only a first-order linear approximation to the real response of springs and other elastic bodies to applied forces. The general principle, however, of increasing restorative force with increasing displacement from a neutral position holds true with respect to the restorative forces contemplated in the present invention. That is, as displacement of the movable body is increased, so too will the restorative force acting against the associated movable structure. In the case of the dispensation piston **70**, for example, the second restorative force increases with displacement of dispensation piston **70** under the fluid force, F_2.

[0044] The effective surface area (A) of the movable structure exposed to fluid pressure in dispensation chamber **72** is defined herein as the area of a profile surface that is normal to the applicable restorative force. A schematic illustration of a profile surface area of a hypothetical frusto-conical movable structure analogous to plunger **95** of discharge valve **90** is illustrated in FIG. **8**. As illustrated therein, surface **202** of body "A" is exposed to fluid pressure, with the applicable restorative force "F_R" is acting upon body A in the direction indicated. The effective surface area for the purposes of determining a pressure resistance of the present invention is the profile surface area **204** which, in the case of a frusto-conical body A, is the square of the radius dimension "r" multiplied by π. In the illustrated embodiment of spray mechanism **20**, the effective surface area of dispensation piston **70** exposed to fluid pressure in dispensation chamber **72** is substantially greater than the effective surface area of plunger **95** exposed to the fluid pressure in dispensation chamber **72**. With such an arrangement, in an example condition in which the second restorative force is equal to the third restorative force, the pressure resistance of the discharge valve **90** is substantially greater than the pressure resistance of dispensation piston **70**. As described above with respect to changing restorative force with displacement, however, the relative pressure resistances among dispensation piston **72** and discharge valve **90** correspondingly changes with displacement of dispensation piston **70** against the second restorative force.

[0045] The profile surface area of plunger **195** of discharge valve **190** is the area of shoulder portion **197** normal to the third restorative force. As in the embodiment of discharge valve **90**, the effective surface area of dispensation piston **70** exposed to fluid pressure in dispensation chamber **72** is substantially greater than the effective surface area of plunger **195** exposed to the fluid pressure in dispensation chamber **72**.

[0046] FIGS. **5** and **10** are enlarged views of a portion of spray mechanism **20** wherein a fluid pressure is present in dispensation chamber **72** sufficient to displace dispensation

piston **70**, but is less than the threshold pressure required to open discharge valve **90**, **190**. This condition is indicative of a first initial pressure resistance of discharge valve **90**, **190** in a closed condition ("R_V") that is greater than a second initial pressure resistance of dispensation piston **70** in a rest condition ("R_P"). The "rest condition" of dispensation piston **70** is illustrated, for example, in FIGS. **3** and **9**, but overall represents a condition in which dispensation piston **70** moves no further at the urging of second spring **76**. Such condition may therefore be reached through either contact between dispensation piston **70** and another body, such as stop flange **82**, or when second spring **76** reaches its neutral condition at which the second restorative force equals zero, because the displacement value (X) is zero. FIGS. **5** and **10** illustrate an embodiment in which second spring **64** is calibrated with a spring force (k) suitable to permit dispensation piston **70** to move against the second restorative force when the fluid pressure in dispensation chamber **72** is less than the threshold pressure required to open discharge valve **90**, **190**. In such an embodiment, the dispensation chamber volume expands with increasing fluid pressure in dispensation chamber **72**, at least until the threshold pressure is reached.

[0047] A further condition of spray mechanism **20** is illustrated in FIGS. **6** and **11**, in which outlet valve **66** is closed subsequent to a pump discharge phase driving fluid from collection chamber **42** through first passage **38** into dispensation chamber **72**. In the condition illustrated in FIGS. **6** and **11**, fluid pressure in dispensation chamber **72** has displaced dispensation piston **70** to an extent at which a pressure resistance of dispensation piston **70** is equal to or greater than the first initial pressure resistance of discharge valve **90**, **190**. Fluid pressure in dispensation chamber **72** in FIGS. **6** and **11** is equal to or greater than the threshold fluid pressure, which causes plunger **95**, **195** to move against the third restorative force exerted by third spring **98**, **198**. Discharge valve **90**, **190** is illustrated in FIGS. **6** and **11** in an open condition permitting liquid flow along pathway L_2 through aperture **94**, **194** and second passage **86**, **186**, and finally out from orifice **100**. In some embodiments, the threshold fluid pressure is greater than a minimum fluid pressure required in dispensation chamber **72** to maintain discharge valve **90**, **190** in an open condition. In other words, the "break" pressure required to open discharge valve **90**, **190** may be greater than the fluid pressure required to maintain discharge valve **90**, **190** in an open condition, such as with plunger **95**, **195** separate from discharge valve seat structure **96**, **196**. A fluid pressure in dispensation chamber **72** that permits discharge valve **90**, **190** to close may be termed a second threshold pressure, such that, in some embodiments, the first threshold pressure may be greater than the second threshold pressure.

[0048] To aid in extending the time period for dispensing liquid from spray mechanism **20** while discharge valve **90**, **190** is in an open condition, orifice **100** may have a diameter that develops a desired flow restriction, thereby generating a back pressure to liquid flow out from orifice **100**. In one aspect of the present invention, a liquid dispensing time is at least twice the discharge phase time of the pump cycle, and may more preferably be at least thrice the discharge phase time of the pump cycle. For the purposes hereof, the term "dispensation time" means the time of liquid dispensation out from orifice **100** for each discharge valve opening cycle, which itself is defined by the cycle from discharge valve open to discharge valve close. For the purposes hereof, the term "discharge phase time" is intended to mean the time of movement of charge piston **40** in forcing liquid from collection chamber **42** through outlet **46** for each pump cycle operation applied to actuator **56**. By way of example, one discharge phase occurs during the time that a user depresses actuator **56**. In some embodiments, orifice **100** may be in the range of between about 0.3-0.5 mm and more preferably between about 0.35-0.45 mm. Such diameter range is exemplary only for a particular embodiment, and is intended to demonstrate an appropriate orifice size for generating a flow restriction suitable to extend liquid dispensation cycle times.

[0049] Discharge valve **190** is preferably configured to close aperture **194** immediately upon the fluid pressure in dispensation chamber **72** falling below the threshold pressure and, in some embodiments, below the first threshold pressure. It is desirable that liquid flow along pathway L_2 out from orifice **100** changes abruptly from an "on" condition to an "off" condition. To do so, plunger **195** is arranged to immediately re-seat with discharge valve seat structure **196** with a corresponding drop in fluid pressure in dispensation chamber **72**. Thus, plunger **195** preferably includes a sealing portion **195**A that quickly engages with discharge valve seat structure **196** and effectively closes aperture **194** to thereby close discharge valve **190**. In the illustrated embodiment, sealing portion **195***a* of plunger **195** may have a substantially frusto-conical configuration that is engagable into a correspondingly-configured aperture **194** of discharge valve seat structure **196** to close discharge valve **190**.

[0050] FIG. **7** illustrates the "collection phase" of the pump cycle, wherein the force F_1 is either reduced or removed from trigger portion **58** of actuator **56**, to permit the first restorative force to move charge piston **40** back toward a base position, as illustrated in FIG. **3**. In this illustrated condition, outlet valve **66** is in a closed condition, while inlet valve **48** is forced into an open condition as a consequence of a reduced pressure in collection chamber **42**. The reduced pressure is developed as a consequence of the expanding collection chamber volume of collection chamber **42** with first spring **64** acting with the first restorative force against charge piston **40**. The reduced pressure developed in collection chamber **42** is sufficient to draw liquid from container **12** through tube **106** and third channel **50** to open inlet valve **48** for passage into collection chamber **42**. Direction arrow "L_3" illustrates the liquid flow from container **12** through inlet **44** into collection chamber. Return of charge piston **40** to its base position substantially fills collection chamber **42** with liquid, and substantially equalizes fluid pressure between collection chamber **42** and interior **16** of liquid container **12**. Inlet valve **48** thus re-closes, preventing drainage of liquid from collection chamber **42** through inlet **44**.

[0051] The invention has been described herein in considerable detail in order to comply with the patent statutes, and to provide those skilled in the art with the information needed to apply the novel principles and to construct and use embodiments of the invention as required. However, it is to be understood that various modifications may be accomplished without departing from the scope of the invention itself.

What is claimed is:

1. A liquid sprayer apparatus, comprising:

a liquid container having an opening;

a spray mechanism sealingly engageable to said liquid container adjacent said opening to fluidically communicate with an interior of said liquid container, said spray mechanism including:

(i) a main body defining a first channel with a first channel wall and a second channel with a second channel wall fluidically connected to each other through a first passage;

(ii) a charge piston coordinating with said first channel wall to define a collection chamber, said charge piston defining a third channel through which liquid may be introduced to said collection chamber;

(iii) a one-way inlet valve permitting liquid flow from said container to said collection chamber;

(iv) a dispensation piston and a discharge valve base coordinating with said second channel wall to define a dispensation chamber, said dispensation piston being responsive to a fluid pressure in said dispensation chamber against a second restorative force;

(v) a one-way outlet valve permitting liquid flow from said collection chamber to said dispensation chamber through said first passage;

(vi) an actuator for selectively moving said charge piston with respect to said first channel wall against a first restorative force to reduce a collection chamber volume of said collection chamber; and

(vii) a one-way discharge valve for permitting liquid flow from said dispensation chamber through a second passage in said discharge valve base, wherein said discharge valve includes a plunger with a sealing portion sealingly engagable with an aperture in a discharge valve seat structure, wherein said dispensation chamber is fluidly connected to said second passage through said aperture when said discharge valve is open with said sealing portion of said plunger disengaged from said discharge valve seat structure, said plunger being responsive to the fluid pressure in said dispensation chamber.

2. A liquid sprayer apparatus as in claim **1** wherein said plunger is urged against the fluid pressure by a third restorative force.

3. A liquid sprayer apparatus as in claim **2** wherein said third restorative force acts along a direction that is substantially parallel to a liquid flow direction through said aperture.

4. A liquid sprayer apparatus as in claim **2** wherein said discharge valve opens when the fluid pressure in said dispensation chamber exceeds a first threshold pressure.

5. A liquid sprayer apparatus as in claim **4**, including a first spring capable of exerting said first restorative force against said charge piston.

6. A liquid sprayer apparatus as in claim **5**, including a second spring capable of exerting said second restorative force against said dispensation piston.

7. A liquid sprayer apparatus as in claim **6** wherein said second spring is calibrated to permit said dispensation piston to move against said second restorative force when the fluid pressure in said dispensation chamber is less than said threshold pressure.

8. A liquid sprayer apparatus as in claim **7** wherein a dispensation chamber volume expands with increasing fluid pressure in said dispensation chamber at least until said first threshold pressure is reached.

9. A liquid sprayer apparatus as in claim **8** wherein said discharge valve closes when the fluid pressure in said dispensation chamber falls below a second threshold pressure.

10. A liquid sprayer apparatus as in claim **9** wherein said first threshold pressure is greater than said second threshold pressure.

11. A liquid sprayer apparatus as in claim **1** wherein said discharge valve is connected to said discharge valve base.

12. A liquid sprayer apparatus as in claim **1**, including a tube for conveying liquid from said container to said third channel of said charge piston.

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