US012384615B2

(12) **United States Patent**
Hudson et al.

(10) **Patent No.: US 12,384,615 B2**
(45) **Date of Patent: Aug. 12, 2025**

(54) **FLUID DISPENSING METHOD AND APPARATUS**

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(73) Assignee: **SWIMC LLC**, Cleveland, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 48 days.

(21) Appl. No.: **17/918,133**

(22) PCT Filed: **Apr. 30, 2021**

(86) PCT No.: **PCT/US2021/030338**
§ 371 (c)(1),
(2) Date: **Oct. 11, 2022**

(87) PCT Pub. No.: **WO2021/222859**
PCT Pub. Date: **Nov. 4, 2021**

(65) **Prior Publication Data**

US 2023/0132918 A1 May 4, 2023

Related U.S. Application Data

(60) Provisional application No. 63/018,413, filed on Apr. 30, 2020.

(51) **Int. Cl.**
B65D 83/20 (2025.01)
B65D 83/16 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***B65D 83/20*** (2013.01); ***B65D 83/164*** (2025.01); ***B65D 83/32*** (2013.01); ***B65D 83/382*** (2013.01); ***B65D 83/70*** (2013.01)

(58) **Field of Classification Search**
CPC B65D 83/205; B65D 83/207; B65D 83/32; B65D 83/382; B65D 83/70
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,899,222 A * 2/1933 Werder B65D 83/207 239/375
2,271,715 A * 2/1942 Saffell F16K 21/04 251/303

(Continued)

FOREIGN PATENT DOCUMENTS

CN 101988598 A * 3/2011 ..... B65D 83/207
CN 101988598 B * 5/2012 ..... B65D 83/207

(Continued)

OTHER PUBLICATIONS

International Search Report filed in the corresponding PCT Application dated Aug. 17, 2021; 4 pages.

(Continued)

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(74) *Attorney, Agent, or Firm* — Rankin, Hill & Clark LLP

(57) **ABSTRACT**

A fluid storage system includes a container defining an interior space that lacks an internal valve. A product and a propellant are stored under pressure within the interior space. A container cap includes a membrane that encloses a space defined by a coupling element, which includes a releasable fastener that releasably couples a fluid dispensing apparatus to the container. The container cap also includes a dip tube comprising a proximate end that extends at least partially into the space defined by the coupling element, and a distal end that protrudes from the space in a direction generally away from the container cap, into the interior space defined by the container. The dip tube defines an interior passage extending between the proximate end and

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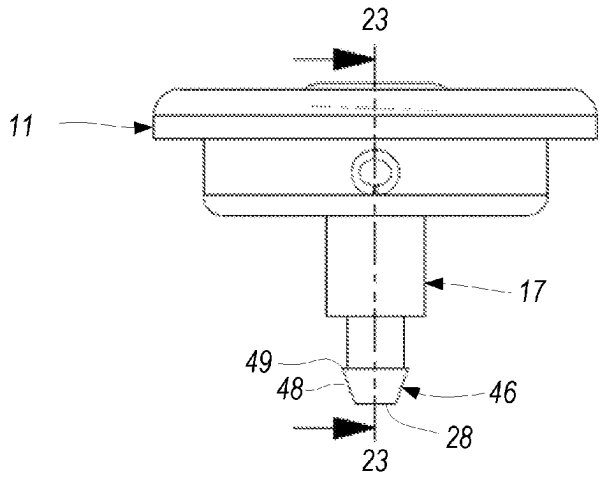

the distal end through which the product is to be expelled from the container by the propellant.

14 Claims, 19 Drawing Sheets

(51) **Int. Cl.**
B65D 83/32 (2006.01)
B65D 83/38 (2006.01)
B65D 83/70 (2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,802,696	A	8/1957	Franco	
3,270,919	A *	9/1966	Frangos	B65D 83/382 222/394
3,589,446	A *	6/1971	Bower	A62C 13/76 222/82
4,228,933	A *	10/1980	Elson	B05B 9/0805 222/400.7
6,016,934	A *	1/2000	Moriguchi	B65D 83/42 222/402.18
9,656,310	B2	5/2017	Johnson	
10,124,356	B2 *	11/2018	Johnson	B65D 83/207
10,926,277	B2	2/2021	Johnson	
11,583,878	B2	2/2023	Johnson	
2015/0273543	A1 *	10/2015	Johnson	B65D 83/207 141/4
2015/0314316	A1 *	11/2015	Kusz	B05B 15/30 222/105
2018/0244460	A1	8/2018	Zeik et al.	
2019/0270576	A1	9/2019	Johnson et al.	

FOREIGN PATENT DOCUMENTS

GB	855794	A *	12/1960	
WO	WO-9805853	A1 *	2/1998	B01F 5/0451
WO	WO-2006018593	A2 *	2/2006	B65D 83/382
WO	WO-2017130186	A1 *	8/2017	B65D 83/0061
WO	WO-2018090102	A1 *	5/2018	

OTHER PUBLICATIONS

Written Opinion filed in the corresponding PCT Application dated Aug. 17, 2021; 7 pages.

International Preliminary Report on Patentability filed in the corresponding PCT Application dated Oct. 27, 2022; 8 pages.

* cited by examiner

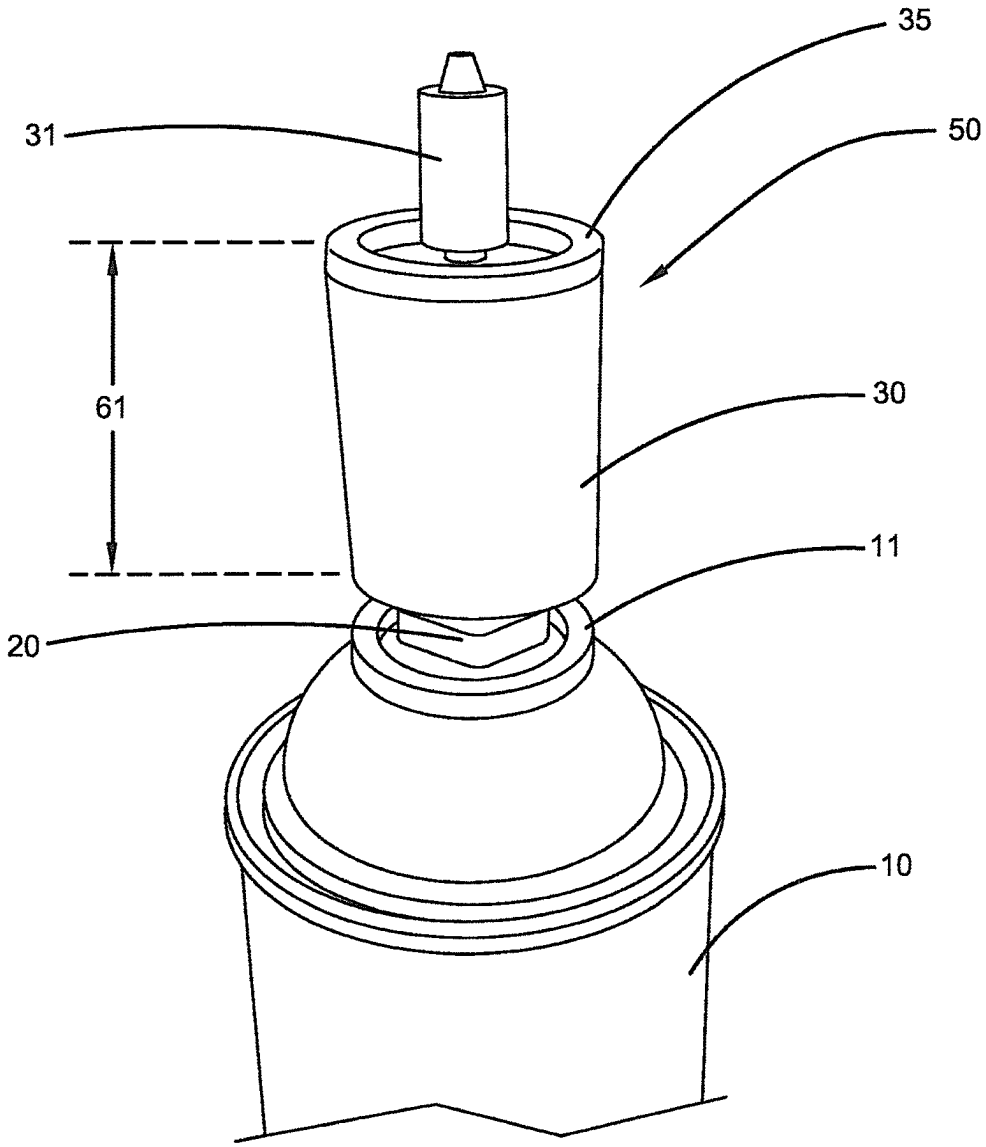

FIG. 1

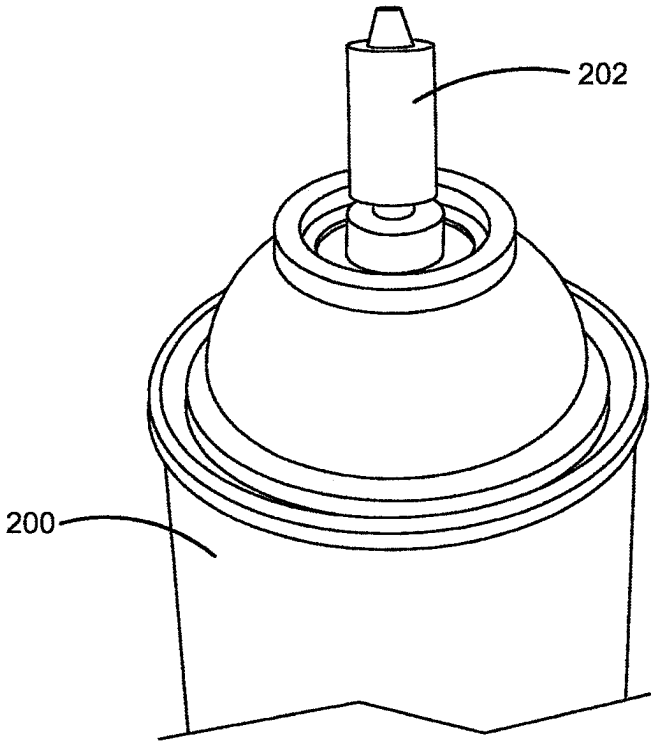

FIG. 2
PRIOR ART

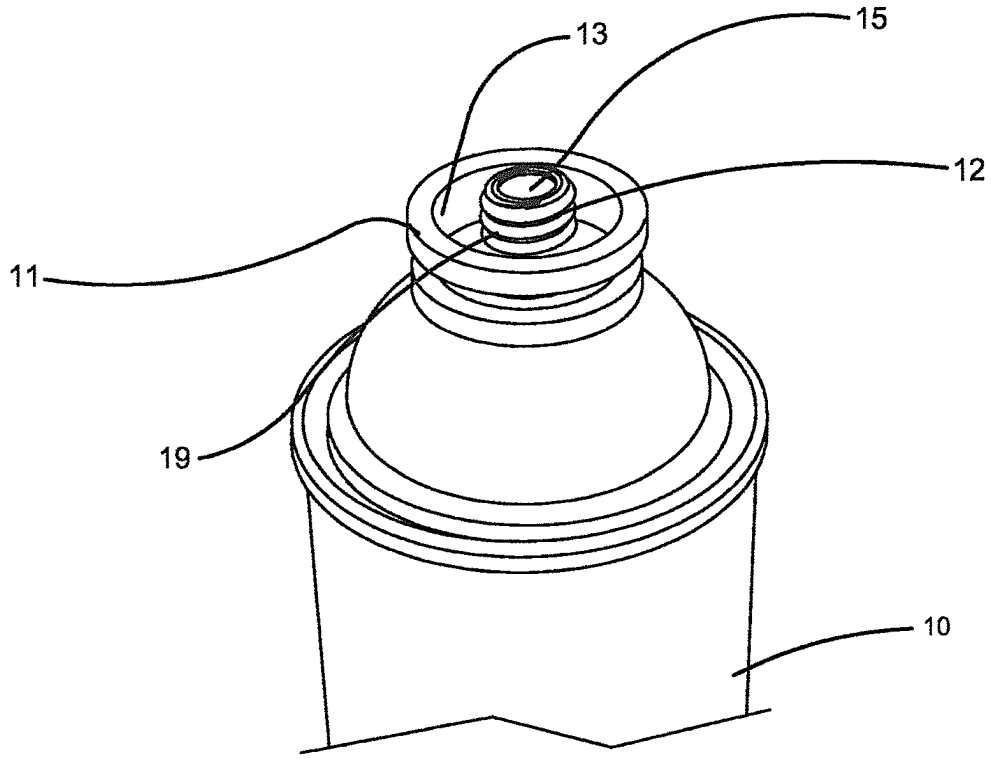

FIG. 3

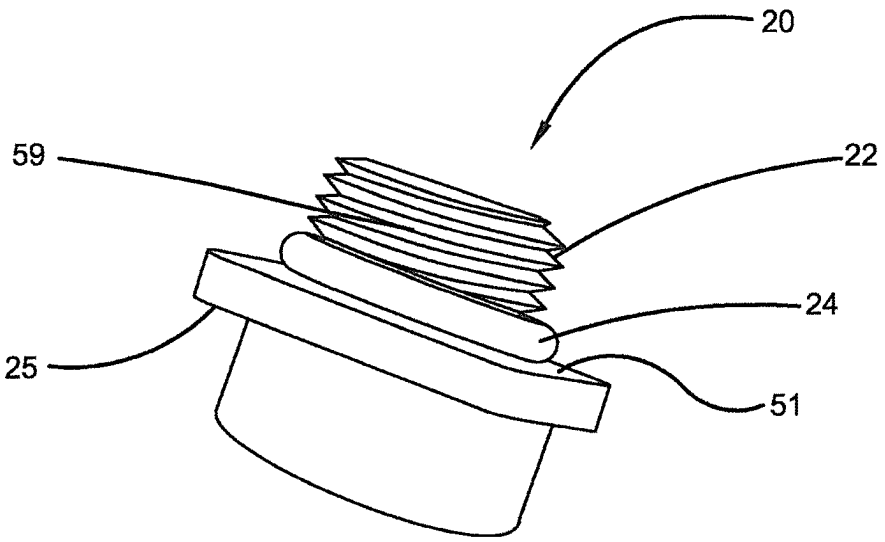

FIG. 4A

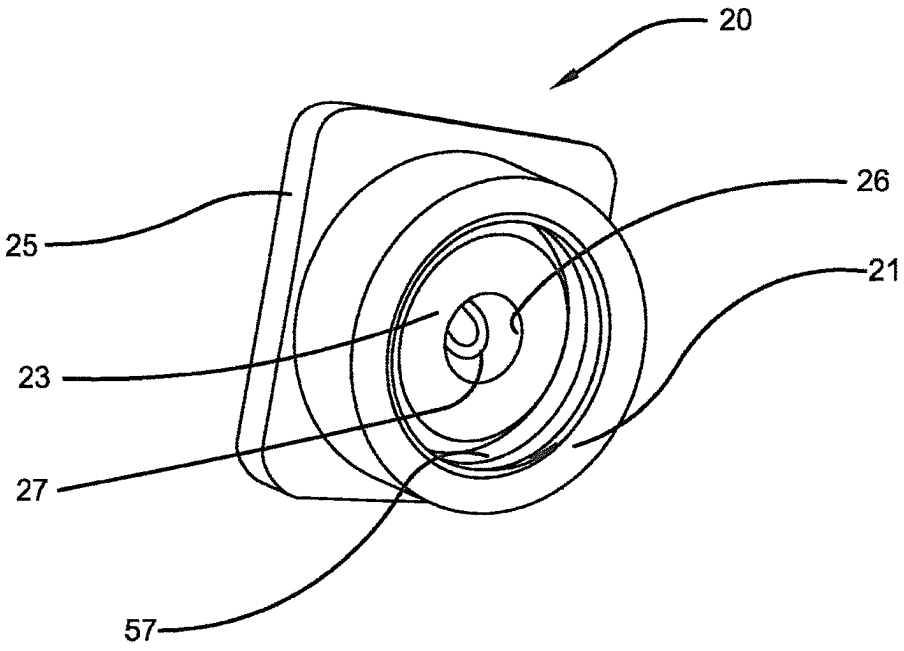

FIG. 4B

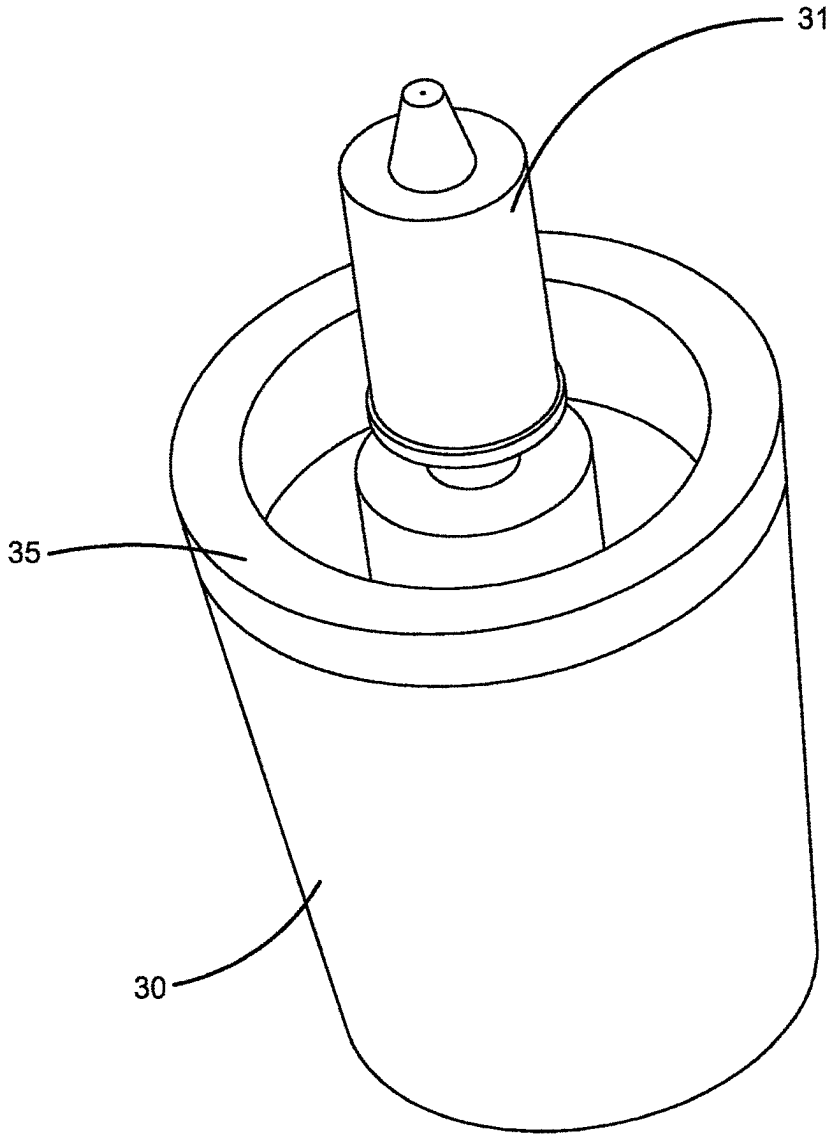

FIG. 5

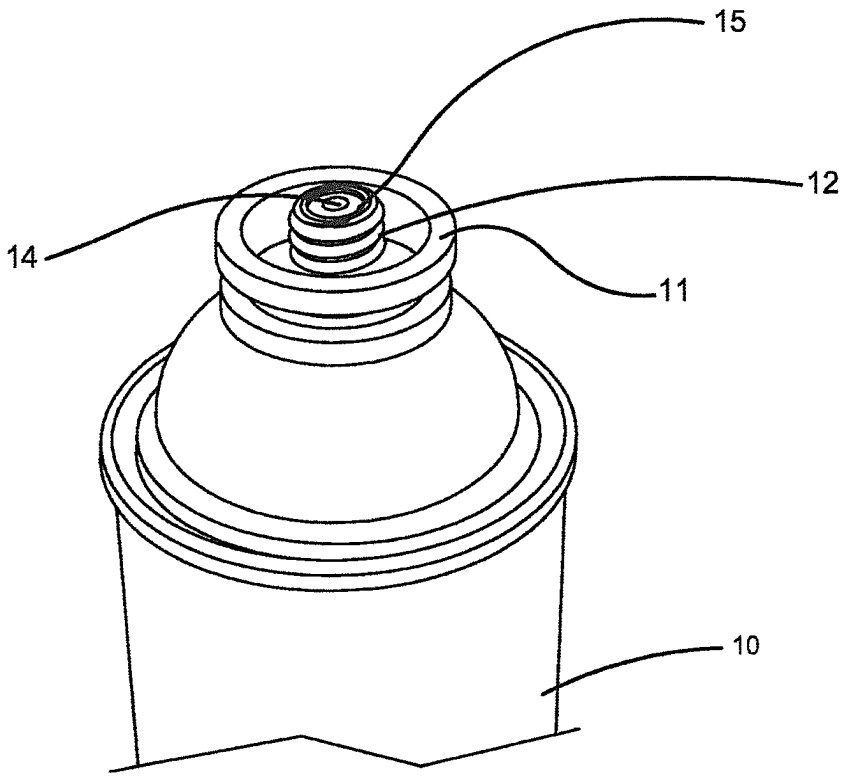

FIG. 6

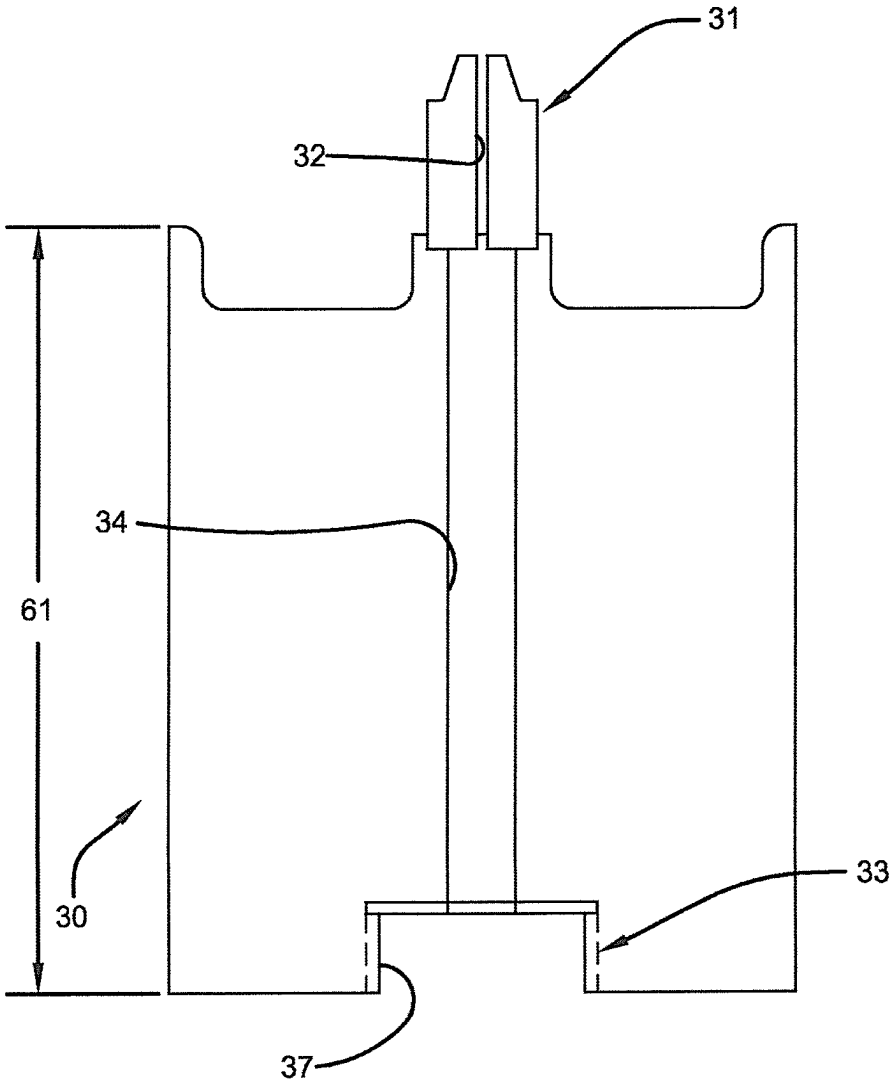

FIG. 7

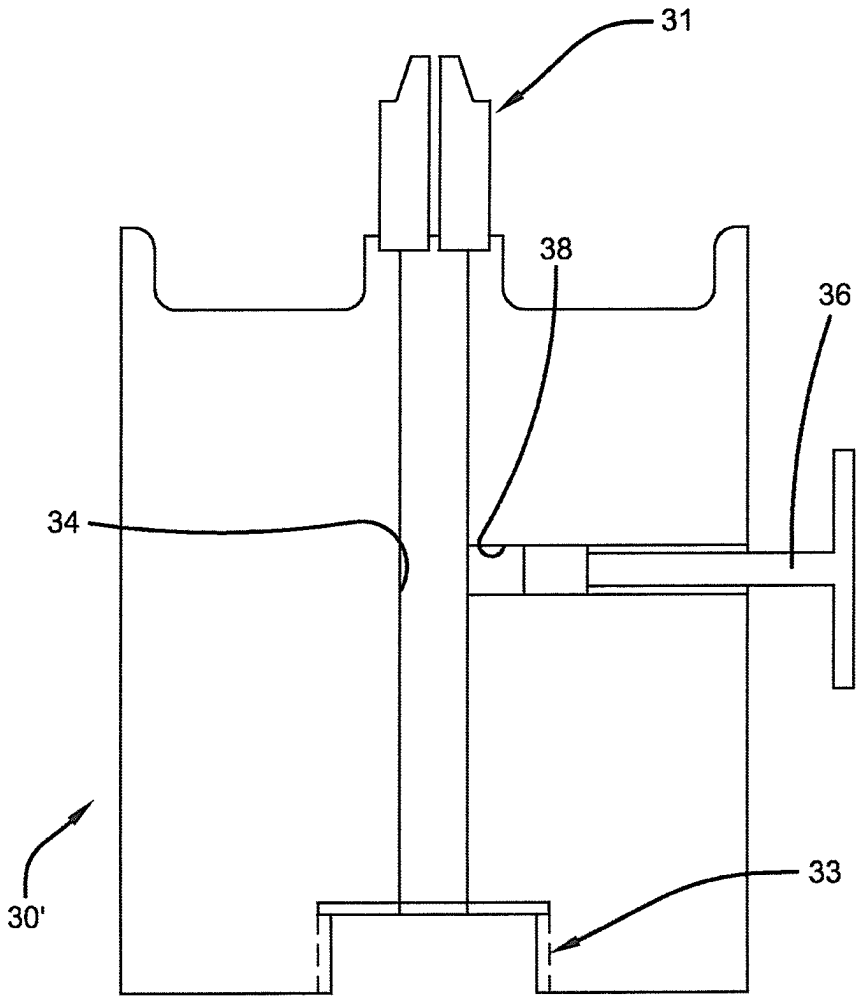

FIG. 8

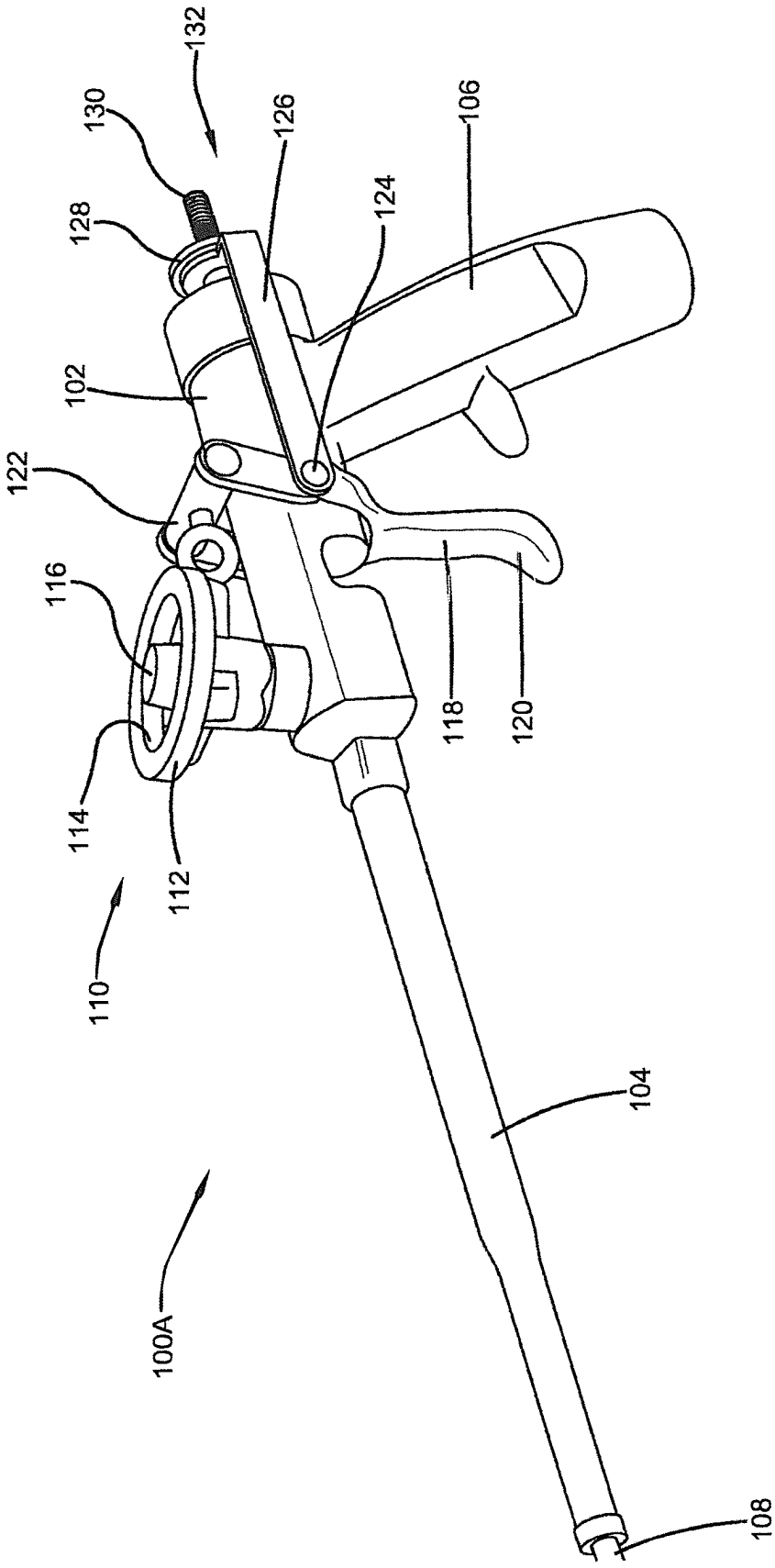
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FIG. 9

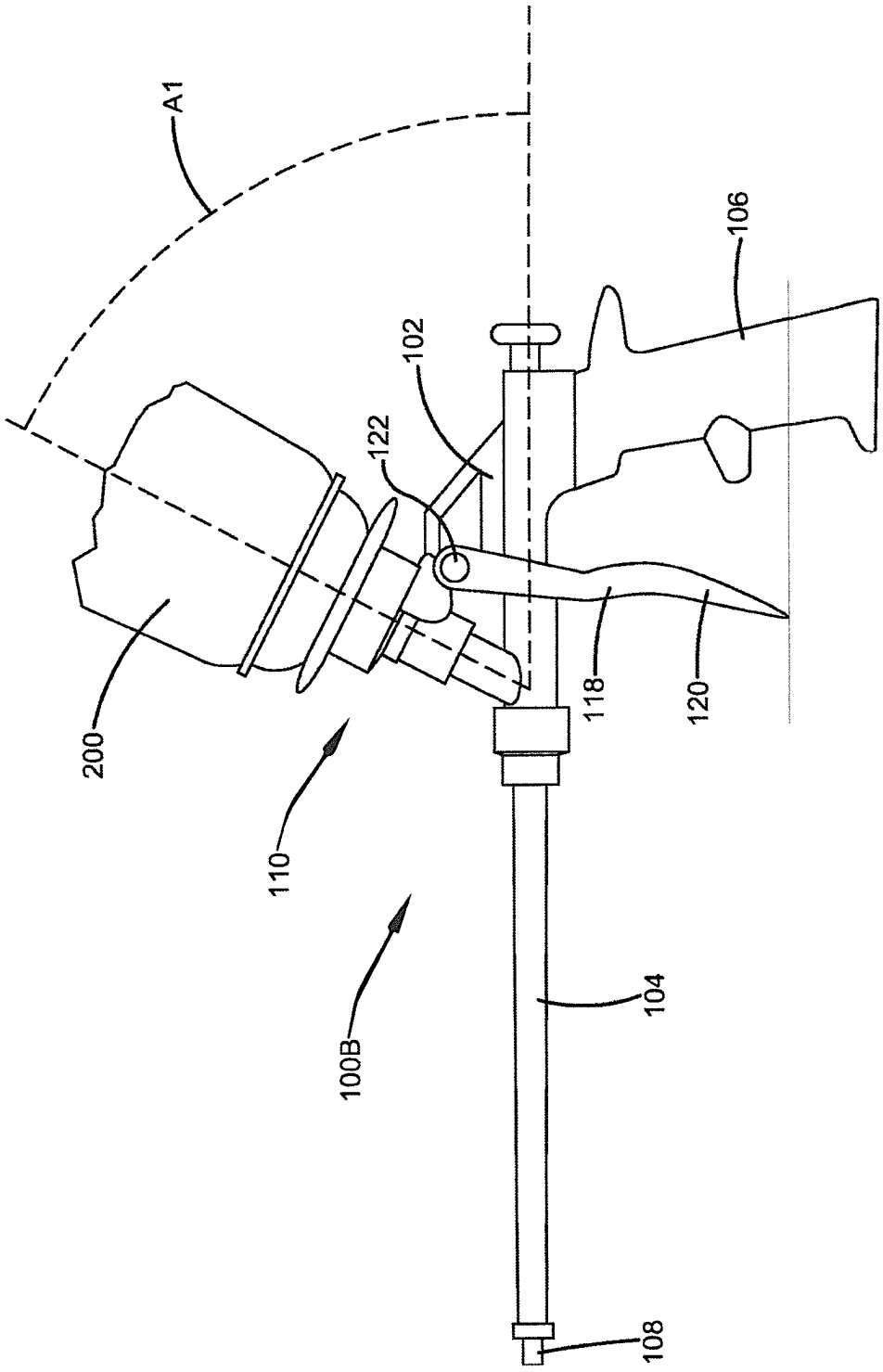

FIG. 10

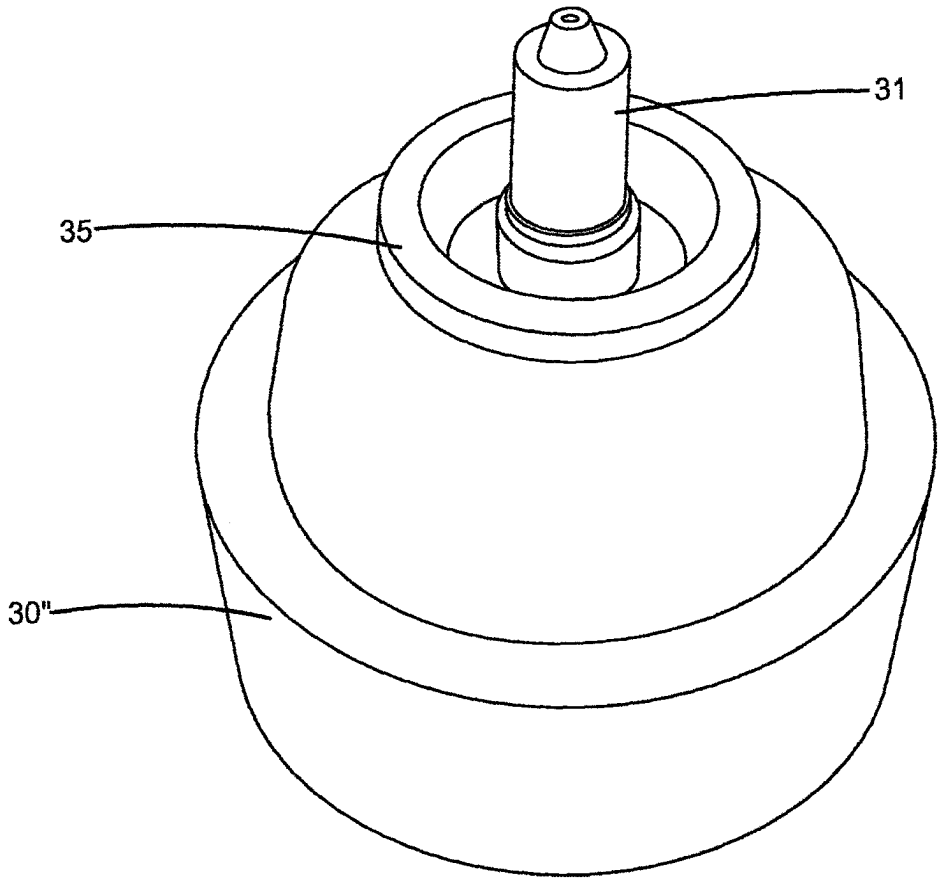

FIG. 11

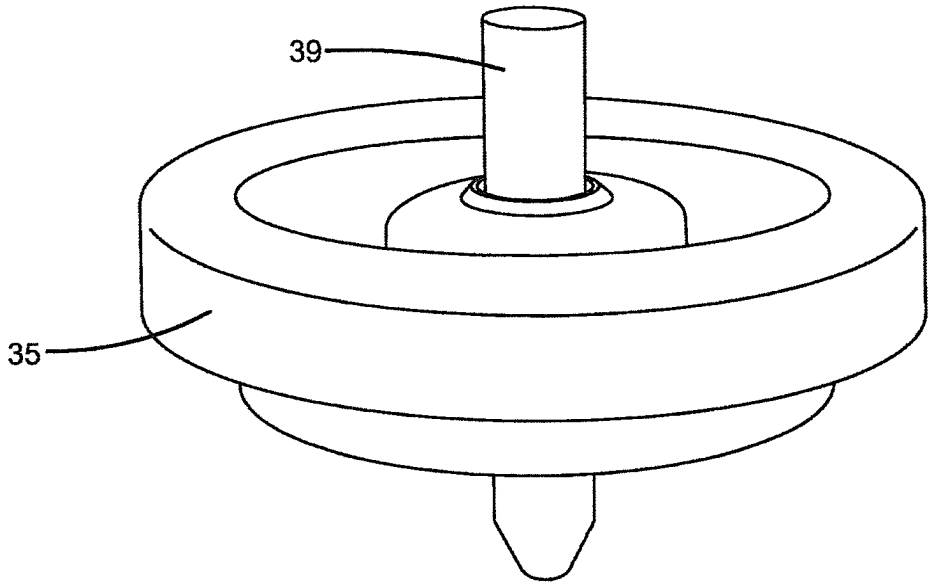

FIG. 12

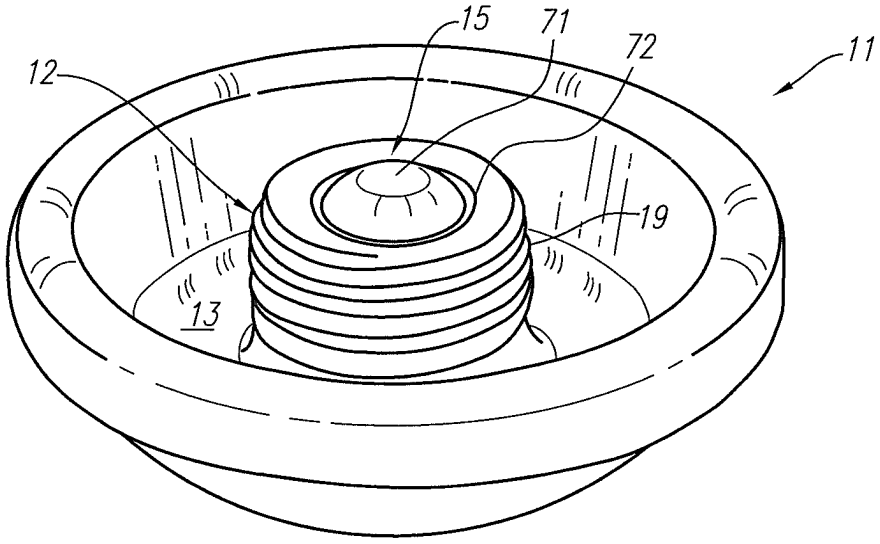

FIG. 13

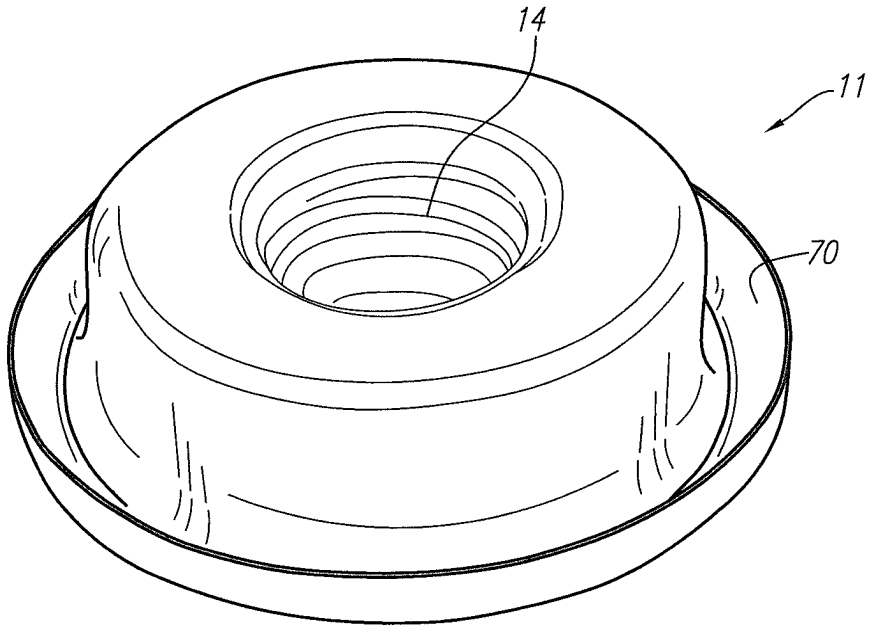

FIG. 14

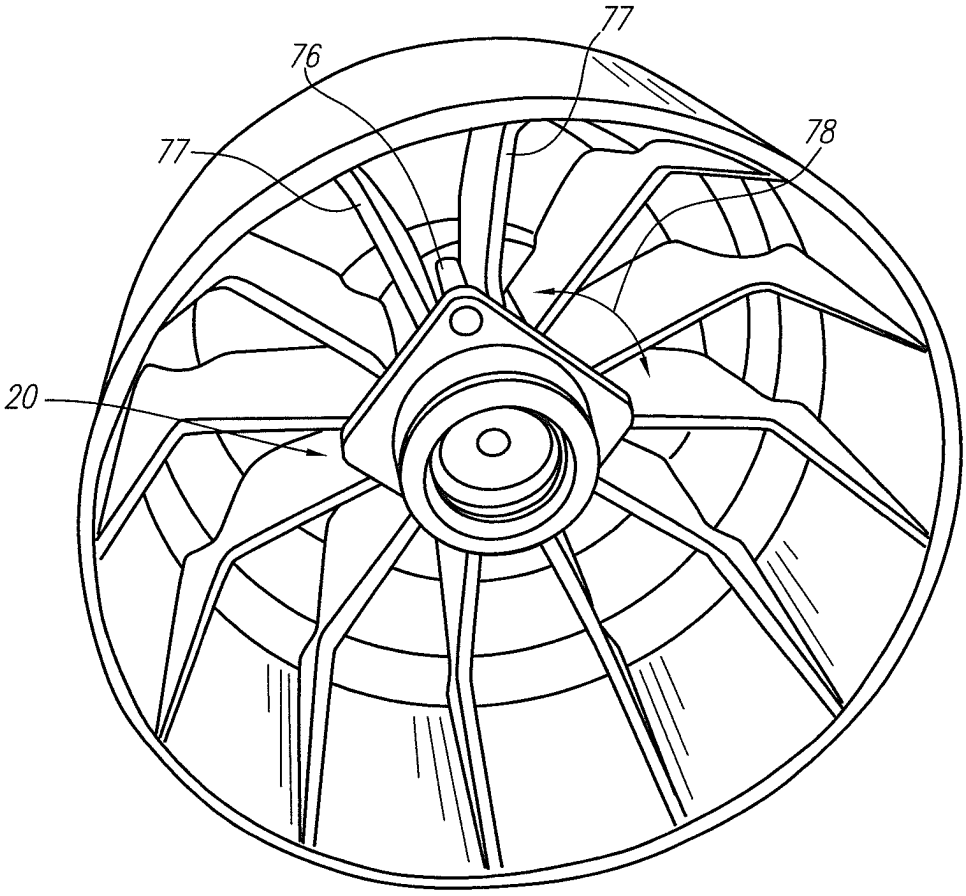

FIG. 15

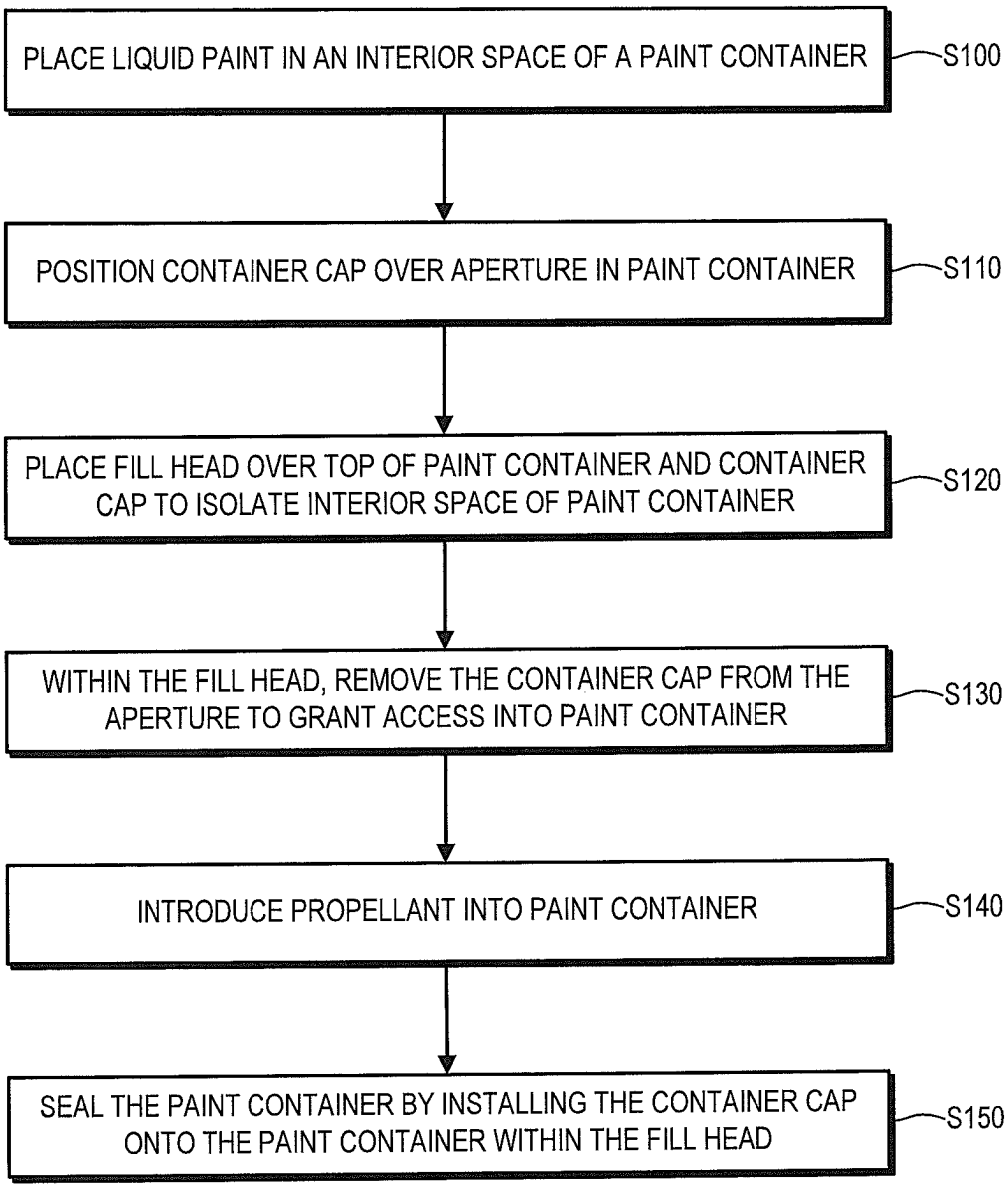
PLACE LIQUID PAINT IN AN INTERIOR SPACE OF A PAINT CONTAINER
S100
POSITION CONTAINER CAP OVER APERTURE IN PAINT CONTAINER
S110
PLACE FILL HEAD OVER TOP OF PAINT CONTAINER AND CONTAINER CAP TO ISOLATE INTERIOR SPACE OF PAINT CONTAINER
S120
WITHIN THE FILL HEAD, REMOVE THE CONTAINER CAP FROM THE APERTURE TO GRANT ACCESS INTO PAINT CONTAINER
S130
INTRODUCE PROPELLANT INTO PAINT CONTAINER
S140
SEAL THE PAINT CONTAINER BY INSTALLING THE CONTAINER CAP ONTO THE PAINT CONTAINER WITHIN THE FILL HEAD
S150

FIG. 16

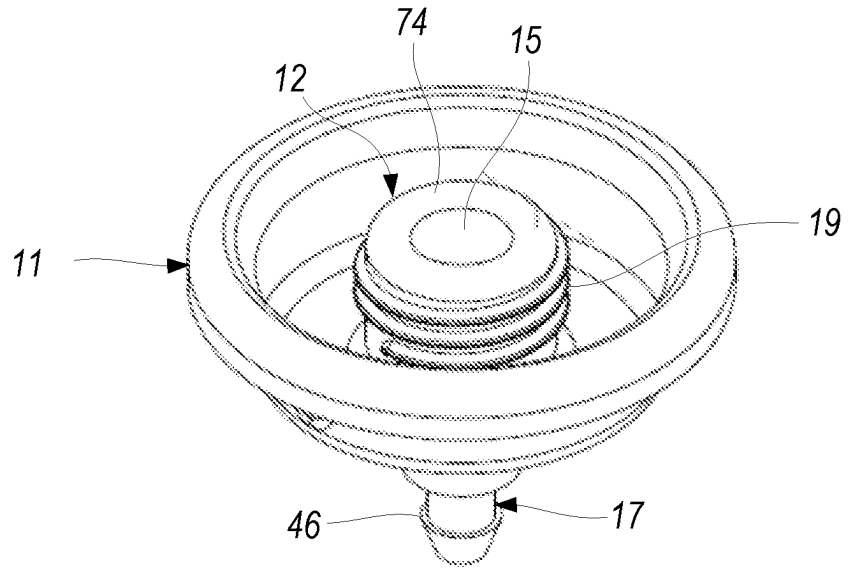

FIG. 17

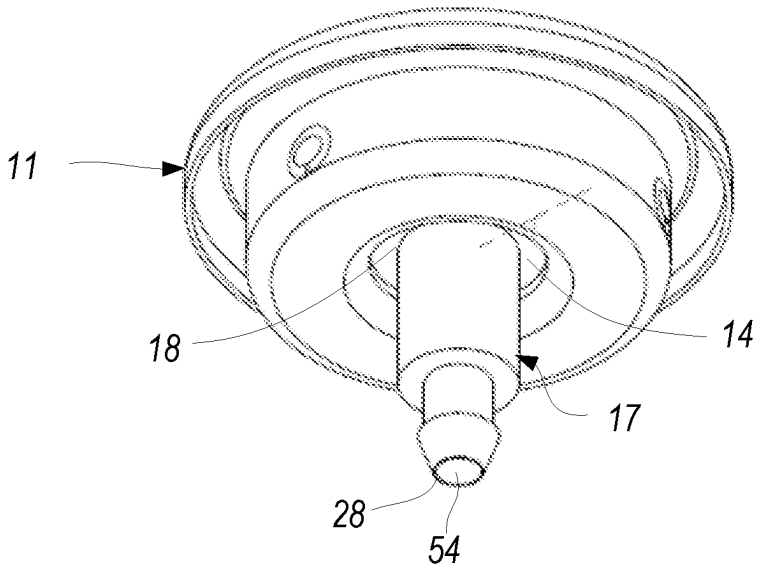

FIG. 18

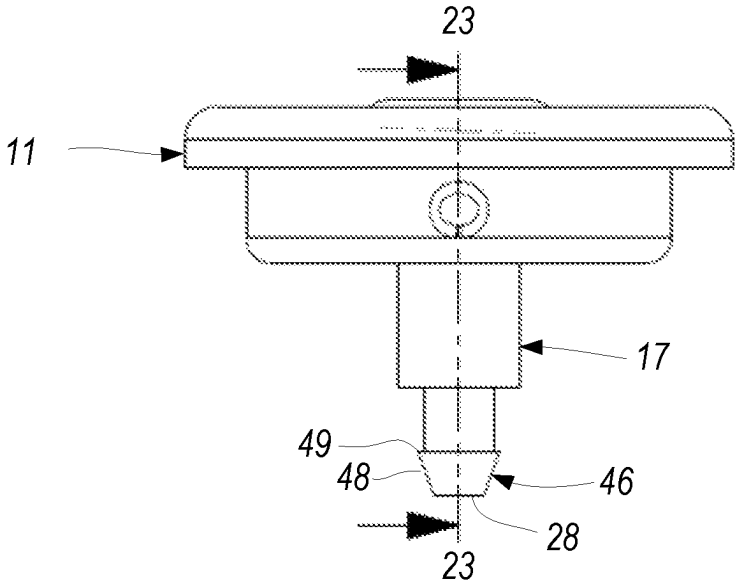
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FIG. 19

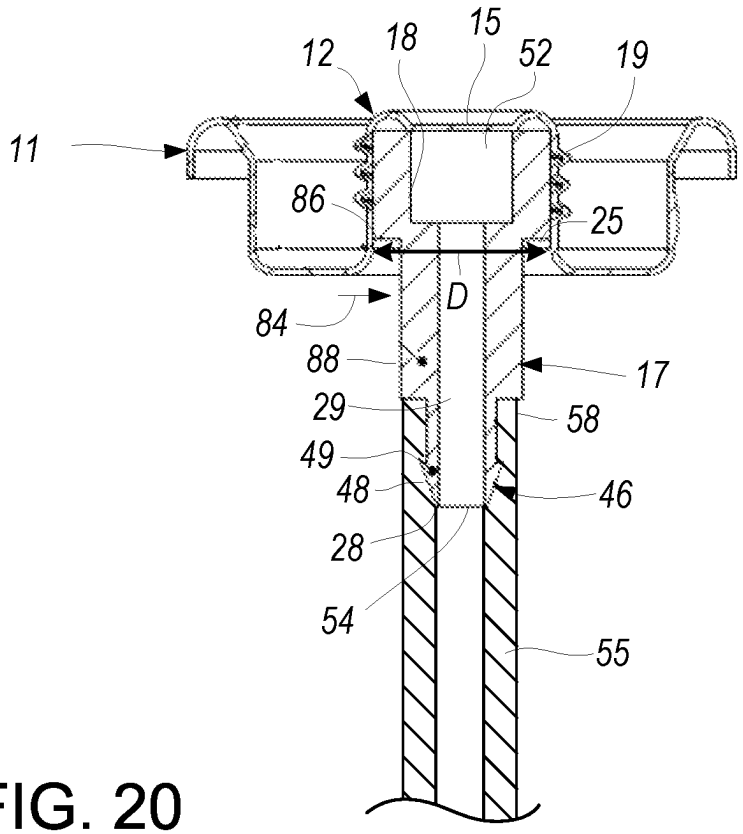
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FIG. 20

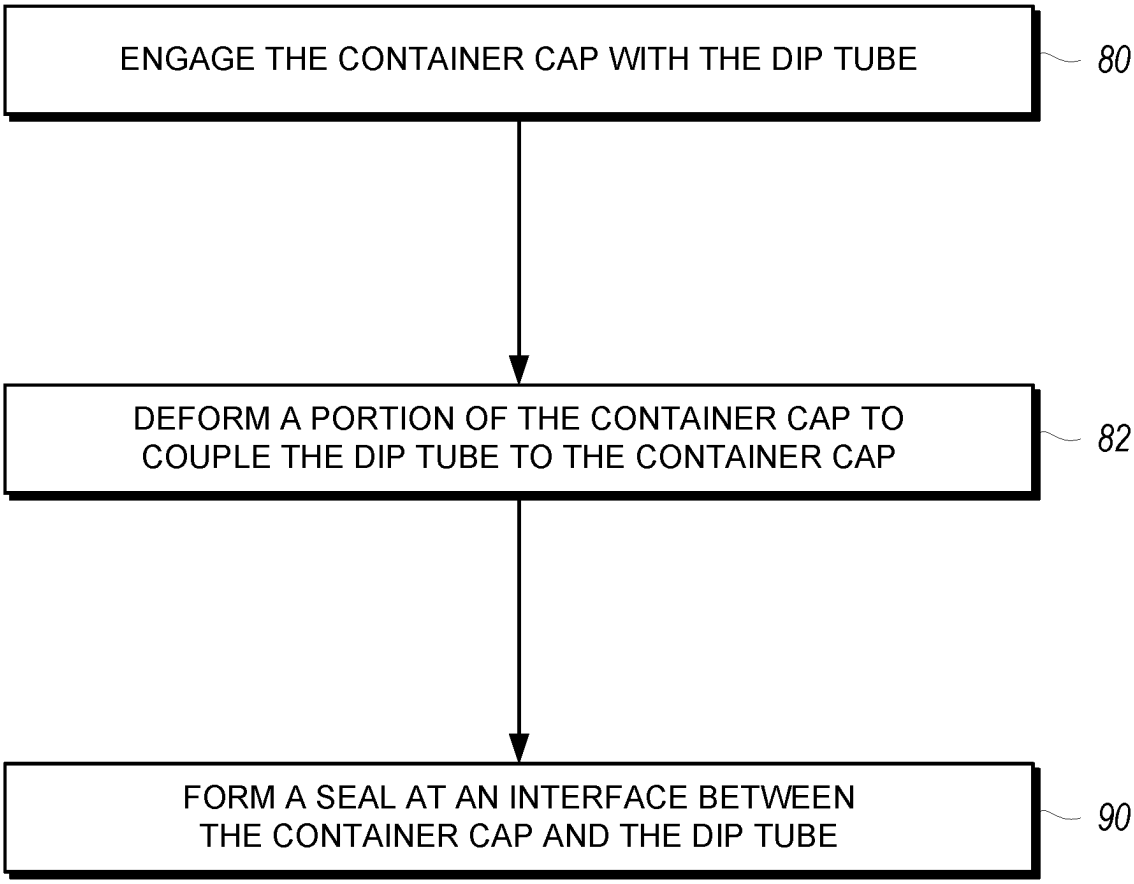
ENGAGE THE CONTAINER CAP WITH THE DIP TUBE
80
DEFORM A PORTION OF THE CONTAINER CAP TO COUPLE THE DIP TUBE TO THE CONTAINER CAP
82
FORM A SEAL AT AN INTERFACE BETWEEN THE CONTAINER CAP AND THE DIP TUBE
90

FIG. 21

FLUID DISPENSING METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention generally relates to methods and apparatuses for dispensing paint or another product from pressurized containers and, more specifically, to a replaceable product dispensing apparatus to be used on more than one pressurized container and methods of manufacturing and using a replaceable product dispensing apparatus.

2. Description of Related Art

Traditionally, cans of spray paint are formed from a metallic canister defining an interior space with paint and a valve assembly sealed therein. A nozzle is exposed externally of the canister to be actuated by a user to discharge a mist of paint to apply a coating of paint onto a target surface. Since the valve assembly is sealed within the interior space defined by the canister, however, the valve is usable only with that one canister and is not removable. Also, any unused paint and propellant within the interior space require users to follow special disposal instructions, or require the user to manually discharge the unused contents through the nozzle by manually actuating the nozzle as is done during painting.

Such traditional cans of spray paint have also been manufactured by first sealing the valve within the canister and installing the nozzle on a valve stem that is exposed externally of the canister. Only then would the nozzle or valve stem be actuated to cause the valve to open the interior passage leading into the interior of the canister to allow the paint and propellant to be inserted into the canister through that open interior passage. Since the valve is already in place within the canister, once the canister is sufficiently filled the nozzle and/or valve stem could be released, thereby causing the valve to once again close the interior passage leading into the interior of the canister and trapping the paint and propellant therein. Filling the canister in this manner necessarily requires the valve to first be installed within the canister to close the interior passage and contain the contents once they have been inserted into the canister.

More recently, attempts have been made to position the valve assembly externally of the canister. When such a valve assembly is installed on the canister, a cap is punctured, thereby establishing fluid communication between the valve assembly and the interior of the canister. In use, the canister is inverted to cause the paint or other contents within the canister to be positioned adjacent to an inlet of the valve assembly under the force of gravity. Actuation of the valve assembly causes the paint pooled at the inlet of the valve assembly to be expelled by a propellant also contained within the canister. However, when the canister containing the paint is not inverted to cause the paint to pool at the inlet to the valve assembly actuation of the valve assembly fails to reliably cause paint to be expelled.

BRIEF SUMMARY OF THE INVENTION

Thus, there is a need in the art for a reusable aerosol dispensing apparatus including a valve assembly that can be removably installed on a plurality of different pressurized canisters, and a method of preparing an aerosol canister that lacks a dedicated valve assembly installed within the canister. Some embodiments of the present canister can include a container cap including a dip tube. The dip tube includes a proximate end that is adjacent to the container cap, optionally coupled to the container cap. The proximate end of the dip tube can be sealed prior to installation of the external valve assembly onto the canister. Installation of the external valve assembly onto the canister can puncture the seal, establishing fluid communication between the dip tube and the external valve assembly.

The dip tube extends generally away from the container cap, toward a floor of the canister while the canister is oriented upright, terminating at a distal end of the dip tube that is positioned adjacent to the floor. Paint or another product is dispensed from the canister through actuation of the external valve assembly. Although any liquid chemical composition or other material that can be dispensed as an aerosol is encompassed by the present disclosure, paint represents an illustrative example of such a product that is dispensed from the canister through actuation of the external valve assembly. For the sake of brevity and clarity, however, the substance that is to be dispensed from the canister according to the present disclosure will be generically referred to as a "product." As a result of the external valve assembly being actuated, the product is caused to enter the distal end of the dip tube by the propellant, and to pass through an interior passage of the dip tube toward the proximate end. Product passing through the dip tube exits the proximate end and enters an interior passage extending through the external valve assembly, which is selectively opened as a result of actuation of the external valve assembly. Product pooled at the floor of the canister while the canister is in an upright orientation (e.g., the container cap is positioned vertically above the floor of the canister) can thus be conveyed by the dip tube from the distal end, serving as an inlet aperture, to the proximate end at the container cap, serving as an outlet aperture.

According to some embodiments of this invention, a fluid dispensing apparatus may be used in dispensing a product fluid from an associated container under a pressure greater than ambient. The associated container may contain associated product and may have a pierceable membrane. The fluid dispensing apparatus may comprise: a valve body having a top, a bottom and a bore that extends through the valve body; an adaptor having a top, a bottom, a bore that extends through the adaptor and a piercing member; and, a nozzle attached to the top of the valve body and having a bore that is communicatable with the valve body bore. The bottom of the valve body may be attached to the top of the adaptor and the adaptor bore may communicate with the valve body bore. The fluid dispensing apparatus may be operable by attaching the bottom of the adaptor to the associated container to pierce the pierceable membrane with the piercing member to communicate the associated product within the container with the adaptor bore and thus with the valve body bore. The nozzle may be operable to permit the associated product within the associated container to flow under the pressure out of the associated container, through the adaptor bore, through the valve body bore and through the nozzle bore to ambient.

According to other embodiments of this invention, a method of dispensing a liquid product from an associated container under a pressure greater than ambient may be provided. The associated container may contain associated product and may have a pierceable membrane. The method may comprise the steps of: (A) providing a fluid dispensing apparatus comprising: (1) a valve body having a top, a bottom and a bore that extends through the valve body; (2)

an adaptor having a top attached to the bottom of the valve body, a bottom, a bore that extends through the adaptor and a piercing member; wherein the adaptor bore communicates with the valve body bore; and, (3) a nozzle attached to the top of the valve body and having a bore that is communicatable with the valve body bore; (B) attaching the bottom of the adaptor to the associated container to pierce the pierceable membrane with the piercing member to communicate the associated product within the container with the adaptor bore and thus with the valve body bore; and, (C) operating the nozzle to permit the associated product within the associated container to flow under the pressure out of the associated container, through the adaptor bore, through the valve body bore and through the nozzle bore to ambient.

According to still other embodiments of this invention, an apparatus may comprise: (A) a container containing a product fluid under a pressure greater than ambient and having a pierceable membrane; (B) a fluid dispensing apparatus comprising: (1) a valve body having a top, a bottom and a bore that extends through the valve body; (2) an adaptor having a top, a bottom, a bore that extends through the adaptor and a piercing member, wherein the bottom of the valve body is attached to the top of the adaptor and the adaptor bore communicates with the valve body bore; and, (3) a nozzle attached to the top of the valve body and having a bore that is communicatable with the valve body bore. The fluid dispensing apparatus may be operable by attaching the bottom of the adaptor to the container to pierce the pierceable membrane with the piercing member to communicate the product within the container with the adaptor bore and thus with the valve body bore. The nozzle may be operable to permit the product within the container to flow under the pressure out of the container, through the adaptor bore, through the valve body bore and through the nozzle bore to ambient.

The above summary presents a simplified summary in order to provide a basic understanding of some aspects of the systems and/or methods discussed herein. This summary is not an extensive overview of the systems and/or methods discussed herein. It is not intended to identify key/critical elements or to delineate the scope of such systems and/or methods. Its sole purpose is to present some concepts in a simplified form as a prelude to the more detailed description that is presented later.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWING

In the accompanying drawings, structures are illustrated that, together with the detailed description provided below, describe exemplary embodiments of the claimed invention. The invention may take physical form in certain parts and arrangement of parts, embodiments of which will be described in detail in this specification and illustrated in the accompanying drawings which form a part hereof and wherein:

FIG. **1** is a perspective view of a fluid dispensing apparatus in accordance with some embodiments of this invention;

FIG. **2** is a perspective top view showing a prior art paint can and nozzle;

FIG. **3** is a perspective view of a container in accordance with some embodiments of this invention;

FIG. **4**A is a perspective side view of an adaptor in accordance with some embodiments of this invention;

FIG. **4**B is a perspective bottom view of an adaptor in accordance with some embodiments of this invention;

FIG. **5** is a perspective view of a dispensing apparatus in accordance with some embodiments of this invention;

FIG. **6** shows a container in accordance with some embodiments of this invention with a pierceable membrane pierced;

FIG. **7** shows a sectional view of a valve body in accordance with some embodiments of this invention;

FIG. **8** shows a sectional view of a valve body with pressure relief valve in accordance with some embodiments of this invention;

FIG. **9** is a side perspective view of a spray apparatus according to some embodiments of this invention;

FIG. **10** is a side view of a spray apparatus with a can, only a portion shown, attached to the can receiving portion;

FIG. **11** is a top perspective view of a valve body according to some embodiments of this invention;

FIG. **12** is a side perspective view of a valve cap according to some embodiments of this invention;

FIG. **13** is a top perspective view of an embodiment of a container cap;

FIG. **14** is a bottom perspective view of the embodiment of the container cap shown in FIG. **13**;

FIG. **15** is a bottom perspective view of the valve body shown in FIG. **11**;

FIG. **16** is a flow diagram schematically representing a method of producing a container in accordance with an embodiment of the present disclosure;

FIG. **17** is a top, perspective view of an illustrative embodiment of a container cap that includes a dip tube through which a liquid product is expelled from a container;

FIG. **18** is a bottom, perspective view of the illustrative embodiment of the container cap appearing in FIG. **17**;

FIG. **19** is a side view of the illustrative embodiment of the container cap appearing in FIG. **18**;

FIG. **20** is a sectional view taken along line **20**-**20** in FIG. **19**, with an extension tube installed; and

FIG. **21** is a flow diagram graphically representing a process of forming a container cap, according to some embodiments.

DETAILED DESCRIPTION OF THE INVENTION

Certain terminology is used herein for convenience only and is not to be taken as a limitation on the present invention. Relative language used herein is best understood with reference to the drawings, in which like numerals are used to identify like or similar items. Further, in the drawings, certain features may be shown in somewhat schematic form.

Referring now to the drawings wherein the showings are for purposes of illustrating embodiments of the invention only and not for purposes of limiting the same, and wherein like reference numerals are understood to refer to like components, FIG. **1** shows a perspective view of a pressurized container **10** equipped with a fluid dispensing apparatus **50** equipped with an external valve body **30** according to some embodiments of this invention. The pressurized container **10** shown is a can made from one or more metals, metal alloys and/or one or more plastic materials, and is devoid of an internal valve within an interior space defined by the container **10** containing the product. In other words, the external valve body **30** is required to control and regulate the expulsion of the product under the pressure generated within the interior space of the container **10** by the propellant. Puncturing the membrane **15** as described below without the external valve body **30** would result in the uncontrolled release and depletion of the propellant from the

container **10** to the ambient environment. However, the fluid dispensing apparatus **50** described herein will work with any type, size and shape of pressurized container **10**. The product dispensed by the fluid dispensing apparatus **50** may be a pressurized chemical that is a liquid, gas, vapor, or a mixture thereof. While the fluid dispensing apparatus **50** is designed to dispense any product such as paint, it may have application to other chemicals as well.

With continuing reference to FIG. **1**, the fluid dispensing apparatus **50** may, in some embodiments, include a nozzle **31**, a valve body **30**, and an adaptor **20**. The nozzle **31** may be like nozzle **202** discussed above. Because the operation of such nozzles **31**, **202**—laterally displaceable to permit the contents to exit the nozzle and biased into a non-displaced position where the contents cannot exit the nozzle—are well known to people of skill in the art, no details will be provided here.

With reference now to FIGS. **3** and **6**, in order to use the fluid dispensing apparatus, it may be necessary to attach a container cap **11** to the pressurized container **10**. The container cap **11** may, in one embodiment, be fixedly joined to the top of the pressurized container **10** such as being crimped in a known manner. The container cap **11** may be, in one embodiment, positioned substantially concentrically with the container's longitudinal axis. The container cap **11** may have a well **13**, a coupling element **12**, and a fluid passage bore **14** (visible in FIG. **6**). A membrane **15** may cover the bore **14**. Membrane **15** may be pierceable and located with respect to fluid passage bore **14** in such a manner as to seal bore **14** and prevent fluid from exiting container **10** until it is pierced. The embodiment of the membrane **15** shown in FIG. **3** includes a planar metal surface integrally formed as part of a monolithic structure along with the other portions of the container cap **11**, such as the coupling element **12**, well **13** and threaded section **19** described below, for example. Such structures can be integrally formed together by stamping a flat sheet of suitable metal stock into the desired shape of the container cap **11**. FIG. **6** shows membrane **15** in a pierced or punctured condition which exposes fluid passage bore **14** to outside of the pressurized container **10**, and establishes fluid communication with the fluid dispensing apparatus **50**. In the illustrated embodiments, the membrane **15** is fixedly connected to the coupling element **12** to close an uppermost region of that coupling element **12**. The coupling element **12** in FIGS. **3** and **6** is generally cylindrical, protruding upward from a base of the container cap **11** at the bottom of the well **13**, but may be of any desired size, shape and relative position to the other portions of the container cap **11** to releasably couple the fluid dispensing apparatus **50** to the container cap **11**. To be releasably coupled, the fluid dispensing apparatus **50** can be installed on, and subsequently removed from a plurality of containers **10** without being damaged to an extent that would prevent reuse of the fluid dispensing apparatus **50**. In one embodiment coupling element **12** may have an externally threaded (male threading) section **19**, as shown. For the embodiment shown, the coupling element **12** is cylindrical in shape and the threaded section **19** is on the exterior surface of the coupling element **12**. The threading extends along a suitable length of the cylindrical coupling element **12** to urge the fluid dispensing apparatus **50** toward the container **10** a suitable distance to both: (i) compress an elastomeric gasket **23**, interchangeably referred to herein as a seal **23** described below with reference to FIG. **4**B, provided to the fluid dispensing apparatus **50** against a surface of the container cap **11**, and (ii) form the seal that interferes with the escape of the propellant from the interior space of the container **10** between the container cap **11** and the fluid dispensing apparatus **50**. Materials used to form container cap **11** can include any metal or metal alloy having dimensions that permit stamping a planar sheet of the metal or metal alloy into the desired shape of the container cap **11**, although other materials are also considered to be within the scope of the present disclosure.

An alternate embodiment of the container cap **11** is shown in FIGS. **13** and **14**. Like the previous embodiment, the present embodiment of the container cap **11** includes a cylindrical coupling element **12** with a threaded section **19** and a well **13** disposed between the coupling element **12** and a collar defining a downward-opening, annular channel **70** (FIG. **14**) that extends about an external periphery of the container cap **11**. However, the membrane **15** of the embodiment shown in FIG. **13** includes an elevated region **71** or plateau that protrudes upward from a neighboring or surrounding region **72** of the membrane **15**. The coupling element **12** of any of the embodiments can also include a sealing surface **74** against which the gasket **23**, described below, can be compressed against to interfere with the leakage of propellant between the fluid delivery apparatus **50** and the coupling element **12** of the container cap **11**.

With reference now to FIGS. **1**, **4**A, **4**B and **6**, embodiments of adaptor **20** will now be described. Adaptor **20** may be, in some embodiments, a generally cylindrically shaped component with a top and an opposing bottom. Referring to FIG. **4**B, located on the bottom of adaptor **20** may be a coupling element **21**. Coupling element **21** may engage with coupling element **12** of container cap **11**. In one specific embodiment, shown, coupling element **21** may be formed on an inner cylindrical shaped portion of adaptor **20** and may have a threaded section **57**. The adaptor **20** may have a fluid passage bore **26** that may extend from the top to the bottom of the adaptor **20**. The adaptor **20** may also have a piercing member **27** used to pierce membrane **15** (shown unpierced in FIG. **3** and pierced in FIG. **6**). The piercing member **27**, in some embodiments, may be located concentric to the longitudinal axis of fluid passage bore **26** and may extend beyond bottom surface of fluid passage bore **26**. The piercing member **27** may be positioned at least partially within the adaptor bore **26**. On the end of piercing member **27** that extends beyond the bottom surface of bore **26**, a tip may be formed and configured to pierce membrane **15**. The adaptor **20** may also have a seal or gasket **23** that interferes with, and optionally prevents the escape of propellant and/or product except through the bore **26**. The gasket **23** may be formed of an elastomeric material.

Alternate embodiments of the container cap **11** are shown in FIGS. **17-20**. Similar to preceding embodiments, the container cap **11** in FIG. **17** includes the coupling element **12** defining the bore **14** (FIG. **18**). External threading **19** can be provided to an external periphery of the coupling element **12** for cooperating with the compatible threaded section **57** provided to the fluid dispensing apparatus **50** to releasably couple the fluid dispensing apparatus **50** to the container **10**, as described herein. The membrane **15** to be punctured is provided adjacent to a distal end of the coupling element **12** that protrudes generally away from the container **10** while the container cap **11** is installed on the container **10**.

As shown in FIGS. **18** and **20**, a proximate end **18** of a dip tube **17** extends into the bore **14** defined by the coupling element **12**. A distal end **28** of the dip tube **17** is supported at an elevation vertically beneath an elevation of the proximate end **18**, while the container cap **11** is installed on a container **10** in an upright orientation. In the upright orientation, a floor of the container **10**, forming a bottom surface

on which the container **10** rests in the upright orientation, supports the liquid product within the container **10** under the force of gravity. In other words, the container cap **11** is positioned at an elevation vertically above an elevation of the floor of the container **10** while the container **10** is in the upright orientation, and the product within the container **10** is caused to pool on the floor by the force of gravity.

According to some embodiments, the container cap **11** and the dip tube **17** can be formed as part of a common, monolithic structure. According to such embodiments, the dip tube **17** can be formed from a metal, metal alloy, or any other material used to form the container cap **11**. According to other embodiments, the dip tube **17** can be formed as a separate structure, distinct from the container cap **11**. For example, the dip tube **17** can be formed from a polymeric material, and a proximate end **18** of the dip tube **17** coupled to a portion of the container cap **11**.

FIG. **21** represents an illustrative embodiment of a process of forming the container cap **11** including a separate structure. A portion of the dip tube **17** can engage a portion of the container cap **11** at block **80**. For example, at least a portion of the proximate end **18** of the dip tube **17** can be received within the space **52** defined by an internal periphery of the coupling element **12**, as shown in FIG. **20**. As described in detail elsewhere herein, the coupling element **12** can include a releasable fastener such as the threading **19**, that engages the compatible threaded section **57** of the fluid dispensing apparatus **50**, to couple the fluid dispensing apparatus **50** to the container cap **11**.

With the proximate end **18** of the dip tube **17** at least partially received within the interior space **52**, a portion of the container cap **10** can be deformed at block **82** to interfere with removal of the proximate end **18** of the dip tube **17** from the interior space **52**. For example, the container cap **11** can be stamped from a sheet of a metallic material. The proximate portion **18** of the dip tube **17** can be at least partially inserted into the space **52** defined by the interior periphery of the coupling element **12**, and a portion of the container cap **11**, such as a base **25** (FIG. **20**) of the coupling element **12** adjacent to the well **13** for example, can be crimped against or about a portion of the proximate end **18** of the dip tube **17**, or otherwise deformed to secure the proximate end **18** of the dip tube **17** within the space **52**.

Crimping can deform the base **25** in a radially-inward direction indicated generally by arrow **84** (FIG. **20**). As a result, the dimension D (FIG. **20**) of the interior space **52** is suitable to allow insertion of a portion of the proximate end **18** of the dip tube **17** into the interior space **25** before crimping. According to some embodiments, the proximate end **18** of the dip tube **17** can optionally include a flange **86** that extends radially outward from another region **88** of the dip tube **17**. The dimension D is smaller after crimping than it was before crimping as a result of the deformed portion of the container cap **11** projecting radially inward in the direction indicated by arrow **84**, thereby interfering with removal of the proximate end **18** of the dip tube **17** from the interior space **52**.

Crimping the portion of the container cap **11** about the portion of the dip tube **17** can optionally form a seal at block **90** (FIG. **21**), at an interface between the dip tube **17** and the container cap **11**. The seal can be substantially hermetic, or at least be suitable to interfere with the escape of the paint or other aerosol product from the container **10**, and provide the container **10** with a shelf life of at least six months, or at least a year, etc. According to some embodiments, a gasket, adhesive, or other sealant can optionally be used to fortify the seal between the container cap **11** and the dip tube **17**. A distal end **54** of the dip tube **17** protrudes outwardly from an underside of the container cap **11**, to be positioned at least partially within the container **10** with the container cap **11** coupled to the container **10**.

The dip tube **17** defines an interior passage **29** (FIG. **20**) extending between the proximate end **18** and the distal end **28**. The dip tube **17** can be formed from any suitable metallic, polymeric or other plastic material with rigidity sufficient to maintain a shape of the dip tube **17** when the container **10** is angularly displaced from the upright orientation. Thus, the distal end **28** remains closer to the floor of the container **10** than the proximate end **18** of the dip tube **17** when the container **10** on which the container cap **11** is installed is angularly adjusted away from the upright orientation.

Some embodiments of the dip tube **17** have an external barb **46**, as shown in FIGS. **19** and **20**. The barb **46** can be formed in an inverted frustoconical shape, including a tapered region **48** extending between the distal end **28** and a flange **49**. The barb **46** can engage an extension tube **55** (FIG. **20**) by allowing a first end **58** of the extension tube **55** to be slid along or otherwise placed over the tapered region **48** of the barb **46**, in a direction generally toward the proximate end **18** of the dip tube **17**. Once the first end **58** of the extension tube **55** reaches the flange **49**, a portion of the extension tube **55** extends in a radial inward direction, generally toward the interior passage **29**, to engage the flange **49**. Engagement of the flange **49** by the portion of the extension tube **55** interferes with movement of the first end **58** of the extension tube **55** away from the proximate end **18** of the dip tube **17**, thereby interfering with removal of the extension tube **55** from the dip tube **17**.

Alternate embodiments of the dip tube **17** can optionally extend a distance from the container cap **11** toward the floor of the container **10**, to position a portion of the distal end **28** of the dip tube **17** adjacent to the floor of the container **17** (e.g., within a quarter (¼ in.) of an inch, within a third ($\frac{1}{3}^{rd}$ in.) of an inch, or in contact with the floor), in the absence of the extension tube **55** as a separate structure. For example, the dip tube **17** can optionally include the extension tube **55** formed as part of a common monolithic structure that extends substantially the entire distance between the container cap **11** and the floor of the container **10**, eliminating the need for the assembly of separate parts, and simplifying the manufacture of the present container **10**, for use with the present fluid dispensing apparatus **50**. For the embodiments where the distal end **28** of the dip tube **17** or the second end of the extension tube **55** is positioned adjacent to the floor of the container **10**, the fluid dispensing apparatus **50** is operable to control the discharge of the paint or other aerosol product from the container **10** lacking an internal valve, while the container **10** is in the upright orientation.

As shown in FIG. **20**, the proximate end **18** of the dip tube **17** can be sealed by the membrane **15**, to interfere with expulsion of the product through the dip tube **17** while the membrane **15** is intact. For example, prior to installation of the fluid dispensing apparatus **50** to puncture the membrane **15** as described herein, the membrane **15** encloses a space **52** (FIG. **20**) defined, at least in part, by portions of the coupling element **12**, including the membrane **15**. While the membrane **15** is intact, the pressure within the space **52** is suitable to interfere with the uncontrolled expulsion of the product from the container **10** through the dip tube **17** by the propellant. Thus, the dip tube **17** can include an open, unobstructed interior passage **29** through which the product would be expelled from the container **10** by the propellant in the absence of the membrane **15** or other plug member. The

container **10**, including the container cap **11** with the dip tube **17** installed on the container **10**, can optionally be devoid of a valve within the interior space defined by the container **10** that selectively controls the release of the product through the dip tube **17**.

Upon installation of the fluid dispensing apparatus **50** as described herein, the membrane **15** can be pierced by the piercing member **27**, for example, thereby establishing fluid communication between the fluid dispensing apparatus **50** and the space **52**, and accordingly the interior space of the container **10** through the dip tube **17**. For example, the piercing member **27** can define an interior passage and extend into the space **52**, allowing paint introduced into the space **52** to be urged through the piercing member **27** as described elsewhere herein. A nozzle **31** of the fluid dispensing apparatus **50** can be laterally displaced, pushed downward, in a direction generally toward the container **10**, or otherwise manipulated to selectively open the valve provided to the fluid dispensing apparatus **50**. Such manipulation of the nozzle **31** causes the valve body bore defined by the fluid dispensing apparatus **50** to be opened. The propellant operates to cause the product to be introduced to the interior passage **29** of the dip tube **17** at an elevation adjacent to the floor of the container **10** through an aperture **54** (FIG. **18**) formed at the distal end **28**. The product so introduced is urged through the interior passage **29** of the dip tube **17**, and expelled from the dip tube **17** through an aperture formed at the proximate end **18** of the dip tube **17**. The product is urged through the valve body bore of the fluid dispensing apparatus **50**, and through the nozzle **31**.

Although the expulsion of paint is an example of a product that can be dispensed via the present apparatus and method, the present disclosure is not so limited. Any chemical or other substance in the form of a liquid, gas or other fluid can be dispensed as an aerosol or in any other form as described herein. For example, the fluid dispensed can be a cosmetic product such as hairspray, an aromatic substance such as aftershave, a food product such as cooking oil, and any other substance that can be dispensed as an aerosol.

Regardless of the form of the container cap **11**, the threading provided to the threaded section **57** of the adaptor **20** engages compatible threading provided to the container (e.g., threading **19** provided to the coupling element **12** of the container cap **11**) to couple the fluid dispensing apparatus **50** to the container **10**. As the adaptor **20**, and accordingly the various embodiments of the valve body **30**, **30'**, **30"** described herein, are brought together during installation through cooperation between the respective threaded sections, the piercing member **27** is caused to puncture the membrane **15** substantially simultaneously with compression of the gasket **23** against the sealing surface **74** of the coupling element **12**. Premature contact between the gasket **23** and the sealing surface **74** may interfere with sufficient insertion of the piercing member **27** to puncture the membrane **15**. However, recessing the gasket **23** too far into the adaptor **20** may prevent the gasket from reaching the sealing surface **74** of the coupling element **12**, thereby allowing propellant to leak between the fluid dispensing apparatus **50** and the container cap **11**. Thus, the arrangement of the gasket **23**, piercing member **27** and the threaded section **57** of the adaptor **20** can be arranged to cause the gasket **23** to contact the sealing surface **74** approximately simultaneously (e.g., within one rotation of the adaptor **20** relative to the coupling member **12**, or within three-quarters, half or one quarter rotation of the adaptor **20** relative to the coupling member **12**, etc.) with the puncture of the membrane **15** by the piercing member **27**. Engagement between the threading provided to the adaptor **20** and the coupling member **12** can define a range of travel of the fluid dispensing apparatus **50** relative to the container **10** during installation. The piercing member **27** can be arranged to puncture the membrane **15** and the gasket can be arranged to be compressed against a portion of the container cap **11** along that range of travel.

With reference now to FIG. **4**A, located on the top of the adaptor **20** may be a coupling element **22**. In one specific embodiment, shown, coupling element **22** may be formed on an outer cylindrical shaped portion of adaptor **20** and may have a threaded section **59**. The coupling element **22** may be used to engage with a coupling element of the valve body **30**, as will be discussed further below. A seal **24** may be used to seal the connection between the top of the adaptor **20** and the bottom of the valve body **30**. For the embodiment shown, the seal **24** is an O-ring received around the cylindrically shaped portion of the adaptor **20** that has the coupling element **22**. The seal **24** may be formed of an elastomeric material. The adaptor **20** may have a shoulder **25** extending outwardly, as shown. The top of the shoulder **25** may have a surface **51** that acts as a stop that contacts a surface of the valve body **30** when the adaptor **20** and valve body **30** are attached together. The adaptor **20** may be formed of any material(s) chosen with the sound judgment of a person of skill in the art. In one embodiment, the adaptor **20** is formed of copper.

With reference now to FIGS. **1**, **5** and **7**, embodiments of the valve body **30** will now be described. The valve body **30** may have a valve cap **35** on its top, as shown. The valve cap **35** may have any design suitable to properly receive the nozzle **31** as chosen by a person of skill in the art. In one embodiment, shown, the valve cap **35** is similar in design to the top of the can **200**, just below the nozzle **202**, shown in FIG. **2**. The valve body **30** may be substantially cylindrical in shape and may have a height **61**. The height **61** may range between 1.0 to 4.0 inches. Valve body **30** may have a fluid passage bore **34**, as shown in FIG. **7**. The bore **34** may extend from bottom to the top of the valve body **30**, as shown. In one embodiment, the bore **34** may be centered along the valve body's longitudinal axis. A coupling element **33** may be located on a bottom surface, as shown. In one specific embodiment, shown, coupling element **33** may be formed on an inner cylindrical shaped portion of valve body **30** and may have a threaded section **37**. The coupling element **33** may be used to engage with coupling element **22** of the adaptor **20**. In one specific embodiment, threaded section **37** engages threaded section **59** to attach the valve body **30** to the adaptor **20**. The valve body **30** may be formed of any material chosen with the sound judgment of a person of skill in the art.

With reference now to FIGS. **1**, **5** and **7**, the nozzle **31**, which may have a fluid passage bore **32**, may be joined to the valve cap **35** in a known manner—similar to how the nozzle **202** is joined to can **200** in FIG. **2**. Nozzle **31** may dispense product out of the valve body **30** to the ambient when the nozzle **31** is operated in a known manner (similar to nozzle **202** in FIG. **2**). Specifically, nozzle **31** may be configured such that it can be selectively deflected from its longitudinal axis and when so deflected its bore **32** is in fluid communication with central bore **34**. Nozzle **31** may be configured such that it is capable of being deflected by manually generated forces. Nozzle **31** may also be configured with a biased position such that when no force is applied, nozzle **31** returns to a position that prevents fluid communication with central bore **34**.

FIG. **8** illustrates another embodiment valve body **30'**. Valve body **30'** is similar to valve body **30** described above except that it may include a pressure relief valve **36**. In this

embodiment valve body **30'** may include a transverse fluid passage bore **38**. Bore **38** may communicate on one end with bore **34** and on the opposing end with the area outside of the confines of valve body **30'**. Located in bore **38** may be pressure relief valve **36**. Pressure relief valve **36** may be chosen to operate in a plurality of modes. One mode may be such that in an initial condition relief valve **36** substantially seals bore **38** from the area outside. A second mode may be, once the user depresses relief valve **36**, transverse bore **38** connects central bore **34** with the area outside of the confines of valve body **30'**. Operating in this second mode, when attached to valve body **30'**, the pressure inside container **10** is minimized or released to the ambient without the fluid also being dispensed to the ambient. A third mode is the relief valve **36** opens automatically when pressure inside the container **10** exceeds a predetermined value. When this occurs, the pressure inside container **10** is minimized or released to ambient. Materials used in forming pressure relief valve **36** may be chosen with the sound judgment of a person of skill in the art. The operation modes of pressure relief valve **36** may also be chosen with the sound judgment of a person of skill in the art.

With reference now to FIG. **11**, another embodiment valve body **30"** is shown. Valve body **30"** has a valve cap **35** and attaches to a nozzle **31** as with previously described valve bodies **30** and **30'**. Valve body **30"**, however, is designed to resemble the size and shape of the container **10**. Compare FIG. **11** with FIG. **2**. FIG. **12** shows stem **39** which extends through the valve cap **35** and is used to operate nozzle **31** in a known manner.

A bottom view of the valve body **30"** is shown in FIG. **15**. The adaptor **20** such as that described above is coupled to the underside of the valve body **30"** in fluid communication with a valve mechanism housed by the valve body **30"**. For embodiments where the adaptor **20** is not integrally formed with the valve body **30** and/or valve mechanism, rotating the valve body **30"** in a counterclockwise direction about the longitudinal axis of the container **10** to remove the valve body **30"** imparts a force that could cause counterclockwise rotation of the adaptor **20** relative to the valve body **30"**. Such relative rotation could result in separation of the adaptor **20** from the valve body **30"**. To interfere with such separation, one or more locking structures **76** such as a post can optionally extend through the shoulder **25** of the adaptor **20** and into the underside (between two reinforcing gussets **77** in FIG. **15**) of the valve body **30"** to prevent rotation of the adaptor **20** relative to the valve body **30"** in the directions indicated by arrows **78**, during installation and removal of the fluid dispensing apparatus **50**.

With reference now to FIGS. **1**, **2**, **9** and **10**, spray apparatuses **100**A, **100**B are shown. Because many of the components are similar, many of the same reference numbers will be used in both. Each spray apparatus **100**A, **100**B may include a housing **102**, a barrel **104** supported to the housing **102** and a handle **106** also supported to the housing **102**. For the embodiments shown, the spray apparatuses **100**A, **100**B may have a pistol-shape but other shapes may work well also. The barrel **104** may be hollow and may extend distally (away from the handle) to a tip **108**. The hollow barrel **104** and tip **108** may define a fluid passageway bore. In one embodiment, the tip **108** is the distal end of the apparatus **100**A, **100**B and the point from which product fluid is dispensed. In another embodiment, the tip **108** comprises a fitting to which another component (not shown) may be attached and from which the product fluid is dispensed. The barrel **104** may decrease in outside diameter, as shown in FIG. **9**, in the distal direction.

With continued reference to FIGS. **9** and **10**, a container receiving portion **110** may be supported to the housing **102** and sized and shaped to securely retain/support a container **10** or **200**. For the embodiment seen best in FIG. **9**, the container receiving portion **110** may include an outer, generally circular ring **112** defining an opening **114**, and a nozzle reception connector **116**. The user may attach the pressurized container **10**, **200** to the apparatus **100**A, **100**B, as shown in FIG. **10**, such that the nozzle **31**, **202** is received within the nozzle reception connector **116** and the valve body **30** or top of can **200** is received within the opening **114**. The nozzle reception connector **116** communicates with the fluid passageway in the barrel **104** so that the fluid product within the pressurized container **10**, **200** can be dispensed out the tip **108**, when desired. For the embodiments shown, the container receiving portion **110** is positioned on a top portion of the apparatus **100**A, **100**B. As a result, gravity assists in assuring that all the liquid within the container is used. The receiving portion **110** may extend from the apparatus at an angle **A1**, as shown in FIG. **10**, with respect to the longitudinal axis of the housing **102** and/or barrel **104**. Angle **A1** may be, in one embodiment, between 0 degrees and 90 degrees. In another embodiment, angle **A1** may be between 10 degrees and 80 degrees. In yet another embodiment, angle **A1** may be between 20 degrees and 70 degrees. For the embodiment shown, angle **A1** is approximately 75 degrees.

Still referring to FIGS. **9** and **10**, the spray apparatus **100**A, **100**B may also include a trigger **118** which is moveable relative to the housing **102** in order to deflect the nozzle **31**, **202** to dispense the product fluid. The trigger **118** may have a first end with a user contact surface **120** and a second end with a discharge contact surface **122**. When the trigger **118** is manually operated, in one embodiment moved, by the user, such as by squeezing the user contact surface **120** toward the handle **106** with the user's hand, the discharge contact surface **122** contacts the nozzle **31**, **202** to deflect it and dispense the fluid. The trigger **118** may be moveably attached to the housing **102** in any manner chosen with the sound judgment of a person of skill in the art.

For the embodiment shown in FIG. **9**, the second end of the trigger **118** has a U-shaped portion with legs that extend juxtaposed to opposite sides of the housing **102** and pivots about pivot pin **124** which is received through the legs and through the housing **102**. In an alternate embodiment, one pivot pin connects one leg to the housing on one side and a second pivot pin connects the other leg to the housing on the opposite side. To provide container size adjustability, an adjustment mechanism **132** may be used. The adjustment mechanism **132** may include bracket **126** that extends from the trigger **118** to a nut **128** that is threadingly received on a threaded rod **130** that is supported to and extending from the housing **102**. For the embodiment shown in FIG. **9**, the bracket **126** has an opening that receives the pivot pin **124**. In an alternate embodiment, another bracket (not visible) extends from the nut **128** to the trigger **118** on the other side of the apparatus **100**A. To adjust the apparatus **100**A to fit different sized containers, the nut **128** can be rotated about rod **130** to move the bracket **126** and thus the trigger **118** along the longitudinal axis of the housing **102** (that is, along the longitudinal axis of the barrel **104**) either closer to the receiving portion **110** or farther away.

With reference again to FIGS. **9** and **10**, to use the spray apparatuses **100**A, **100**B, the user attaches the container **200** or container **10** equipped with the adaptor **20** and valve body **30**, to the container receiving portion **110**, as explained above. If necessary, the user adjusts the adjustment mecha-

nism **132** to fit the container. The user then only has to position the tip **108** (or other component that is attached to the tip) to the desired location and then move the trigger **118** with respect to the handle **106** (such as by squeezing the trigger **118** toward the handle **106**). The trigger **118** movement deflects the nozzle **31**, **202** dispensing the fluid out of the container and out of the tip **108**.

With reference now to FIGS. **1** and **3**, methods of using the fluid dispensing apparatus **50** will now be described. The container **10** may be equipped with container cap **11** by the manufacturer, in one embodiment. The fluid dispensing apparatus **50** may come to the user as a kit, in one embodiment, including the adaptor **20** and the valve body **30**. In one embodiment, the adaptor **20** may already be attached to the valve body **30**. In another embodiment, the coupling element **22** (see FIG. **4**A) is attached to coupling element **33** (see FIG. **7**) to attach the adaptor **20** to the valve body **30**. In one specific embodiment, this may comprise rotating the adaptor **20** with respect to the valve body **30** with threaded section **59** engaged with threaded section **37** to "tighten" them together. This action may compress seal **24** and a lower service of the valve body **30** may contact surface **51**, or come near to contacting it. In another embodiment, the fluid dispensing apparatus **50** may come to the user already attached to the pressurized container **10**.

With reference now to FIGS. **1**, **3**, **4**B, **6** and **7**, the user then attaches the fluid dispensing apparatus **50** to the container **10**. In one embodiment, this means attaching the coupling element **21** of the adaptor **20** (see FIG. **4**B) with the coupling element **12** of container **10** (see FIG. **3**). In one specific embodiment, this may comprise rotating the fluid dispensing apparatus **50** with respect to the container **10** with threaded section **57** engaged with threaded section **19** to "tighten" them together. This action may compress seal **23**. As the fluid dispensing apparatus **50** is attached to the container **10**, piercing member **27** (see FIG. **4**B) contacts and pierces membrane **15** (see FIG. **3** to see the membrane **15** before it is pierced, and FIG. **6** to see the membrane **15** after it is pierced). Once the membrane **15** is pierced, container bore **14** communicates with adaptor bore **26** which communicates with valve body bore **34**. Thus, once the fluid dispensing apparatus **50** is attached to the pressurized container **10**, all the user needs to do to dispense the paint is operate nozzle **31**, such as by deflecting the nozzle **31**, as described above. Thus, operation of the fluid dispensing apparatus **50** with container **10** as shown in FIG. **1** is similar to the use of container **200** and nozzle **202** shown in FIG. **2**.

In another embodiment, container **10** may be depressurized and substantially emptied of paint fluid according to the following method. The user may uncouple or detach container **10** from adaptor **20** (and thus from fluid dispensing apparatus **50**) and separate the two components. With container **10** separated from adaptor **20**, pierced membrane **15** is exposed to the ambient thus resulting in container **10** becoming depressurized. Next, container **10** may be substantially emptied of fluid by placing it with pierced membrane **15** facing down and thus using gravity to force the paint fluid out of container **10**. At this point container **10** may be easily deposed of. The fluid dispensing apparatus **50** may then be reused with another container.

Since conventional spray cans include an internal valve, producing such spray cans has typically involved filling the spray cans through the valve, which could then prevent those contents from escaping once filling was complete. However, since the container of the present disclosure lacks an internal valve, the present container must be filled and the container cap installed to seal the interior space of the container without installing a valve.

A method of producing a container is schematically depicted in FIG. **16**. At step S**100**, liquid paint is added to the interior space defined by a housing of the container **10** through an aperture defined by a rim of the container **10**. The paint can optionally be added to the container **10** under atmospheric pressure before the container cap **11** is positioned adjacent to the aperture defined by the rim at step S**110**, and optionally before the container **10** is covered by an enclosure for introduction of the propellant as described below. Positioning the container cap **11** at step S**110** can optionally include using a mechanical arm or other grasping device to mechanically grasp a handling member **60** projecting from the container cap **11** and, under the control of a programmed computer processor, nearly concentrically aligning the longitudinal axis of the holding member **60** with the aperture defined by the rim. With the handling member **60** aligned with the aperture defined by the rim, the container cap **11** with the handling member **60** can be lowered into place such that the channel **70** receives the rim. Since the handling member **60** does not fully block the bore **14** and prevent paint and propellant from passing through the bore **14**, the handling member **60** can remain within the container **10** even though it has already served its purpose to align the container cap **11** over the aperture defined by the rim. Even if the friction fit between the container cap **11** and the handling member **60** allows the handling member **60** to separate from the container cap **11** within the sealed container **10**, no degradation of the assembled system is expected.

A containment device such as a filler head is placed over the container cap **11** resting on, or positioned over the rim aperture to form an enclosure in which a pressure above atmospheric pressure can be maintained during introduction of the propellant into the container **10**. Since the propellant is volatile, and evaporates at atmospheric pressure, the filler head, containment device or other enclosure can be positioned over a portion of the container **10** comprising the aperture to abut against the container **10** or other structure to form the enclosure in which the elevated pressure can be maintained during introduction of the propellant. The container cap **11** can be separated from the rim if resting thereon at step S**130** and, with the enclosure in place over at least a portion of the container **10**, a quantity of a propellant is introduced into the interior space of the container **10** through the aperture at step S**140**. The amount of the propellant introduced is suitable to establish a pressure within the interior space to propel the paint from the container **10**. As the fluid is introduced, the pressure within the enclosure rises above atmospheric pressure. While the enclosure is still in place, the container cap **11** is installed on the rim of the container **10** within the enclosure, at step S**150**, after the propellant has been fully introduced to close the aperture and seal the container **10** to contain the combination comprising the liquid paint and the propellant. The container **10** can then be removed from the containment device after the container cap **11** has been installed to seal the aperture.

Embodiments of the present method allow for the insertion of a split, elastomeric gasket between the container cap **11** and the rim to promote a strong seal. The annular channel **70** extending about a periphery of the container cap **11** is placed on, and receives the rim of the container in a first state, shown in FIG. **17**. Without installing a valve within the interior space of the container **10**, a collet or other suitable crimping tool can be used to deform the rim of the container

10 within the annular channel 70 as shown in FIG. 18, in which the rim is rolled onto itself within the annular channel 70, as an example of suitable deformation. The deformation of the rim into a second state establishes a friction fit between the annular channel 70 of the container cap 11 and the container 10 suitable to interfere and prevent the escape of significant portions of the propellant between the container cap 11 and the container 10.rim

The foregoing description of examples and embodiments have been presented for purposes of illustration and description. It is not intended to be exhaustive or limiting to the forms described. Numerous modifications are possible in light of the above teachings. Some of those modifications have been discussed, and others will be understood by those skilled in the art. The examples and embodiments were chosen and described in order to best illustrate principles of various examples as are suited to particular uses contemplated. The scope is, of course, not limited to the examples and embodiments set forth herein, but can be employed in any number of applications and equivalent devices by those of ordinary skill in the art. It will be apparent to those skilled in the art that the above methods and apparatuses may incorporate changes and modifications without departing from the general scope of this invention. It is intended to include all such modifications and alterations.

We claim:

1. A fluid storage system comprising:

a container defining an interior space that lacks an internal valve;

a product and a propellant stored under pressure within the interior space; and

a container cap coupled to the container to enclose the container and maintain the product and the propellant within the interior space of the container, the container cap comprising:

a coupling element that defines a fluid passage bore, the coupling element comprises an externally threaded section,

a collar,

a well disposed between the coupling element and the collar, defining a downward-opening, annual channel,

a membrane enclosing a first end of the fluid passage bore defined by the coupling element that seals the product and the propellant within the interior space of the container,

the externally threaded section engages a compatible fastener provided to a reusable dispensing apparatus to releasably couple the reusable dispensing apparatus to the container cap wherein the membrane is pierced by a portion of the reusable dispensing apparatus when the reusable dispensing apparatus is installed on the container cap to establish fluid communication between the interior space and the reusable dispensing apparatus and establish a seal that interferes with an escape of the propellant between the container cap and the reusable dispensing apparatus after the membrane has been pierced, and

a dip tube comprising a proximate end arranged adjacent to the fluid passage bore defined by the coupling element, and a distal end that protrudes in a direction away from the container cap, into the interior space defined by the container, wherein the dip tube defines an interior passage extending between the proximate end and the distal end through which the product is to travel to be expelled from the container through the container cap and the reusable dispensing apparatus by the propellant.

2. The fluid storage system of claim 1, wherein the distal end of the dip tube is supported at a vertical elevation within the interior space of the container that is closer to a floor of the container than a vertical elevation of the proximate end of the dip tube adjacent to the fluid passage bore.

3. The fluid storage system of claim 1 further comprising an extension tube comprising a first end defining an aperture that cooperates with a portion of the distal end of the dip tube to couple the extension tube to the dip tube, establishing fluid communication between a second end of the extension tube and the distal end of the dip tube.

4. The fluid storage system of claim 3, wherein the dip tube further comprises a barb adjacent to the distal end of the dip tube.

5. The fluid storage system of claim 4, wherein the barb comprises a tapered region and a flange, wherein the first end of the extension tube extends over the tapered region to the flange.

6. The fluid storage system of claim 3, wherein the extension tube extends an entire distance between the dip tube and a floor of the container, and supports the second end of the extension tube adjacent to the floor of the container.

7. The fluid storage system of claim 1 further comprising an extension tube formed as a portion of a monolithic structure with the dip tube, wherein the extension tube extends an entire distance between the dip tube and a floor of the container, and supports an end of the extension tube adjacent to the floor of the container.

8. The fluid storage system of claim 1, wherein the proximate end of the dip tube extends at least partially into the fluid passage bore defined by the coupling element.

9. A process of dispensing a product from a container, the process comprising:

introducing a fluid dispensing apparatus comprising a valve to a coupling element provided to a container cap, wherein the container cap: (i) encloses the product and a propellant in an interior space of the container that is devoid of an internal valve, and (ii) supports a dip tube that protrudes in a direction from the container cap into the interior space of the container, wherein an extension tube extends from a distal end of the dip tube toward a floor of the container, introducing the fluid dispensing apparatus comprises releasably coupling the fluid dispensing apparatus onto an externally threaded section of a coupling element that defines a fluid passage bore of the container cap, and establishing a seal that interferes with an escape of the propellant between the container cap and the fluid dispensing apparatus, the container cap comprises a collar, and a well disposed between the coupling element and the collar, defining a downward-opening, annual channel;

puncturing a membrane provided to the container cap to establish fluid communication between the fluid dispensing apparatus and the interior space of the container, forming an interior passage through which the product is to travel from the interior space of the container to the fluid dispensing apparatus; and

dispensing the product from the container through the fluid dispensing apparatus while the container is in an upright orientation, by actuating the valve provided to the fluid dispensing apparatus, causing a portion of the product pooled at the floor of the container in the upright orientation to be expelled by the propellant through the fluid dispensing apparatus.

10. The process of dispensing the product of claim 9, wherein introducing the fluid dispensing apparatus to the container comprises pivotally adjusting the fluid dispensing

apparatus relative to the container, causing engagement between the threaded section of the container cap, and a compatible threaded portion of the fluid dispensing apparatus.

11. The process of dispensing the product of claim **9**, wherein introducing the fluid dispensing apparatus comprises compressing a gasket between a portion of the container cap and a portion of the fluid dispensing apparatus to interfere with an escape of the product between the container cap and the fluid dispensing apparatus.

12. The process of dispensing the product of claim **9**, wherein dispensing the product from the container comprises causing the product to enter an end of the extension tube adjacent to the floor, and travel through the dip tube and the fluid dispensing apparatus.

13. The fluid storage system of claim **1**, further comprising:

an elevated region that protrudes upward from the coupling element; and

wherein the membrane is disposed at an end of the protruding region.

14. The fluid storage system of claim **13**, the elevated region further comprises a sealing surface.

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