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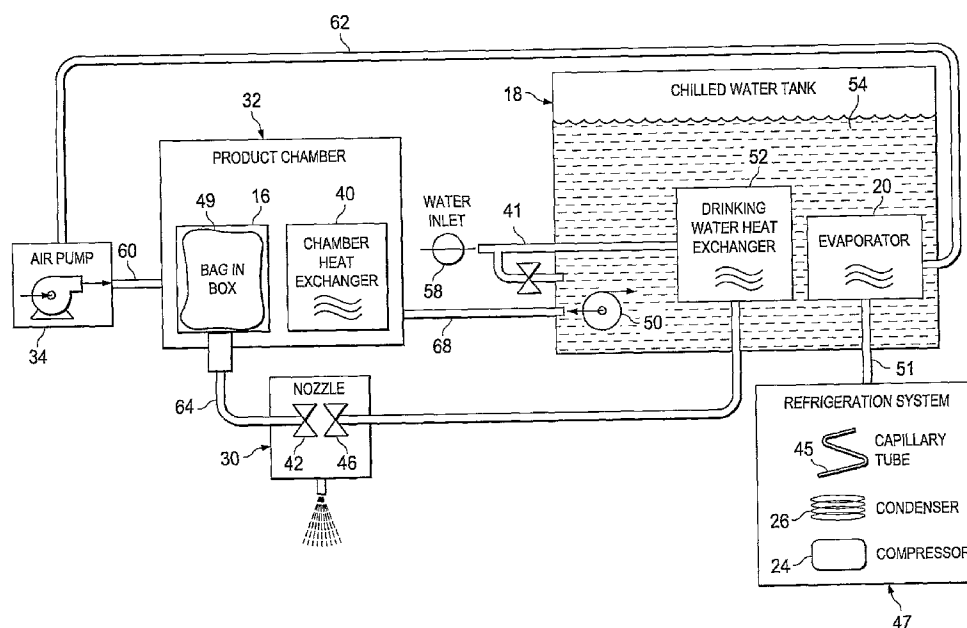
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(54) Title: **LIQUID FOOD DISPENSER SYSTEM AND METHOD**



(57) Abstract: A system and method for dispensing fluids is introduced. A preferred embodiment comprises a sealed tank, a bag containing fluid inside the sealed tank, an outlet for dispensing the liquid in the bag, and a pressure generating device to create pressure in the sealed tank.

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**HRP-002PCT****PCT International Patent Application****Liquid Food Dispenser System and Method****RELATED APPLICATION DATA**

This application receives the benefit of and claims priority to two U.S. Provisional Applications: U.S. Provisional Application No. 60/819,178, filed on July 7, 2006, entitled "Liquid Food Dispenser System and Method," and U.S. Provisional Application No. 60/912,626, filed on April 18, 2007, entitled "Liquid Food Dispenser System and Method." Both of these applications are hereby incorporated herein by reference.

**TECHNICAL FIELD**

The present invention relates generally to a system and method of dispensing fluids, and more particularly to a system and method for dispensing liquid beverages.

**BACKGROUND**

Beverage dispensing machines generally are intended to expel or deliver a beverage or beverage concentrate in a reasonably sanitary manner. Generally, beverage dispensing machines require a mechanism to pump or expel the beverage, a nozzle or interface between the beverage and the external environment, and a method or device to control the flow rate of the beverage.

Typically beverage dispensing machines expel the beverage or beverage concentrate either by using a diaphragm pump, a peristaltic pump, a direct gas pump, or by using gravity to cause the liquid to flow out of the ingredient storage container.

A diaphragm pump uses a movable diaphragm to directly push the beverage out of the storage container. A disadvantage of this type of prior art pump is that the ingredient being pumped comes in direct contact with internal parts of the diaphragm pump. Such contact increases the risk of bacterial contamination and makes the system difficult to clean and sanitize.

A peristaltic pump, on the other hand, comprises a rotating apparatus which periodically squeezes a substance through a flexible tube. One disadvantage with using a peristaltic pump is that whenever new product is loaded into the system, the operator must mate the disposable tube to the permanent peristaltic pump tube. Another disadvantage of the peristaltic pump is that the permanent tube comes in contact with the product and must be washed out regularly to maintain appropriate levels of sanitation.

Another way to expel a beverage is with a compressed gas system as is done, for example, with a beer keg. In a compressed gas system, a compressed gas is introduced into the liquid container, the pressure of which expels the liquid. A major drawback with this method, however, when applied to edible or organic products, is that the propellant gas coming in direct contact with the product makes the product more prone to spoilage or environmental contamination.

In a gravity flow system, the weight of the ingredient is used to provide the force to expel the product. One disadvantage of the gravity flow system, however, is that the flow rate of the dispensed liquid is dependent on the head pressure of the ingredients. As the ingredient empties, the head pressure decreases, which results in a reduction of flow rate. A second disadvantage of the gravity flow system is that more viscous ingredients will flow at unacceptably slow flow rates.

In order to maintain a sanitary environment to dispense beverages and other liquid food items, attention must be given to the dispensing and closure nozzle, the designs of which can vary widely, because the nozzle provides an interface between the liquid and the external environment. This is particularly an issue with low-acid products that are high in nutrients, which are particularly prone to bacterial growth.

In the bag-in-box industry, for example, it is common for a bag to have a long tube with a closed tip used for transportation and storage. When the beverage is ready for dispensing, the tube is placed through a pinch valve mechanism and the end of the tube is cut, allowing the product to be dispensed when the pinch valve is open. One disadvantage with this method is that once the tube is cut, it cannot be resealed without resorting to a mechanical means to pinch the tube shut. Another disadvantage with this method is that the end of the tube is exposed to the environment, resulting in the possibility of contamination and the potential for the ingredient to dry in the tube. Another disadvantage is that, because the tube must be physically cut, the cutting device also requires cleaning and sanitizing. In addition, the cutting device can be lost, dulled, misused and left unclean. The tube can also be incorrectly cut, whether cut at an angle, jagged, or cut too high or too low on the tube.

Another dispensing and closure nozzle technique employed in the bag-in-box industry is to use a bag cap that mates to a receiving fitting that is connected to a larger dispensing system. A disadvantage with this method is that it requires at least two external pieces. Another disadvantage with this method is that these external pieces and the associated pumping mechanism need to be cleaned regularly or replaced if good sanitation is to be maintained.

Another issue with prior art beverage dispensing machines involves automatic product changeover for beverage dispensing systems that employ a plurality of product storage containers. Generally, vacuum sensors either mechanically or electromechanically switch from an empty product container to a full product container by sensing the level of vacuum pulled on the empty product container. A disadvantage of sensing vacuum levels, however, is that an in-line device is necessary to determine if a vacuum level is low. An in-line device, such as a vacuum sensor, can come in contact with the beverage and create contamination issues.

Another issue with prior art beverage dispensing machines involves splattering during the initiation of dispensing. With some nozzle designs, there may be a problem during the opening or closing of the nozzle, especially when the opening or closing is performed slowly. As the nozzle plunger lifts into the nozzle body,

breaking the nozzle seal and allowing product to flow through the newly-created gap, the flow may disassociate and splatter as it dispenses in a non-uniform fashion. When the nozzle becomes fully open, the flow generally returns to a smooth and uniform flow.

Another issue with prior art beverage dispensing machines is that prior art machines have been unable to provide precise mixtures of various dairy products, for example, milk, cream, and water. While mixing dairy products is used in the large scale commercial production of dairy goods, an ability to mix dairy products on the fly in a dispensing machine has not been introduced in dairy dispensing machines. One of the difficulties in providing dairy mixtures is that precisely controlling the ratios of dairy products is difficult to achieve with gravity flow dairy dispensing devices, and also machines that dispense individual servings. Another difficulty involves mixing different products in a manner that is not apparent to the user.

Yet another issue with beverage dispensing systems pertains to tracking the amount of remaining product left in the machine that is available for dispensing. Beverage dispensers may employ both direct and indirect methods to determine the amount of product remaining.

Indirect methods of determining the remaining quantity of product include counting the number of cycles a pump turns to expel a product and counting the time during which the dispensing valve is open. With the pump cycle count method, if the amount of material dispensed for each pump cycle is known as well as the initial amount of ingredient prior to pumping, the remaining ingredient amount can be calculated. In the time count method, the remaining ingredient amount can be calculated if the flow rate and the initial ingredient amount are known. Indirect methods of determining remaining product quantity, however are prone to error because of inaccuracies in flow rate assumptions and inaccuracies in initial product volume.

A direct method of measuring remaining product quantity, on the other hand, weighs the ingredient container using a load cell or pressure sensor. The product container might rest on a shelf integrated with a sensor, or it might sit directly on a sensor. A disadvantage of this method is that the sensing system or portions of the sensing system sit below the ingredient container. Since food ingredient containers need to be washable, any sensor that sits below an ingredient container may be prone to issues relating to cleaning, sanitation, and difficulties caused by spilling or leaking ingredients. Another problem with the load cell approach is that the product package is usually attached to the product cavity whose volume is being measured. Since the product package is weighed along with the product inside it, measuring inaccuracies may result.

Another direct method of measuring product volume is to put measuring devices in-line with product flow. Vacuum, pressure, or conductivity can be sensed in-line to determine when the product bag is empty. A disadvantage of the in-line sensing method is that it requires measuring devices that come in physical contact with the product. This is a potential source of contamination that requires proper cleaning and sanitation.

## SUMMARY OF THE INVENTION

These and other problems are generally solved or circumvented, and technical advantages are generally achieved, by preferred embodiments of the present invention, which include a system and methods for dispensing liquid in a sanitary manner, determining the quantity of remaining liquid, and utilizing nozzles limiting exposure of the liquid to the external environment.

In accordance with a preferred embodiment of the present invention, a system for dispensing a liquid beverage comprises a pressure sealed chamber having an interior environment, a compressible container containing the liquid beverage, the compressible container disposed inside of the sealed chamber, wherein the compressible container isolates the liquid beverage from the sealed chamber interior environment, an outlet for dispensing the liquid beverage in the compressible container, a gas source providing gaseous pressure in the sealed chamber, the gaseous pressure exerting force on an exterior surface of the compressible container, a pressure sensor disposed within the sealed chamber interior environment, and an electronic controller controlling the gas source based on input from the pressure sensor.

In accordance with another preferred embodiment of the present invention, a system for dispensing a liquid beverage system comprises a gas-tight chamber having an interior environment, a compressible container containing the liquid beverage, the compressible container disposed inside of the gas-tight chamber, wherein the compressible container isolates the liquid beverage from the gas-tight chamber interior environment, a nozzle for dispensing the liquid beverage in the compressible container, wherein the nozzle seals the liquid beverage from an external environment when the nozzle is closed and minimizes a surface area of surfaces exposed to both the liquid beverage and the external environment, a gas source providing gaseous pressure in the gas-tight chamber, the gaseous pressure exerting force on an external surface of the compressible container, a pressure sensor disposed within the gas-tight chamber interior environment, a temperature sensor disposed within the gas-tight chamber interior environment, and an electronic controller controlling the gas source based on input from the pressure sensor and the temperature sensor.

In accordance with another preferred embodiment of the present invention, a nozzle for dispensing a liquid comprises a nozzle adapter having a cylindrical inner surface, a nozzle tip comprising an outer surface, an inner surface having a helical groove, and a top end rotatably coupled to the nozzle adapter cylindrical inner surface, and a plunger disposed within the nozzle tip, the plunger comprising a body having a cylindrical outer surface, a top end, a tapered lower end that mates with a bottom of the nozzle tip inner surface to form a liquid tight seal between the plunger and the nozzle tip when the nozzle is closed, and at least one projection along the body outer surface between the top end and the lower end keyed to fit within the helical groove of the nozzle tip, wherein rotational motion of the nozzle tip causes axial motion of the plunger relative to the nozzle adapter without appreciable axial motion of the nozzle tip relative to the nozzle adapter.

In accordance with another preferred embodiment of the present invention, a method for operating a nozzle, wherein the nozzle comprises a nozzle tip with a tapered cavity and a plunger with a tapered end disposed within the nozzle tip, comprises rotating the nozzle tip in a first rotational direction to move the plunger in a first axial

direction, thereby opening the nozzle and dispensing a liquid, and rotating the nozzle tip in a second rotational direction opposite the first rotational direction to move the plunger in a second axial direction opposite the first axial direction, thereby closing the nozzle and forming a liquid tight seal.

In accordance with another preferred embodiment of the present invention, a method for dispensing a liquid comprises measuring the temperature inside a chamber, the chamber containing a membrane having the liquid to be dispensed, measuring a first pressure inside the chamber introducing an amount of gas inside the chamber after measuring the first pressure, measuring a second pressure inside the chamber after introducing the amount of gas, and adjusting the pressure in the chamber to dispense the liquid at a desired flow rate after measuring the second pressure.

In accordance with another preferred embodiment of the present invention, a method for dispensing a liquid beverage comprises measuring the temperature inside a chamber containing a compressible container having a liquid to be dispensed, measuring a first pressure inside the chamber, introducing an amount of air inside the chamber by running an air pump for a predetermined period of time after the measuring the first pressure, measuring a second pressure inside the chamber after the introducing the amount of air, adjusting the pressure inside the chamber to dispense the liquid beverage at a desired flow rate after the measuring the second pressure, opening a nozzle, dispensing a liquid beverage out of the nozzle, closing the nozzle, and repeating the adjusting the pressure inside the chamber to dispense the liquid at a desired flow rate.

In accordance with another preferred embodiment of the present invention, a method for determining a volume of a liquid in a container comprises measuring a temperature inside a sealed chamber containing the container of the liquid, measuring a first pressure inside the chamber, introducing an amount of gas into the chamber after the measuring the first pressure, measuring a second pressure inside the chamber after the introducing the amount of gas, and, after the measuring the second pressure, determining the volume according to the equation  $VP = VC - (n \cdot R \cdot T) / (P2 - P1)$ , where  $n$  is the amount of gas introduced into the chamber between the first measuring and the second measuring,  $R$  is a gas constant,  $T$  is the measured temperature of the chamber,  $P1$  is the first measured pressure,  $P2$  is the second measured pressure, and  $VC$  is a volume of the chamber.

In accordance with another preferred embodiment of the present invention, a system for dispensing a liquid beverage comprises a source of a liquid beverage, the source being under pressure, a nozzle coupled to the source, wherein the pressure causes the liquid beverage to flow from the source to the nozzle when the nozzle is in an open position, and a hat valve attached to the nozzle, wherein the hat valve prevents flow of the liquid beverage from the nozzle to the source.

In accordance with another preferred embodiment of the present invention, a method for dispensing a liquid beverage comprises pressurizing a source of a liquid beverage, the source of the liquid beverage coupled to a nozzle comprising a hat valve separating the source of the liquid beverage from an interior of the nozzle, opening the nozzle, wherein the opening comprises opening the hat valve, wherein the liquid beverage flows past the hat valve through the nozzle, and closing the nozzle, wherein the closing comprises closing the hat valve.

In accordance with another preferred embodiment of the present invention, a pressurized beverage dispensing system comprises a pressurized gas source, and a source of a liquid beverage contained within a bag-in-box container, the bag-in-box container comprising a flexible fluid container disposed within a box, wherein the box comprises outer walls and a vent hole disposed in an outer wall, and wherein pressurized gas from the pressurized gas source exerts pressure on the source of the liquid beverage.

In accordance with another preferred embodiment of the present invention, a bag-in-box container for storing and dispensing a liquid beverage comprises a box disposed within a pressure-sealed chamber, the box comprising an opening through which pressurized gas can pass, a flexible fluid container disposed within the box, wherein gas pressure exerted on the surface of the flexible fluid container is transferred to contents of the flexible fluid container via flexible walls of the flexible fluid container.

In accordance with another preferred embodiment of the present invention, a method for operating a beverage dispenser comprises installing a bag-in-box container in a pressure-sealed chamber in the beverage dispenser, the bag-in-box container comprising a liner disposed within a box, wherein a liquid beverage is contained within the liner, pressurizing the chamber, and dispensing the liquid beverage.

In accordance with another preferred embodiment of the present invention, a nozzle for dispensing a liquid comprises a nozzle adapter having a barbed fitting for attaching to a tube, a nozzle tip comprising an outer surface, an inner surface having a helical groove, and a top end rotatably coupled to the nozzle adapter, and a plunger disposed within the nozzle tip, the plunger comprising a body having a cylindrical outer surface, a top end, a tapered lower end that mates with a bottom end of the nozzle to form a liquid tight seal between the plunger and the nozzle tip when the nozzle is closed, and at least one projection along the body outer surface between the top end and the bottom end keyed to fit within the helical groove of the inner surface of the nozzle tip, wherein rotational motion of the nozzle tip causes axial motion of the plunger relative to the nozzle adapter without appreciable axial motion of the nozzle tip relative to the barbed fitting.

In accordance with another preferred embodiment of the present invention, a system for dispensing a liquid comprises a product chamber, a first product container comprising a liquid disposed within the product chamber, wherein the first product container comprises a path for a gas pressure to be exerted on the liquid, and wherein a height of the first product container is less than a width and a length of the product chamber, a gas pressure source coupled to the product chamber, wherein the gas pressure source exerts the gas pressure on the liquid to be dispensed, and an outlet disposed on the first product container through which the liquid is dispensed.

In accordance with another preferred embodiment of the present invention, a method for dispensing a liquid beverage comprises applying a gas pressure to an inside of a chamber, wherein the gas pressure is transferred to a liquid beverage contained within a container disposed in the chamber, and dispensing the liquid beverage from the container, wherein the container comprises a height less than each of a width and a length of the chamber.

In accordance with another preferred embodiment of the present invention, a system for dispensing a liquid beverage comprises a storage container comprising a liquid beverage, the storage container disposed within a pressure-sealed chamber, a tube, wherein a first end of the tube is coupled to the storage container, whereby the

liquid beverage can pass from the storage container through the tube, a tube chute, wherein the tube is disposed within the tube chute; and a nozzle coupled to a second end of the tube opposite the first end of the tube.

In accordance with another preferred embodiment of the present invention, a system for dispensing a liquid beverage comprises a first liquid storage container disposed within a first chamber, the first liquid storage container comprising an outlet for dispensing the liquid beverage, a second liquid storage container disposed within a second chamber, the second storage container comprising an outlet for dispensing the liquid beverage, a first check valve coupled to the first liquid storage container outlet, wherein the first check valve is oriented so that the liquid beverage is prevented from flowing back toward the first liquid storage container, a second check valve coupled to the second liquid storage container outlet, wherein the second check valve is oriented so that the liquid beverage is prevented from flowing back toward the second liquid storage container, and a tee fitting comprising a first input port coupled to the first check valve, a second input port coupled to the second check valve, and an exit port.

In accordance with another preferred embodiment of the present invention, a method for dispensing a liquid beverage comprises dispensing a liquid stored in a first container within a first chamber at a first flow rate until the first container is substantially empty, after the first container is almost empty, dispensing a liquid stored in a second container within a second chamber at a second flow rate while dispensing the remaining liquid in the first container at a third flow rate until the first container is empty, wherein the liquid flow from the first container is combined with a liquid flow from the second container to form a combined flow, the combined flow comprising a fourth flow rate, and after the first container is empty, dispensing the liquid from the second container within the second chamber at a fifth flow rate.

In accordance with another preferred embodiment of the present invention, a tube set for a beverage dispensing machine comprises a fluid tee connector comprising a first port, a second port and a third port, a first tube attached to the first port of the fluid tee connector, a second tube attached to the second port of the fluid tee connector, and a third tube attached to the third port of the fluid tee connector.

In accordance with another preferred embodiment of the present invention, a nozzle for dispensing a liquid comprises a nozzle tip comprising an outer surface and an inner surface, and a plunger disposed axially within the nozzle tip, wherein liquid is prevented from flowing through the nozzle when the plunger is in a closed position, and wherein liquid flows through the nozzle when the plunger is in an open position, and the plunger has a tip comprising a shape that redirects transaxial fluid flow to axial fluid flow.

In accordance with another preferred embodiment of the present invention, a liquid storage system comprises a chamber, a pressurized gas source coupled to the chamber, a liquid storage container disposed inside the chamber, wherein the liquid storage container comprises an orifice, and wherein the pressurized gas source imparts a pressure on liquid stored within the liquid storage container, and a dispensing nozzle coupled to the orifice, the dispensing nozzle dimensioned to couple with a check valve disposed on a serving container.

In accordance with another preferred embodiment of the present invention, a method for dispensing a beverage comprises placing a serving container on a nozzle disposed on a counter-top, wherein a check valve disposed on a bottom of the serving container mates with the nozzle, and filling the serving container with a liquid



beverage, wherein the liquid beverage flows from a pressurized container through the nozzle and into the serving container. -

In accordance with another preferred embodiment of the present invention, a method for dispensing a beverage comprises dispensing relative proportions of water, cream, and concentrated skim milk for making a first dispensed beverage, wherein the dispensing comprises dispensing a first amount of water, dispensing a second amount of cream, and dispensing a third amount of concentrated skim milk, and combining the water, the cream, and the concentrated skim milk of the first dispensed beverage.

In accordance with another preferred embodiment of the present invention, a system for dispensing a liquid comprises a first liquid source, the first liquid source being under a first pressure, a second liquid source, the second liquid source being under a second pressure, and a combiner comprising a first input port coupled to the first liquid source with a first connection, a second input port coupled to the second liquid source with a second connection, and an output port, wherein liquids entering the first input port combine with liquids entering the second input port to form a combined liquid, and wherein the combined liquid exits the output port, wherein flow rates of the first and second liquid sources can be adjusted by adjusting the first and second pressures, and wherein the ratio of the relative concentration of the first and second liquids at the output port is related to the ratio of the first and second flow rates.

In accordance with another preferred embodiment of the present invention, a nozzle for dispensing a plurality of liquids comprises a nozzle adapter, the nozzle adapter comprising an outer input port and an inner input port, an upper nozzle tip rotatably coupled to the nozzle adapter, the upper nozzle tip comprising an inner surface and an outer surface, a lower nozzle tip rotatably coupled to the upper nozzle tip, the lower nozzle tip comprising an inner surface and an outer surface, an outer plunger disposed within the upper lower nozzle tip, the outer plunger comprising an inner surface and an outer surface, and an inner plunger disposed within the outer plunger, the inner plunger comprising an inner surface and an outer surface.

In accordance with another preferred embodiment of the present invention, a system for a nozzle comprises a plurality of outer components, wherein each outer component is capable of independent rotational motion, a plurality of plungers, wherein an axial position of one of the plurality of plungers is controlled by a rotational position of one of the plurality of outer components, and a plurality of fluid paths, wherein a flow of one of the fluid paths is dependent on the axial position of one of the plurality of plungers.

An advantage of a preferred embodiment of the present invention is that generally there is no external contact with the liquid food product except for at the nozzle tip. Such a lack of external contact provides a sanitary environment and decreases the risk of bacterial contamination of the liquid food product. The liquid food product is further protected from bacterial contamination because the propellant gas acts against the walls of the bag containing the liquid food product and does not come in contact with the liquid food product to be dispensed.

Further advantages of a preferred embodiment of the present invention are related to the dispensed beverage pour quality. The dispensed product's flow rate generally remains constant regardless of the product level and regardless of the beverage or liquid food product's viscosity. The pour is smooth, and there is no pulsation

resulting from the pumping system as there would be with a peristaltic or diaphragm pumping system. Furthermore, the flow rate can be varied to specific values.

Yet another advantage of a preferred embodiment of the present invention is that the volume of the remaining product can be simply and accurately determined without any additional scales or sensors, and without requiring any additional cleaning steps as would be required by systems in which the dispensed product comes in physical contact with the measuring device.

The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures or processes for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims.

**BRIEF DESCRIPTION OF THE DRAWINGS**

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

Figures 1a-1d illustrate one embodiment of a beverage dispensing system;

Figure 2 is a block diagram of the fluid and gas components of a beverage dispensing system;

Figures 3a-3d illustrate an embodiment of a bag-in-box beverage container;

Figure 4 is a block diagram showing the sensor and control interfaces of a system microcontroller;

Figures 5a and 5b are flowcharts describing the operation of a beverage dispensing system;

Figures 6a and 6b are flowcharts describing a product volume measurement procedure;

Figure 7 is an explanatory illustration for a product volume measurement procedure;

Figure 8 is a flowchart describing a target pressure calculation procedure;

Figure 9 is a cross-sectional illustration showing a nozzle situated within a beverage dispensing system;

Figure 10 illustrates an exploded view of a nozzle assembly;

Figures 11a and 11b illustrate a nozzle assembly;

Figures 12a-12f illustrate a nozzle plunger;

Figures 13a-13f illustrate a nozzle tip;

Figures 14a-14e illustrate a nozzle adapter;

Figure 15 illustrates a nozzle drive mechanism;

Figure 16 illustrates an isometric view of a nozzle drive mechanism;

Figure 17 illustrates an alternate embodiment of a nozzle system;

Figure 18 illustrates another alternate embodiment of a nozzle system;

Figures 19a-19c illustrate another alternate embodiment of a nozzle system;

Figures 20a-20c illustrate another alternate embodiment of a nozzle system;

Figure 21 illustrates another alternate embodiment of a nozzle system;

Figure 22 illustrates another alternate embodiment of a nozzle system;

Figure 23 illustrates an embodiment of a slim-package dispensing system;

Figures 24a-24h illustrate embodiments of a remote nozzle dispensing system;

Figures 25a and 25b illustrate an embodiment of a remote container beverage dispensing system;

Figures 26a-26d illustrate an embodiment system and method of an automatic changeover system for beverage dispensing;

Figures 27a and 27b illustrate tube set embodiments;

Figures 28a-28d illustrate an embodiment of a liquid tee;

Figure 29 illustrates an embodiment of a liquid tee;

Figures 30a-30e illustrate embodiment systems for dispensing and mixing beverages;

Figures 31a-31c illustrate an embodiment of a dynamic mixing nozzle;

Figures 32a-36e illustrate embodiment components of a dynamic mixing nozzle;

Figure 37 illustrates an embodiment tube set for dispensing and mixing beverages;

Figures 38a and 38b illustrate alternate embodiment systems for dispensing and mixing liquid beverages;

Figure 39a and 39b illustrate an embodiment system for an aseptic nozzle;

Figure 40 illustrates an embodiment nozzle system; and

Figures 41a-41d illustrate embodiment systems for anti-splatter nozzle tips.

## DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The making and using of the presently preferred embodiments are discussed in detail below. It should be appreciated, however, that the present invention provides many applicable inventive concepts that can be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative of specific ways to make and use the invention, and do not limit the scope of the invention.

The present invention will be described with respect to preferred embodiments in a specific context, namely a beverage dispensing machine. The invention may also be applied, however, to other dispensing systems, or other systems with sanitary or fluid measurement requirements.

In illustration of one embodiment of the present invention, Figure 1a shows a three-dimensional view of a beverage dispensing machine 10. The liquid product is stored in a bag (not shown) disposed within boxes 16a and 16b. The liquid product could be milk, juice, beverage concentrate, or other liquids. The liquid product is usually sold by the box, and the beverage dispensing machine operator will replace the bag-in-box with a new one when the liquid product has been depleted. Boxes 16a and 16b are placed within a respective product chamber 32a or 32b. Most commercially available bag-in-box products are shipped in cardboard boxes inside of which the product is contained in a bag liner usually made of a flexible plastic material which is capable of being heat sealed together. In a preferred embodiment, the liner is made up of four panels. The first and second panels are made of linear low density polyethylene and the third and fourth panels are made of metallized polyester laminated to polyethylene, however, other materials, including polyolefin, polypropylene, polyvinyl chloride, polyester, nylon, and the like, including co-extruded and laminated materials, which exhibit similar characteristics, may be used. The product is dispensed through a respective product outlet 30a or 30b, usually comprising a spout or a flexible plastic tube.

Turning to Figure 1b, the product chambers 32a and 32b (Figure 1) are pressurized by pump 34, and the product is dispensed through outlets 30a and 30b. Product chambers 32a and 32b are defined by inner walls 13 made of stainless steel in the present embodiment, but, in other embodiments, they can be made of high density polyethylene. Between outer wall 11 and inner wall 13 is a layer of foam insulation 15. In preferred embodiments of the present invention, foam sheets or injected foam may be used. In a preferred embodiment of the present invention, polyurethane foam is used, although other types of foam such as phenolformaldehyde may be used in other embodiments. Alternatively, non-foam forms of insulation such as evacuated air packets may be used also. Foam insulation 15 serves a number of purposes. First, foam insulation 15 acts as thermal insulation to keep the product warm or cold. Second, foam insulation 15 provides mechanical support to inner walls 13 which, in some embodiments, may be flexible and wobbly without the support. Without support, inner walls 13 may be prone to "tin canning" when pressurized. Because the product volume determination, discussed herein below, uses the inner volume of the chamber as a constant in the calculation, making inner walls 13 more rigid using foam insulation 15 will provide a more accurate estimate of the product volume.

Outer wall 11, in a preferred embodiment, is made from stainless steel, but any other appropriate material such as powder-coated steel or high density polyethylene may be used.

Referencing Figures 1b, 1c and 1d, the product is kept cold in part by a refrigeration system consisting in part of a compressor 24, a condenser 26, a chilled water tank 18 (not shown), and an evaporator 20. The refrigeration system operates in a manner consistent with other refrigeration systems used in the beverage dispensing industry.

The operation of a gas, fluid and refrigeration system is shown in Figure 2. A liquid product is stored in bag 49 contained within box 16, which is contained within a pressurized product chamber 32. This combination of bag 49 and box 16 is commonly referred to within the beverage dispensing industry as bag-in-box. Box 16 provides structure for handling and shipping, and bag 49 provides a fluid liner in which to store the liquid product. Pressurized systems usually exert pressure on a fluid directly without a liner or on a membrane separating the pressurized air from the liquid. Other methods, for example, those used in the medical industry, include hanging a bag from a bracket and then applying pressure to the bag.

In a preferred embodiment of the invention, Figures 3a-3d illustrate a system and method for a packaging integration with a pressurized dispenser for the beverage dispensing industry. An integrated bag 49 in box 16 package is manufactured such that it can be punctured or torn open and used in a pressured chamber. A spout nozzle 552 is located within a box opening 554 to allow for easy attachment to a beverage dispensing system. When box 16 is sold and transported, spout nozzle 552 resides behind a perforated tear-out 550 (Figure 3c). When the bag-in-box is ready to be attached to a beverage dispensing machine, perforated tear-out 550 is removed from the box, and spout 552 is placed within tear-out section 556 (Figure 3b). Opening 554 (Figure 3d) and the structure of box 16 allow pressure to accurately impact the fluid liner container or bag 49 inside box 16. In alternative embodiments, pressure can be provided to bag 49 through vent holes, or other means of providing pressure to bag 49. These embodiments may be used with any compatible embodiment or combination of embodiments disclosed herein, such as the embodiments disclosed in Figures 1-2, 23-27, 30 and 37, for example.

Turning back to Figure 2, air pump 34 provides air pressure to bag 49 via chamber port 60 and through vent holes or tear-outs (not shown) in box 16. Air pressure squeezes bag 49 and pushes the liquid product through tube 64 to nozzle 30, a nozzle within nozzle valve actuator assembly 42. Chilled water emanating from water inlet 58 travels through water inlet pipe 41, drinking water heat exchanger 52, chilled drinking water pipe 66 and finally through drinking water valve 46. The water can either be mixed with the liquid product if valve 46 is open while the liquid product is being dispensed, or the drinking water can be used to clean or wash nozzle 30.

In a preferred embodiment of the present invention, refrigeration system 47 consists of a compressor 24, a condenser 26, and a capillary tube 45. Refrigerant travels through re-circulating refrigerant line 51 and through evaporator 20 within chilled water tank 18. Cold air chilled by evaporator 20 is sent from evaporator 20 to air pump 34 through a chilled air duct 62. The cold air prevents heat from entering product chamber 32 and thus ensures that the liquid product stays chilled during operation of air pump 34.

Chilled water tank 18 stores cold water 54 chilled by evaporator 20. Water pump 50 pumps cold water 54 from chilled water tank 18 to chamber heat exchanger 40 via re-circulating cooling water pipe 68 in order to keep product chamber 32 cool. Cold water 54 is also used to chill drinking water via drinking water heat exchanger 52. Alternatively, other methods of cooling product chamber 32 may be used, such as blowing air across a heat

exchanger that has chilled water running through it. The resulting cold air may then be vented through product chamber 32 for cooling. Other methods of chilling the water may be used, such as implementing a direct heat exchanger by running a water line through an evaporator for direct cooling of the drinking water supply. In some embodiments, on the other hand, the water may be warmed through a water heater instead of chilled and used to deliver hot water to the liquid product to supply a hot product.

A preferred embodiment of the present invention uses a microcontroller 92 to process sensor input and to control the operation of the beverage dispensing machine as shown in Figure 4. Product chamber 32 contains a temperature sensor 74 and a pressure sensor 76 that provide sensor data to microcontroller 92. The data collected from temperature sensor 74 and pressure sensor 76 are used to provide feedback to maintain a constant flow rate and to monitor the system's performance.

Chilled water tank 18 contains a water tank level sensor 80, an ice bath temperature sensor 82, and an ice bank sensor 84. Ice bank sensor 84 measures the size of the ice buildup by measuring the change in conductivity in the region surrounding an ice bank sensing probe. The data from these sensors 80, 82 and 84 are used by the microcontroller 92 to maintain the proper temperature and water level within chilled water tank 18. Also within chilled water tank 18 is a submersible water pump 50 that pumps chilled water to product chamber 32 for cooling. Submersible water pump 50 is activated by microcontroller 92 in order to keep the temperature of product chamber 32 within a defined temperature range, typically between 32°F and 40°F.

Microcontroller 92 is also used to control valves in the beverage dispensing system. Drinking water valve 46 is activated by microcontroller 92 whenever drinking water is dispensed either for dispensing as a beverage or for washing the nozzle, such as nozzle 30 of Figure 2. Water tank valve 56 is activated by microcontroller 92 whenever the water level of chilled water tank 18 falls below a certain threshold as determined by water tank level sensor 80. Nozzle valve actuator assembly 42, on the other hand, has a bidirectional interface. Microcontroller 92 sends a signal which activates nozzle valve actuator assembly 42, and nozzle valve actuator assembly 42 sends valve position feedback to microcontroller 92. In one embodiment, nozzle valve actuator assembly 42 contains a valve drive motor and an optical position sensor that sends a signal back to microcontroller 92 indicating whether the valve is open. Normal operation of nozzle valve actuator assembly 42 would comprise microcontroller 92 activating the valve motor, waiting for the sensor to indicate that the valve is open, and then microcontroller 92 shutting off the valve. Alternatively, different valve control schemes could be used. In some embodiments, the position feedback of nozzle valve actuator assembly 42 can be used to allow the valve to be opened to a range of positions to help achieve varying desired flow rates. In other embodiments, valves that do not require feedback could be used, or valves that use non-optical position sensors, such as limit switches, could be used.

In a preferred embodiment of the present invention, microcontroller 92 also receives input from a product dispense switch 77 and a door detect switch 79. When product dispense switch 77 is pressed, microcontroller 92 starts a beverage dispensing sequence as discussed below. Door detect switch 79 signals microcontroller 92 that one of the doors or access panels on the beverage dispensing machine is open. This signal could be used to prevent the machine from dispensing product, or to articulate a warning signal.

Microcontroller 92 also can be configured to provide a user display such as an LCD display 94, one or more LEDs 96, or other user displays such as incandescent and fluorescent lights, electro-mechanical displays, CRTs, or other user displays. In other embodiments, the beverage dispensing machine may not have any user displays at all.

In a preferred embodiment of the present invention, microcontroller 92 is used to control the beverage dispenser. In other embodiments, however, a microprocessor, a computer, application specific integrated circuits, or any other device capable of controlling the system may be used.

Figure 5a shows a control diagram for a preferred embodiment of the present invention. When power to the beverage dispenser is first applied, the program enters step 100, which is the start state. A microcontroller, such as microcontroller 92 of Figure 4, then polls a product dispense switch, such as product dispense switch 77 of Figure 4, in step 101 to determine if the product dispense switch is closed. If the microcontroller detects that the product dispense switch is closed, the product dispense sequence begins. First, a volume measurement is performed in step 102 as shown in Figure 6a and as discussed below. Second, a target pressure calculation is performed in step 104 as shown in Figure 8 and as discussed below. Next, in step 108, an air pump, such as air pump 34 of Figure 4, is turned on in order to pressurize a product chamber, such as product chamber 32 of Figure 4, the drinking water valve, such as drinking water valve 46 of Figure 4, is opened to provide water to mix with the dispensed liquid product, and a nozzle drive is run in a forward direction to open a nozzle valve actuator assembly, such as nozzle valve actuator assembly 42 of Figure 4. In some embodiments, the drinking water valve may not be opened if an undiluted beverage is dispensed.

The microcontroller then determines whether the product dispense switch is still pressed in step 109. If the product dispense switch is pressed (yes to step 109), the microcontroller checks to see if the nozzle valve actuator assembly is open (step 110) via the bidirectional nozzle interface.

In a preferred embodiment, an optical sensor determines whether the nozzle valve actuator assembly is open in step 110. If the nozzle valve actuator assembly is not yet open (no to step 110), the microcontroller stays at step 110 until the nozzle valve actuator assembly is open. Once the nozzle valve actuator assembly is determined to be open (yes to step 110), the nozzle drive is shut off in step 112.

In step 114, after the nozzle has been opened, the microcontroller monitors the chamber pressure via a chamber pressure sensor, such as chamber pressure sensor 76 of Figure 4. If the target pressure has been reached (yes to step 114), the air pump is shut off in step 116. If the target pressure has not been reached (no to step 114), however, the air pump remains on (step 118). After steps 116 and 118, the control routine goes back to step 109 and the microcontroller cycles through steps 109, 110, 112, 114 and 116 or 118 until the product dispense switch is opened (no to step 109).

Returning to step 109, if the product dispense switch is opened (no to step 109), the control routine will enter step 120 and begin to shut off the nozzle drive and turn off the air pump. That is, the air pump 34 (Figure 4) is shut off and the nozzle drive is turned on in the reverse direction. In step 122, the control routine monitors the nozzle valve actuator assembly via the bidirectional nozzle interface. If the nozzle valve actuator assembly is open (no to



step 122), the control routine continues to monitor the nozzle valve actuator assembly at step 112. If the nozzle valve actuator assembly is closed, i.e., when the optical sensor indicates that the nozzle is closed, the control routine proceeds to step 124. In step 124, the nozzle drive is shut off. In step 126, the microcontroller delays the execution of the control routine for a predetermined period of time. In a preferred embodiment of the present invention, this delay is approximately 0.20 seconds. In other embodiments, this delay may be longer, shorter, or substantially 0 seconds. Step 128 is then entered and the drinking water valve is closed. The delay (step 126) between the time that the nozzle drive is shut off (step 124) and the drinking water valve is closed (step 126) allows the nozzle to be rinsed with water after each time the liquid product is dispensed. Once the drinking water valve is closed, the control routine returns to step 101 and waits for the product dispense switch to be closed again.

Alternatively, Figure 5b shows a control flowchart 180 of another preferred embodiment of the present invention.

Figure 6a shows a flowchart describing a product volume measurement routine 141 for a preferred embodiment of the present invention. In step 140, chamber pressure and temperature measurements,  $P_1$  and  $T_1$  respectively, are made via a chamber temperature sensor, such as chamber temperature sensor 74 of Figure 4, and a chamber pressure sensor, such as chamber pressure sensor 76 of Figure 4. Next, in step 142, a known quantity of gas mass,  $n_\Delta$ , is introduced into the chamber. In a preferred embodiment, an air pump, such as air pump 34 of Figure 4, is run for a predetermined period of time. Another set of chamber pressure and temperature measurements,  $P_2$  and  $T_2$ , are taken in step 144. The product volume is then calculated according to the equation  $V_p = V_C - (n_\Delta RT_1) / (P_2 - P_1)$ , in step 146, where  $V_C$  is the volume of the chamber and  $R$  is the gas constant.

Figure 7 provides a descriptive illustration 150 of the product chamber and the variables related to the product volume calculation discussed previously. Product chamber 152 is depicted as a box with volume  $V_C$ . Bag-in-box 154 contains the product volume denoted as  $V_p$ . Variables  $P_i$ ,  $V_i$ ,  $n_i$ , and  $T_i$ , refer to the chamber pressure, the chamber volume, the quantity of gas, and the chamber temperature, respectively, at time  $i$ . Inlet 158 represents the gas inlet port of chamber 152 that receives pressurized gas from valve 156.

In order for an accurate measurement of the product volume to be made, generally the quantity of gas or air added to the chamber,  $n_\Delta$ , should be known within a reasonable certainty. This quantity of air, however, is dependent on pump speed and the physical properties of the pump used. One way to determine the quantity of air added per unit time would be to calibrate the system at the time of manufacture, or to simply use the pump manufacturer's data in the product volume calculation. Unfortunately, as air pumps get older, the diaphragm inside wears out, and any initial estimates or measurements of the pump's performance become less accurate over time. A calibration of the pump volume for a given period of operation can be made by taking a pressure measurement  $P_1$ , running the pump for a predetermined period of time, then taking a second pressure measurement  $P_2$ . The nozzle should remain closed during this operation. The quantity of gas added to the chamber,  $n_\Delta$ , can then be determined by the equation,  $n_\Delta = (P_2 - P_1) * V_C / (RT)$ , where  $V_C$  is the volume of the chamber,  $R$  is the gas constant, and  $T$  is the measured chamber temperature.

Alternatively, Figure 6b shows a flowchart 182 describing the product measurement routine of another preferred embodiment of the present invention.

The flowchart in Figure 8 describes a method 161 used to calculate the target pressure in a preferred embodiment of the present invention. In step 160, the product volume,  $V_p$ , is calculated as shown in Figure 6a. Next, in step 162, the head height of the product,  $H_p$ , is calculated according to the equation  $H_p = V_p / (W_C * D_C)$  where  $W_C$  is the width of the product chamber and  $D_C$  is the depth of the product chamber. In step 164, the head pressure,  $P_p$ , due to the product head height is calculated according to the equation  $P_p = H_p * \rho_p * g$ , where  $\rho_p$  is the density of the product and  $g$  is the gravitational constant. Once the head pressure,  $P_p$ , is calculated, the product compartment pressure,  $P_{TC}$ , desired to achieve the total head pressure corresponding to the desired flow rate is calculated in step 168 according to the equation  $P_{TC} = P_{TH} - P_p$ , where  $P_{TH}$  is an experimentally derived parameter. The magnitude of  $P_{TH}$  can be up to about 10 psi or higher, but is preferably in the range of about 0.5 psi to about 3.0 psi. Alternatively,  $P_{TH}$  can be determined in optional step 166 according to the equation  $P_{TH} = H_{PT} * \rho_p * g$  where  $H_{PT}$  is a target head pressure.

The equation for the desired product compartment pressure,  $P_{TC}$ , written in terms of product volume,  $V_p$ , is  $P_{TC} = P_{TH} - (\rho_p * g * V_p) / (W_C * D_C)$ . This equation shows that the larger the value of the  $W_C * D_C$  product in the denominator, the less sensitive the desired product compartment pressure,  $P_{TC}$ , is to the product volume,  $V_p$ . For very wide and/or deep product chambers, the applied compartment pressure can be chosen to be a constant and the product volume calculation need not be calculated in order to maintain a near constant flow rate. Therefore, alternate embodiments of the present invention may be constructed with low, slim packages that allow the desired product compartment pressure,  $P_{TC}$ , to be a constant value. The magnitude of  $P_{TC}$  can be up to about 10 psi or higher, but is preferably in the range of about 0.2 psi to about 2.8 psi.

Figure 9 shows a cross-sectional view of a nozzle assembly 200 situated within a beverage dispensing system. A bag-in-box (not shown) is connected to nozzle assembly 200 by mating a product spout 214 to a nozzle adapter 212. A nozzle tip 216 extends from one end of nozzle adapter 212, inside of which is situated a plunger 210. If nozzle tip 216 is rotated, plunger 210 will move vertically, propelled by a helical nozzle tip rotation track 242, formed in nozzle tip 216, pushing against a nozzle plunger rotation pin 240. Rotational motion of plunger 210 is prevented by the mating of vertical ridges 244 on the body of plunger 210 with vertical guides or tracks 202 inset within the inner diameter of nozzle adapter 212. In a preferred embodiment of the present invention, plunger 210, nozzle adapter 212, and nozzle tip 216 are made of high density polyethylene. Alternatively, in other embodiments, these components can be made from low density polyethylene, polyethylene terephthalate, and polypropylene.

When the tip 248 of plunger 210 is in its lowest vertical position resting against the bottom 256 of nozzle tip 216, a seal is formed at the bottom of nozzle tip 216 and no liquid product may flow out of the nozzle. When nozzle tip 216 is rotated and plunger 210 is lifted, the liquid product flows from the bag-in-box, through nozzle adapter 212, around the body of plunger 210, and out the bottom of nozzle tip 216.

Figures 10-14 are drawings of nozzle assembly components. Figure 10 shows an exploded view of a nozzle assembly and Figures 11a and 11b show isometric cross-sectional views of the nozzle assembly and illustrate how

the components fit together. In particular, plunger 210 has slide stop tabs 246 that fit within grooves 202 (Figure 14c) in the inner circumference of nozzle adapter 212. The tab and groove system allows vertical motion of plunger 210 while preventing rotational motion. Also shown in Figure 11a is a nozzle tip ridge 258. Nozzle tip ridge 258 provides a surface through which to transfer rotational motion from nozzle drive 228 (Figure 9) to nozzle tip 216. Rotation of nozzle tip 216 is limited to 90 degrees by the interplay of tab 260 on the outer circumference of nozzle tip 216 as shown in Figure 13a, channel 277 in the inner circumference of nozzle adapter 212 as shown in Figure 14c, and projection 278 within channel 277 as shown in Figure 14c. When the upper end of nozzle tip 216 is inserted into the inner diameter of nozzle adapter 212, tab 260 rests within channel 277 where nozzle tip 216 is free to rotate radially but axial motion is prevented. Projection 278, however, limits the radial motion of nozzle tip 216 to 90 degrees by stopping the radial motion of tab 260. Figures 12a-12f show isometric and cross-sectional views of plunger 210; Figures 13a-13f show isometric and cross-sectional views of nozzle tip 216; and Figures 14a-14e show isometric and cross-sectional views of nozzle adapter 212.

Referring back to Figure 9, in a preferred embodiment of the present invention, rotational motion of nozzle tip 216 is provided by rotating an actuator gear 222 with a worm gear (not shown) attached to a drive shaft 224. Actuator gear 222 is connected to nozzle drive 228 inside of which rests nozzle tip 216. O-rings 230 and 232 provide a seal between nozzle tip 216 and nozzle adapter 212 and prevent the liquid product from flowing down the sides of nozzle tip 216. O-ring 234 provides a liquid-tight seal for a product seal, and o-ring 236 provides an air seal. In a preferred embodiment of the present invention, o-rings 230, 232, 234, and 236 are made of ethylene propylene, or alternatively in other embodiments they can be made of buna-nitrile. In other embodiments, however, these o-rings can be eliminated and an interference fit may be used to prevent the product from leaking out from the bag liner. As with o-rings, the interference fit may provide a product and air seal while still allowing proper nozzle rotation. This may eliminate the additional cost of the o-rings and the associated assembly steps.

Within nozzle system 200 of a preferred embodiment of the present invention, a water inlet path 218 is provided to allow for the mixing of water with the liquid product. Water enters the system through a water line fitting 226, flowing through nozzle support section 220, through water inlet path 218, and around the outside of nozzle tip 216. Water can be used to mix and dilute a beverage, to dispense water, or simply to wash nozzle system 200. In a preferred embodiment of the present invention, water line fitting 226 is made of acetal, or alternatively in other embodiments it can be made of polypropylene. In a preferred embodiment of the present invention, nozzle support section 220 is made of acetal (Delrin), or alternatively in other embodiments it can be made of high density polyethylene.

The nozzle drive mechanism is shown in Figure 15. In a preferred embodiment of the present invention, nozzle (not shown) is opened and closed by rotating nozzle tip 216 (Figure 9). An actuator gear 222 is attached to nozzle drive 228 (Figure 9) in which nozzle tip 216 (Figure 9) is situated. Worm drive 300 mounted on worm drive shaft 224 drives actuator gear 222. Worm drive shaft 224 and the nozzle assembly are mounted in nozzle adapter cradle 241. In a preferred embodiment of the present invention, actuator gear 222 is made of bronze, or alternatively in other embodiments it can be made of nylon (Nylatron). In a preferred embodiment of the present invention, worm drive 300 is made of carbon steel, or alternatively in other embodiments it can be made of nylon. In a preferred embodiment of the present invention, worm drive shaft 224 is made of stainless steel, or alternatively in

other embodiments it can be made of aluminum. In a preferred embodiment of the present invention, nozzle adapter cradle 241 is made of acetal, or alternatively in other embodiments it can be made of high density polyethylene.

Position feedback is provided back to microcontroller 92 (Figure 4) through the interplay between interrupter plate 310 and photo interrupter detector 302. Interrupter plate 310 is attached to actuator gear 222 so that each end of interrupter plate 310 passes by photo interrupter detector 302 when the nozzle is completely open and completely closed. Photo interrupter detector 302 signals microcontroller 92 (Figure 4), or provides enough data to microcontroller 92 (Figure 4) so that microcontroller 92 (Figure 4) can determine if the nozzle is completely open, completely closed, or in some intermediate state. Connections (not shown) between photo interrupter detector 302 and microcontroller 92 (Figure 4) are made to electrical contacts 304 on photo interrupter detector 302. Figure 16 shows a three-dimensional semi-transparent view of worm drive 300 and actuator gear 222. Figure 18 shows a three-dimensional view of worm drive 300, actuator gear 222, and drive motor 360.

An alternate embodiment of the nozzle assembly and nozzle drive is shown in Figure 17. Instead of using a mechanical worm drive to open and close the nozzle as is used in a preferred embodiment, water pressure is used to open and close the nozzle. In this embodiment, nozzle tip 330 is situated within nozzle socket 344. During nozzle operation, water is introduced into nozzle socket water inlet 350. Water pressure pushes up against the walls of water inlet 350 and rotates nozzle socket 344 while stretching or compressing spring 340. When the water stops flowing, spring 340 rotates nozzle socket 344 back into the nozzle closed position.

Another alternate embodiment of nozzle drive system 400 is shown in Figure 19a. In this embodiment, nozzle tip 406 moves with a helical spin axially down a base and stem 408 to dispense liquid from container 410. Projections 412 in nozzle tip 406 fit into a helical drive slot 404 in an annular drive 402. Figure 19a shows the nozzle in its closed position where the tip of base and stem 408 is aligned with the end of nozzle tip 406. Figure 19b shows the nozzle in the open position where nozzle tip 406 is in a lower position with respect to base and stem 408. Figure 19c shows a top view of annular drive 402 with arrows indicating spin. Annular drive 402 is coupled to a motor (not shown) or other mechanical means to spin annular drive 402 to open and close the nozzle.

Yet another alternate embodiment of nozzle drive system 420 is shown in Figure 20a. In this embodiment, nozzle tip 428 moves directly axially down base and stem 426. External drive fingers 424 fit within a circular groove 422 and move nozzle tip 428 directly up and down. Figure 20a shows nozzle drive system 420 in the closed position. Figure 20b shows that when external drive fingers 424 move downward, an opening 427 is created between nozzle tip 428 and base and stem 426. Liquid from container 430 is then able to flow through 427. Figure 20c shows a top view of nozzle drive system 420. External drive fingers 424 are coupled to a motor (not shown) or other mechanical means to move external drive fingers 424 vertically to open and close the nozzle.

In Figure 21, an alternate embodiment of nozzle system 440 is shown where nozzle adapter 442 is welded directly to bag liner 444. By welding nozzle adapter 442 directly to bag liner 444, nozzle adapter 212 (Figure 9) and product spout 214 (Figure 9) are combined into one piece. In this embodiment, nozzle adapter 442 is welded onto bag liner 444 ultrasonically. One advantage to this embodiment is that one piece is eliminated from the system by combining the spout and the nozzle adapter.

Figure 22 shows an alternate embodiment of the present invention where nozzle adapter 464 is attached to the end of a tube 462. This alternate embodiment can be used where the product storage container (not shown) is located in a place other than the dispensing location. For example, the product storage container may be placed under a counter, while the nozzle is located above the counter. Attached to nozzle adapter 464 is a nozzle tip 466 and a plunger 468. Operation of this embodiment is similar to the operation of a preferred embodiment of this invention, however the alternate location for the dispense head (not shown) impacts the pressure equations. The height distance between the bottom of the product bag (not shown) to the bottom of the dispensing point (not shown) may be taken into consideration. Assuming the dispensing point is above the bottom of the product bag, the additional head pressure created by having the dispensing point above the product bag bottom is added to the starting system target pressure,  $P_{TC}$ . Therefore, the compensated system starting pressure is denoted by the equation  $P_{TCC}=P_{TC}+P_p$ , where  $P_p$  is the pressure due to head height.

Figure 23 illustrates a preferred embodiment of a slim package pressurized dispenser 630. Dispenser 630 includes a pressurized chamber 632 coupled with a low, slim profile bag-in-box package 634a to substantially reduce or effectively eliminate the impact of head height pressure changes for the purpose of dispensing beverage concentrates. In a preferred embodiment, a first slim profile bag-in-box package 634a sits in pressurized chamber 632 connected to a nozzle 650a via product extension tube 636. Below the first slim profile bag-in-box package 634a, a second slim profile bag-in-box package 634b is installed and connected to nozzle 650b, which allows for an additional type of product to be dispensed from the same dispenser 630. For example, bag-in-box package 634a can contain whole milk, while bag-in-box package 634b below can contain skim milk. In a preferred embodiment, the slim profile bag-in-box packages 634a and 634b are installed in dispenser 630 behind door 638. A chamber seal gasket 640 attached to the inside perimeter of door 638 provides a thermal and pressure seal when dispenser 630 is in operation.

The pressure of chamber 632 may be regulated to a specific pressure as described hereinabove. Even though the head pressure may change slightly as the product empties, the difference in head pressure is not significant in comparison to the overall system pressure. As an example, if the head pressure changes only 0.1 psi and the system pressure is 5 psi, the impact of the head pressure change is only 2%. In addition, if the target flow rate is set when the bag is half full, the flow rate will be only 1% fast when the bag is full and only 1% slow when the bag is empty. Head height pressure exerted per foot of head height is usually in the range of about 0.4 psi to about 0.5 psi for most beverage concentrates. Therefore, to achieve a 0.1 psi drop from a full bag to an empty bag, the bag may be about 3" in height. Preferably, the slim profile bag-in-box package 634a or 634b is less than about 6" in height, more preferably less than about 5 inches in height, and still more preferably less than about 3" in height. In other embodiments, other dimensions may be used, and other packages besides bag-in-box packages may be employed. Because of the relative insensitivity head pressure to product volume for slim profile packages, more than one slim profile package 634a and 634b can share the same chamber 632 while maintaining similar product flow rates, even if one package contains a different volume from the other package.

The chamber may be pressurized by many methods, including pumping air or releasing pressurized CO<sub>2</sub> into chamber 632. The air pressure in chamber 632 may be held constant with an air pressure regulator (not shown).

These embodiments may be used with any compatible embodiment or combination of embodiments disclosed herein, such as the embodiments disclosed in Figures 1-2, 23-27, 30 and 37, for example.

As discussed hereinabove, a beverage dispensing system and method may comprise a product bag with a spout and adapter that makes a seal to its product chamber. The spout is the outlet port of the bag that is physically welded to the bag liner, and the adapter is snapped into the spout. It has a feature that acts as a shutoff valve and a seal to the product chamber when placed in the product chamber. The adapter is designed to make an air-tight fit with the product chamber. In a preferred embodiment of the invention, however, the adapter can be connected to a tube, so that a nozzle can be connected remotely.

Figure 24a illustrates a side view of an embodiment of the present invention where beverage dispenser 700 includes a remote nozzle 702 and bag-in-box product container 706 within pressurized product chamber 704 connected to tube or tube set 708 via bag adapter 710. Bag adapter 710 is connected to an outer bag tube or tube set 708, which may be run through a tube chute 712 within neck 711. Tube set 708 may comprise one or more of the following: the tube set adapters or connectors that connect to bag adapters 710, the tubing, a tee check valve, and nozzle 702 fitted with a hat or cap. The tubing may be made of linear low density polyethylene (LLDPE), polyurethane, Tygon®, nylon, or numerous other materials. The length and diameter of the tubing may be varied.

An alternative to bag-in-box product container 706 is shown in Figure 24b. Instead of having a spout positioned near the bottom of container, product container 756 contains a tube 750 routed inside container 756 affixed to the bottom of the container 756 with a weld 752. Container 756 is usually made from a flexible plastic material such as linear low density polyethylene and/or other materials such as metallized polyester laminated to polyethylene, however, other materials, including polyolefin, polypropylene, polyvinyl chloride, polyester, nylon, and the like. Tube 750 is preferably made from linear low density polyethylene (LLDPE), polyurethane, Tygon®, nylon, or numerous other materials, and can be ultrasonically welded to the bottom of container 756. Pressure from the chamber (not shown) against the walls of container 756 propels product 758 through tube 750 and out through spout 754.

Turning back to Figure 24a, tube set 708 may be routed through a tube chute 712 within neck 711 to dispense head 714. Tube set 708 may be easily replaced, allowing disposal after each use or after a designated period of time. Tube chute 712 may be refrigerated for products that require refrigeration. Tube chute 712 may be made of copper, stainless steel, plastic, or numerous other materials. Refrigeration of tube chute 712 may be omitted for aseptic products or other products that do not require refrigeration.

A preferred embodiment of the present invention can also include dispensing switch 716, which can be electrically coupled to a controller (not shown) in beverage dispensing machine 700. Switch 716 and nozzle 702 can be electrically connected to a controller (not shown) via a wire bus (not shown) running from dispense head 714 to the controller (not shown) in the body of machine 718. In alternative embodiments of the present invention, dispensing switch 716 can mechanically actuate nozzle 702.

Figure 24c illustrates a side-view of a preferred embodiment of beverage dispenser 700 discussed hereinabove. Beverage dispensing machine 718 contains two product packages 706a and 706b connected to tube

708 via tee check valve 720. Tee check valve 720 allows product packages 706a and 706b with the same product to be connected together. Product packages 706a and 706b each sits in its own separately regulated pressurized chamber 707a and 707b. By taking pressure measurements and using the volume measurement methods described hereinabove, a controller (not shown) can determine which of the two product packages 706a and 706b has a lower volume. In alternative embodiments, other methods of measuring the product volume in product packages 706a and 706b can be used, for example, measuring the weight of the product.

In a preferred embodiment of the present invention, the product package 706a or 706b with the lower of the two volumes is selected to be the package from which to dispense product first. By applying pressures to each of the two product packages 706a and 706b, so that the total head pressure of the chamber to be dispensed from slightly exceeds the total head pressure of the chamber not to be dispensed from, flow from the desired chamber can be achieved. In a preferred embodiment of the present invention, a pressure differential of only 0.1 psi between chambers is necessary to cause product to flow from one chamber 707a or 707b to nozzle 702, while preventing the product from flowing from the other chamber 707a or 707b.

Figure 24d illustrates an isometric view of beverage dispensing machine 700 with its inner components exposed, and Figure 24e illustrates an isometric view of beverage dispensing machine 700 without its internal components exposed.

Figure 24f illustrates an alternative embodiment of a preferred embodiment shown in Figure 24e, wherein beverage dispensing machine 730 includes two dispense heads 714a and 714b. Alternatively, more than two dispensing heads could be included in a beverage dispensing machine.

A cut-open view of dispense head 714 attached to neck 711 is shown in Figure 24g. An end of tube 708 exiting tube chute 712 is attached to a barbed end of tube adapter 722 connected to nozzle 702. In addition to product tube 708, water line 730 and cooling lines 726 and 728 are also routed through tube chute 712. Water from water line 730 can be used to mix with the dispensed product and/or to rinse the end of nozzle 702 after product is dispensed. In a preferred embodiment of the present invention, the ends (not shown) of cooling lines 726 and 728 are connected together to allow for a cold liquid, such as water or other liquids, to re-circulate within tube chute 712 and dispense head 714 in order to keep the product in tube 708 cool. Cup 732, which holds nozzle 702, also comprises a mechanical nozzle drive (not shown) which actuates nozzle 702, thus allowing for product to be dispensed.

Figure 24h shows a bottom view of neck 711 including tube chute 712 extending from the bottom end of neck 711. Water line 730 and cooling lines 726 and 728 encased in insulation 734 are also shown routed through neck 711. In a preferred embodiment of the present invention, water line 730 and cooling lines 726 can be made of copper or other metals, or rigid or flexible plastic materials such as PVC or polyethylene. Insulation 734 may comprise spray-on foam insulation such as polyurethane foam. Other types of foam and non-foam insulation may be used also. Electrical bus 740, which is also routed through neck 711, provides signaling and power to and from dispense switch 716 (Figure 24a) and actuators (not shown) present on nozzle 702 (Figure 24a). These embodiments may be used with any compatible embodiment or combination of embodiments disclosed herein, such as the embodiments disclosed in Figures 2-3, 8, 23 and 25, for example.

In the prior art, an open fluid container generally is filled from the top as the container captures liquid from a dispenser. Typically, the open fluid container is disposed under a nozzle or valve, the nozzle is opened, and the container is filled with product flowing out of the nozzle and through the top of the container. In a preferred embodiment of the invention, Figures 25a and 25b illustrate a beverage dispenser system 800 and a method for filling a pitcher or other storage container from the bottom of a container 802.

As shown in Figure 25a, by placing a container 802 with a check valve 804 on top of a milk valve 806 that acts to both open the check valve 804 and dispense liquid into container 802, both the check valve 804 and milk valve 806 may be opened by valve actuator 805 to allow the product to be forced into container 802.

When container 802 is removed from milk valve 806, check valve 804 on container 802 closes, generally preventing product from flowing back out the bottom of container 802. A rinse supplied by water line 808 may be added to milk valve 806 to rinse the bottom of container 802 upon removal so that container 802 is substantially cleaned of any product residual on the outer surface. In a preferred embodiment of the present invention, milk tube set 816 is connected on one end to main product storage container 810 by adapter 814 and is connected to milk valve 806 on the other end. This system and method allow the main product storage container 810 to sit underneath countertop 812 while providing a way to transport the product up past countertop 812 and into container 802.

Figure 25b shows a detailed view of the bottom of container 802, check valve 804, and milk valve 806. Check valve 804 includes a flow diverter 820, a spring 822, a valve ball 824, a check valve actuator 805, and an o-ring seal 826. Flow diverter 820 diverts the flow of product when check valve 804 is open so that product does not shoot directly out of container 802. O-ring seal 826 provides a seal between check valve 804 and the bottom of container 802, thereby preventing liquid from leaking from the bottom of container 802.

Alternatively, container 802 may be filled from the side instead of the bottom. The connection from container 802 to check valve 804 may be modified accordingly. Another alternative is to electromechanically open and close check valve 804 of container 802 instead of relying upon milk valve 806 to push open check valve 804. This may further assist in preventing any backflow as container 802 is disengaged from the fill nozzle or milk valve 806. Alternatively, a combination of electromagnetic and nozzle forces may be used to control check valve 804 of container 802. These embodiments may be used with any compatible embodiment or combination of embodiments disclosed herein, such as the embodiments disclosed in Figures 2-8, 23 and 26, for example.

Prior art soda dispensers may implement automatic product changeover. Generally, vacuum sensors either mechanically or electromechanically switch from an empty product container to a full container by sensing the level of vacuum pulled on the empty container.

A preferred embodiment of the invention is a beverage dispensing system and method for automatic changeover from used (e.g., empty) to new (e.g., full) product containers. As illustrated in Figures 26a-26d, check valves 1310 and 1312 may be used in combination with a pressurized dispensing system, as disclosed herein, to automatically change a dispenser from an empty product bag to a full product bag.



Figures 26a-26d illustrate a functional system level view of an embodiment of the present invention. Liquid product is located in two separate pressure chambers 1302 and 1304, labeled “chamber 1” and “chamber 2” in the figures. In preferred embodiments, each chamber 1302 and 1304 contains liquid product stored in a bag-in-box container or other container that comprises flexible walls so that pressure present in the chamber can be applied to the liquid product. Each chamber 1302 and 1304 is connected to a check valve 1310 and 1312 and oriented so that product generally flows away from each chamber, but product is prevented from flowing back toward each chamber. Liquid product that flows out of check valves 1310 and 1312 can be combined by a tee section 1314 and directed toward nozzle 1316. If one chamber is pressurized, product flows from that chamber, through its check valve, through the tee, and then up the common tube set tube 1315 to the exit nozzle. Generally, the product does not flow into the other bag because the other bag’s check valve prevents backward product flow.

Figure 26a illustrates a typical initial condition for dispensing machine 1300 where both product chambers 1302 and 1304 are filled with product, as denoted by product level indicators 1306 and 1308. Pressure is applied to both chambers 1302 and 1304, so that the pressure applied by the liquid product at exit point 1318 at the first chamber 1302 exceeds the pressure applied by the liquid product at exit point 1320 at the second chamber 1304. In preferred embodiments of the present invention, the pressure at exit point 1318 at the first chamber 1302 exceeds the pressure applied by the liquid product at exit point 1320 at the second chamber 1304. When nozzle 1316 is open, product will flow from first chamber 1302, through check valve 1310, tee section 1314 and out through nozzle 1316. Product will not flow through check valve 1312 and into second chamber 1304 because the pressure at the output of check valve 1312 exceeds the pressure at the input to check valve 1312.

In preferred embodiments of the present invention, beverage dispensing system 300 will select which bag to empty first. For example, beverage dispensing system 300 may select to dispense the liquid product from the container that contains the least amount of liquid product. Alternatively, the system can dispense a user selected chamber first. The system can determine the volume present in each container using the volume measurement techniques described hereinabove. For example, the volume of the liquid product present in each chamber can be determined by using differential pressure measurements described hereinabove. Alternatively, the volume of the product in each chamber can be measured using other methods, such as weighing the liquid product.

Turning to Figure 26b, product level 1306 of first chamber 1302 is shown to be at a low level. In a preferred embodiment of the present invention, the pressure applied to first chamber 1302 is increased so that the remaining product can be squeezed from the first chamber 1302. In some embodiments the pressure may be increased when the product level of the first chamber 1302 reaches about 5% of its full capacity, and in other embodiments, the pressure may be increased when the product level reaches about 1% or about 0.5% of full capacity. Alternatively, other levels above and below 5% of full capacity may be chosen at the point at which to start increasing pressure to the first chamber 1302. As first chamber 1302 is emptying, the pressure of second chamber 1304 may be increased to the pressure of first chamber 1302 less a small amount of pressure, for example, in the range of about 0.05 psi to about 1.0 psi. By making the pressure of first chamber 1302 higher than the pressure of second chamber 1304, product generally will flow from first chamber 1302 until it is substantially empty.

Alternatively, as first chamber 1302 is emptying, the pressure in first chamber 1302 may be increased above the system target pressure to help evacuate the product from first chamber 1302. Because first chamber 1302 is close to empty, any increased flow from first chamber 1302 generally is immaterial as the liquid of first chamber 1302 is combined with the liquid of second chamber 1304. The increased pressure in first chamber 1302 may be maintained for a predetermined time period after the changeover to help force out any residual product in first chamber 1302. This generally does not impact the product dispensing from second chamber 1304 because, although the pressure in first chamber 1302 is higher than that in second chamber 1304, the actual pressure introduced into the tube 1315 from first chamber 1302 generally is less than that from second chamber 1304 if little or no product is coming out of first chamber 1302.

As the product empties from first chamber 1302, second chamber 1304 may be pressurized so that its product may begin flowing out of second chamber 1304, as shown in Figure 26c. As first chamber 1302 empties, second chamber 1304's product is ready to take the place of first chamber 1302's product. After first chamber 1302 is substantially empty, the pressure in second chamber 1304 may be increased by a small amount of pressure to the target system pressure. This generally allows for a transparent changeover from first chamber 1302 to second chamber 1304. As long as the pressure of second chamber 1304 is higher than the atmospheric pressure plus any head pressure that must be overcome at exit point 1320, product generally will flow from second chamber 1304 to nozzle 1316. If the pressure in first chamber 1302 is removed or sufficiently reduced, its check valve 1310 will close and the product from second chamber 1304 generally will be prevented from entering into the empty first chamber 1302.

Figure 26d illustrates the system as second chamber 1304 is emptying. As second chamber 1304 empties, the pressure applied to second chamber 1304 continues to be increased in order to compensate for the decrease in head pressure due to the decreased head height.

An advantage of this system and method is that it is very effective in emptying first chamber 1302 substantially completely while allowing a seamless changeover to second chamber 1304. The changeover may take place over a longer time period, such as one, two or more minutes of operation, versus a split-second of time when a determination of empty is made as happens in most prior art automatic changeover systems.

In preferred embodiments of the present invention, check valves 1310 and 1312, tee connector 1314, quick disconnect valves 1336 and 1338, tube sections 1330, 1332 and 1334, and nozzle 1316 can be included in tube set 1350 shown in Figure 27a. Tube set 1350 is preferably disposable. Typically, bag-in-box storage containers 1340 and 1342 comprising product bags 1344 and 1346, respectively, are discarded after all of the product has been dispensed from each bag 1344 and 1346. Tube set 1350, on the other hand, can be discarded after product from multiple bag-in-box containers has been dispensed. Quick disconnect valves 1336 and 1338, which couple tubes 1330 and 1332 to bag adapters 1341 and 1343, respectively, can be designed to easily snap on and off bag adapters 1341 and 1343 according to conventional techniques used in the art. In preferred embodiments of the present invention, quick disconnect valves 1336 and 1338 comprise a female configuration, however, in alternative embodiments of the present invention, other configurations, such as a male configuration, may be used. In some embodiments, bag adapters 1341 and 1343, or quick disconnect valves 1336 and 1338 may include shutoff valves

built into them to allow for easy connection and disconnection to prevent spills. The connection allows each bag's content to flow out of bag 1344 or 1346 and into tube set 1350.

In preferred embodiments of the present invention, check valves 1310 and 1312 are included within tee connector 1314. In alternative embodiments, however, check valves 1310 and 1312 may be positioned outside of tee connector 1314. For example, check valves 1310 and 1312 may be integrated in bag adapters 1341 and 1343, or as independent sections attached to tubes 1330 and 1332.

Tube set 1350 may be implemented with lasting materials and cleaned in place, or it may be implemented with low cost materials and replaced on a routine basis, such as from a couple of hours to a couple of weeks. Advantages of using disposable low cost materials include the ability to easily maintain and clean a sanitary beverage dispensing system without incurring high maintenance costs. In alternative embodiments of the present invention, a combination or subset of the elements that comprise tube set 1350 may be disposable, while other elements are constructed to be long lasting. Numerous or all parts of tube set 1350 may be recycled, cleaned for additional use, or disposed of. For example, tubes 1330, 1332 and 1334 may be disposable, but tee connector 1314 may not be disposable. Furthermore, tube set 1350 may have various nozzle styles connected to its end. The check valves, tee, and adapters may be made from numerous materials, including polyethylene, polypropylene, nylon, or stainless steel.

Figures 28a-28d illustrate isometric and cross-sectional views of tee connector 900 according to a preferred embodiment of the present invention. Tee connector 900 includes barbed fittings 902 which couple to product tubes. Internal to the tee connector 900 are check valves 940. Figure 29 illustrates a partially transparent three-dimensional view of tee connector 900.

An example of a system which utilizes the automatic bag changeover system described hereinabove is illustrated in Figures 24c. Product packages 706a and 706b are shown connected to tee connector 720, which in turn is connected to nozzle 702 via tube section 708.

These embodiments may be used with any compatible embodiment or combination of embodiments disclosed herein, such as the embodiments disclosed in Figures 1, 23-25 and 30, for example.

For example, in beverage dispensing systems that only utilize a single bag-in-box product source, tube set 1360 shown in Figure 27b can be used. Tube set 1360 is similar to tube set 1350 shown in Figure 27a, but does not include the tee section used to combine two product sources. Quick disconnect valve 1336, tubes 1330 and 1334, and nozzle 1316 function similarly, and are constructed similarly as described hereinabove.

In the beverage dispensing industry, the blending of two or more products to create a specific drink routinely occurs. For example, orange juice machines blend concentrated orange juice and water to produce orange juice, and soft drink machines blend carbonated water and syrup to produce soft drinks. The rate of water carbonation and syrup addition are controlled with mechanical and electromechanical valves. Once the valves for the carbonator, water, and syrup are initially calibrated and set, the system generally yields properly calibrated drinks. In addition, there are pressure regulating and other similar devices employed to ensure the integrity of the

system. Some newer soft drink machines blend a flavoring with the syrup and carbonated water to create a flavored soft drink. Within the dairy beverage dispensing industry, however, milk usually is dispensed directly as milk.

In preferred embodiments, a system and method for beverage dispensing blends two or more separate components in varying amounts to create numerous different types of drinks. The beverage dispenser system and method provide multiple output products from minimal product inputs, and may deliver the products with a variety of techniques. In a preferred embodiment, as illustrated in Figure 30a, a dairy beverage dispensing system 1000 and associated method dispense dairy products through a dispensing system and blends the dairy products with water to create numerous different dairy drinks. Alternatively, liquids other than dairy may be accurately mixed according to desired formulations.

With respect to dairy products, water may be added to concentrated milk to deliver milk. Milk may be separated into cream and skim milk. The cream and skim milk may be recombined to form various fat percentage milk drinks, including skim milk, known as non-fat milk, 1% fat milk, known as low-fat milk, 2% fat milk, known as reduced-fat milk, 3% to 4% fat milk, known as whole milk, and 12.5% fat milk, which is half whole milk and half cream, known as half & half. Furthermore, the skim milk portion of the milk may be concentrated. Therefore, using separate concentrated skim milk, cream, and water products, it is possible to mix and produce a large variety of milk products, including non-fat milk, low-fat milk, reduced-fat milk, whole milk, and half & half. Generally, the cream should be a cream source of high enough percentage of butterfat to enable desired drinks to be formulated when it is combined with the concentrated skim milk source and water, depending on the specific application.

The method of separating milk into cream and skim milk or concentrated skim milk is employed in the dairy industry when producing ice creams, yogurts, and milks in large scale commercial production facilities. Preferred embodiments of the present invention provide a system and method for accurately combining appropriately prepared cream, concentrated skim milk and water through a beverage dispenser to create numerous dairy products, preferably from only two dairy sources. Furthermore, the beverage dispenser may provide these dairy products at the individual serving level and may provide a different dairy product from one individual serving to the next.

Again, Figure 30a illustrates a preferred embodiment system 1000 and an associated method for dispensing dairy beverages, wherein the system and method accurately combine cream 1002, concentrated skim milk 1004, and water from supply 1006 to generate numerous dairy products from only the two dairy sources. The system and method may comprise a tube set component that may be easily replaced and disposed of to minimize cleaning requirements. The beverage dispenser can comprise a control panel 1008, a controller such as a microprocessor 1010, flow rate meters, such as water flow meter 1014, fluid pumps (not shown), control valves, such as water control valve 1018, a tube set, and a nozzle 1012.

Control panel 1008 provides an input for the user to indicate the type of product desired. Within the realm of milk products, the user might select non-fat, low-fat, reduced-fat, whole milk, or half & half. Microprocessor 1010 may sense signals from control panel 1008 for a specific drink, and then may formulate the proper ratio of water, skim milk concentrate, and cream to produce the drink. Microprocessor 1010 then may modulate in real time (on the fly) the flow rate of all three liquids to deliver the correct ratio drink.

For example one low-fat drink might have the ratio of 1 part cream, 5 parts skim concentrate, and 10 parts water dispensed. Another higher fat drink might have the ratio of 3 parts cream, 5 parts skim concentrate, and 12 parts water dispensed. Here the ratio of cream to skim concentrate is increased to yield a higher fat drink.

To accurately ratio the liquids, constant flow rate dispense methods discussed here can be used with respect to cream 1002 and concentrated skim milk 1004. To control the flow rate of the water, water flow meter 1014 can be used along with water control valve 1018 in order to accurately control the flow rate of the water while the product is being dispensed. For example, a preferred embodiment system and method may utilize a magnetic spinner water meter for metering the water and an ideal gas law method outlined hereinabove for metering the cream and skim concentrate. Other metering methods also may be employed, such as magnetic flow meters, measuring changes in weight with mass meters or scales, and the like.

The embodiments comprise fluid pumps to pump the water, skim concentrate, and cream. For example, water inlet 1016 may be connected to water flow meter 1014, water control valve 1018 or a larger facility pump (not shown) that creates pressure to deliver the water. Cream 1002 and skim concentrate 1004 may be pumped by pressurizing a chamber (not shown) surrounding a product such as a bag-in-box as outlined hereinabove. Other pumping methods also may be used to pump the dairy liquids, such as peristaltic pumps, diaphragm pumps, centrifugal pumps, and the like.

Modulating the pump speeds or the control valves or both allows the system and method to control the ratio of the liquids. For water, the system and method may use an electromechanical modulating valve. For the dairy liquids, the system and method may vary the pressure of the pumping chambers to deliver the correct quantity of cream and skim concentrate. At higher pressure, more dairy product is delivered, and at lower pressure, less dairy product is delivered. Another approach that may be employed is to electromechanically modulate a product valve (not shown) to control the delivery of the dairy liquids. By modulating the product valve, the flow rate of dairy liquid is adjusted to deliver the appropriate amount.

In a preferred embodiment of the present invention, all components of the dispensed beverage are mixed and combined in nozzle 1012 as described herein below. In alternative embodiments, however, other methods of mixing the liquid product may be used, such as routing the product flow to a separate mixing chamber and dispensing the product from a single, unified nozzle. Other alternative methods may include using multiple dispense nozzles to dispense cream 1002, concentrated skim milk 1004 and water components of the liquid beverage. In a preferred embodiment, cream 1002 is dispensed from an innermost port, skim concentrate 1004 is dispensed from a middle layer port, and water is flowed around the outer part of nozzle 1012. The result is three streams (inner, middle, and outer) that mix in real time or on-the-fly to deliver a uniform appearing drink made to the user's component specifications.

Figure 30b illustrates a preferred embodiment of the present invention that uses a tee hose nozzle assembly 1020 to combine and dispense two liquid components. Tee hose nozzle assembly 1020 includes a two liquid tee 1022 that routes two liquids into concentric hose 1025. Concentric hose 1025 includes an internal tube pathway 1024 and an external tube pathway 1026, and is attached to a unified nozzle 1028, which combines and dispenses two liquids. An advantage of a preferred embodiment disclosed herein is that the two liquids remain separate

without commingling until they reach unified nozzle 1028. In a preferred embodiment, internal tube pathway 1024 carries cream and external tube pathway 1026 carries concentrated skim milk. In alternative embodiments of the present invention, other liquid products may be routed through internal tube pathway 1024 and external tube pathway 1026. In a preferred embodiment of the present invention, water can be supplied to the exterior of nozzle 1028 via a separate pathway.

A two liquid tee 1022 is illustrated in Figure 30c. In a preferred embodiment of the present invention, two liquid tee 1022 includes check valves 1040a and 1040b for each of the two product flow paths, an internal tube pathway 1042 and an external tube pathway 1044. Check valves 1040a and 1040b prevent product flow back through two liquid tee 1022 and into the product chambers (not shown). Barbs 1046 attached to an output port of two liquid tee 1022 are used to securely attach an end of external tube pathway 1044 to two liquid tee 1022.

Figure 30d illustrates an isometric cut-away view of a static unified nozzle 1028. Nozzle 1028 includes nozzle body 1032, plunger 1030, adapter 1034, inner tube retainer 1038, and barbs 1036 used to secure an end of the external tube pathway to nozzle 1028. To dispense product, nozzle body 1032 is rotated with respect to adapter 1034, which remains rotationally static. A pin (not shown) attached to a cylindrical interior of nozzle body 1032, which rests in a helical groove on the external surface of plunger 1030, pushes plunger 1030 axially downward. As opening 1054 at the tip of plunger 1030 becomes exposed to the external environment, a flow path is created allowing for product to be dispensed. Adapter 1034 and nozzle body 1032 preferably comprise ribs 1052 so that these pieces can be secured within the beverage dispensing machine. The contents which flow from the external tube pathway 1026 and internal tube pathway 1024 (Figure 30b) combine and mix within the interior of plunger 1030. Combining product within nozzle 1028 is advantageous because it appears to a user of a beverage dispenser employing embodiments of the present invention that a single and uniform beverage is being dispensed. Another isometric view of nozzle 1028 is shown illustrated in Figure 30e.

In a preferred embodiment of the present invention, nozzle 1028 would be secured in a dispensing cup (not shown). A static portion of the dispensing cup secures adapter 1034 with grooves that correspond to ribs 1052, while a mechanical actuator (not shown) secures nozzle body 1032 and turns nozzle body 1032 in order to dispense a beverage. More detail about the general construction of dispensing nozzles and nozzle actuation is described herein below.

Figures 31a-31c and 32-36 illustrate a dynamic on-the-fly mixing nozzle 1400. In a further preferred embodiment of the present invention, a dynamic nozzle 1400 is shown that can independently control the flow of at least two separate liquids, as well as keep each liquid separate from each other when dynamic nozzle 1400 is closed. In a preferred embodiment of the present invention, dynamic nozzle 1400 is attached to internal tube pathway 1042 (Figure 30c) and external tube pathway 1044 (Figure 30c).

Figure 31a shows an isometric cut-away view of dynamic nozzle 1400. Dynamic nozzle 1400 consists of lower nozzle body 1402, upper nozzle body 1404, adapter 1406, outer plunger 1410, and inner plunger 1412. Adapter 1406 is fitted with barbs 1408, onto which external tube pathway 1044 (Figure 30c) is attached, and includes an inner circular ridge 1428 used to secure internal tube pathway 1042 (Figure 30c) to dynamic nozzle 1400.

Turning lower nozzle body 1402 actuates outer plunger 1410, pushing outer plunger 1410 inward toward adapter 1406. When outer plunger 1410 is pushed inward, liquid emanating from external tube pathway 1044 (Figure 30c) flows from adapter 1406 to the end of dynamic nozzle 1400, between the outer circumference of the outer plunger 1410 and the inner circumference of lower nozzle body 1402, and out of the end of dynamic nozzle 1400. When lower nozzle body 1402 is rotated, helical grooves 1442 (Figure 33c) set into the inner circumference of lower nozzle body 1402 and push against projection 1466 (Figure 35b) on the outer circumference of outer plunger 1410, thereby making the axial position of outer plunger 1410 dependent on the angular position of lower nozzle body 1402. Outer plunger 1410 also includes a locking feature 1462 (Figure 35a) which fits into corresponding grooves 1432 (Figure 32b) in the inner circumference of upper nozzle body 1404. This locking feature 1462 prevents outer plunger 1410 from rotating within dynamic nozzle 1400 relative to upper nozzle body 1404, as well as allowing upper nozzle body 1404 to rotate outer plunger 1410 as described herein below. Outer plunger 1410 also contains a vertical riding rib 1460 (Figure 35d). Because the axial position of outer plunger 1410 is dependent on the rotational position of lower nozzle body 1402, the flow rate of the liquid emanating from the external tube pathway 1044 (Figure 30c) will be dependent on the angular position of lower nozzle body 1402. When outer plunger 1410 is actuated, inner plunger 1412 moves along with outer plunger 1410.

Similarly, turning upper nozzle body 1404 actuates inner plunger 1412, pushing inner plunger 1412 inward toward adapter 1406. When inner plunger 1412 is pushed inward, liquid emanating from internal tube pathway 1042 flows from the adapter 1406 end of dynamic nozzle 1400 inside the inner circumference of inner nozzle 1412 and through cavities 1474 set in the tip of inner plunger 1412, and out through the tip of dynamic nozzle 1400 within the inner circumference of outer nozzle 1410. When upper nozzle body 1404 is rotated, grooves 1432 (Figure 32b) within the inner circumference of upper nozzle body 1404 move locking feature 1462 (Figure 35a) on the outer circumference of outer plunger 1410. A guide feature 1464 (Figure 35c) set into the inner circumference of outer plunger 1410 is set into a helical groove 1470 (Figure 36b) on the outer circumference of inner plunger 1412. Rotational motion of upper nozzle body 1404 thereby pushes plunger 1412 upward by the motion of guide feature 1464 (Figure 35c) relative to helical groove 1470 (Figure 36b). The inner circumference of inner plunger 1412 also comprises a vertical rib 1472 (Figure 36c) which fits into inner plunger guide slot 1452 (Figure 34b) of adapter 1406 to prevent inner plunger 1412 from rotating with respect to adapter 1406.

In preferred embodiments of the present invention, dynamic nozzle 1400 is installed within an actuator cup (not shown) within a beverage dispensing system. The cup comprises two rotational actuators that rotate upper nozzle body 1404 and lower nozzle body 1402. The cup and its actuators includes grooves keyed to fit around ribs 1440 on lower nozzle body 1402, ribs 1430 on upper nozzle body 1404, and ribs 1450 on adapter 1406. These ribs 1440, 1430 and 1450 prevent slippage between dynamic nozzle 1400 and the actuator cup. Embodiments of the actuator cup are similar to details of actuator embodiments with respect to nozzle actuators described herein below with respect to single plunger nozzles. Preferred embodiments of the present invention can also include a water dispensing path (not shown) surrounding dynamic nozzle 1400. Water from the water dispensing path can be used to mix water with the liquid beverage products. The water dispensing path can be further used to rinse dynamic nozzle 1400 after each use by closing outer plunger 1410 and inner plunger 1412 after each use.

Dynamic nozzle 1400 also includes o-rings 1420, 1422, 1424, and 1426, which provide seals to various components of dynamic nozzle 1400. O-ring 1426 provides a seal between inner circular ridge 1428 that secures internal tube pathway 1042 (Figure 30c) and outer plunger 1410, which prevents product from internal tube pathway 1042 (Figure 30c) from mixing with the product from external tube pathway 1044 (Figure 30c). O-ring 1426 seals upper nozzle body 1404 to adapter 1406, and o-ring 1422 seals upper nozzle body 1404 to lower body 1402.

In preferred embodiments of the present invention, dynamic nozzle 1400 is typically installed in a system where the upper sections of nozzle 1400 reside in a pressurized environment. O-ring 1420 is used to seal lower nozzle body 1402 to the inner circumference of a dispensing cup and thereby maintain a pressurized environment within the beverage dispensing machine. In alternative embodiments of the present invention, however, some or all of the o-rings may be omitted and an interference fit be used instead to provide sealing between components of dynamic nozzle 1400 and between dynamic nozzle 1400 and the beverage dispensing machine.

In preferred embodiments of the present invention, major portions of the product flow path are included in a tube set 1360, as shown in Figure 37. Check valves 1372 and 1374, two liquid tee connector 1370, quick disconnect valves 1336 and 1338, tube sections 1330 and 1332, tube-within-a-tube 1368 comprising internal tube 1364 and external tube 1366, and nozzle 1362 can be included in tube set 1350 shown in Figure 27a. Nozzle 1362 can comprise either a static or dynamic unified nozzle. Tube set 1360 is preferably disposable and made constructed as and installed in a similar manner as the other tube sets disclosed hereinabove. Tube set 1360 and the nozzle assembly may be designed so that they can be easily removed from the dispenser and cleaned, or disposed of and replaced. The water flowing across the other parts of nozzle 1362 allow for a rinse feature that rinses nozzle 1362 substantially free of residual milk on the surface of the nozzle tip.

When tube set 1360 is used with the pressurized pumping method as described above, the tube-within-a-tube tube set 1368 may utilize a check valve in each product's delivery line to prevent backflow of the higher pressure dairy liquid into the lower pressure line. By using a one-nozzle exit port with a small mixing area for the dairy liquids to mix, the end user is unaware of the mixing of the two dairy ingredients.

Alternative nozzle designs may be employed for allowing the liquid products to flow, such as the two nozzle designs shown in Figures 38a-38b.

As shown in Figure 38a, an alternative implementation of a tube-within-a-tube tube set 1100 uses an attached two-valve nozzle 1102 at the dispensing point that mechanically opens for both an inner product line 1104 and an outer product line 1106. Inner product line 1104 is preferably used for cream and outer product line 1106 is preferably used for skim milk concentrate. The two separate nozzles 1108a and 1108b may eliminate the need for the check valves to prevent backflow in the product lines. In addition, the two-valve nozzle 1102 including nozzles 1108 also prevents any commingling of the dairy ingredients prior to dispensing. This nozzle may have an adapter 1120 that secures both the inner and outer tubes. In preferred embodiments, inner product line 1104 and outer product line 1106 are routed through tube chute 1118. Each adapter 1120 and nozzle 1108 comprises ribs 1114 and 1116 which are used to hold the adapters and nozzles securely in place. The nozzles 1108a and 1108b also comprise separate valves for the inner product line 1104 and for the outer product line 1106. The nozzle may allow two external drives 1110 to actuate both valves independent of each other. This embodiment may allow a



microprocessor to control the amount that the valves are open so that the correct amount of dairy products can be delivered for a given user selection. Nozzles 1108a and 1108b in tube set 1100 are angled toward each other in order to create a product stream that is seen visually as a single stream of product. Alternatively, the nozzles 1108a and 1108b may be positioned parallel to each other as shown in tube set 1101 depicted in Figure 38b.

In the embodiments shown in Figures 38a-38b, each nozzle 1108a and 1108b is attached to a nozzle drive 1110 which provides a mechanical actuator to open and close each nozzle 1108a and 1108b. Nozzles 1108a and 1108b and associated nozzle drives 1110 sit in cup 1112.

Various other embodiments, modifications and alternatives are possible, as discussed in further detail below.

Prior art systems for use with aseptic products such as dairy milk assume that the product only flows in the intended direction and that contaminants will not travel upstream. This is not always the case, however, and aseptic products may become contaminated when using prior art systems.

In a preferred embodiment of the invention, Figures 39a and 39b illustrate a system 500 and method for maintaining an aseptic product when dispensing with a pressurized dispensing system. A cap or hat 502 on nozzle 530 prevents contamination of higher chamber product reservoir 520 from fluid in lower chamber 522. Coupled with a positive pressure dispensing system, this system and method generally prevent product from flowing in the wrong direction and allow the product to maintain an aseptic condition. These embodiments may be used with any compatible nozzle/dispenser disclosed herein.

Figure 39a shows aseptic nozzle 530 in a closed position. In a preferred embodiment of the present invention, nozzle 530 is made up of a nozzle body 504 in which a plunger 510 capable of axial motion is inserted. Nozzle hat 502 is attached to the top of plunger 510. When nozzle 530 is in a closed position, the edges of hat 502 are positioned flush against an adapter sealing surface 508, which prevents product from leaking from higher chamber 520 to lower chamber 522. A liquid proof seal is maintained between adapter sealing surface 508 and nozzle body 504 with an o-ring 506. O-ring 506 can be made of ethylene propylene, or alternatively in other embodiments they can be made of buna-nitrile. Nozzle hat 502, plunger 510, nozzle body 504, and adapter sealing surface 508 are preferably made from high density polyethylene. Alternatively, in other embodiments, these components can be made from low density polyethylene, polyethylene terephthalate, and polypropylene.

In preferred embodiments of the present invention, a pressure sensor 514 is positioned in hat 502 in order to measure a pressure difference between higher chamber 520 and lower chamber 522. In the event that pressure sensor 514 senses that the pressure in lower chamber 522 exceeds the pressure in higher chamber 520, which signifies a loss of pressure resulting in the possibility of a contaminated product, a signal is sent to a warning system 518 and/or a lockout system 516. Warning system 518 can create a user perceptible warning that signals the user of the possibility of a contaminated product. Lockout system 516, on the other hand, can be used to prevent the system from dispensing the product in the event of possible contamination. In preferred embodiments of the present invention, the warning system 518 and lockout system 516 can be implemented with a microcontroller or

microprocessor. In alternative embodiments of the present invention, warning system 518 and lockout system 516 can be implemented by other electrical or mechanical means.

Figure 39b illustrates aseptic nozzle 530 in an open position. When plunger 510 and nozzle hat 502 are moved axially upward, product passes between nozzle hat 502 and adapter sealing surface 508. As long as positive pressure is maintained while product is being dispensed, sanitary and aseptic conditions can be maintained.

The nozzles disclosed herein, such as the one shown in Figure 22, may be adapted to fit on the end of a tube with a barbed fitting 602, as shown in Figure 40. In preferred embodiments of the present invention, nozzle 600 typically includes a nozzle body 606, an adapter 608, and an o-ring 610 to provide a seal between nozzle body 606 and adapter 608. In some embodiments of the present invention, nozzle 600 is internally constructed similar to other nozzle embodiments described herein. By including a barbed fitting 602, however, the nozzle can be force-fit on the end of a tube, and located in various locations away from the bag and box, depending on the specific application. Different sizes and number of barbs 602 may be used depending on the tubing used and desired flow rates.

These embodiments may be used with any compatible embodiment or combination of embodiments disclosed herein, such as the embodiments disclosed in Figures 2, 23-24, 26 and 27, for example.

As discussed hereinabove, with some nozzle designs, there may be a problem during the opening or closing of the nozzle, especially when the opening or closing is performed slowly. As the nozzle plunger lifts into the nozzle body, breaking the nozzle seal and allowing product to flow through the newly-created gap, the flow may disassociate and splatter as it dispenses in a non-uniform fashion. When the nozzle becomes fully open, the flow generally returns to a smooth and uniform flow.

Figure 41a illustrates a preferred embodiment of nozzle assembly 1200 in a closed position, and Figure 41b shows the same nozzle assembly 1200 in an open position. Nozzle assembly 1200 includes nozzle body 1206, nozzle adapter 1208, and plunger 1204, which function in a similar manner as preferred nozzle embodiments disclosed hereinabove. In a preferred embodiment of the invention, vanes 1212 are implemented on the bottom tip of plunger 1204. Vanes 1212 generally terminate in a single conical point 1210. This configuration draws the exiting product that surrounds plunger 1204 to conical point 1210 as opposed to the product simply dropping off plunger 1204. In addition, vanes 1212 help redirect the fluid forces axially instead of transaxially. This may be especially useful at the cracking point where plunger 1204 and nozzle body 1206 just become open. At that point, there are more transaxial forces than axial forces acting upon the exiting fluid. The combination of conical tip 1210 and vanes 1212 may overcome this and significantly reduce disassociation of the product upon the opening of nozzle assembly 1200, thus providing a substantially a smooth and uniform flow during nozzle opening and closing. There may be three, four, five, or more vanes 1212 on nozzle tip 1210.

Figure 41c illustrates an alternative embodiment nozzle tip. Plunger 1204 may be implemented with only conical point 1210 and without vanes 1212 (Figure 41a), which generally will provide an improvement over a flat tip nozzle plunger. Conical point 1210 may create a surface for the product to follow down to the bottom point of plunger 1204, uniting the fluid exiting on all sides of plunger 1204. Having a conical point 1210 without vanes

1212 offers several advantages over a plunger tip 1210 with vanes 1212. First, product does not get trapped on the vanes 1212, thereby making the plunger tip easier to clean. Second, implementing conical tip 1210 without vanes 1212 is preferable for beverage dispensing systems which provide an initial pressure of up to about 1 psi when the nozzle first opens. For systems with an initial pressure of greater than about 1 psi, however, the presence of vanes 1212 becomes preferable to prevent erratic product flow.

Alternatively, plunger 1204 may be implemented with only vanes 1212 and without a conical point, as shown in Figure 41d. Preferably, nozzle body 1206 is slotted to receive vanes 1212. In this case, the vanes 1212, alone, help to direct the product axially instead of transaxially, thus reducing the possibility of product splattering as plunger 1204 opens.

These embodiments may be used with any compatible embodiment or combination of embodiments disclosed herein, such as the embodiments disclosed in Figures 1, 9, 12, 19, 20-24, 26-27, 30-31, and 35-40, for example.

Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

## WHAT IS CLAIMED IS:

1. A system for dispensing a liquid beverage, the system comprising:
  - a pressure sealed chamber having an interior environment;
  - a compressible container containing the liquid beverage, the compressible container disposed inside of the sealed chamber, wherein the compressible container isolates the liquid beverage from the sealed chamber interior environment;
  - an outlet for dispensing the liquid beverage;
  - a gas source providing gaseous pressure in the sealed chamber, the gaseous pressure exerting force on an exterior surface of the compressible container;
  - a pressure sensor disposed within the sealed chamber interior environment; and
  - an electronic controller controlling the gas source based on input from the pressure sensor.
2. The system of claim 1, wherein the outlet for dispensing the liquid beverage comprises a nozzle.
3. The system of claim 1, wherein the sealed chamber comprises a rigid inner wall disposed within an outer wall.
4. The system of claim 3, further comprising insulation between the inner wall and the outer wall, wherein the insulation provides rigidity to the inner wall.
5. The system of claim 4, wherein the insulation comprises foam sheets.
6. The system of claim 4, wherein the insulation comprises injected foam.
7. The system of claim 1, wherein the electronic controller comprises a microprocessor.
8. The system of claim 1, wherein the electronic controller is configured to dispense the liquid beverage at a substantially constant flow rate at the outlet when the outlet is open.
9. The system of claim 1, further comprising a temperature sensor disposed within the sealed chamber interior environment, wherein the electronic controller controls the gas source based on input from the temperature sensor.

10. The system of claim 9, wherein the electronic controller comprises a microprocessor.
11. The system of claim 9, wherein the electronic controller is configured to dispense the liquid beverage at a constant flow rate at the outlet when the outlet is open.
12. The system of claim 1, wherein the gas source comprises a pump.
13. The system of claim 1, wherein the gas source comprises a gas canister with a control valve.
14. The system of claim 1, wherein the gas source provides air.
15. The system of claim 1, wherein the sealed chamber interior environment is refrigerated.
16. A system for dispensing a liquid beverage, the system comprising:
  - a gas-tight chamber having an interior environment;
  - a compressible container containing the liquid beverage, the compressible container disposed inside of the gas-tight chamber, wherein the compressible container isolates the liquid beverage from the gas-tight chamber interior environment;
  - a nozzle for dispensing the liquid beverage, wherein the nozzle seals the liquid beverage from an external environment when the nozzle is closed and minimizes a surface area of surfaces exposed to both the liquid beverage and the external environment;
  - a gas source providing gaseous pressure in the gas-tight chamber, the gaseous pressure exerting force on an external surface of the compressible container;
  - a pressure sensor disposed within the gas-tight chamber interior environment;
  - a temperature sensor disposed within the gas-tight chamber interior environment; and
  - an electronic controller controlling the gas source based on input from the pressure sensor and the temperature sensor.
17. The system of claim 16, wherein the gas-tight chamber comprises an inner wall disposed within an outer wall and insulation between the inner wall and the outer wall, wherein the insulation provides rigidity to the inner wall.

18. The system of claim 16, wherein the electronic controller is configured to dispense the liquid beverage at a substantially constant flow rate at the nozzle when the nozzle is open.
19. The system of claim 16, wherein the gas source comprises an air pump.
20. The system of claim 16, wherein the gas source comprises a gas canister with a control valve.
21. The system of claim 16, wherein the surface area exposed consists essentially of a nozzle plunger lower end when the nozzle is closed.
22. The system of claim 16, wherein the surface area exposed consists essentially of an inner surface of a nozzle tip below a nozzle plunger when the nozzle is open.
23. The system of claim 22, wherein the surface area exposes further consists essentially of a lower end of the nozzle plunger.
24. A nozzle for dispensing a liquid, the nozzle comprising:  
a nozzle adapter having a cylindrical inner surface;  
a nozzle tip comprising  
    an outer surface,  
    an inner surface having a helical groove, and  
    a top end rotatably coupled to the nozzle adapter cylindrical inner surface; and  
a plunger disposed within the nozzle tip, the plunger comprising  
    a body having a cylindrical outer surface,  
    a top end,  
    a tapered lower end that mates with a bottom of the nozzle tip inner surface to form a liquid tight seal between the plunger and the nozzle tip when the nozzle is closed, and  
    at least one projection along the body outer surface between the top end and the lower end keyed to fit within the helical groove of the nozzle tip, wherein rotational motion of the nozzle tip causes axial motion of the plunger relative to the nozzle adapter without appreciable axial motion of the nozzle tip relative to the nozzle adapter.

25. The nozzle of claim 24, wherein the plunger comprises a tip comprising a shape that redirects transaxial fluid flow to axial fluid flow.
26. The nozzle of claim 25, wherein the plunger tip comprises a conical shape.
27. The nozzle of claim 26, wherein the plunger tip further comprises vanes spaced apart on the tip.
28. The nozzle of claim 25, wherein the plunger tip comprises vanes spaced apart on the plunger tip.
29. The nozzle of claim 24, wherein the nozzle adapter further comprises an inner tube retainer, the inner tube retainer being dimensioned to fasten an end of a first tube having a first diameter.
30. The nozzle of claim 29, wherein the nozzle adapter further comprises a barbed fitting dimensioned to fasten an end of a second tube, the second tube having a second diameter greater than the first tube diameter.
31. The nozzle of claim 30, wherein the first tube is disposed within the second tube.
32. The nozzle of claim 24, wherein the nozzle adapter further comprises an upper end configured to mechanically couple onto a spout.
33. The nozzle of claim 24, wherein the nozzle adapter further comprises an upper end that is configured to attach to a container of liquid.
34. The nozzle of claim 33, wherein the upper end of the nozzle adapter is ultra-sonically welded to the container.
35. The nozzle of claim 24, wherein the nozzle adapter further comprises an upper end configured to couple to a hose.
36. The nozzle of claim 35, wherein the upper end of the nozzle adapter comprises a barbed fitting.
37. The nozzle of claim 24, wherein the nozzle adapter has at least one groove spanning at least a portion of the circumference of the cylindrical inner surface, and wherein the cylindrical plunger comprises at least one tab on an

outer surface of the top end disposed to fit within the at least one groove of the nozzle adapter to allow for rotational motion, but substantially no axial motion, of the nozzle tip relative to the nozzle adapter.

38. The nozzle of claim 37, wherein the at least one groove spanning at least a portion of the circumference of the cylindrical inner surface and the at least one tab on the outer surface of the top end of the plunger are configured so that the range of rotational motion of the nozzle tip within the nozzle adapter is substantially 90°.

39. The nozzle of claim 24, wherein the plunger comprises channels running down an axial length of the body outer surface allowing for the flow of the liquid when the nozzle is open.

40. The nozzle of claim 24, wherein vertical grooves are defined along an axial length of the inner surface of the nozzle adapter, and wherein the top end of the plunger comprises vertical projections disposed to fit within the vertical grooves of the nozzle adapter to allow for axial motion without substantial rotational motion of the plunger.

41. The nozzle of claim 24, further comprising a nozzle drive comprising:  
a cylindrical inner surface attached to the outer surface of the nozzle tip;  
a gear disposed around an outer surface of the nozzle drive; and  
a drive mechanism configured to turn the gear to open and close the nozzle.

42. The nozzle of claim 41, wherein the cylindrical inner surface of the nozzle drive and the outer surface of the nozzle tip each comprise projections and recesses keyed to each other so that rotational motion of the nozzle drive causes a corresponding rotational motion of the nozzle tip without substantial slippage.

43. The nozzle of claim 41, wherein the drive mechanism comprises a worm drive.

44. The nozzle of claim 41, wherein the gear further comprises a radial position sensor.

45. The nozzle of claim 44, wherein the radial position sensor comprises a photo-interrupter plate and an optical detector.

46. The nozzle of claim 41, wherein the nozzle drive further comprises a water inlet path to provide water when the nozzle is open.



47. The nozzle of claim 41, wherein the nozzle drive further comprises one or more apertures between the outer surface of the nozzle tip and the inner surface of the nozzle drive, and wherein the inner surface of the nozzle drive is shaped to create a gap between the inner surface of the nozzle drive and the outer surface of the nozzle tip, whereby a water inlet path is formed.
48. The nozzle of claim 24, wherein the nozzle tip further comprises at least one groove along the circumference of the outer surface and an o-ring disposed in the at least one groove.
49. The nozzle of claim 41, wherein the nozzle tip further comprises a plurality of grooves along the circumference of the outer surface positioned so that one groove of the plurality of grooves is adjacent to the inner circumference of the nozzle adapter and the one groove is adjacent to the cylindrical inner surface of the nozzle drive, and an o-ring disposed in each of the plurality of grooves.
50. The nozzle of claim 24, wherein the nozzle tip, the plunger and the nozzle adapter are each constructed of a material selected from the group consisting of high density polyethylene, low density polyethylene, polyethylene terephthalate, polypropylene, and combinations thereof.
51. The nozzle of claim 41, further comprising:  
a cup having a cylindrical hole housing the nozzle drive;  
a water inlet path through the cup;  
a water inlet recess defined on the outer surface of the nozzle drive, the water inlet recess positioned such that the nozzle drive rotates to open the nozzle when pressurized water passes through the water inlet path; and  
a circular spring surrounding the nozzle drive and attached at one end to the nozzle drive and at the other end to the cup, tensioned to close the nozzle when the pressurized water is not flowing through the water inlet path.
52. A method for operating a nozzle, the nozzle comprising a nozzle tip with a tapered cavity and a plunger with a tapered end disposed within the nozzle tip, the method comprising:  
rotating the nozzle tip in a first rotational direction to move the plunger in a first axial direction, thereby opening the nozzle;  
dispensing a liquid; and  
rotating the nozzle tip in a second rotational direction opposite the first rotational direction to move the

plunger in a second axial direction opposite the first axial direction, thereby closing the nozzle and forming a liquid tight seal.

53. The method of claim 52, wherein rotating the nozzle tip further comprises activating a nozzle drive coupled to the nozzle tip.

54. The method of claim 53, wherein activating the nozzle drive further comprises running a motor coupled to the nozzle drive.

55. The method of claim 53, wherein the nozzle drive further comprises a water inlet, the method further comprising:

introducing a flow of water while dispensing the liquid; and  
stopping the flow of water when closing the nozzle.

56. The method of claim 53, wherein the nozzle drive further comprises a water inlet, the method further comprising:

introducing a flow of water while dispensing the liquid; and  
stopping the flow of water at a time after closing the nozzle.

57. The method of claim 56, further comprising washing the nozzle after closing the nozzle.

58. A method for dispensing a liquid, the method comprising:

measuring a temperature inside a chamber, the chamber containing a membrane having the liquid to be dispensed;

measuring a first pressure inside the chamber;

introducing an amount of gas inside the chamber after measuring the first pressure;

measuring a second pressure inside the chamber after introducing the amount of gas; and

adjusting the pressure in the chamber to dispense the liquid at a desired flow rate after measuring the second pressure.

59. The method of claim 58, wherein the adjusting the pressure comprises controlling a gas source to introduce gas into the chamber.

60. The method of claim 58, wherein the gas comprises air.
61. The method of claim 58, wherein the desired flow rate is substantially constant.
62. The method of claim 61, wherein the pressure inside the chamber is adjusted to be a value,  $P_{TC}$ , where  $P_{TC} = P_{TH} + ((\rho_P * g) / (W_C * D_C)) * ((n_A * R * T) / (P_2 - P_1) - V_C)$ , where  $P_{TH}$  is a parameter set to a desired value,  $\rho_P$  is a density of the dispensed liquid,  $g$  is a gravitational constant,  $W_C$  is a width of the chamber,  $D_C$  is a depth of the chamber,  $n_A$  is the amount of gas introduced in the chamber between the first measuring and the second measuring,  $R$  is a gas constant,  $T$  is the measured temperature inside the chamber,  $P_1$  is the first pressure,  $P_2$  is the second pressure, and  $V_C$  is a volume of the chamber.
63. The method of claim 62, wherein  $P_{TH}$  is between about 0 psi and about 10 psi.
64. The method of claim 62, wherein the introducing the amount of gas comprises running a pump for a predetermined period of time, and wherein the amount of gas introduced into the chamber,  $n_A$ , is  $n_A = (P_2 - P_1) * V_C / (R * T)$ , where  $V_C$  is the volume of the chamber,  $R$  is the gas constant, and  $T$  is the measured temperature inside the chamber.
65. The method of claim 62, wherein the introducing the amount of gas comprises running a pump for a predetermined number of cycles, and wherein the amount of gas introduced into the chamber,  $n_A$ , is  $n_A = (P_2 - P_1) * V_C / (R * T)$ , where  $V_C$  is the volume of the chamber,  $R$  is the gas constant, and  $T$  is the measured temperature inside the chamber.
66. The method of claim 62, wherein the introducing the amount of gas comprises opening a gas source for a predetermined period of time, and wherein the amount of gas introduced into the chamber,  $n_A$ , is  $n_A = (P_2 - P_1) * V_C / (R * T)$ , where  $V_C$  is the volume of the chamber,  $R$  is the gas constant, and  $T$  is the measured temperature inside the chamber.
67. The method of claim 61, wherein the pressure inside the chamber is adjusted to be a value,  $P_{TC}$ , where  $P_{TC} = P_{TH}$ , where  $P_{TH}$  is a parameter set to a desired value.

68. The method of claim 67, wherein initial physical dimensions of the membrane comprise a slim profile, wherein a height of the membrane is less than a width and a length of the membrane.
69. The method of claim 68, wherein the initial physical dimensions of the membrane are chosen so that a decrease in a head height pressure from a full membrane to an empty membrane is less than 10% of  $P_{TC}$ .
70. The method of claim 68, wherein the initial physical dimensions of the membrane are chosen so that a decrease in a head height pressure from a full membrane to an empty membrane is less than 20% of  $P_{TC}$ .
71. The method of claim 68, wherein the initial physical dimensions of the membrane comprise a height of the membrane that is less than 61% of the width or the length of the membrane.
72. The method of claim 59, further comprising, after the adjusting:  
opening a nozzle;  
dispensing a portion of the liquid out of the nozzle;  
closing the nozzle; and  
repeating the adjusting the pressure in the chamber.
73. The method of claim 72, further comprising:  
introducing a flow of water at the nozzle while dispensing the liquid; and  
stopping the flow of water when closing the nozzle.
74. The method of claim 67, further comprising:  
introducing a flow of water at the nozzle while dispensing the liquid; and  
stopping the flow of water at a time after closing the nozzle.
75. The method of claim 58, wherein the amount of gas introduced inside the chamber is determined by  $n_A = (P_2 - P_1) * V_C / (RT)$ , where  $V_C$  is a volume of the chamber,  $R$  is a gas constant, and  $T$  is the measured temperature inside the chamber.
76. A method for dispensing a liquid beverage, the method comprising:  
measuring a temperature inside a chamber containing a compressible container having a liquid to be

dispensed;

measuring a first pressure inside the chamber;

introducing an amount of air inside the chamber by running an air pump for a predetermined period of time after the measuring the first pressure;

measuring a second pressure inside the chamber after the introducing the amount of air;

adjusting the pressure inside the chamber to dispense the liquid beverage at a desired flow rate after the measuring the second pressure;

opening a nozzle;

dispensing a liquid beverage out of the nozzle;

closing the nozzle; and

repeating the adjusting the pressure inside the chamber to dispense the liquid at a desired flow rate.

77. The method of claim 76, further comprising mixing water with the dispensed liquid beverage at the nozzle.

78. The method of claim 77, further comprising rinsing the nozzle with water after the dispensing the liquid beverage out of the nozzle.

79. The method of claim 76, wherein the pressure inside the chamber is adjusted to be a value,  $P_{TC}$ , where  $P_{TC} = P_{TH} + ((\rho_P * g) / (W_C * D_C)) * ((n_{\Delta} * R * T) / (P_2 - P_1) - V_C)$ , where  $P_{TH}$  is a parameter set to a desired value,  $\rho_P$  is a density of the dispensed liquid beverage,  $g$  is a gravitational constant,  $W_C$  is a width of the chamber,  $D_C$  is a depth of the chamber,  $n_{\Delta}$  is the amount of air introduced in the chamber between the first measuring and the second measuring,  $R$  is a gas constant,  $T$  is the measured temperature inside the chamber,  $P_1$  is the first pressure,  $P_2$  is the second pressure, and  $V_C$  is a volume of the chamber.

80. The method of claim 79, wherein  $P_{TH}$  is between about 0 psi and about 10 psi.

81. The method of claim 79, wherein the amount of gas introduced inside the chamber,  $n_{\Delta}$ , is  $n_{\Delta} = (P_2 - P_1) * V_C / (R * T)$ , where  $V_C$  is the volume of the chamber,  $R$  is the gas constant, and  $T$  is the measured temperature inside the chamber.

82. A method for determining a volume of a liquid in a container, the method comprising:  
measuring a temperature inside a sealed chamber containing the container of the liquid;  
measuring a first pressure inside the chamber;  
introducing an amount of gas into the chamber after the measuring the first pressure;  
measuring a second pressure inside the chamber after the introducing the amount of gas; and  
after the measuring the second pressure, determining the volume according to  $V_P = V_C - (n_A * R * T) / (P_2 - P_1)$ ,  
where  $n_A$  is the amount of gas introduced into the chamber between the first measuring and the second measuring,  $R$   
is a gas constant,  $T$  is the measured temperature inside the chamber,  $P_1$  is the first pressure,  $P_2$  is the second pressure,  
and  $V_C$  is a volume of the chamber.
83. A system for dispensing a liquid beverage, the system comprising:  
a source of a liquid beverage, the source being under pressure;  
a nozzle coupled to the source, wherein the pressure causes the liquid beverage to flow from the source to  
the nozzle when the nozzle is in an open position; and  
a hat valve attached to the nozzle, wherein the hat valve prevents flow of the liquid beverage from the  
nozzle to the source.
84. The system of claim 83, wherein the nozzle comprises:  
a nozzle body; and  
a plunger disposed within the nozzle body, wherein the plunger can move axially within the nozzle body,  
and wherein the hat valve is coupled to the plunger.
85. The system of claim 84, wherein the plunger is prevented from rotating within the nozzle body.
86. The system of claim 84, wherein the nozzle further comprises an adapter sealing surface coupled to the  
nozzle body, the adapter sealing surface positioned so that the hat valve forms a seal with the adapter sealing surface  
when the nozzle is in a closed position.
87. The system of claim 86, further comprising a seal between the nozzle body and the adapter sealing surface.
88. The system of claim 87, wherein the seal comprises an o-ring.

89. The system of claim 87, wherein the seal comprises an interference fit between the nozzle body and the adapter sealing surface.
90. The system of claim 83, wherein the hat valve prevents contamination of the source.
91. The system of claim 83, wherein the source is refrigerated.
92. The system of claim 83, wherein the pressure comprises a positive pressure.
93. The system of claim 92, wherein the positive pressure prevents source contamination of the source by the nozzle.
94. The system of claim 83, further comprising a higher chamber disposed on a top side of the nozzle, the top side of the nozzle comprising the hat valve, wherein a top side of the hat valve faces the higher chamber, and wherein a lower chamber is defined within the nozzle on a lower side of the hat valve.
95. The system of claim 94, further comprising a pressure sensor disposed between the higher chamber and the lower chamber.
96. The system of claim 95, wherein a pressure difference between a pressure in the higher chamber and a pressure in the lower chamber is sensed by the pressure sensor.
97. The system of claim 96, further comprising a monitoring system that monitors the pressure sensor.
98. The system of claim 97, wherein the monitoring system emits a user perceptible warning when the pressure in the lower chamber exceeds the pressure in the higher chamber.
99. The system of claim 97, further comprising a lockout system, wherein the lockout system prevents a user from dispensing the liquid beverage if the monitoring system senses that the pressure in the lower chamber exceeds the pressure in the higher chamber.
100. The system of claim 97, wherein the monitoring system comprises a microcontroller.

101. A method for dispensing a liquid beverage, the method comprising:  
pressurizing a source of a liquid beverage, the source of the liquid beverage coupled to a nozzle comprising a hat valve separating the source of the liquid beverage from an interior of the nozzle;  
opening the nozzle, wherein the opening comprises opening the hat valve, wherein the liquid beverage flows past the hat valve through the nozzle; and  
closing the nozzle, wherein the closing comprises closing the hat valve.
102. The method of claim 101, wherein closing the hat valve comprises forming a seal between the hat valve and a surface of the nozzle.
103. The method of claim 101, wherein a pressure of the source of the liquid beverage exceeds a pressure of the interior of the nozzle when the nozzle is in a closed state.
104. The method of claim 103, further comprising sensing a difference between the pressure of the source of the liquid beverage and the pressure of the interior of the nozzle.
105. The method of claim 104, wherein the sensing comprises monitoring a pressure sensor disposed between the source of the liquid beverage and the interior of the nozzle.
106. The method of claim 105, further comprising warning a user when the pressure sensor indicates that the pressure of the interior of the nozzle exceeds the pressure of the source of the liquid beverage.
107. The method of claim 106, wherein the warning comprises a user perceptible warning.
108. The method of claim 107, wherein the user perceptible warning comprises an audible alarm.
109. The method of claim 105, further comprising locking out a user when the pressure sensor indicates that the pressure of the interior of the nozzle exceeds the pressure of the source of the liquid beverage, wherein the locking out comprises preventing the user from dispensing the liquid beverage.
110. The method of claim 105, wherein the monitoring comprises monitoring the pressure sensor with a microprocessor.



111. A pressurized beverage dispensing system comprising:  
a pressurized gas source; and  
a bag-in-box container comprising a flexible fluid container disposed within a box, the box disposed within a pressure-sealed chamber, wherein the box comprises outer walls and a vent hole disposed in at least one of the outer walls, and wherein pressurized gas from the pressurized gas source exerts pressure on the flexible fluid container.
112. The dispensing system of claim 111, wherein the bag-in-box container further comprises a spout disposed on the flexible fluid container.
113. The dispensing system of claim 111, wherein the vent hole is closed before use.
114. The dispensing system of claim 113, wherein the vent hole is covered with a perforated tear-out cover before use.
115. The dispensing system of claim 114, further comprising a spout, wherein the spout is covered with a perforated tear-out cover before use.
116. The dispensing system of claim 111, wherein the box comprises cardboard.
117. The dispensing system of claim 111, wherein the pressurized gas source comprises an air pump.
118. The dispensing system of claim 111, wherein the flexible fluid container comprises a flexible liner.
119. The dispensing system of claim 118, wherein the flexible liner comprises linear low-density polyethylene.
120. The dispensing system of claim 118, wherein the flexible liner comprises metallized polyester.
121. The dispensing system of claim 118, wherein the flexible fluid container is capable of sealing with a heat seal.
122. The dispensing system of claim 111, wherein the bag-in-box container is disposable.

123. The dispensing system of claim 111, wherein the bag-in-box container is capable of transport.
124. A bag-in-box container for storing and dispensing a liquid beverage, the bag-in-box container comprising:  
a box comprising an opening through which pressurized gas can pass; and  
a flexible fluid container disposed within the box, wherein gas pressure exerted on the flexible fluid container is transferred to contents of the flexible fluid container via flexible walls of the flexible fluid container.
125. The bag-in-box container of claim 124, wherein the opening comprises a covering prior to a first use.
126. The bag-in-box container of claim 125, wherein the covering comprises a tear-out covering.
127. The bag-in-box container of claim 124, further comprising a spout attached to the flexible fluid container.
128. The bag-in-box container of claim 127, wherein the spout is covered with a tear-out covering prior to a first use.
129. The bag-in-box container of claim 128, wherein the opening comprises a covering prior to the first use, wherein the covering comprises a tear-out covering, and wherein the box, the covering of the opening, and the covering of the spout comprise cardboard.
130. The bag-in-box container of claim 124, wherein the bag-in-box container is disposable.
131. The bag-in-box container of claim 124, further comprising a tube, wherein the tube is attached to an inside bottom of the flexible fluid container.
132. The bag-in-box container of claim 131, further comprising an outlet through which the tube is routed.
133. The bag-in-box container of claim 131, wherein the tube is attached to the inside bottom of the flexible fluid container with an ultrasonic weld.
134. The bag-in-box container of claim 132, wherein the outlet is disposed on a top surface of the flexible fluid container.

135. A method for operating a beverage dispenser, the method comprising:  
installing a bag-in-box container in a pressure-sealed chamber in the beverage dispenser, the bag-in-box container comprising a liner disposed within a box, wherein a liquid beverage is contained within the liner;  
pressurizing the chamber; and  
dispensing the liquid beverage.
136. The method of claim 135, wherein the installing comprises:  
inserting the bag-in-box container into the beverage dispenser; and  
connecting a spout disposed on the liner to the beverage dispenser.
137. The method of claim 136, wherein the installing further comprises opening a vent hole disposed on a surface of the box.
138. The method of claim 137, wherein the opening the vent hole comprises removing a tear-out covering disposed over the vent hole.
139. The method of claim 136, wherein the installing further comprises exposing the spout.
140. The method of claim 139, wherein the exposing comprises removing a tear-out covering disposed over the spout.
141. The method of claim 135, wherein the installing comprises:  
inserting the bag-in-box container into the beverage dispenser; and  
connecting a tube attached to the liner to the beverage dispenser.
142. The method of claim 141, wherein the connecting comprises attaching an end of the tube to a nozzle, wherein the nozzle comprises a barbed fitting, wherein the barbed fitting forms a seal on the tube.
143. A nozzle for dispensing a liquid, the nozzle comprising:  
a nozzle adapter having a barbed fitting for attaching to a tube;  
a nozzle tip comprising  
an outer surface,

an inner surface having a helical groove, and  
a top end rotatably coupled to the nozzle adapter; and  
a plunger disposed within the nozzle tip, the plunger comprising  
a body having a cylindrical outer surface,  
a top end,  
a tapered lower end that mates with a bottom end of the nozzle to form a liquid tight seal between  
the plunger and the nozzle tip when the nozzle is closed, and  
at least one projection along the body outer surface between the top end of the plunger and the  
bottom end of the nozzle keyed to fit within the helical groove of the inner surface of the nozzle tip, wherein  
rotational motion of the nozzle tip causes axial motion of the plunger relative to the nozzle adapter without  
appreciable axial motion of the nozzle tip relative to the barbed fitting.

144. The nozzle of claim 143, wherein the tapered lower end mates with the bottom end of the nozzle using an o-ring.

145. The nozzle of claim 143, wherein the tapered lower end mates with the bottom end of the nozzle using an interference fit.

146. The nozzle of claim 145, wherein the interference fit creates a liquid and air tight seal against an inside of the tube.

147. A system for dispensing a liquid, the system comprising:  
a product chamber;  
a first product container comprising a liquid disposed within the product chamber, wherein the first product container comprises a path for a gas pressure to be exerted on the liquid, and wherein a height of the first product container is less than each of a width and a length of the product chamber;  
a gas pressure source coupled to the product chamber, wherein the gas pressure source exerts the gas pressure on the liquid; and  
an outlet disposed on the first product container through which the liquid is dispensed.

148. The system of claim 147, wherein the first product container comprises a bag-in-box container, the bag-in-box container comprising a flexible membrane disposed within a rigid box.
149. The system of claim 148, wherein the path for the gas pressure to be exerted comprises a hole in the rigid box.
150. The system of claim 147, wherein the gas pressure source pressurizes the product chamber to a target system pressure.
151. The system of claim 150, wherein the target system pressure is selected so that a decrease in a head height pressure of the liquid from a full first product container to an empty first product container is less than 10% of the target system pressure.
152. The system of claim 150, wherein the target system pressure is selected so that a decrease in a head height pressure of the liquid from a full first product container to an empty first product container is less than 10% of the target system pressure.
153. The system of claim 147, further comprising a second product container disposed in the product chamber.
154. The system of claim 153, wherein the second product container comprises similar physical dimensions as the first product container.
155. The system of claim 147, further comprising a nozzle coupled to the outlet.
156. The system of claim 155, further comprising a tube, wherein a first end of the tube is coupled to the outlet, and wherein a second end of the tube opposite the first end is coupled to the nozzle.
157. The system of claim 156, wherein the nozzle is located above a surface and the product chamber is located below the surface.
158. The system of claim 157, wherein the surface comprises a counter-top.

159. A method for dispensing a liquid beverage, the method comprising:  
applying a gas pressure to an inside of a chamber, wherein the gas pressure is transferred to a liquid beverage contained within a container disposed in the chamber; and  
dispensing the liquid beverage from the container, wherein the container comprises a height less than each of a width and a length of the chamber.
160. The method of claim 159, wherein the gas pressure is generated by an air pump.
161. The method of claim 159, wherein the dispensing comprises opening a nozzle coupled to the container.
162. The method of claim 159, wherein a drop in a head height pressure exerted by the liquid beverage in the container from a full container to an empty container does not exceed 10% of the applied gas pressure.
163. The method of claim 159, wherein a drop in a head height pressure exerted by the liquid beverage in the container from a full container to an empty container does not exceed 20% of the applied gas pressure.
164. A system for dispensing a liquid beverage, the system comprising:  
a storage container comprising a liquid beverage, the storage container disposed within a pressure-sealed chamber;  
a tube, wherein a first end of the tube is coupled to the storage container, whereby the liquid beverage can pass from the storage container through the tube;  
a tube chute, wherein the tube is disposed within the tube chute; and  
a nozzle coupled to a second end of the tube opposite the first end of the tube.
165. The system of claim 164, wherein the tube comprises a tube set.
166. The system of claim 164, wherein the tube and the nozzle comprise a tube set.
167. The system of claim 166, wherein the tube attaches to the storage container with a quick disconnect connection, and wherein the tube set further comprises the quick disconnect connection.
168. The system of claim 164, wherein the tube is easily removable from the tube chute.

169. The system of claim 168, wherein the tube slides in and out of the tube chute.
170. The system of claim 164, wherein the tube is disposable.
171. The system of claim 164, further comprising a first tube adapter coupling the first end of the tube to the storage container, and a second tube adapter coupling the second end of the tube to the nozzle.
172. The system of claim 171, wherein the first tube adapter snaps onto the tube.
173. The system of claim 171, wherein an interface between the first tube adapter and the first end of the tube forms a water-tight and air-tight seal.
174. The system of claim 171, wherein an interface between the second tube adapter and the nozzle forms a water-tight and air-tight seal.
175. The system of claim 164, wherein the tube is welded to the storage container.
176. The system of claim 164, further comprising drinking water lines, wherein the drinking water lines are routed through the tube chute.
177. The system of claim 164, further comprising cooling lines, wherein the cooling lines are routed through the tube chute.
178. The system of claim 164, wherein the nozzle comprises an actuator, wherein the actuator comprises an electrical connection, wherein the electrical connection is routed through the tube chute.
179. The system of claim 164, further comprising a user switch and an electrical connection electrically coupled to the user switch, wherein the electrical connection is routed through the tube chute.
180. The system of claim 164, further comprising a dispense head disposed on the tube chute, wherein the dispense head comprises the nozzle.
181. The system of claim 180, wherein the dispense head further comprises a user switch.

182. A system for dispensing a liquid beverage, the system comprising:
- a first liquid storage container disposed within a first chamber, the first liquid storage container comprising an outlet for dispensing the liquid beverage;
  - a second liquid storage container disposed within a second chamber, the second storage container comprising an outlet for dispensing the liquid beverage;
  - a first check valve coupled to the first liquid storage container outlet, wherein the first check valve is oriented so that the liquid beverage is prevented from flowing back toward the first liquid storage container;
  - a second check valve coupled to the second liquid storage container outlet, wherein the second check valve is oriented so that the liquid beverage is prevented from flowing back toward the second liquid storage container;
  - and
  - a tee fitting comprising a first input port coupled to the first check valve, a second input port coupled to the second check valve, and an exit port.
183. The system of claim 182, further comprising a nozzle coupled to the exit port.
184. The system of claim 182, wherein the first and second liquid storage containers each comprises a flexible membrane that allows gas pressure to exert a force on the liquid beverage stored inside each liquid storage container.
185. The system of claim 182, further comprising a controller to control a pressure in the first and the second chambers.
186. The system of claim 185, wherein the controller is configured to control the pressure by applying a pressure to the first chamber greater than a pressure of the second chamber until the first liquid storage container is empty, then applying a pressure to the second chamber, wherein the liquid beverage is dispensed from the first chamber until the first chamber is empty, then the liquid beverage is dispensed from the second chamber.
187. The system of claim 185, wherein the controller is configured to control the pressure by:
- applying a first pressure to the first chamber and a second pressure to the second chamber, wherein the first pressure is greater than the second pressure, and wherein the liquid beverage flows from the first liquid storage container at a first flow rate, and the liquid beverage does not flow from the second liquid storage container until the first liquid storage container is almost empty;



when the first liquid storage container is almost empty, applying a third pressure to the second chamber and applying a fourth pressure to the first chamber so that the liquid beverage flows from the first liquid storage container at a second flow rate, and the liquid beverage flows from the second liquid storage container at a third flow rate until the first liquid storage container is empty; and

when the first liquid storage container is empty, applying a fifth pressure to the second chamber, wherein the liquid beverage flows from the second liquid storage container flows at a fourth flow rate.

188. The system of claim 187, wherein the sum of the second and third flow rates equals the first flow rate, and wherein the fourth flow rate equals the first flow rate.

189. The system of claim 187, wherein the fourth pressure is greater than the first pressure, and wherein the third pressure is greater than the second pressure.

190. The system of claim 188, wherein the third pressure is within about 0.05 psi to about 1 psi of a system target pressure.

191. The system of claim 187, wherein a flow of the liquid beverage remains constant while the liquid beverage changes from being dispensed from the first liquid storage container to the second liquid storage container.

192. The system of claim 182, wherein the first check valve and first input port are coupled by a first tube, and wherein the second check valve and the second input port are coupled by a second tube.

193. The system of claim 192, wherein the first tube and the second tube comprise a tube set.

194. The system of claim 192, wherein the first tube, the second tube, the first check valve, and the second check valve comprise a tube set.

195. The system of claim 193, wherein the tube set further comprises a nozzle.

196. The system of claim 195, wherein the tube set further comprises a third tube, the third tube coupling the tee fitting to the nozzle.

197. The system of claim 196, wherein the tube set further comprises the tee fitting.
198. The system of claim 197, wherein the first and second check valves are disposed within the tee fitting.
199. The system of claim 194, wherein the tube set is disposable.
200. The system of claim 182, wherein the first liquid storage container outlet and the first check valve are coupled by a first tube, and wherein the second liquid storage container outlet and the second check valve are coupled by a second tube.
201. The system of claim 200, wherein the first tube, the second tube, the first check valve, and the second check valve comprise a tube set.
202. A method for dispensing a liquid beverage, the method comprising:  
dispensing a liquid stored in a first container within a first chamber at a first flow rate until the first container is substantially empty;  
after the first container is almost empty, dispensing a liquid stored in a second container within a second chamber at a second flow rate while dispensing the remaining liquid stored in the first container at a third flow rate until the first container is empty, wherein the liquid flowing from the first container is combined with the liquid flowing from the second container to form a combined flow, the combined flow comprising a fourth flow rate; and  
after the first container is empty, dispensing the liquid stored in the second container within the second chamber at a fifth flow rate.
203. The method of claim 202, wherein the first, fourth, and fifth flow rates are substantially equal.
204. The method of claim 202, wherein the dispensing the liquid stored in the first and second containers comprises applying pressure to the first chamber and pressure to the second chamber, wherein the pressures applied to the first and second chambers create a force against the liquid in the first and second containers.
205. The method of claim 204, wherein the pressure applied to the first chamber is increased when the first container is almost empty.

206. The method of claim 204, wherein, before the first container is almost empty, the pressure applied to the first chamber is greater than the pressure applied to the second chamber, wherein the liquid flows from the first container but does not flow from the second container.
207. The method of claim 204, wherein the pressure applied to the second chamber after the first container is almost empty is greater than the pressure applied to the second chamber before the first container is almost empty.
208. The method of claim 207, wherein the pressure applied to the second chamber after the first container is almost empty is about 0.05 psi to about 1.0 psi below a system target pressure.
209. The method of claim 208, wherein the pressure applied to the second chamber is increased to the system target pressure after the first container is empty.
210. A nozzle for dispensing a liquid, the nozzle comprising:  
a nozzle tip comprising an outer surface and an inner surface; and  
a plunger disposed axially within the nozzle tip, wherein  
liquid is prevented from flowing through the nozzle when the plunger is in a closed position, and  
liquid flows through the nozzle when the plunger is in an open position, and the plunger has a tip comprising a shape that redirects transaxial fluid flow to axial fluid flow.
211. The nozzle of claim 210, wherein the plunger tip comprises a conical shape.
212. The nozzle of claim 211, wherein the plunger tip further comprises vanes spaced apart on the plunger tip.
213. The nozzle of claim 210, wherein the plunger tip comprises vanes spaced apart on the plunger tip.
214. A liquid storage system comprising:  
a chamber;  
a pressurized gas source coupled to the chamber;  
a liquid storage container disposed inside the chamber, wherein the liquid storage container comprises an orifice, and wherein the pressurized gas source imparts a pressure on liquid stored within the liquid storage container; and

a dispensing nozzle coupled to the orifice, the dispensing nozzle dimensioned to couple with a check valve disposed on a serving container.

215. The system of claim 214, wherein the serving container has the capacity for multiple individual servings.

216. The system of claim 214, wherein the flask further comprises the check valve disposed within a surface of the serving container, the check valve dimensioned to mate with the dispensing nozzle, wherein the liquid can flow from the liquid storage container to the serving container when the check valve is mated with the dispensing nozzle and the dispensing nozzle is in an open position.

217. The system of claim 216, wherein the dispensing nozzle is disposed on a bottom of the serving container.

218. The system of claim 216, wherein the dispensing nozzle protrudes through a top surface of a counter-top, and wherein the chamber is disposed beneath the top surface of the counter-top.

219. The system of claim 216, wherein the dispensing nozzle opens upon user request.

220. The system of claim 216, further comprising an actuator, wherein the actuator opens and closes the dispensing nozzle.

221. The system of claim 220, wherein the actuator is controlled by a microcontroller.

222. The system of claim 216, further comprising a water line, wherein the water line is coupled to the dispensing nozzle.

223. The system of claim 216, wherein the check valve comprises:  
an outlet through which the liquid flows when the dispensing nozzle is in the open position; and  
a flow diverter disposed over the outlet, whereby the liquid is prevented from escaping the serving container while flowing from the liquid storage container to the serving container.

224. The system of claim 223, further comprising:  
a ball disposed over the outlet, wherein the ball seals the orifice when the serving container is disconnected

from the check valve; and

a spring disposed over the ball, the spring pushing the ball against the orifice.

225. The system of claim 214, wherein the pressurized gas source provides pressurized air.

226. The system of claim 225, wherein the pressurized gas source comprises an air pump.

227. The system of claim 214, wherein the check valve is disposed within a side of the serving container.

228. The system of claim 214, wherein the liquid storage container comprises a bag-in-box container.

229. The system of claim 228, wherein the bag-in-box container comprises a flexible fluid container disposed within a box, wherein the box comprises outer walls and a vent hole disposed in at least one of the outer walls.

230. The system of claim 214, further comprising a tube, wherein a first end of the tube is coupled to the orifice and a second end of the tube, opposite the first end, is coupled to the check valve.

231. The system of claim 214, wherein the check valve prevents the liquid from flowing from the serving container into the liquid storage container.

232. A method for dispensing a beverage, the method comprising:

placing a serving container on a nozzle disposed on a counter-top, wherein a check valve disposed on the bottom of the serving container mates with the nozzle; and

filling the serving container with a liquid beverage, wherein the liquid beverage flows from a pressurized container up through the nozzle and into the serving container.

233. The method of claim 232, further comprising rinsing the check valve after the filling the serving container, wherein the rinsing comprises causing water to flow from the nozzle through the check valve.

234. The method of claim 232, further comprising removing the serving container from the nozzle.

235. The method of claim 234, further comprising rinsing the bottom of the serving container during the removing.

236. The method of claim 235, wherein the rinsing removes substantially all the remaining liquid beverage from the bottom of the serving container.
237. The method of claim 232, wherein the filling comprises filling the serving container from the bottom of the serving container.
238. The method of claim 232, wherein the filling comprises filling the serving container from a side of the serving container.
239. The method of claim 232, wherein the filling comprises opening the nozzle and pressurizing the pressurized container, wherein pressurizing the pressurized container comprises enabling an air pump coupled to the pressurized container.
240. The method of claim 239, wherein the filling commences with an operator request.
241. A method for dispensing a beverage, the method comprising:  
dispensing relative proportions of water, cream, and concentrated skim milk for making a first dispensed beverage, wherein the dispensing comprises  
dispensing a first amount of water,  
dispensing a second amount of cream, and  
dispensing a third amount of concentrated skim milk; and  
combining the first amount of water, the second amount of cream, and the third amount of concentrated skim milk to make the first dispensed beverage.
242. The method of claim 241, further comprising determining the relative proportions of the water, the cream, and the concentrated skim milk for making the first dispensed beverage.
243. The method of claim 241, wherein:  
dispensing the first amount of water comprises dispensing the water at a first flow rate;  
dispensing the second amount of cream comprises dispensing the cream at a second flow rate; and  
dispensing the third amount of concentrated skim milk comprises dispensing the concentrated skim milk at

a third flow rate, wherein relative proportions of the first, second and third flow rates are substantially equal to the relative proportions of the water, the cream, and the concentrated skim milk for making the first dispensed beverage.

244. The method of claim 243, wherein the dispensing the first amount of water, the dispensing the second amount of cream, and the dispensing the third amount of concentrated skim milk are performed simultaneously.

245. The method of claim 241, wherein the first dispensed beverage comprises an individual serving.

246. The method of claim 241, further comprising:

dispensing relative proportions of the water, the cream, and the concentrated skim milk for making a second dispensed beverage, wherein the dispensing comprises

dispensing a fourth amount of water,

dispensing a fifth amount of cream, and

dispensing a sixth amount of concentrated skim milk; and

combining the fourth amount of water, the fifth amount of cream, and the sixth amount of concentrated skim milk to make the second dispensed beverage.

247. The method of claim 246, further comprising determining the relative proportions of the water, the cream, and the concentrated skim milk for making the second dispensed beverage.

248. The method of claim 246, wherein the relative proportions of the water, the cream, and the concentrated skim milk for making the first dispensed beverage are different from the relative proportions of the water, the cream, and the concentrated skim milk for making the second dispensed beverage.

249. The method of claim 241, wherein the determining is performed by a microcontroller.

250. The method of claim 241, wherein the water comprises water from an external water line.

251. The method of claim 250, wherein the water from the external water line is refrigerated.

252. The method of claim 241, wherein the cream and the concentrated skim milk are dispensed from separate pressurized containers.

253. The method of claim 252, wherein each pressurized container comprises:  
a pressurized chamber, wherein an air pump provides pressure to the pressurized chamber;  
a flexible liner, wherein the flexible liner comprises flexible walls which allow pressure from the pressurized chamber to be transferred to liquid stored within the flexible liner; and  
an outlet through which the liquid can flow.
254. The method of claim 253, wherein the flexible liner is disposed within a box disposed within the pressurized chamber, the box comprising vent holes allowing pressurized air to pass through the box and apply pressure on the flexible liner.
255. The method of claim 254, wherein the box and the flexible liner comprise a bag-in-box package.
256. The method of claim 241, wherein the dispensing the first amount of water, the dispensing the second amount of cream, and the dispensing the third amount of concentrated skim milk are not performed simultaneously.
257. The method of claim 241, wherein the combining is performed in a nozzle.
258. The method of claim 241, wherein the combining is performed in a mixer.
259. The method of claim 243, wherein the flow rates are monitored by flow meters.
260. The method of claim 243, wherein:  
the cream and the concentrated skim milk are dispensed from separate pressurized containers, wherein each pressurized container comprises  
a pressurized chamber, wherein an air pump provides pressure to the pressurized chamber,  
a flexible liner, wherein the flexible liner comprises flexible walls which allow pressure from the pressurized chamber to be transferred to liquid stored within the flexible liner, and  
an outlet through which the liquid can flow; and  
the second and third flow rates are controlled by adjusting the pressure to the pressurized containers.
261. The method of claim 260, wherein adjusting the pressure comprises operating the air pump until a target pressure is reached.



262. The method of claim 261, wherein adjusting the pressure further comprises:
- measuring a temperature inside one pressurized chamber;
  - measuring a first pressure inside the one pressurized chamber;
  - introducing an amount of air inside the one pressurized chamber by running the air pump for a predetermined period of time after the measuring the first pressure;
  - measuring a second pressure inside the one pressurized chamber after the introducing the amount of air;
- and
- adjusting the pressure inside the one pressurized chamber to dispense the liquid at a desired flow rate after the measuring the second pressure.
263. A system for dispensing a liquid, the system comprising:
- a first liquid source, the first liquid source being under a first pressure;
  - a second liquid source, the second liquid source being under a second pressure; and
  - a combiner comprising
    - a first input port coupled to the first liquid source with a first connection,
    - a second input port coupled to the second liquid source with a second connection, and
    - an output port, wherein a first liquid entering the first input port combines with a second liquid entering the second input port to create a combined liquid, and wherein the combined liquid exits the exit port,
- wherein flow rates of the first and second liquid sources can be adjusted by adjusting the first and second pressures, and wherein a ratio of a relative concentration of the first and second liquids at the output port is related to a ratio of the first and second flow rates.
264. The system of claim 263, wherein:
- the first connection comprises a first tube; and
  - the second connection comprises a second tube, wherein the first tube and the second tube comprise a tube set.
265. The system of claim 264, wherein the tube set is disposable and easy to replace.
266. The system of claim 264, wherein the tube set comprises quick connect fittings.

267. The system of claim 263, wherein the output port comprises:  
a first nozzle coupled to the first input port; and  
a second nozzle coupled to the second input port.
268. The system of claim 264, wherein:  
the first tube comprises a first diameter;  
the second tube comprises a second diameter, the second diameter being smaller than the first diameter; and  
the combiner comprises  
a modified adapter comprising an inner circular ridge dimensioned to secure the second tube, and  
a larger outer barb to secure the first tube, wherein the outer barb comprises the first input port, and wherein the  
inner circular ridge comprises the second input port, and  
a single nozzle coupled to the modified adapter, wherein the single nozzle comprises the output  
port.
269. The system of claim 268, further comprising:  
a first check valve disposed in series with the first tube, the first check valve oriented to prevent backflow  
from the first input port to the first liquid source; and  
a second check valve disposed in series with the second tube, the second check valve oriented to prevent  
backflow from the second input port to the first liquid source.
270. The system of claim 268, wherein the single nozzle further comprises a mixing area for the first and second  
liquids to come together prior to exiting the single nozzle.
271. The system of claim 264, wherein the tube set comprises a tube-within-a-tube tube set, wherein the second  
tube is disposed within the first tube.
272. The system of claim 271, wherein the tube-within-a-tube tube set is disposable and easy to replace.
273. The system of claim 263, wherein the first and the second liquid sources each comprise an outlet, each  
outlet comprising an adapter sized to accept a tube, and wherein each adapter comprises a quick disconnect port to  
allow for easy removal of the tube.

274. The system of claim 268, wherein the single nozzle contains a first valve coupled to the first input port and a second valve coupled to the second input port.
275. The system of claim 274, further comprising a first actuator and a second actuator, the first actuator coupled to the first valve, and the second actuator coupled to the second valve, wherein the first and second actuators are positioned to open and close the first and second valves.
276. The system of claim 275, wherein the first and second actuators comprise electro-mechanical actuators.
277. The system of claim 268, wherein the single nozzle further comprises a water entry path disposed on the periphery of the single nozzle.
278. The system of claim 277, wherein the water entry path is used to rinse the single nozzle.
279. A nozzle for dispensing a plurality of liquids, the nozzle comprising a nozzle adapter, the nozzle adapter comprising:
- an outer input port and an inner input port;
  - an upper nozzle body rotatably coupled to the nozzle adapter, the upper nozzle body comprising an inner surface and an outer surface;
  - a lower nozzle body rotatably coupled to the upper nozzle body, the lower nozzle body comprising an inner surface and an outer surface;
  - an outer plunger disposed within the upper and lower nozzle bodies, the outer plunger comprising an inner surface and an outer surface; and
  - an inner plunger disposed within the outer plunger, the inner plunger comprising an inner surface and an outer surface.
280. The nozzle of claim 279, wherein:
- the outer input port comprises a barbed fitting dimensioned to secure an end of a first tube; and
  - the inner input port comprises a circular ridge dimensioned to secure an end of a second tube.
281. The nozzle of claim 280, wherein a diameter of the first tube is greater than a diameter of the second tube.

282. The nozzle of claim 281, wherein the second tube is disposed within the first tube.
283. The nozzle of claim 279, wherein rotational motion of the lower nozzle body causes an opening of the outer plunger, wherein the opening of the outer plunger forms an outer path for liquid to flow from the outer input port to an output port disposed at a lower end of the nozzle.
284. The nozzle of claim 283, wherein the opening of the outer plunger comprises axial motion of the outer plunger relative to the lower nozzle body.
285. The nozzle of claim 284, wherein the outer path comprises a space between the inner surface of the lower nozzle body and the outer surface of the outer plunger.
286. The nozzle of claim 279, wherein the outer plunger comprises a tapered end, wherein the tapered end fits flush with the inner surface of the lower nozzle body, the flush fitting forming a liquid seal when the outer plunger is in a closed position.
287. The nozzle of claim 283, wherein a flow rate of the outer path is proportional to a rotational position of the lower nozzle body.
288. The nozzle of claim 284, wherein:  
the inner surface of the lower nozzle body comprises a helical groove;  
the outer surface of the outer plunger comprises a pin disposed within the helical groove; and  
rotational motion of the lower nozzle body is transferred to axial motion in the outer plunger by a relative motion of the helical groove with respect to the pin.
289. The nozzle of claim 279, wherein rotational motion of the upper nozzle body causes an opening of the inner plunger, wherein the opening of the inner plunger forms an inner path for liquid to flow from the inner input port to an output port disposed at a lower end of the nozzle.
290. The nozzle of claim 289, wherein the opening of the inner plunger comprises axial motion of the inner plunger relative to the outer plunger.

291. The nozzle of claim 289, wherein the inner path comprises a space within the inner surface of the inner plunger and through holes disposed at an end of the inner plunger.
292. The nozzle of claim 279, wherein the inner plunger comprises a hole disposed at an end of the inner plunger, wherein the hole is blocked by the outer plunger when the inner plunger is in a closed position.
293. The nozzle of claim 289, wherein a flow rate of the inner path is proportional to a rotational position of the upper nozzle body.
294. The nozzle of claim 290, wherein:  
the outer surface of the inner plunger comprises a helical groove;  
the inner surface of the outer plunger comprises a pin within the helical groove;  
the outer surface of the outer plunger is rotationally fixed with respect to the inner surface of the upper nozzle body; and  
rotational motion of the lower nozzle body is transferred to axial motion in the outer plunger by a relative motion of the helical groove with respect to the pin.
295. The nozzle of claim 294, wherein:  
the inner surface of the lower nozzle body comprises a helical groove;  
the outer surface of the outer plunger comprises a pin disposed within the helical groove; and  
rotational motion of the lower nozzle body is transferred to axial motion in the outer plunger by a relative motion of the helical groove with respect to the pin.
296. The nozzle of claim 279, further comprising a seal disposed on the outer surface of the lower nozzle body, wherein the seal provides an air-tight and water tight seal between an external environment and an interior of a beverage machine.
297. The nozzle of claim 296, wherein the seal comprises an o-ring.
298. The nozzle of claim 279, further comprising:  
a seal between the upper nozzle body and lower nozzle body;

a seal between the upper nozzle body and the nozzle adapter; and  
a seal between the outer plunger and the nozzle adapter.

299. The nozzle of claim 298, wherein at least one seal comprises an o-ring.
300. The nozzle of claim 298, wherein at least one seal comprises an interference fit.
301. A system for a nozzle, the system comprising:  
a plurality of outer components, wherein each outer component is capable of independent rotational motion;  
a plurality of plungers, wherein an axial position of one of the plurality of plungers is controlled by a rotational position of one of the plurality of outer components; and  
a plurality of fluid paths, wherein a flow of one of the plurality of fluid paths is dependent on the axial position of one of the plurality of plungers.
302. The system of claim 301, wherein the plurality of fluid paths comprises concentric fluid paths.
303. The system of claim 302, wherein each of the plurality of plungers is concentrically disposed.
304. The system of claim 303, wherein at least one plunger can slide against another plunger axially.
305. The system of claim 303, wherein the rotational motion of one of the plurality of outer components is coupled to an axial motion of one of the plurality of plungers.
306. The system of claim 305, wherein the rotational motion is coupled to the axial motion with a pin set into a helical groove.
307. The system of claim 306, wherein an outer surface of at least one plunger comprises the helical groove, and an inner section of a plunger adjacent to the at least one plunger comprises the pin.
308. The system of claim 303, wherein a rotational position of at least one of the plurality of plungers is fixed with respect to the rotational position of one of the plurality of outer components.

309. The system of claim 303, wherein a rotational position of at least one of the plurality of plungers is fixed with respect to a rotational position of an adapter.
310. The system of claim 302, wherein the concentric fluid paths comprise concentric tubes.
311. The system of claim 310, further comprising:  
an internal feature that secures an inner tube, the inner tube disposed within an outer tube; and  
an additional feature that secures the outer tube.
312. The system of claim 301, wherein any sliding or rotating surface comprises a sealing component to prevent leakage.
313. The system of claim 312, wherein the sealing component comprises an o-ring.
314. The system of claim 312, wherein the sealing component comprises an interference fit.
315. The system of claim 301, wherein the plurality of outer components and the plurality of plungers snap together.
316. The system of claim 301, wherein outer sealing surfaces of each plunger are washable.
317. The system of claim 316, wherein the outer sealing surfaces are washable with water.
318. The system of claim 301, wherein every surface requiring washing can be easily rinsed with water.
319. The system of claim 301, further comprising an external seal on an outer surface of the nozzle
320. The system of claim 319, wherein the external seal is air-tight and water-tight when the nozzle is seated in a dispensing housing.

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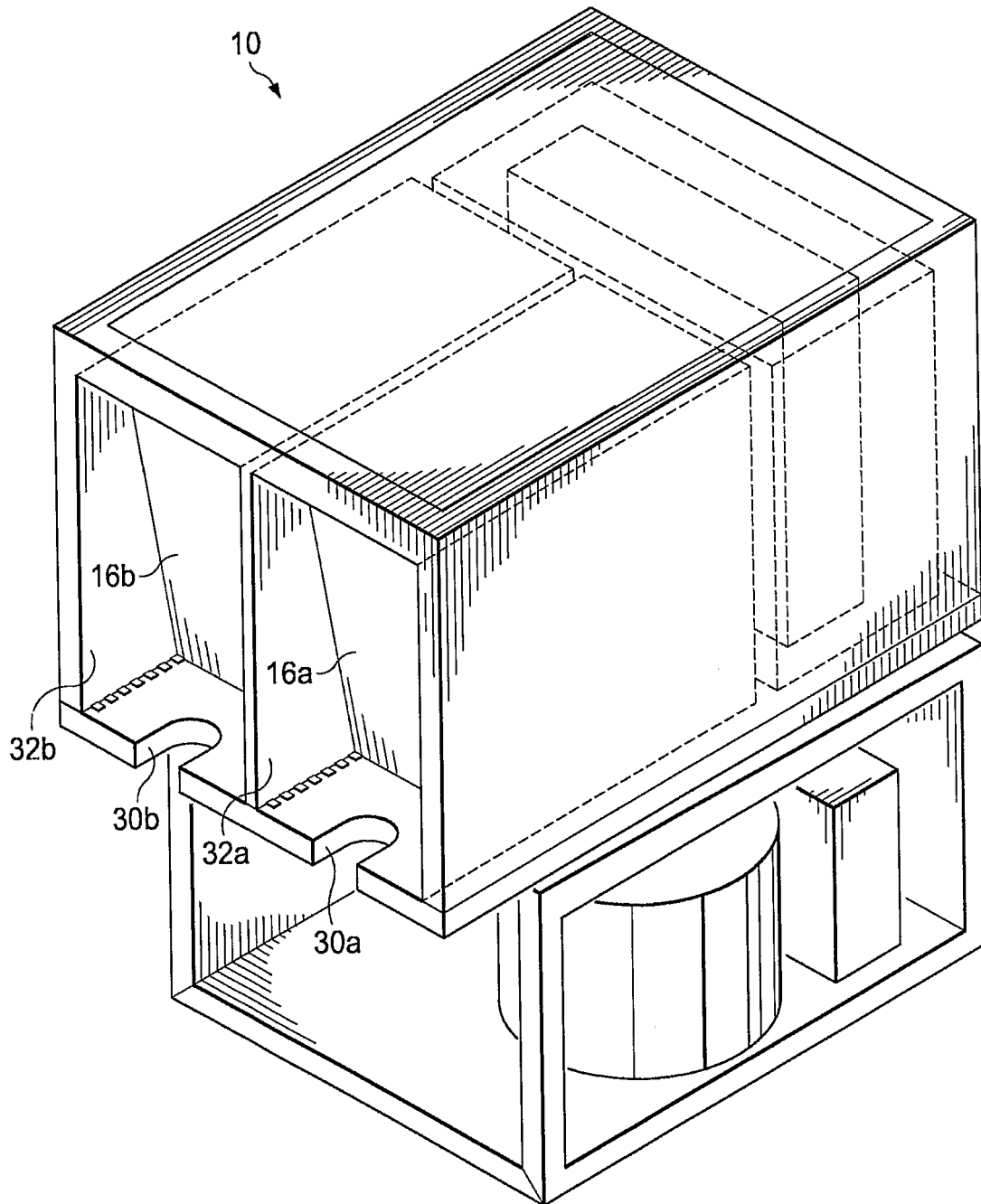


FIG. 1a



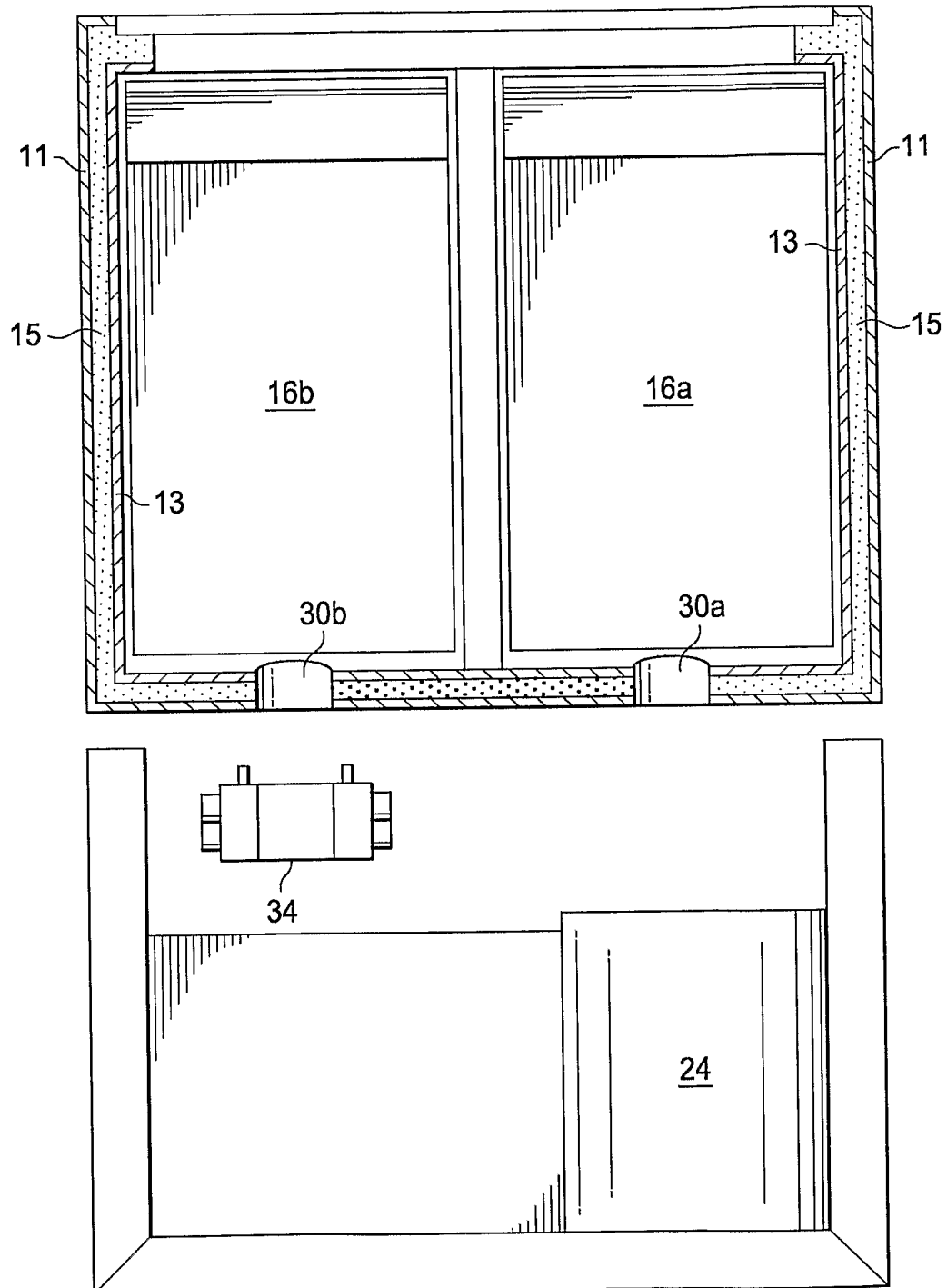


FIG. 1b

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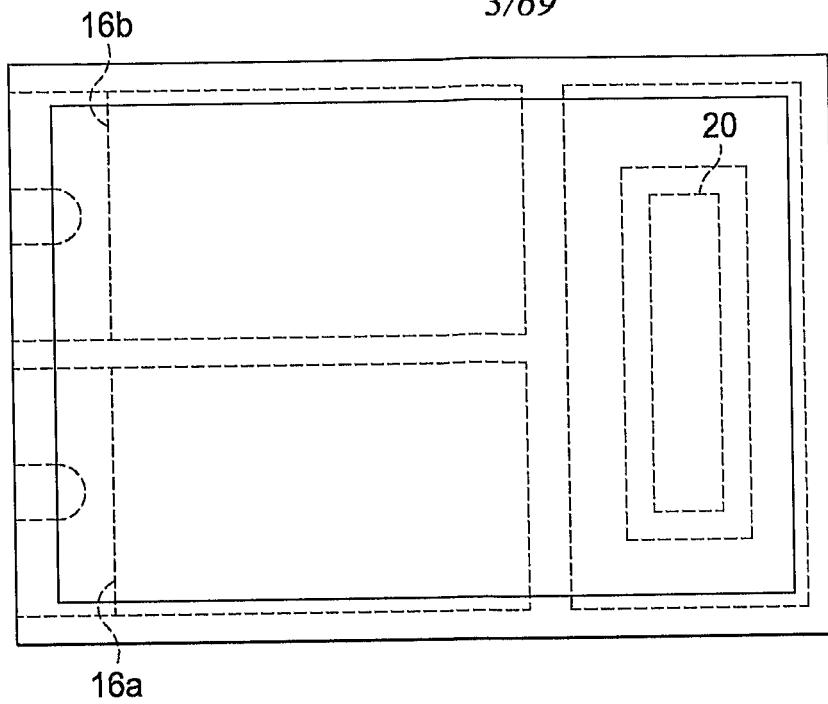


FIG. 1c

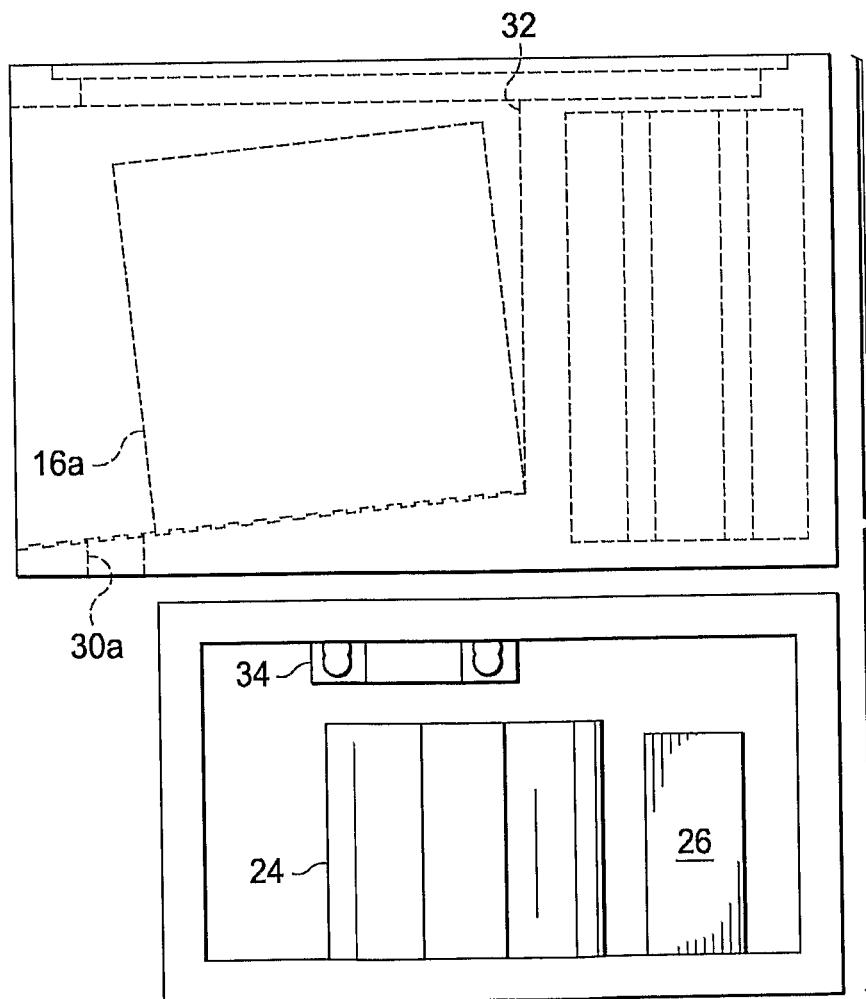
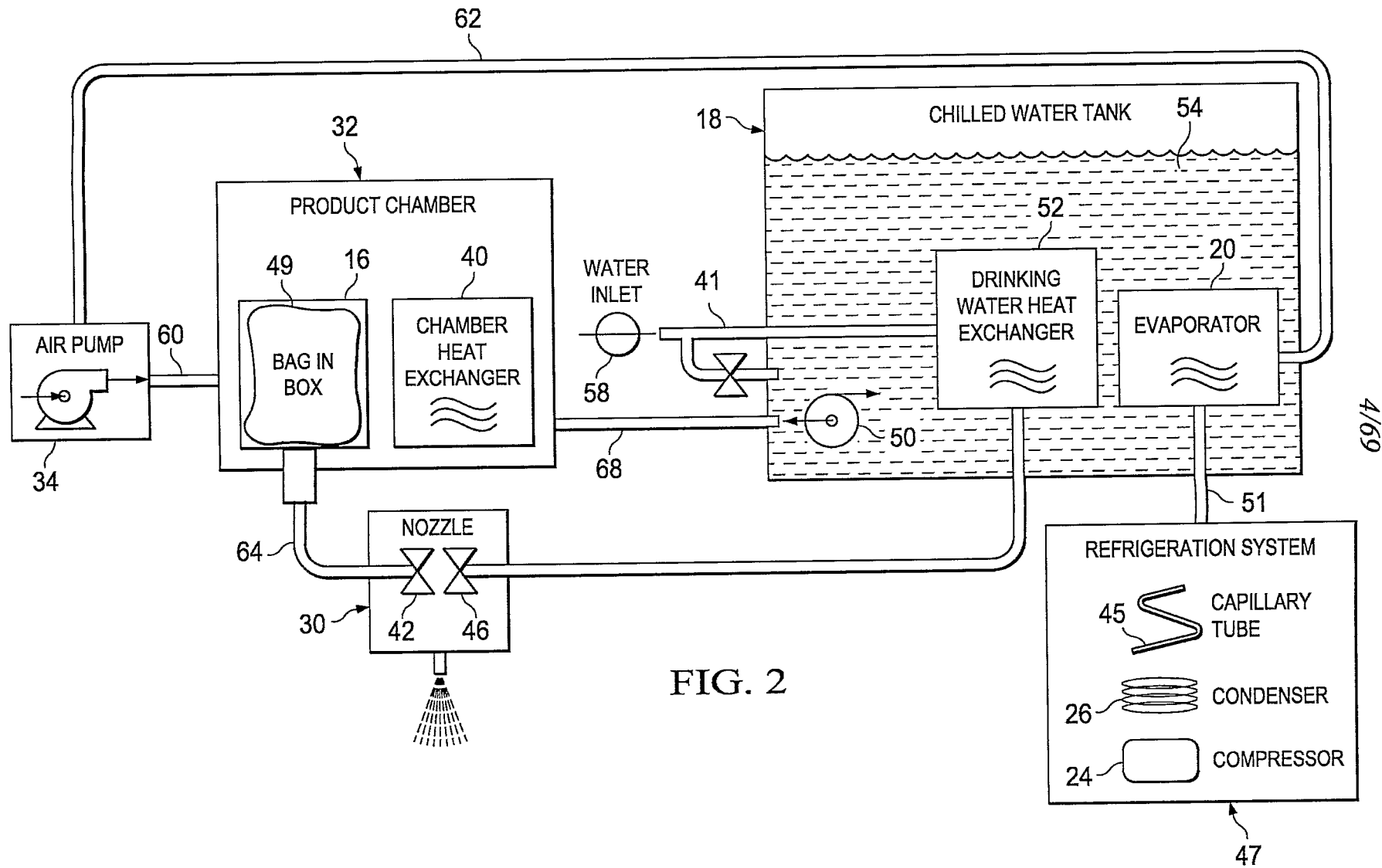
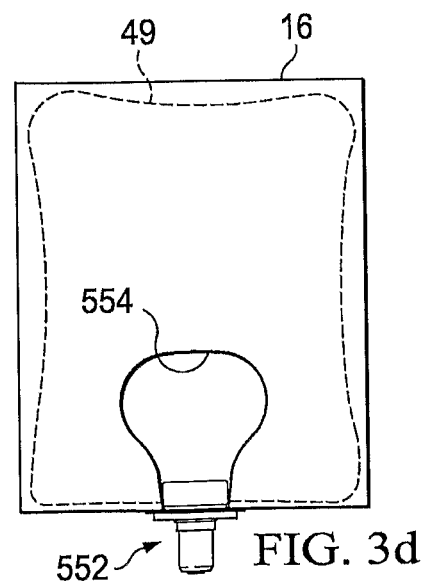
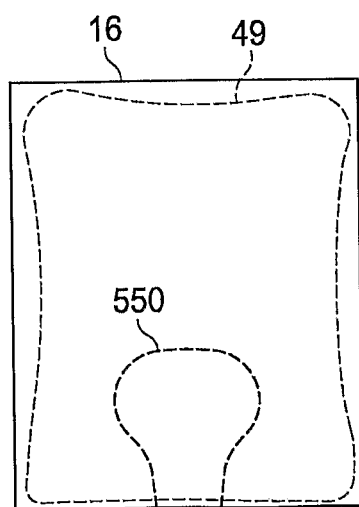
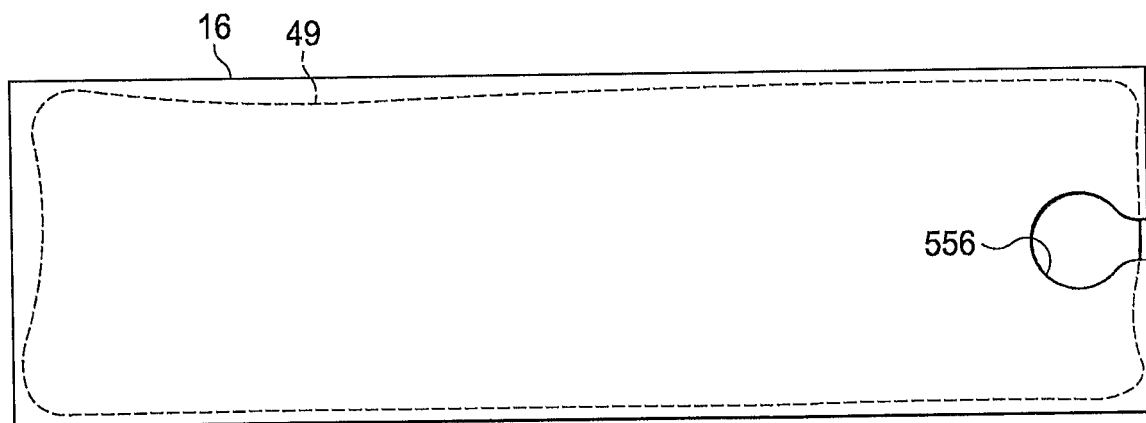
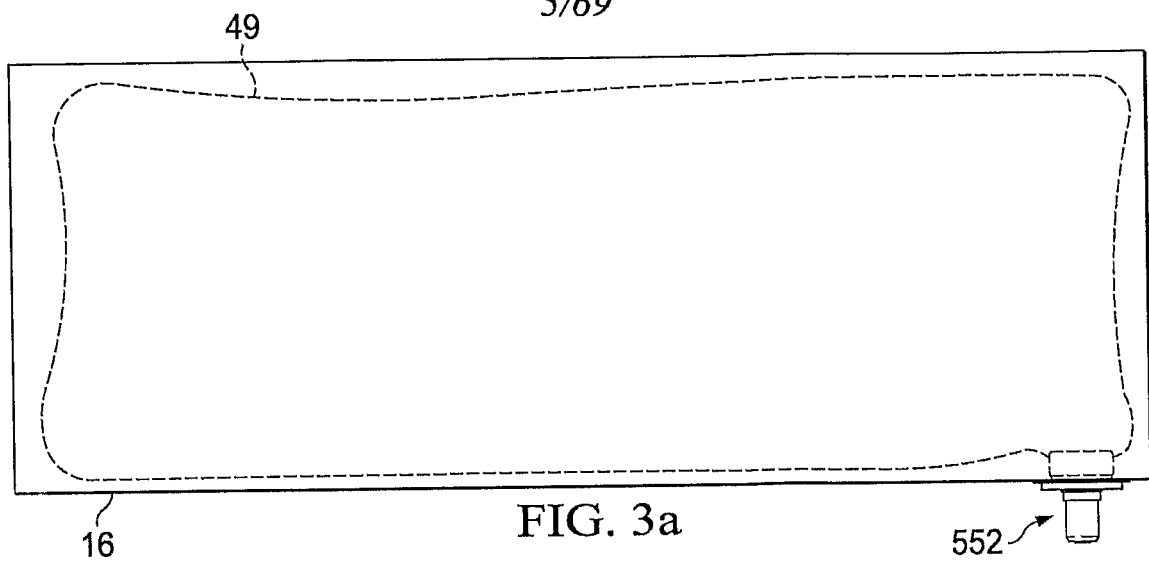


FIG. 1d



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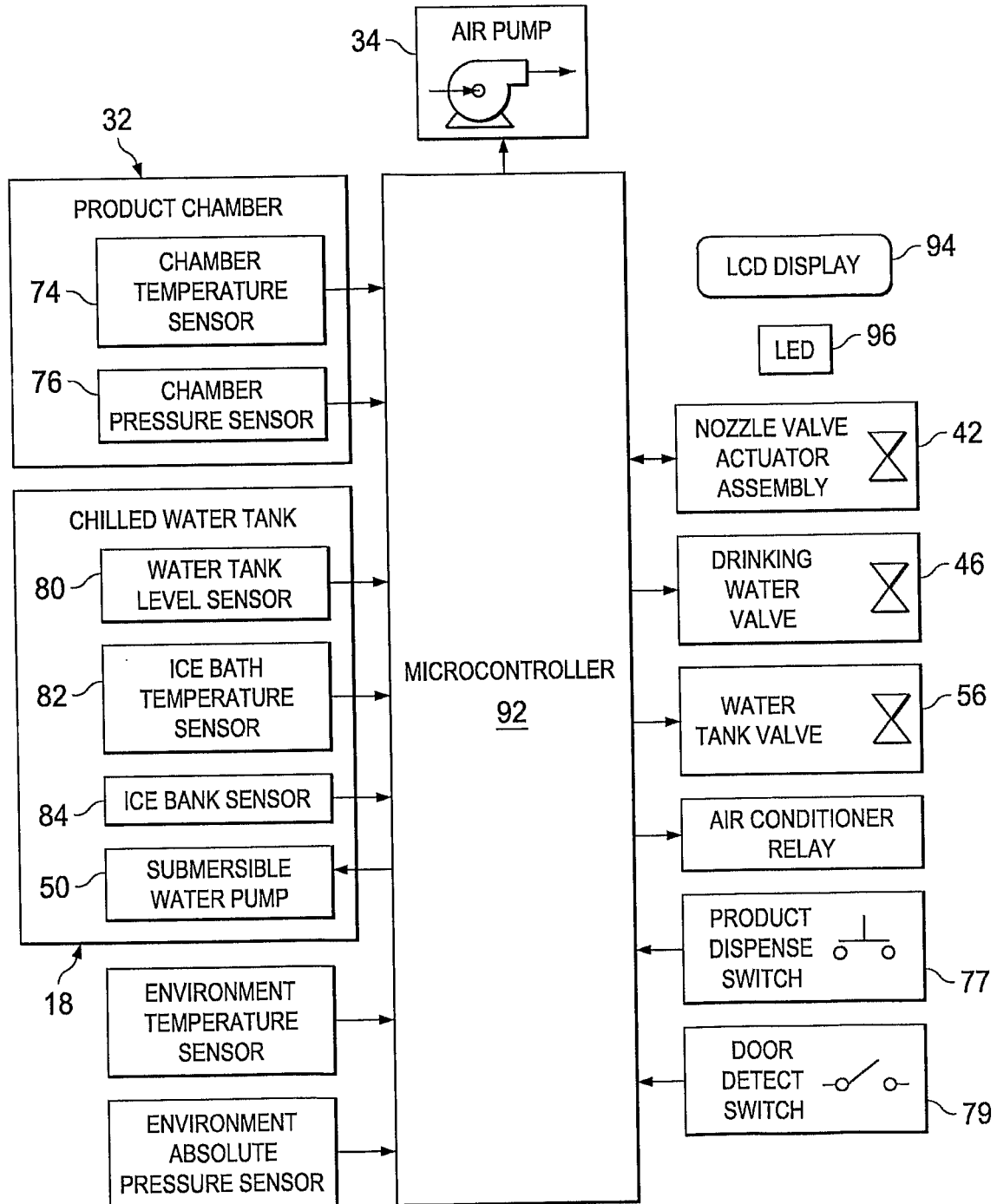
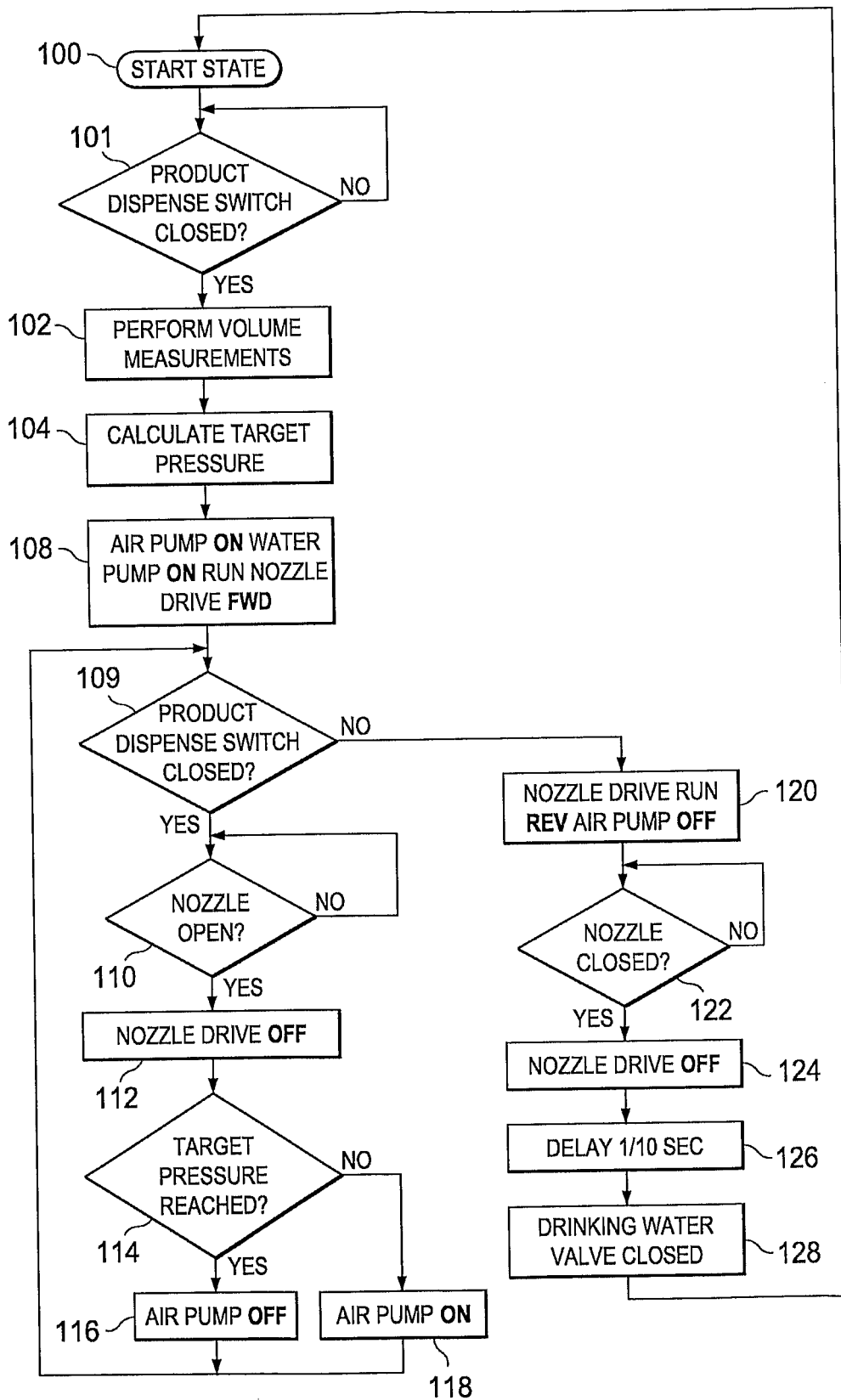
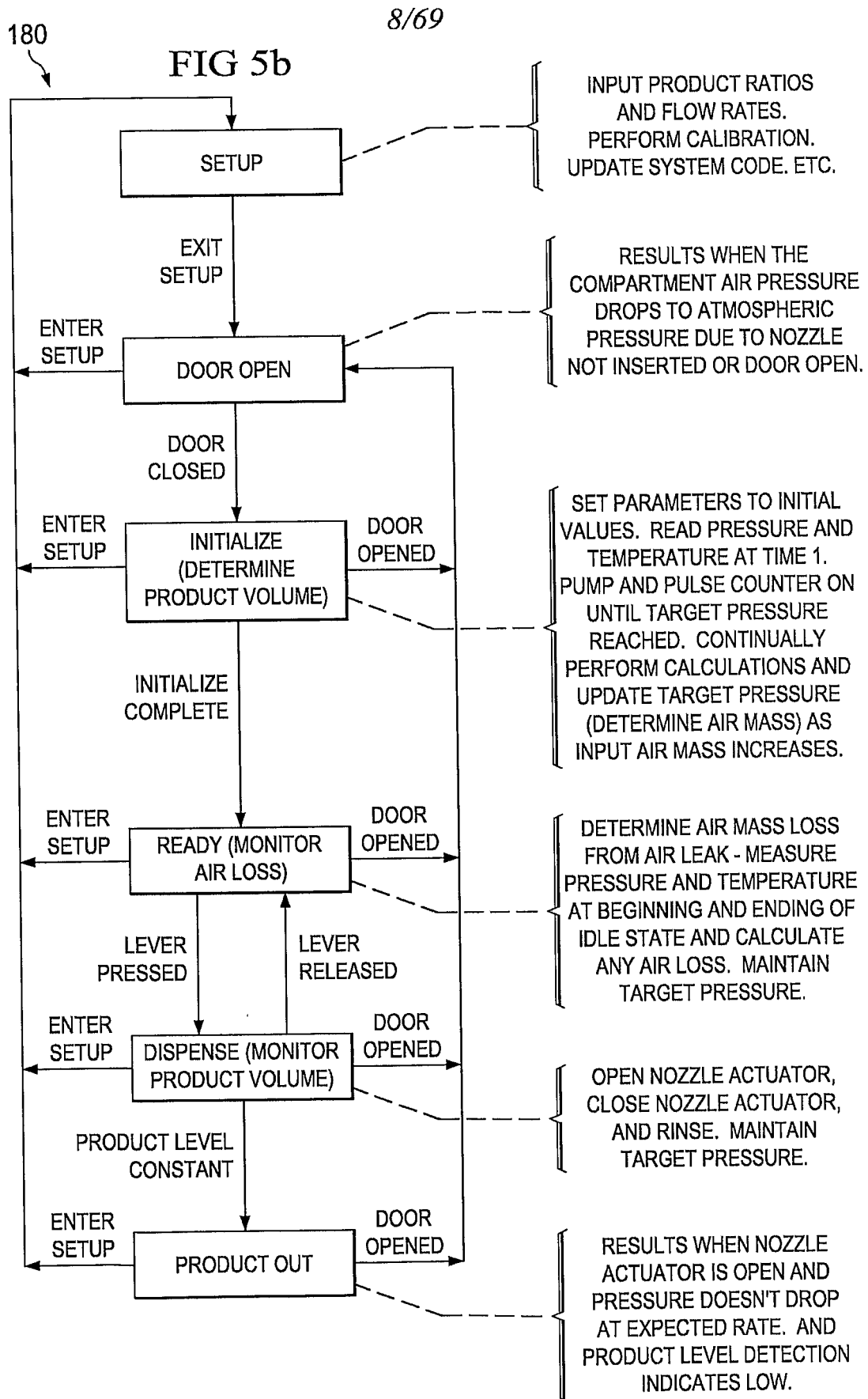


FIG. 4

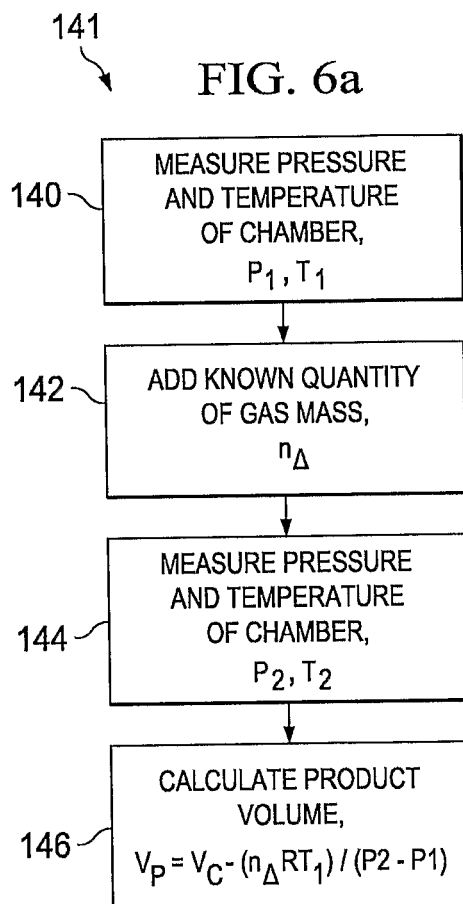
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FIG. 5a





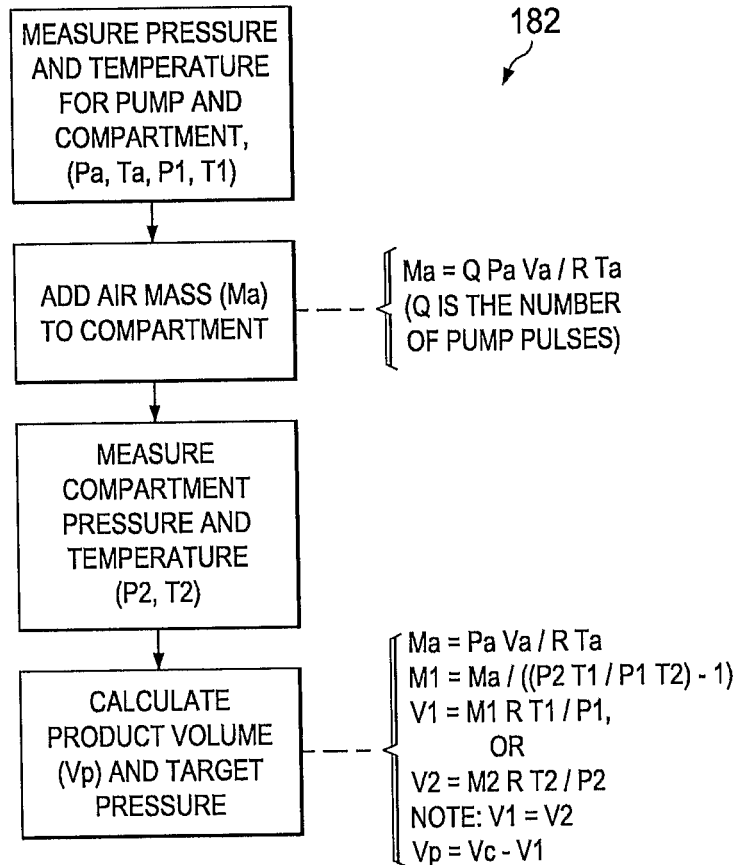
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FIG. 6b



$P_a$  = PRESSURE OF PUMP AIR  
 $T_a$  = TEMPERATURE OF PUMP AIR  
 $V_a$  = VOLUME OF PUMP  
 $Q$  = NUMBER OF PUMP CYCLES  
 $M_a$  = TOTAL MASS OF AIR OUTPUT BY PUMP  
 $R$  = GAS CONSTANT  
 $P_1$  = PRESSURE OF COMPARTMENT AIR, TIME 1  
 $T_1$  = TEMPERATURE OF COMPARTMENT AIR, TIME 1  
 $V_1$  = VOLUME OF COMPARTMENT AIR, TIME 1  
 $M_1$  = MASS OF COMPARTMENT AIR, TIME 1  
 $P_2$  = PRESSURE OF COMPARTMENT AIR, TIME 2  
 $T_2$  = TEMPERATURE OF COMPARTMENT AIR, TIME 2  
 $V_2$  = VOLUME OF COMPARTMENT AIR, TIME 2  
 $M_2$  = MASS OF COMPARTMENT AIR, TIME 2  
 $V_c$  = VOLUME OF COMPARTMENT  
 $V_p$  = VOLUME OF PRODUCT

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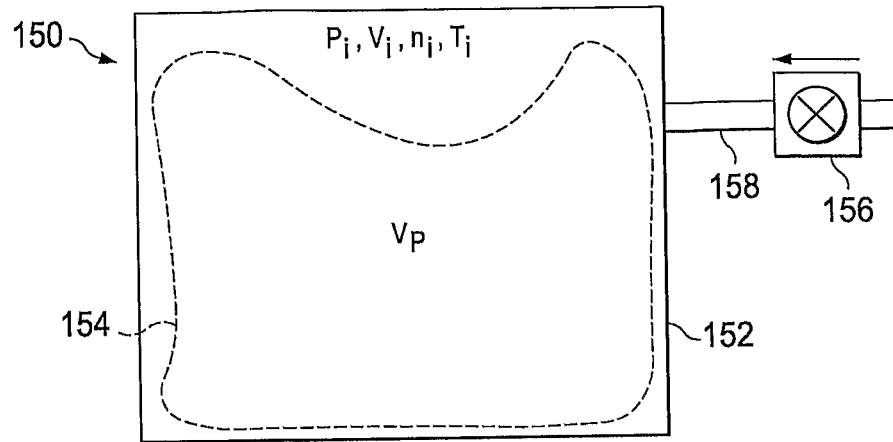


FIG. 7

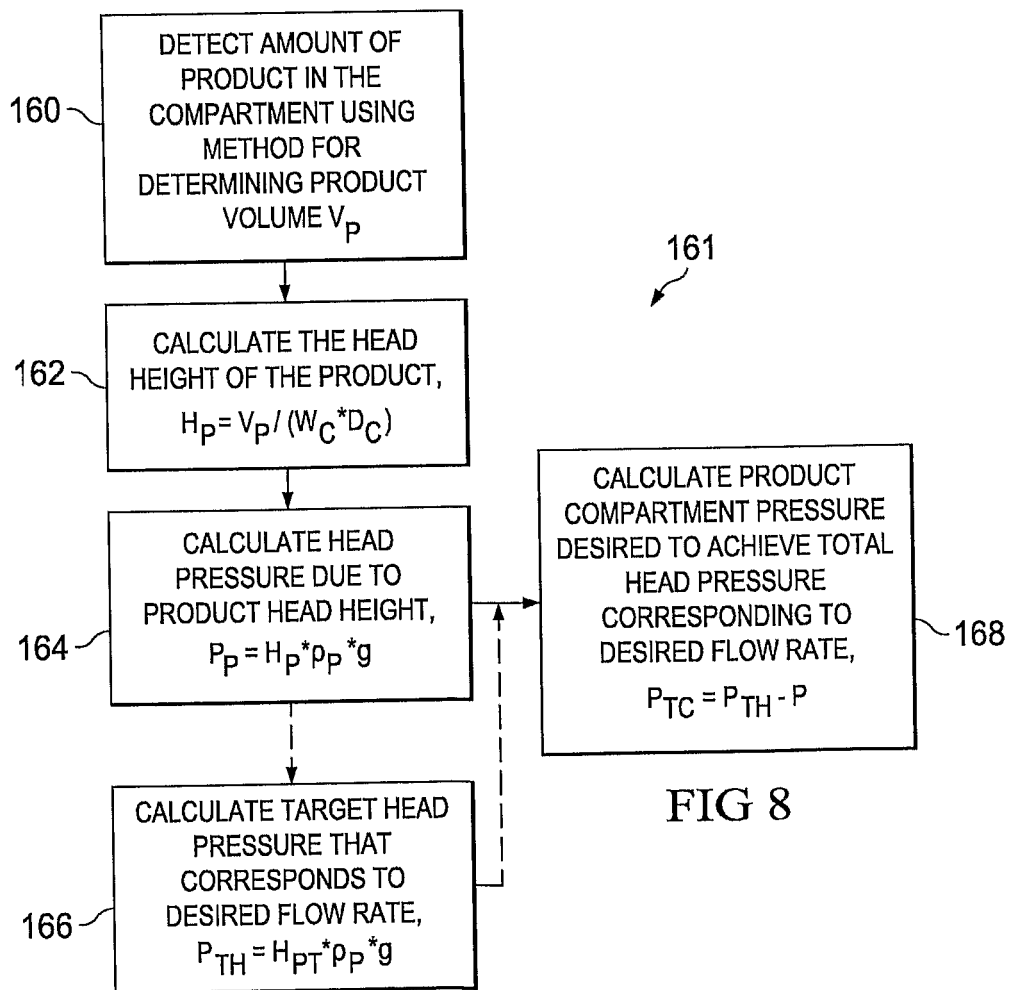
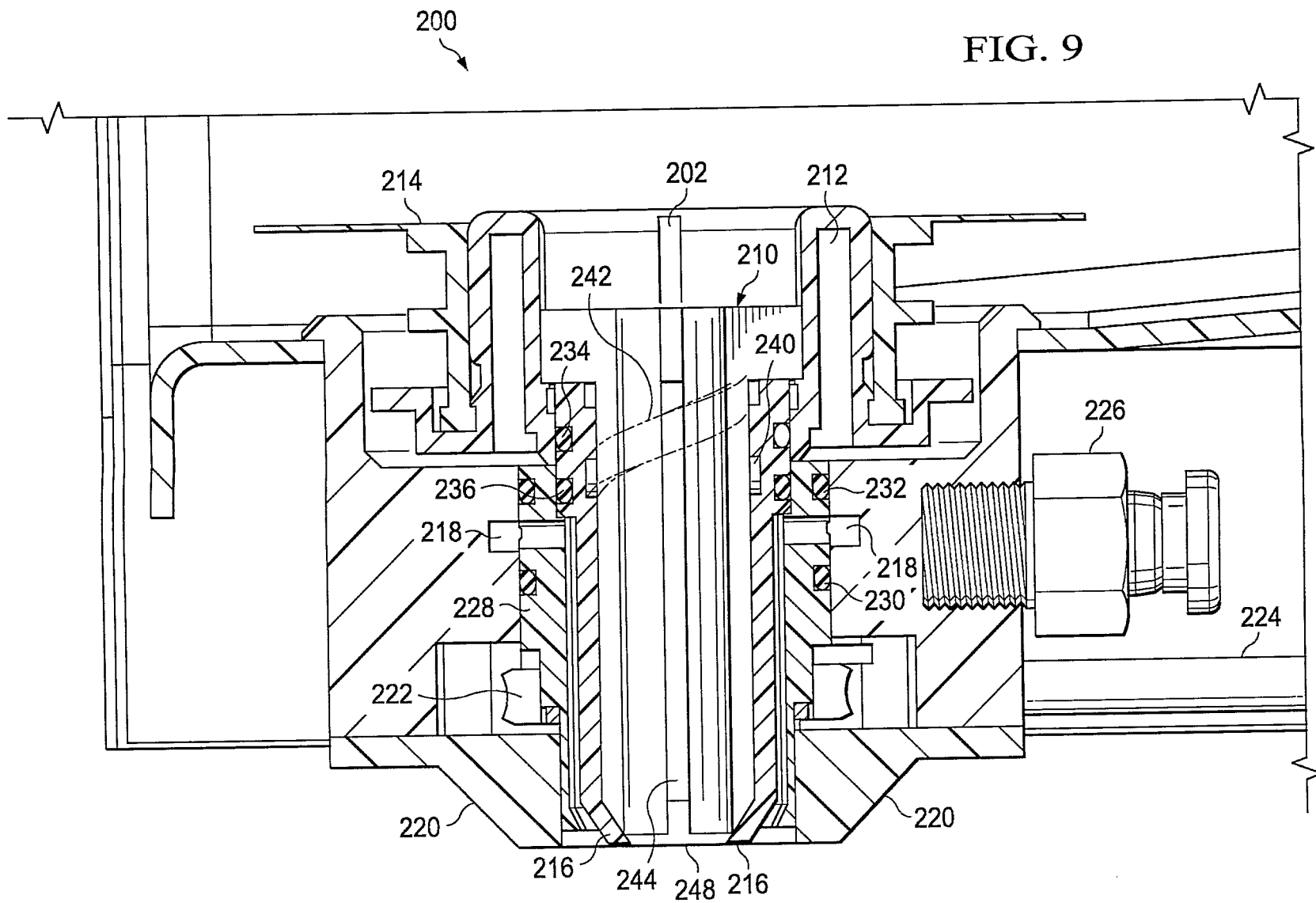


FIG 8

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FIG. 9



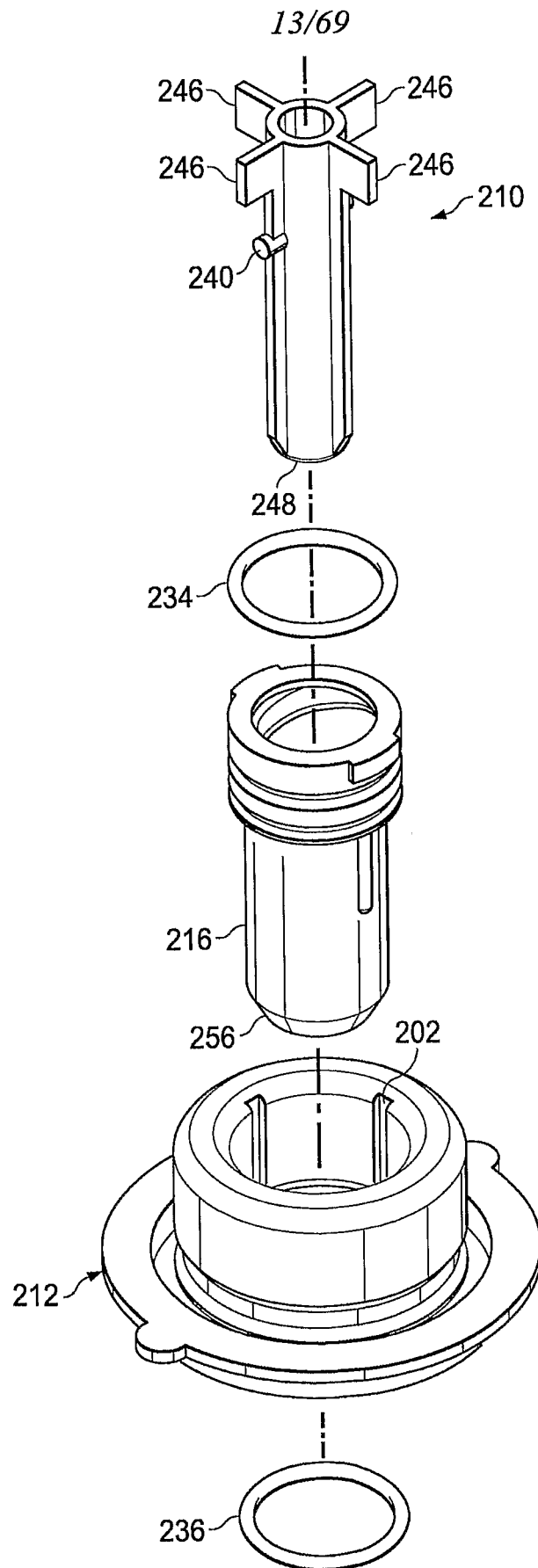
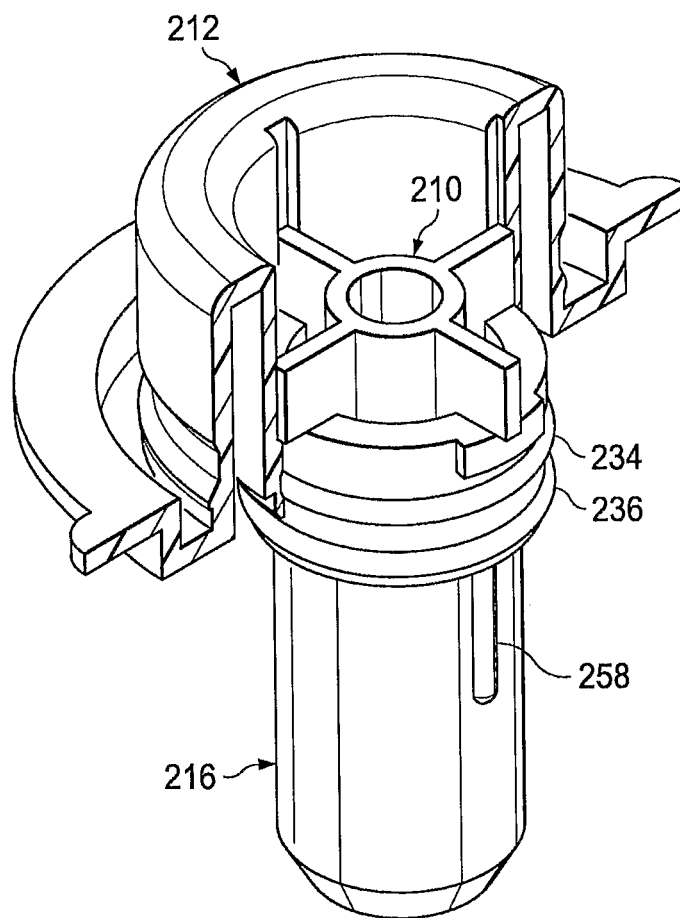


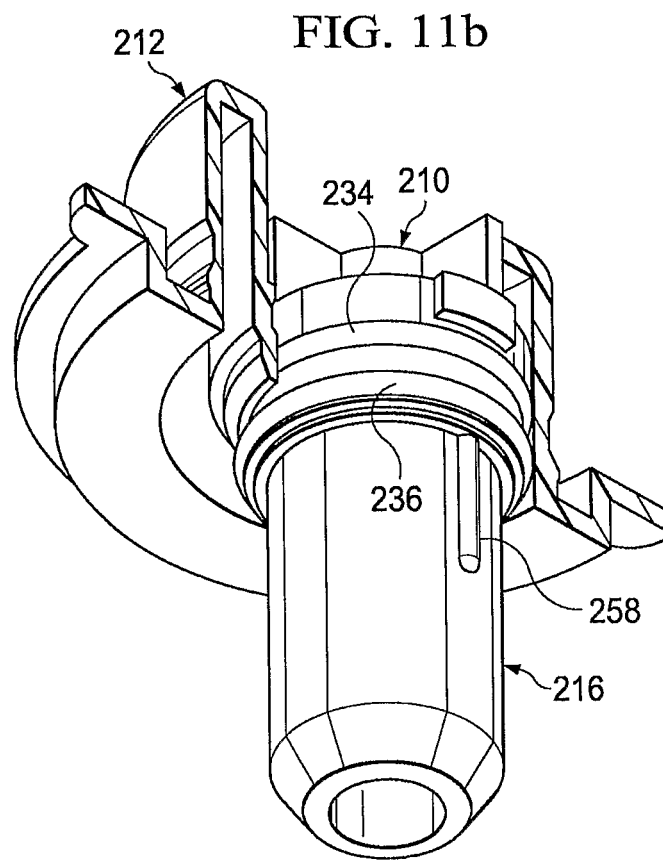
Fig. 10

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FIG. 11a



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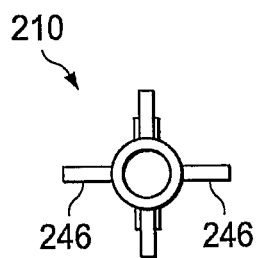


FIG. 12a

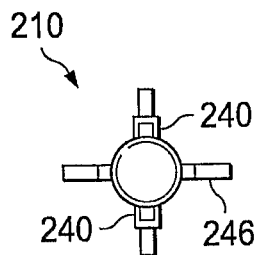


FIG. 12c

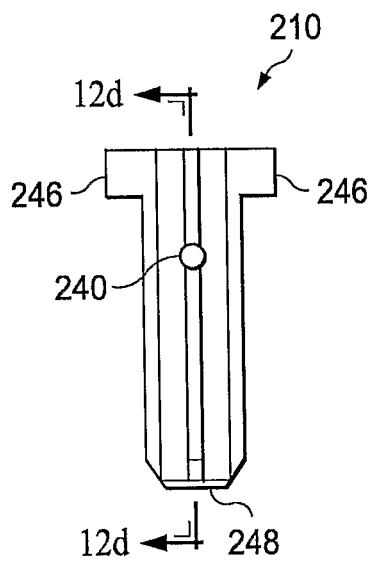


FIG. 12b

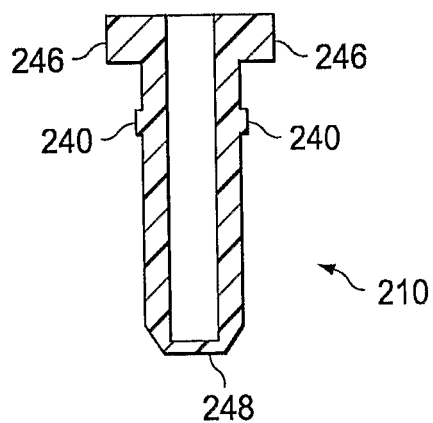


FIG. 12d

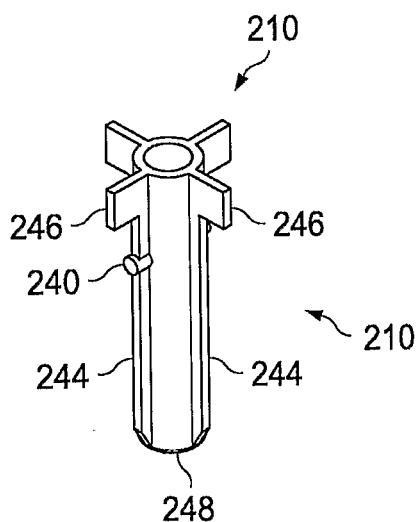


FIG. 12e

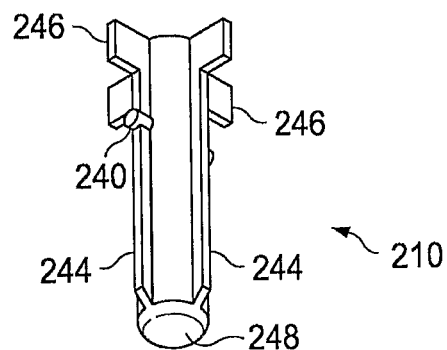


FIG. 12f

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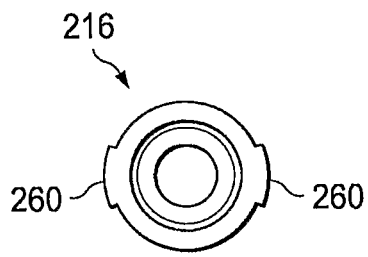


FIG. 13a

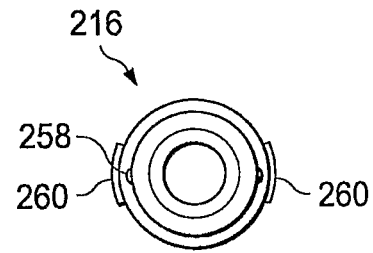


FIG. 13c

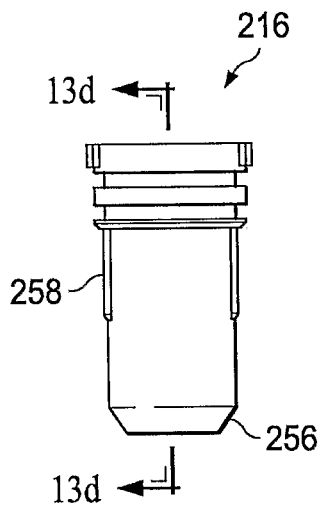


FIG. 13b

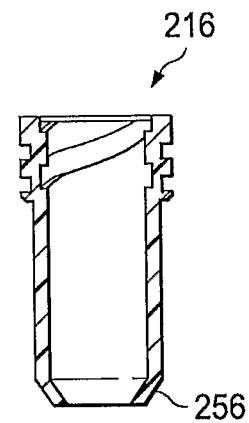


FIG. 13d

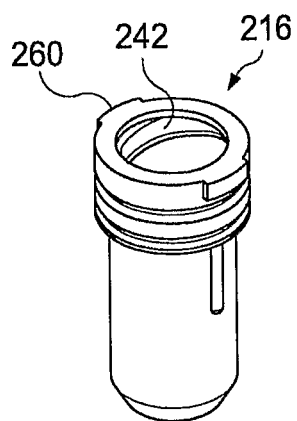


FIG. 13e

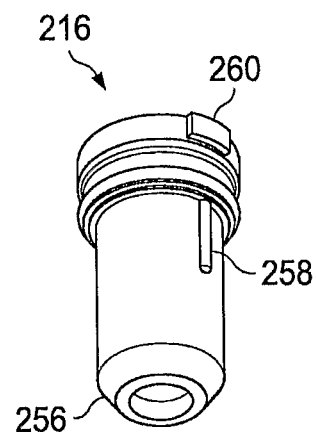


FIG. 13f



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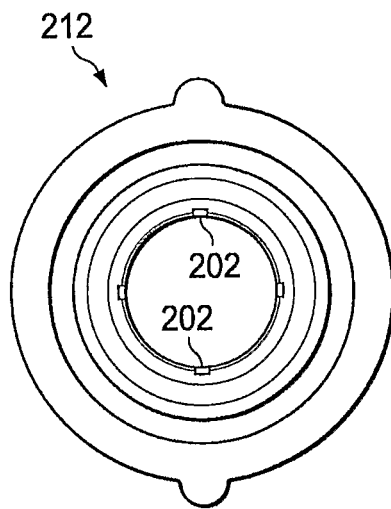


FIG. 14a

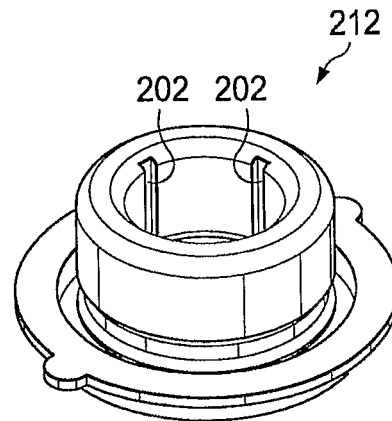


FIG. 14d

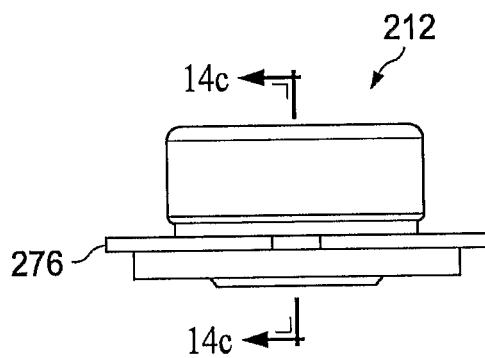


FIG. 14b

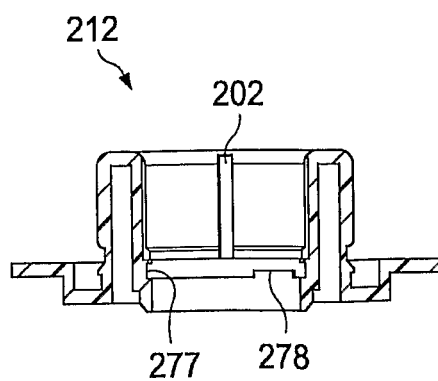


FIG. 14c

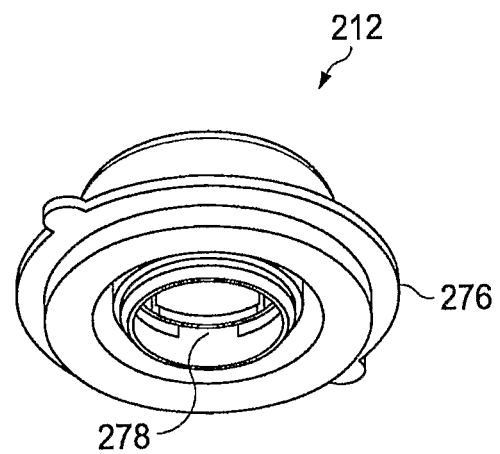


FIG. 14e

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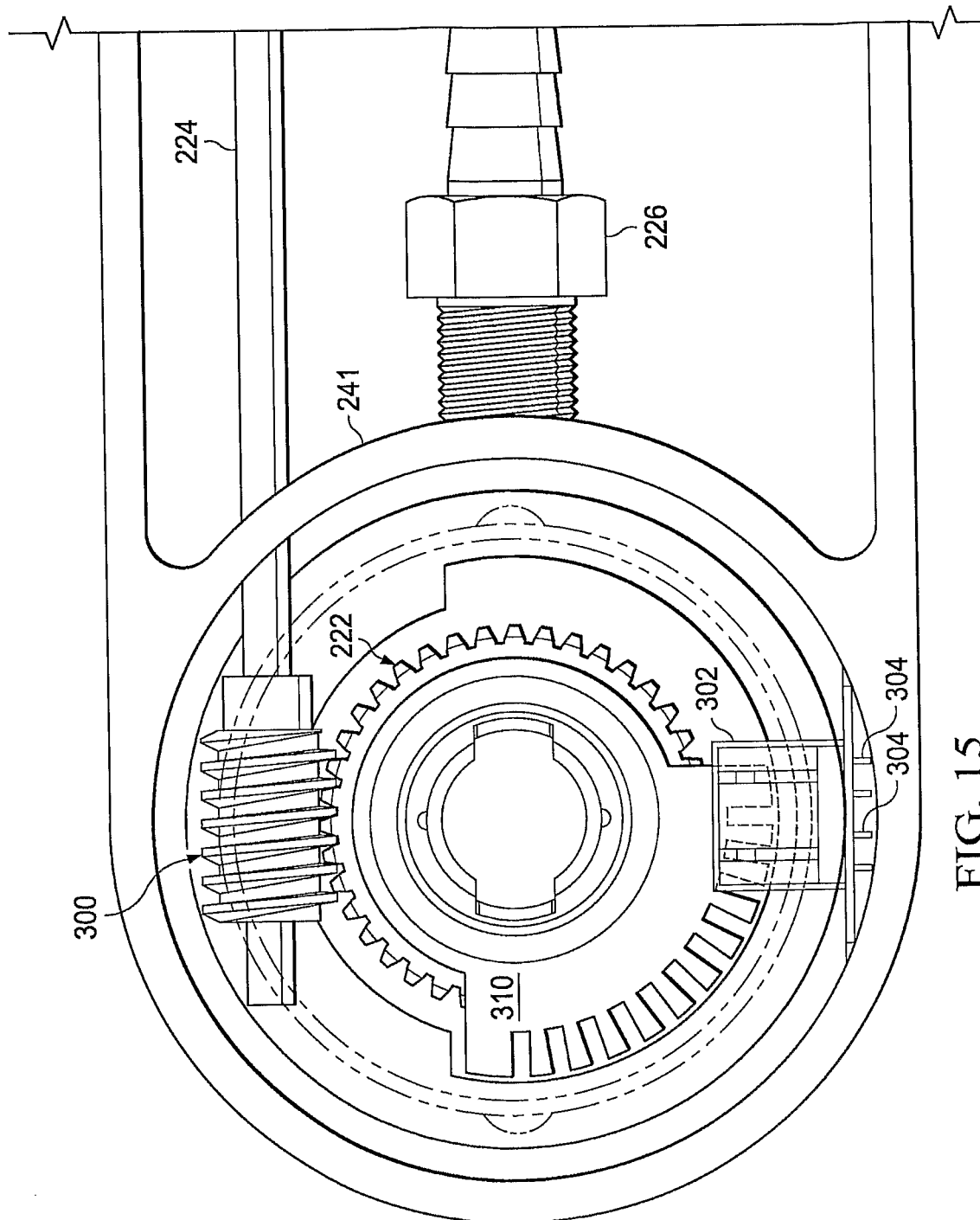
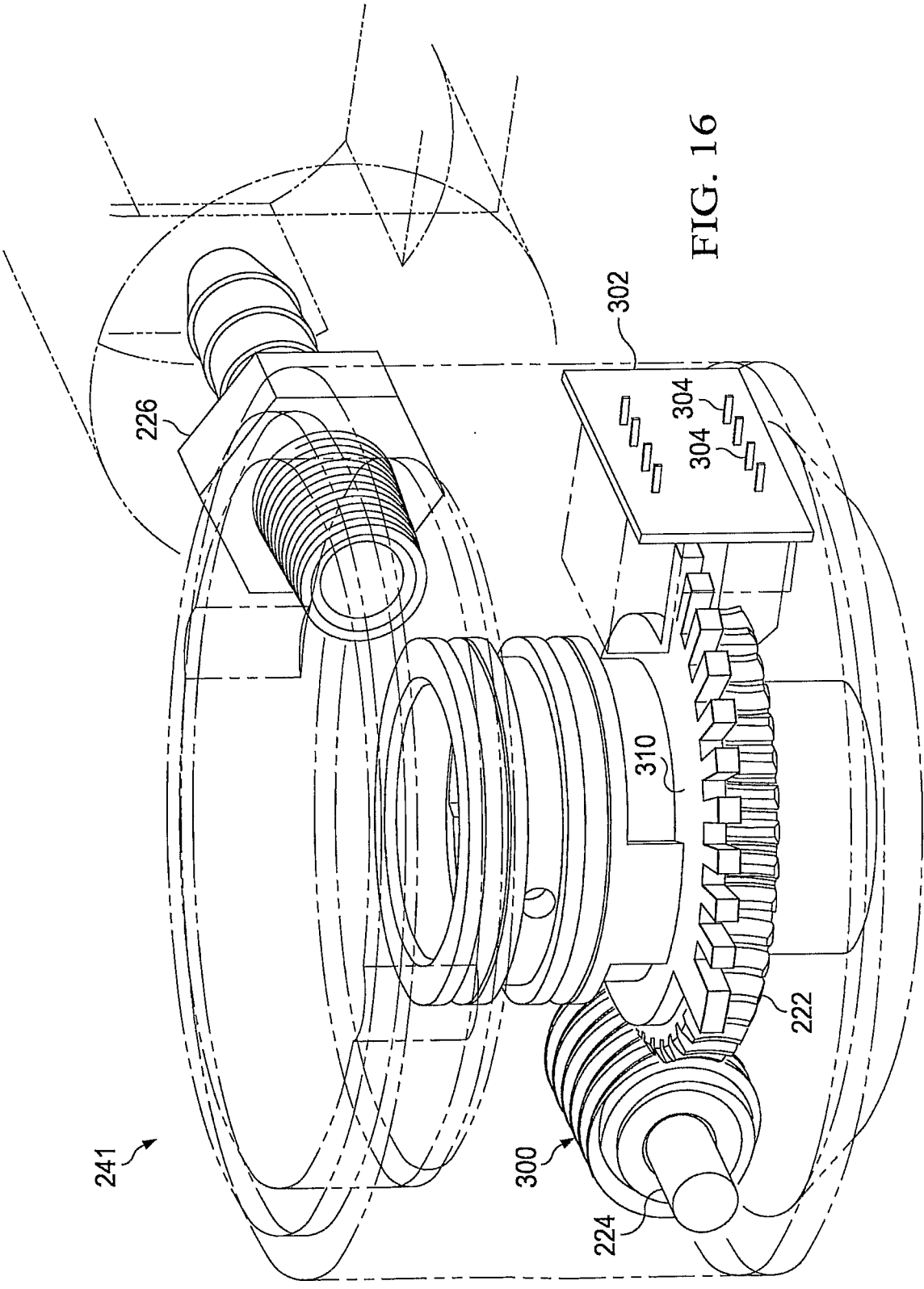


FIG. 15

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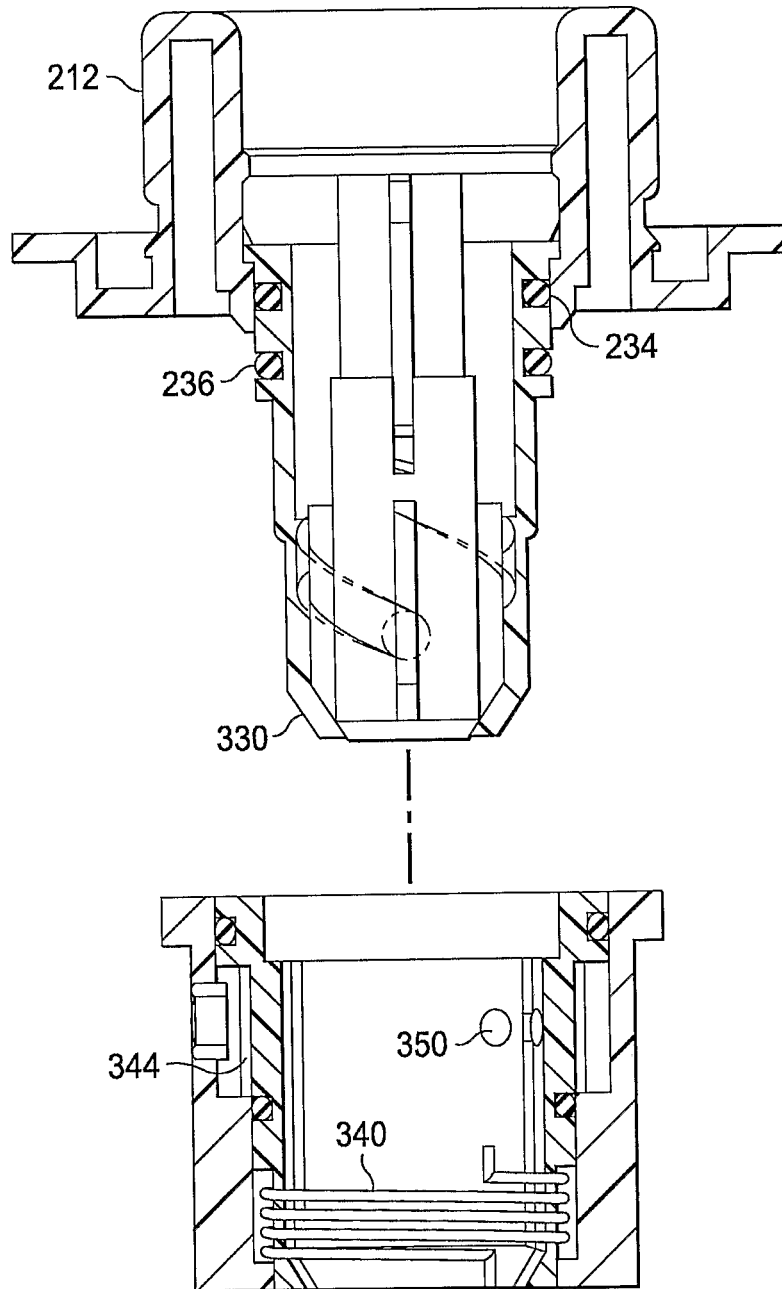


FIG. 17

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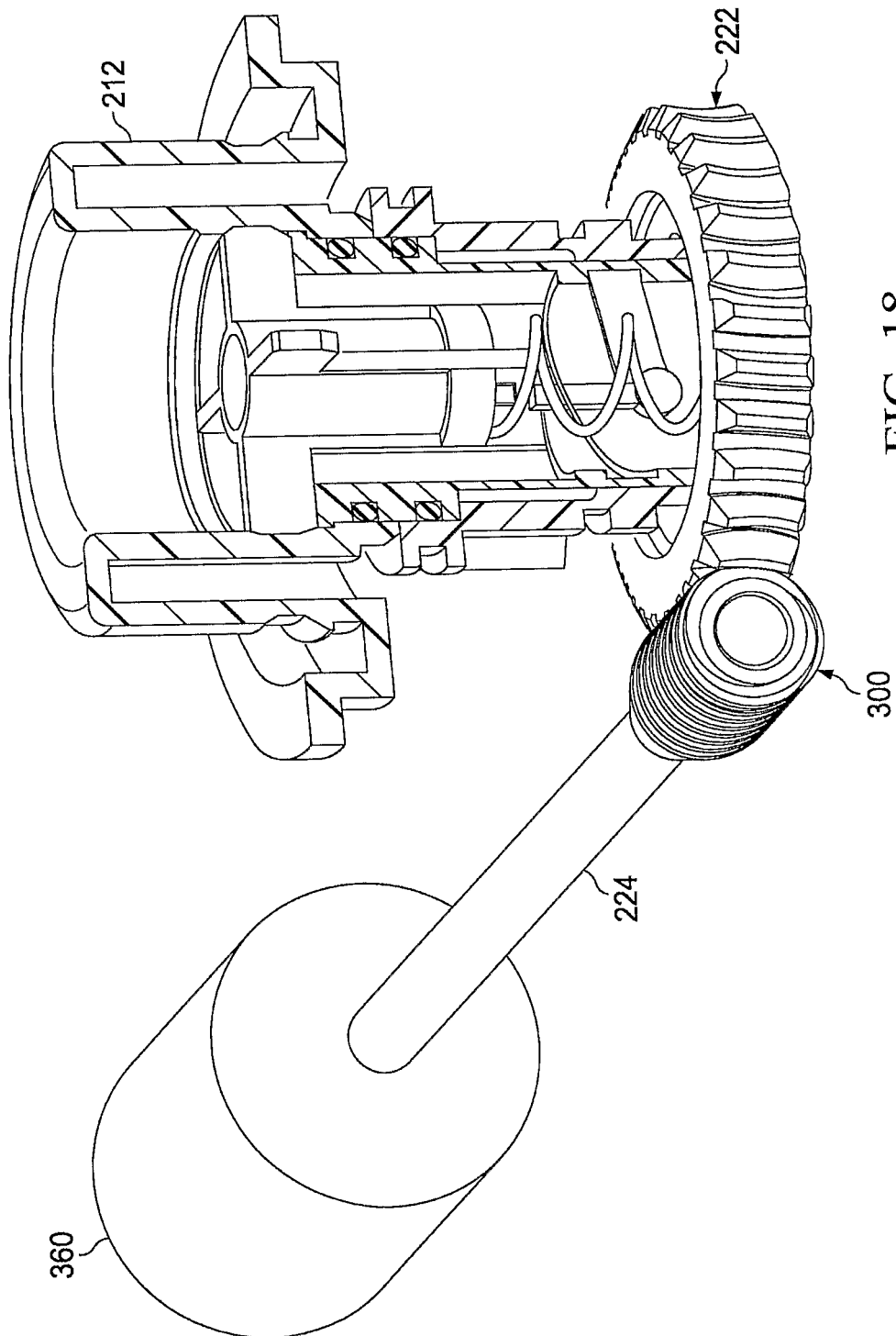
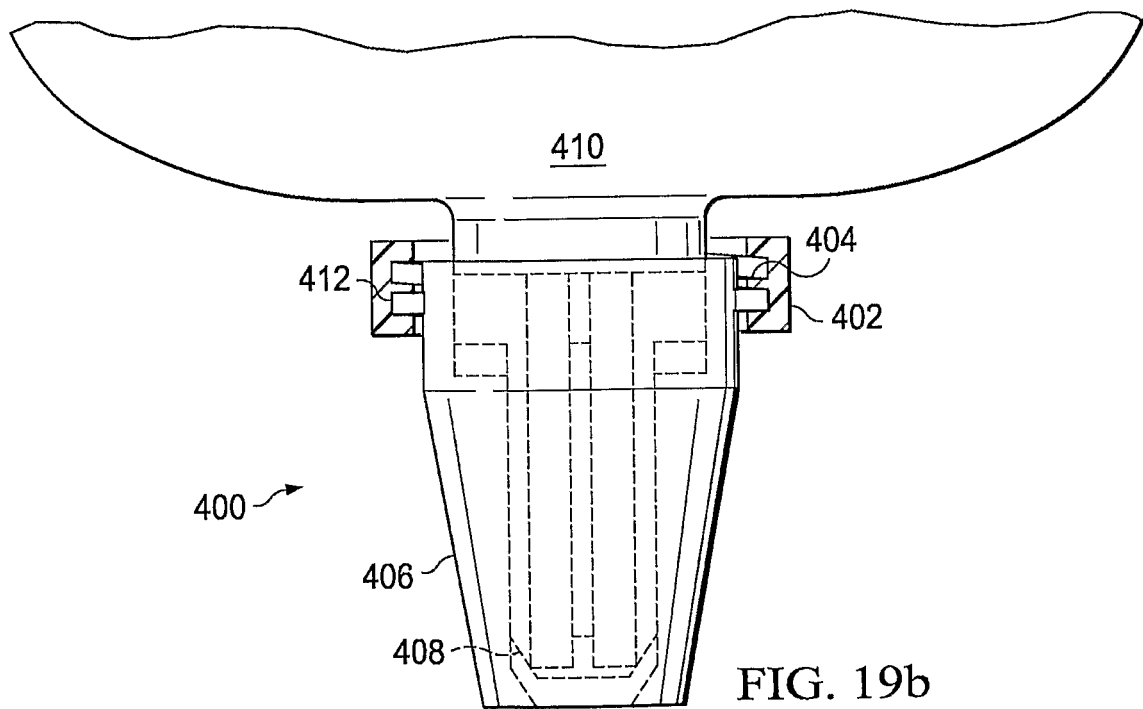
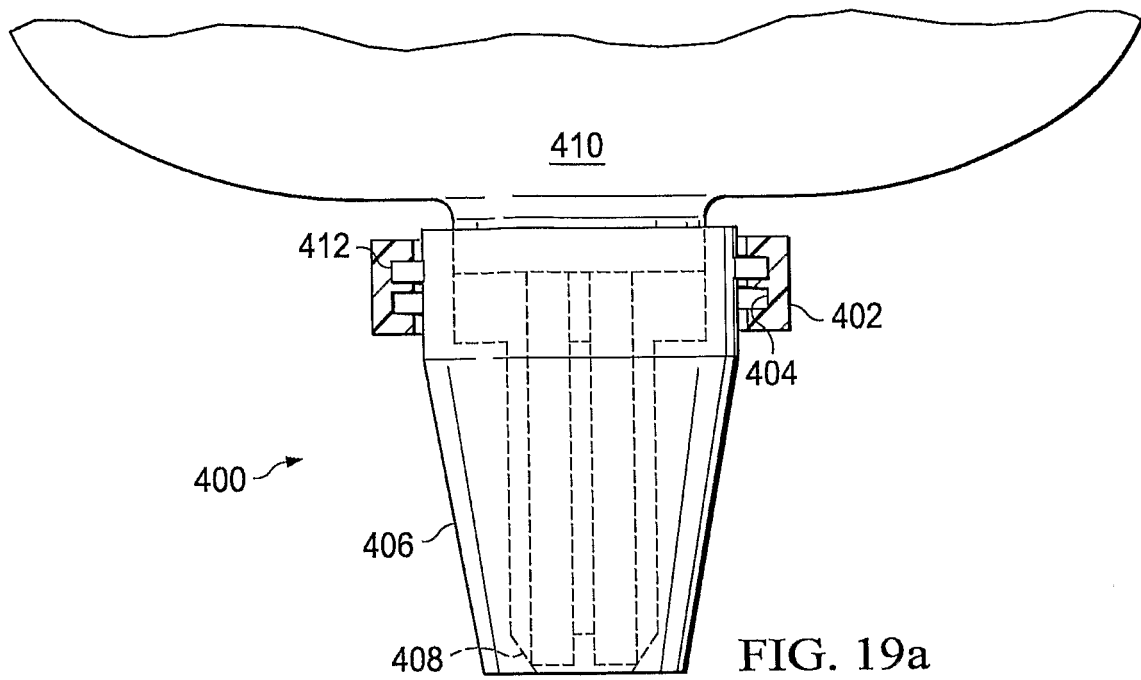


FIG. 18

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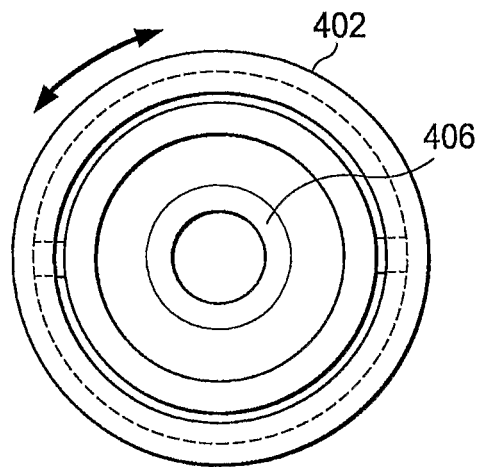


FIG. 19c

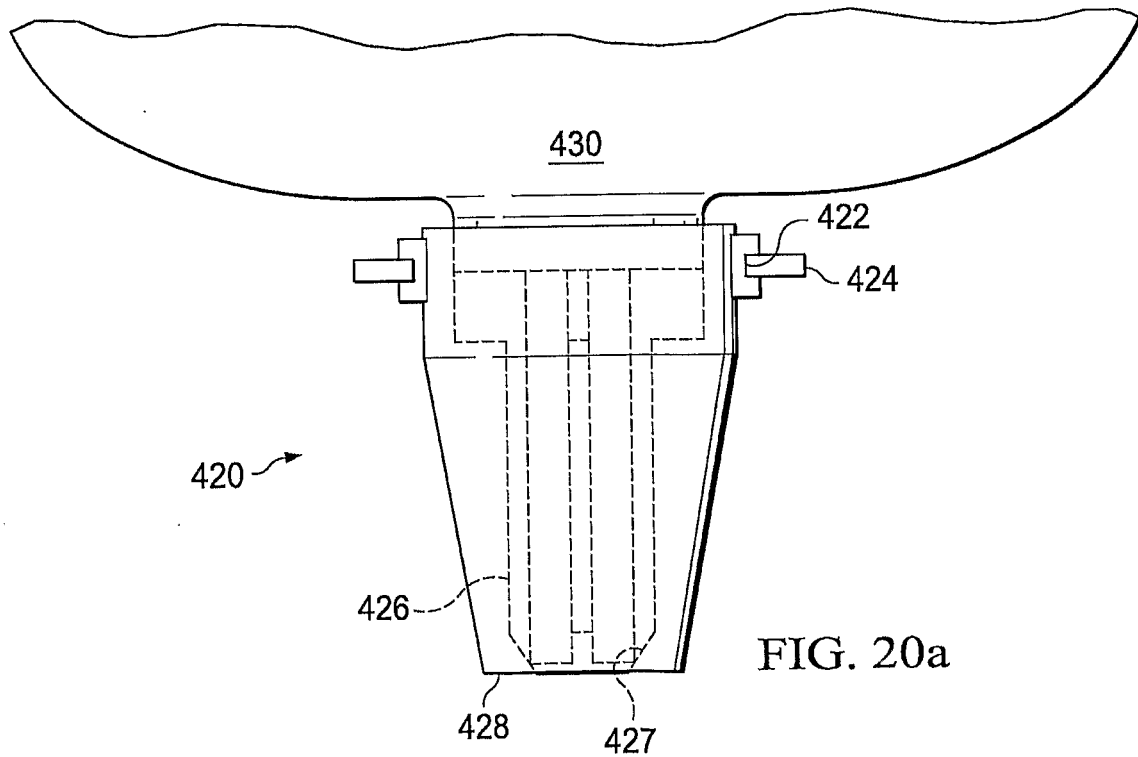
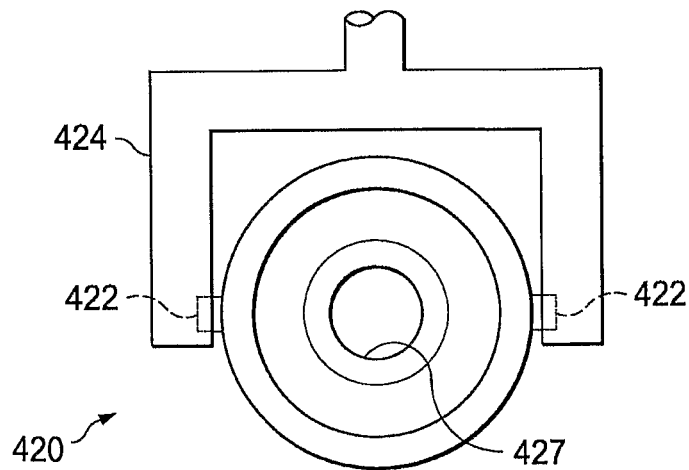
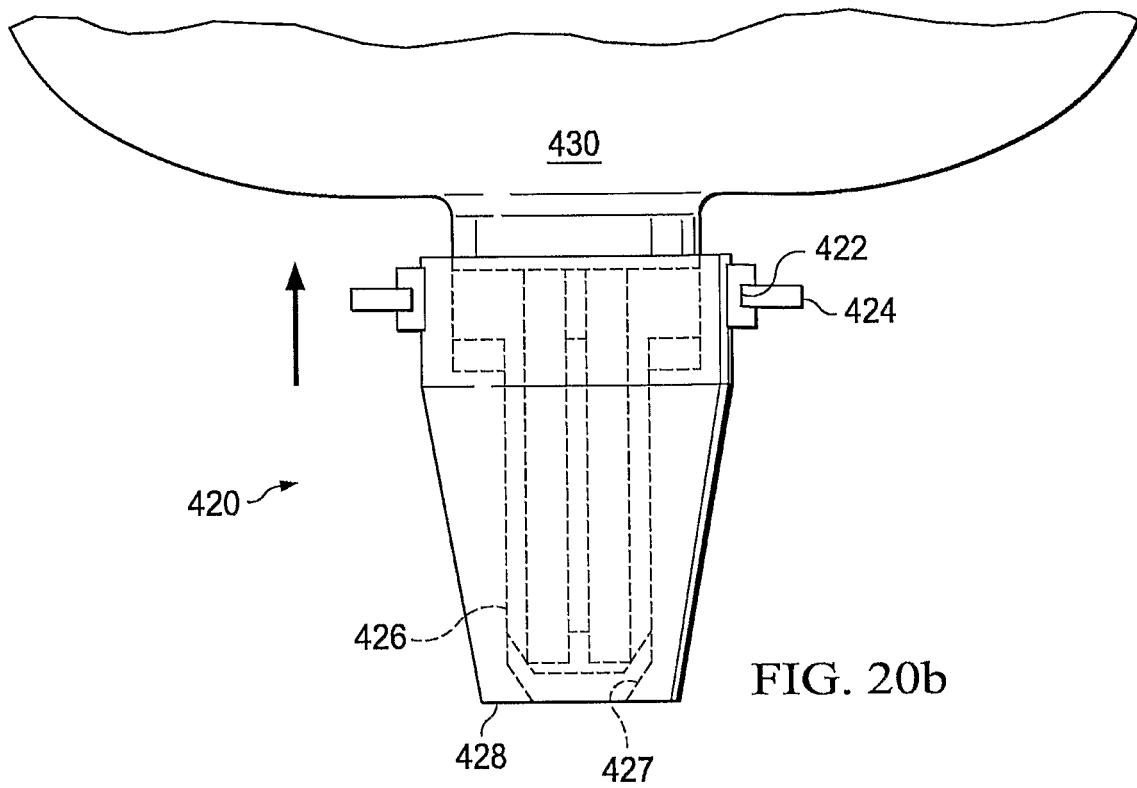


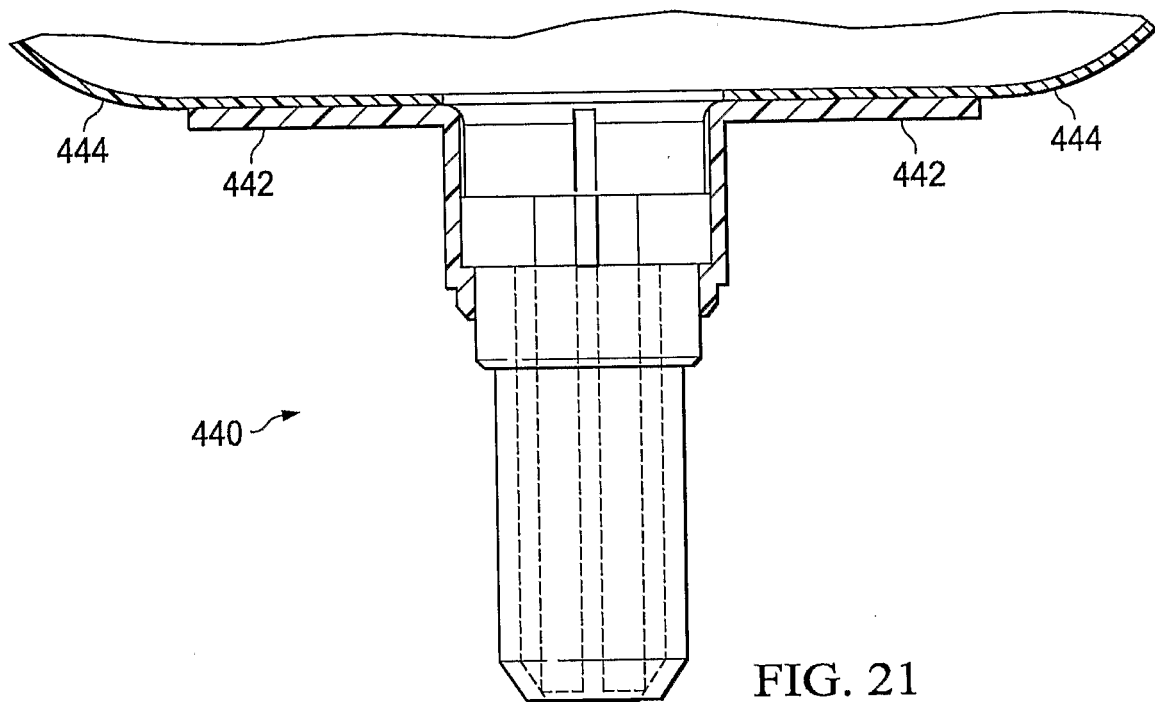
FIG. 20a

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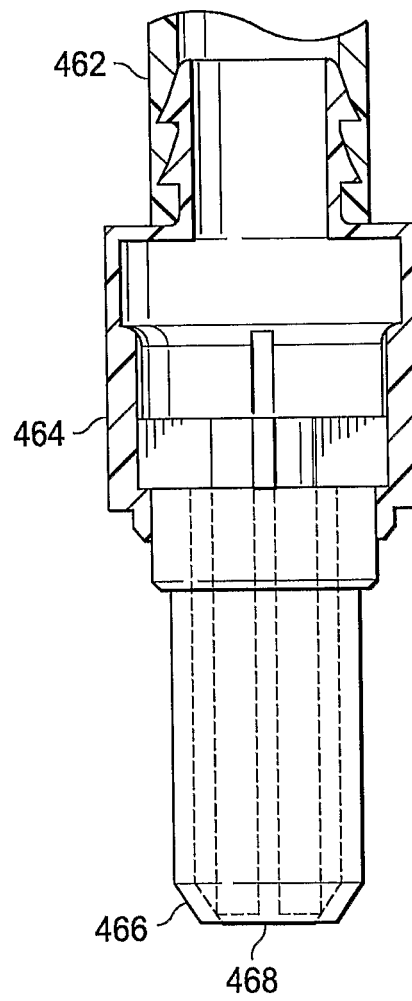


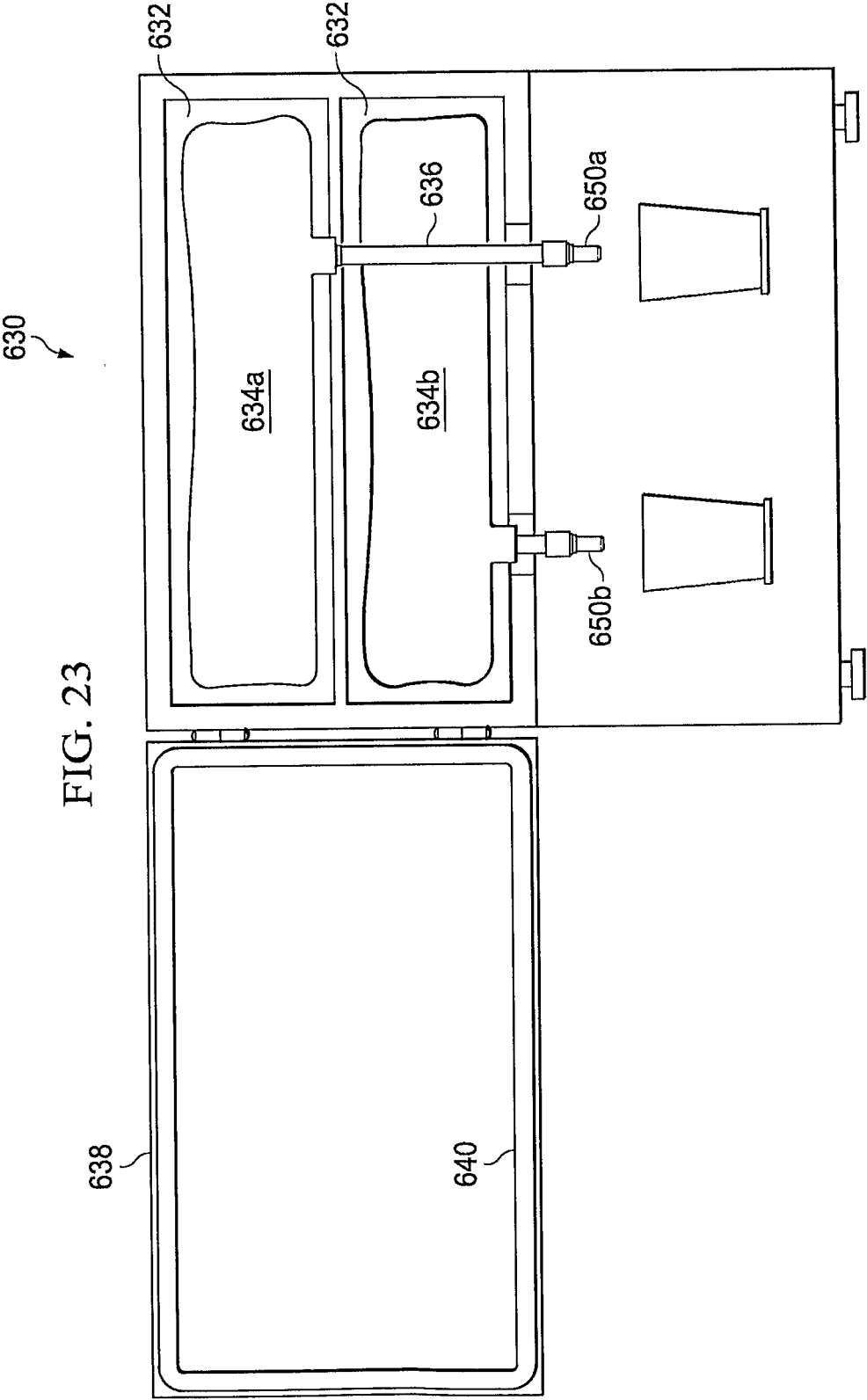
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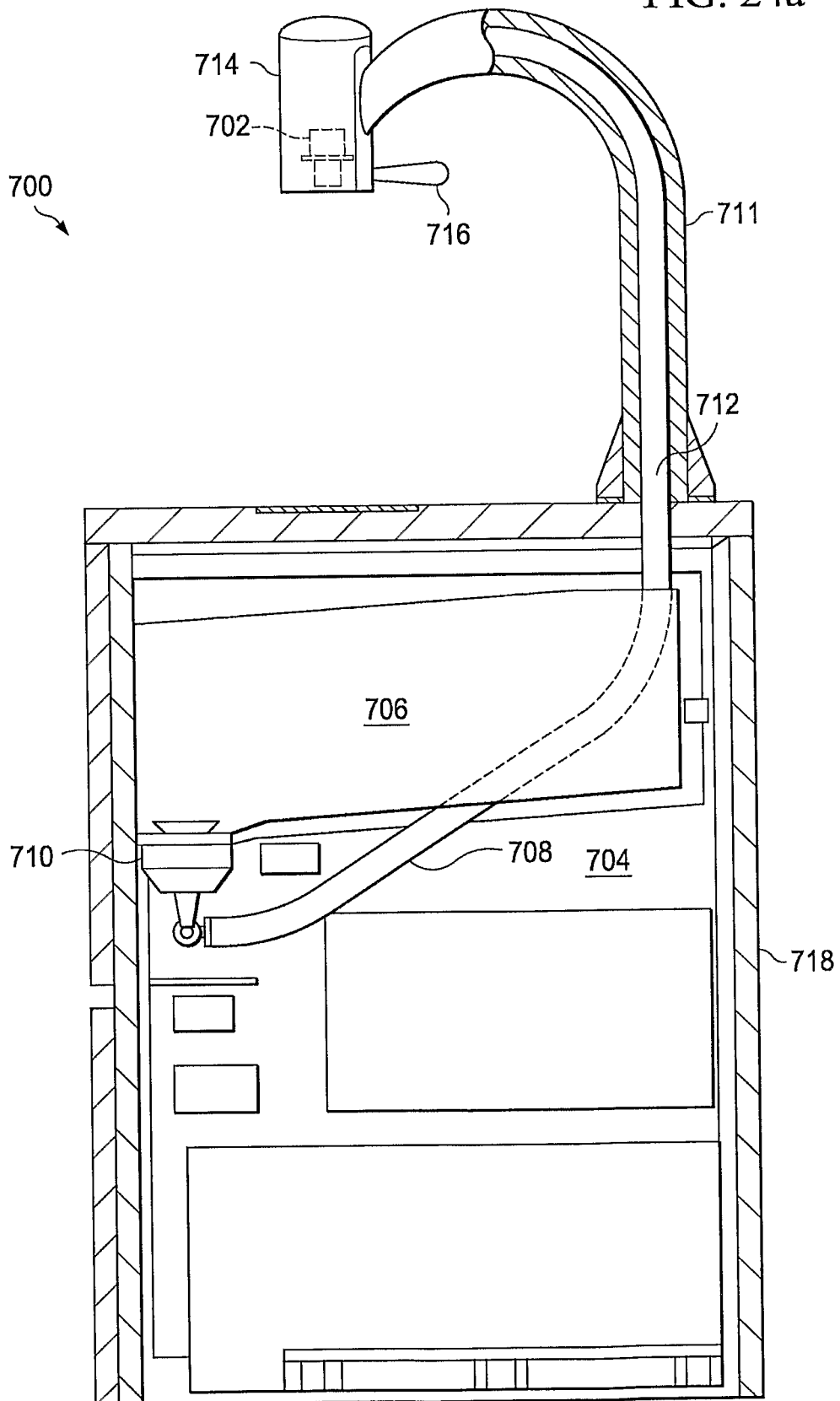
FIG. 22





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FIG. 24a



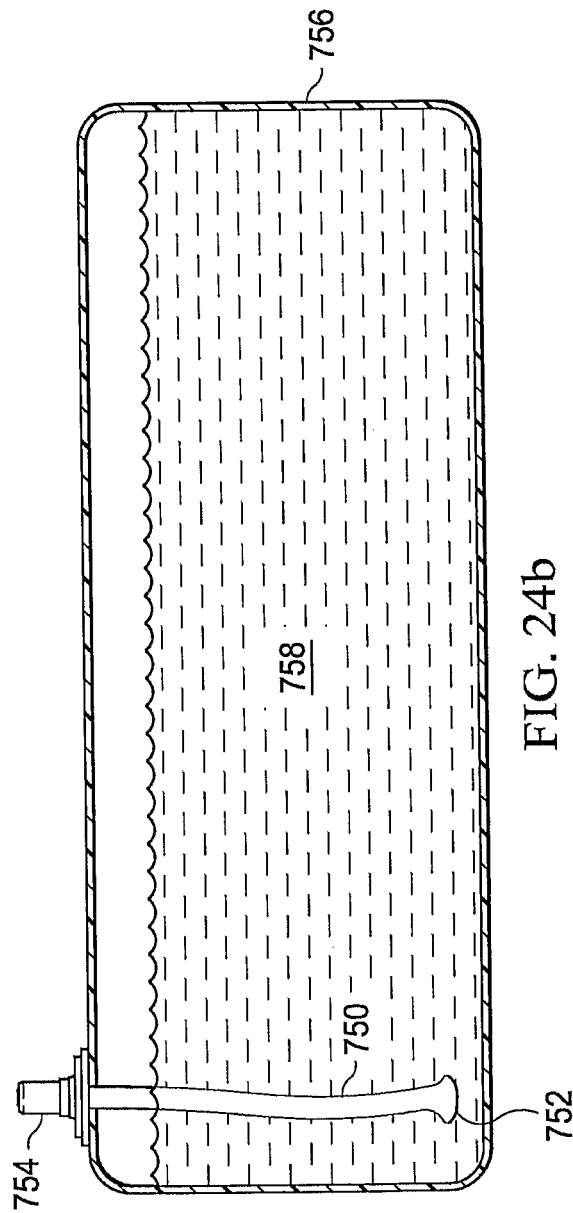


FIG. 24b

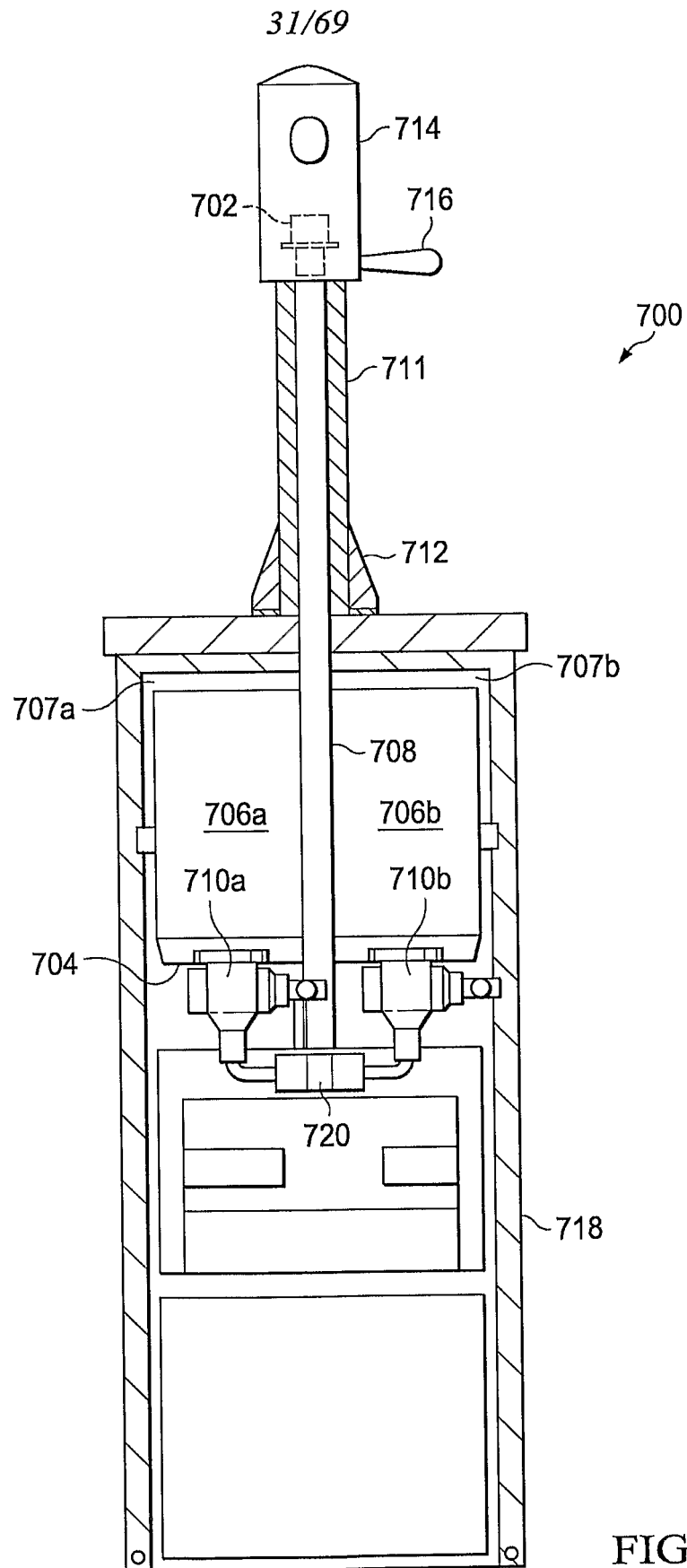
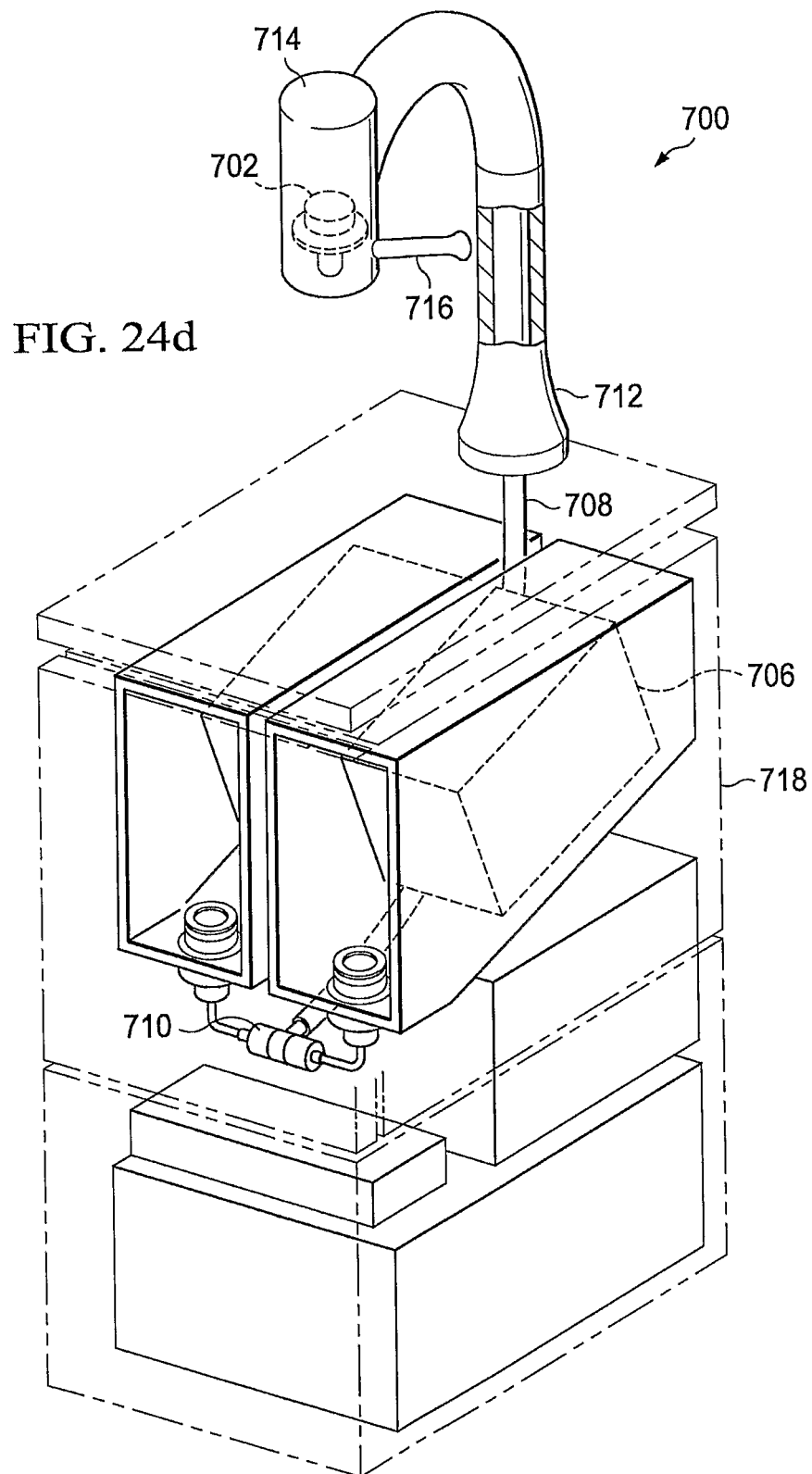


FIG. 24c

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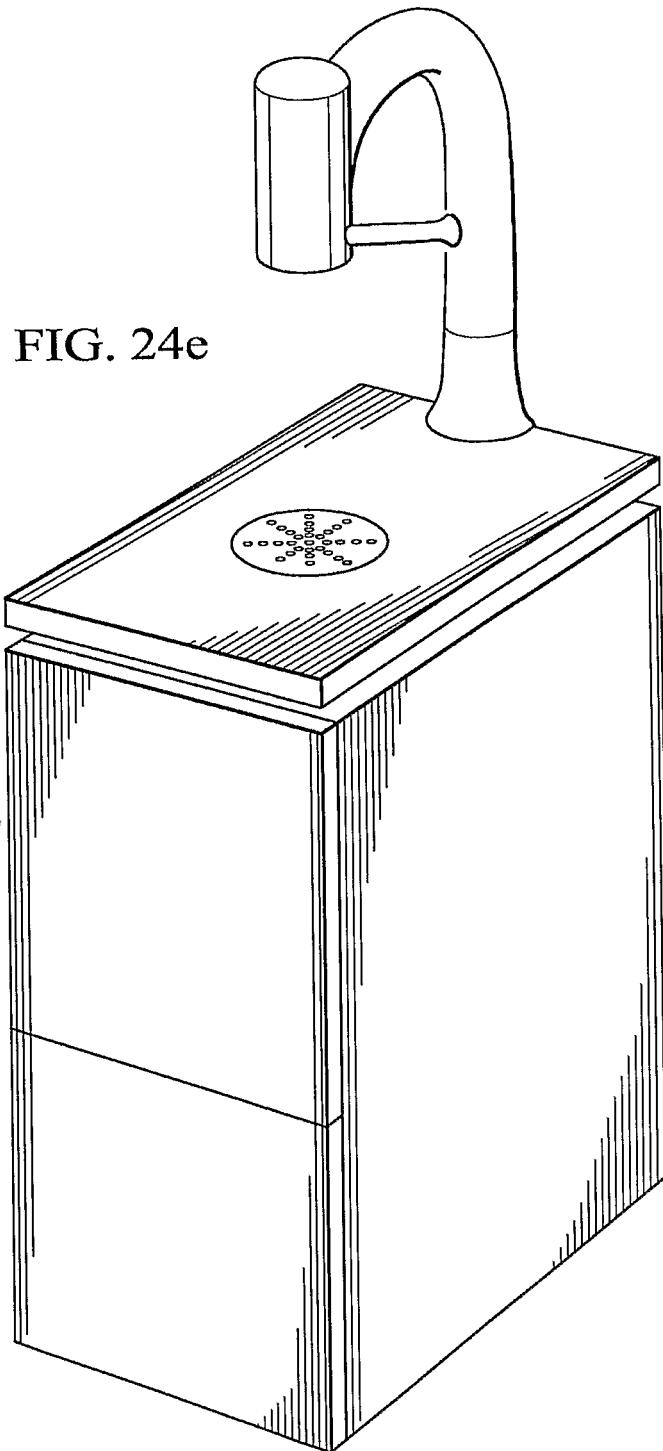


FIG. 24e



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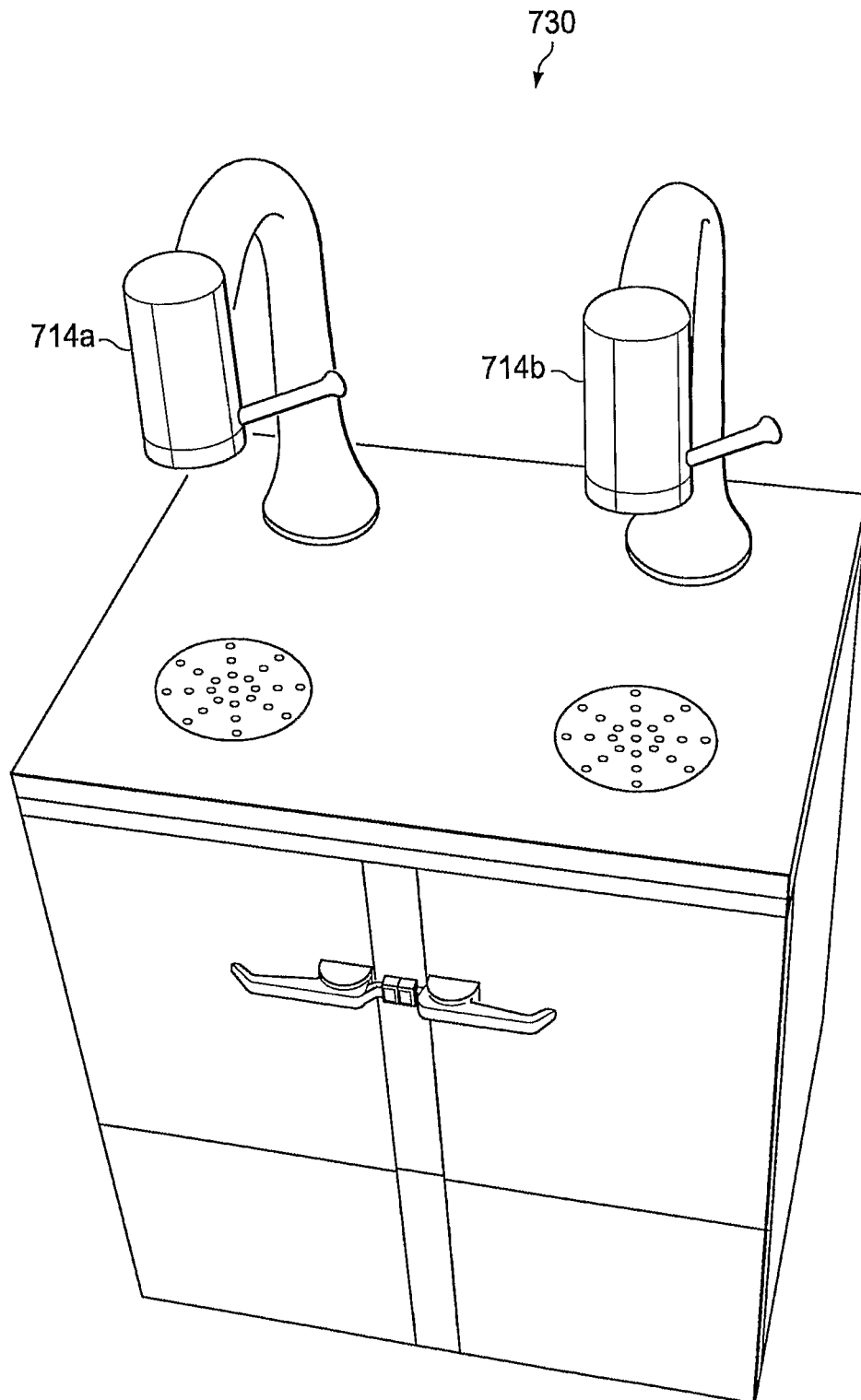


FIG. 24f

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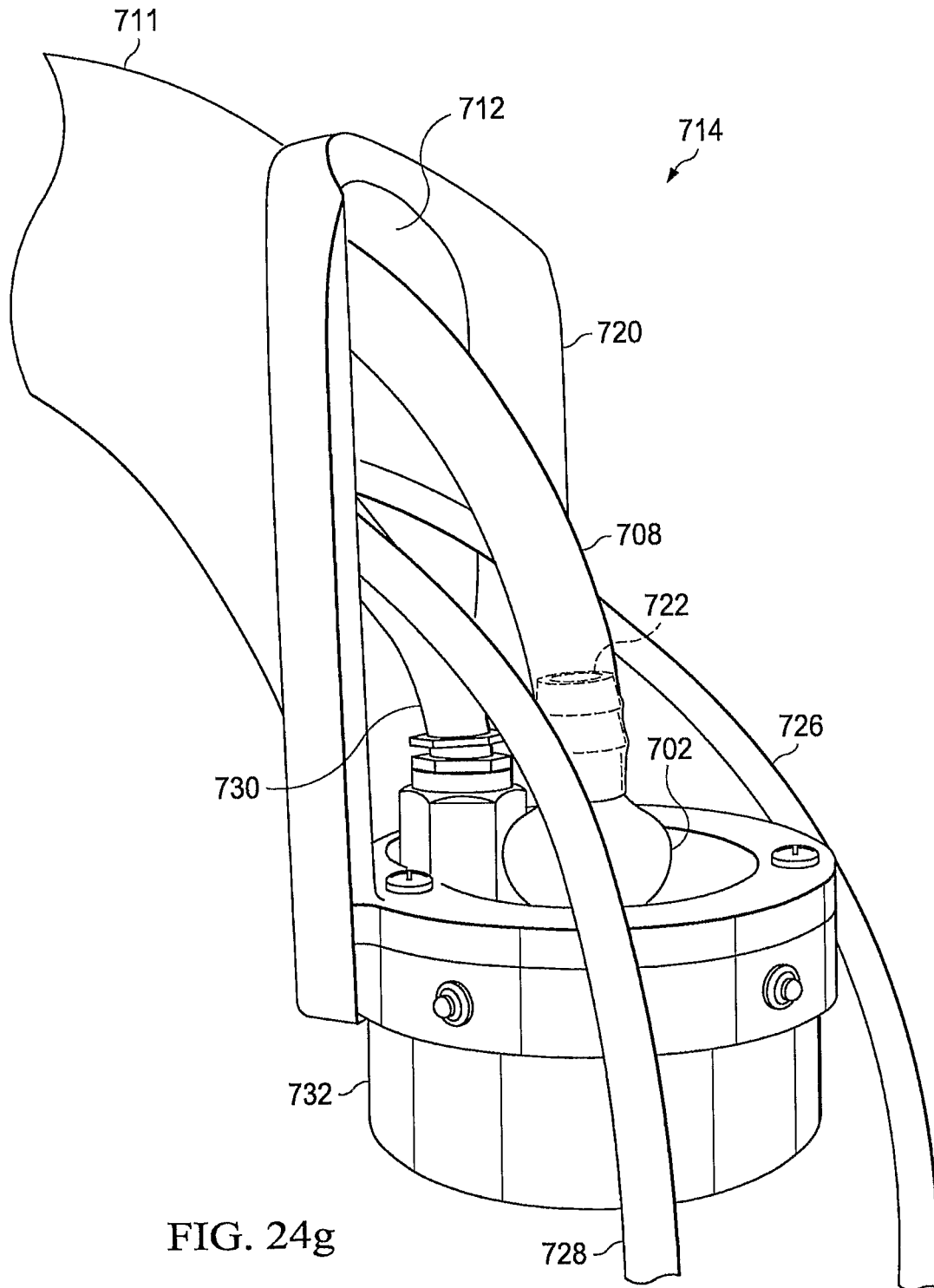
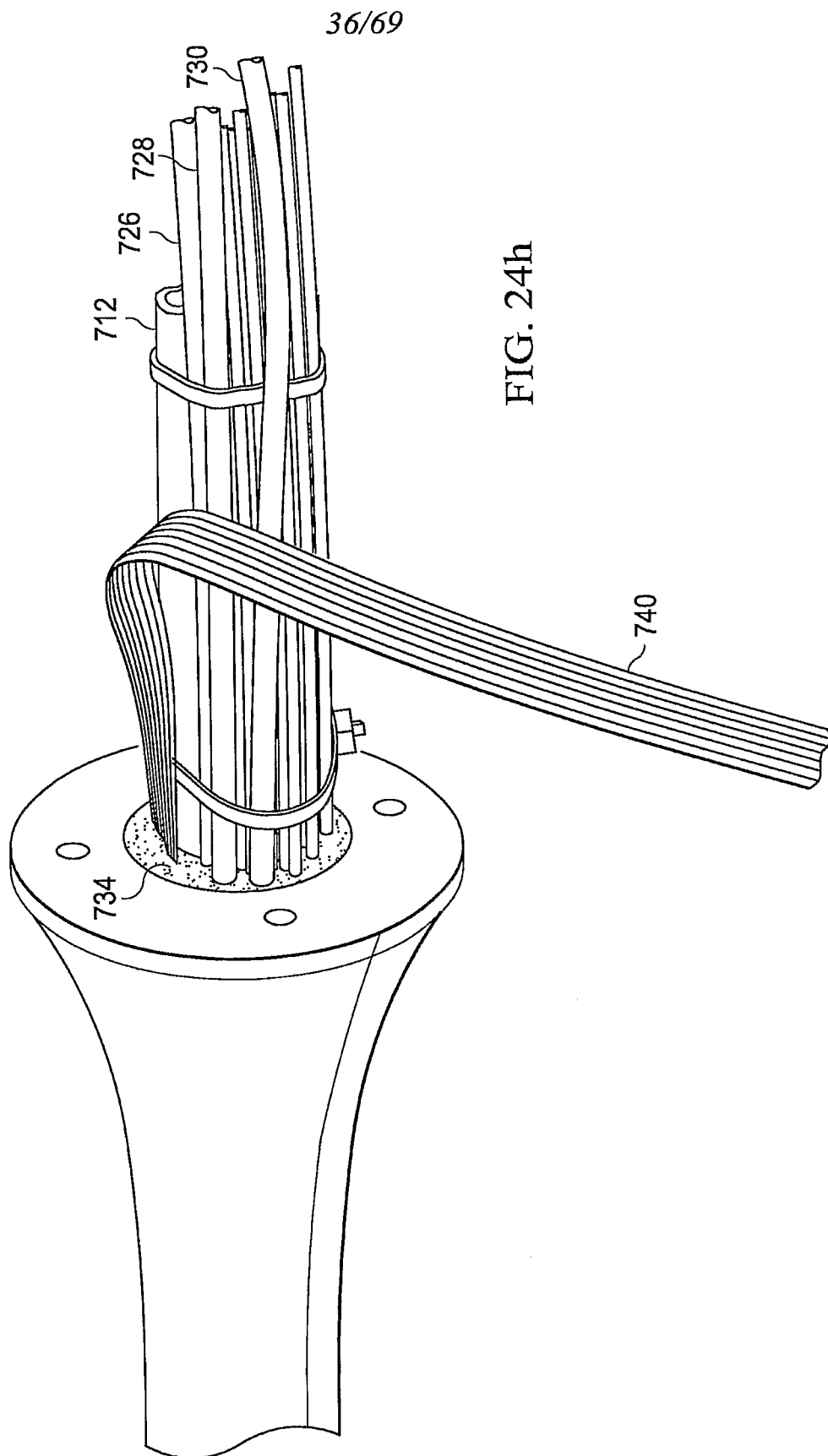


FIG. 24g



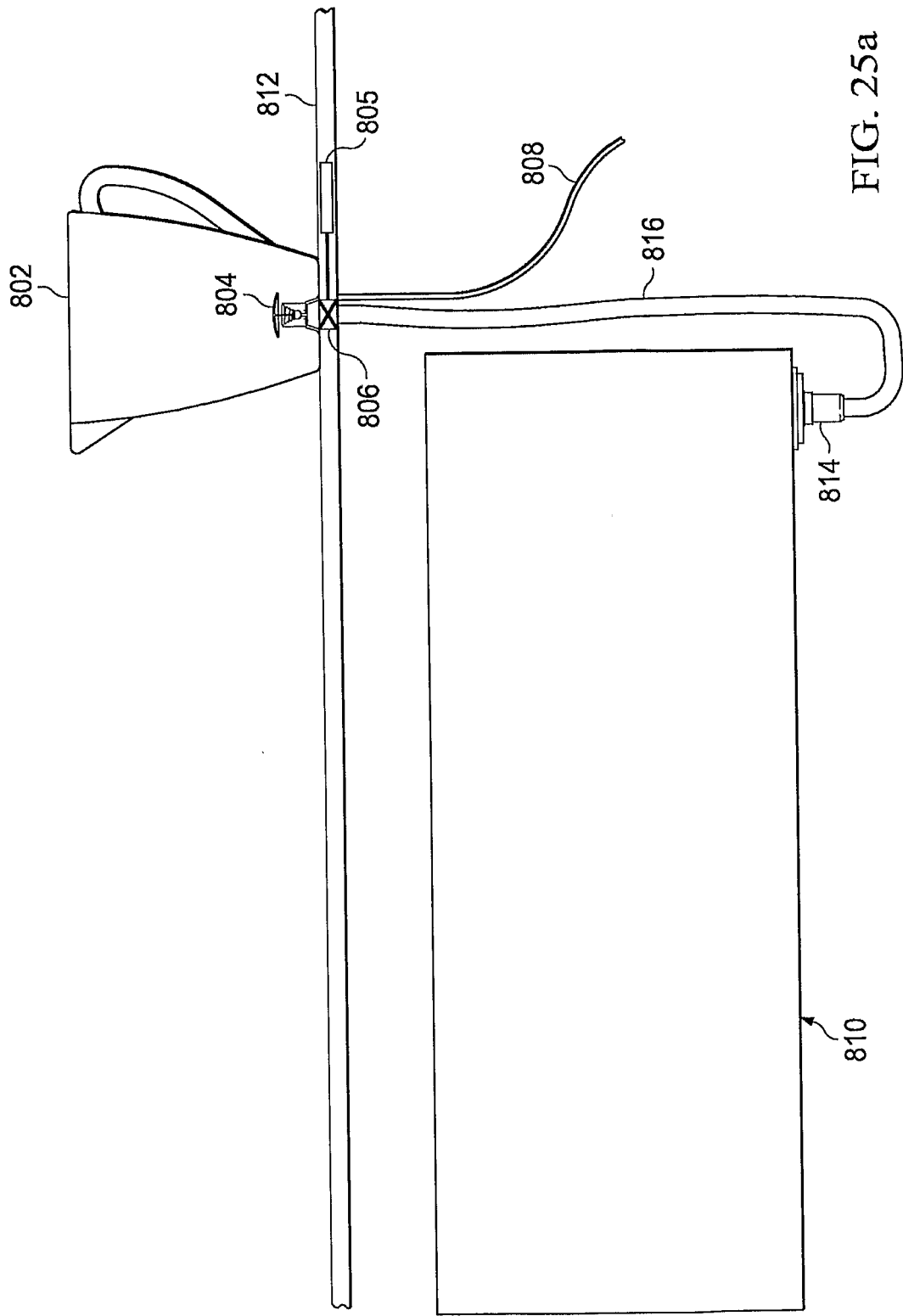


FIG. 25a

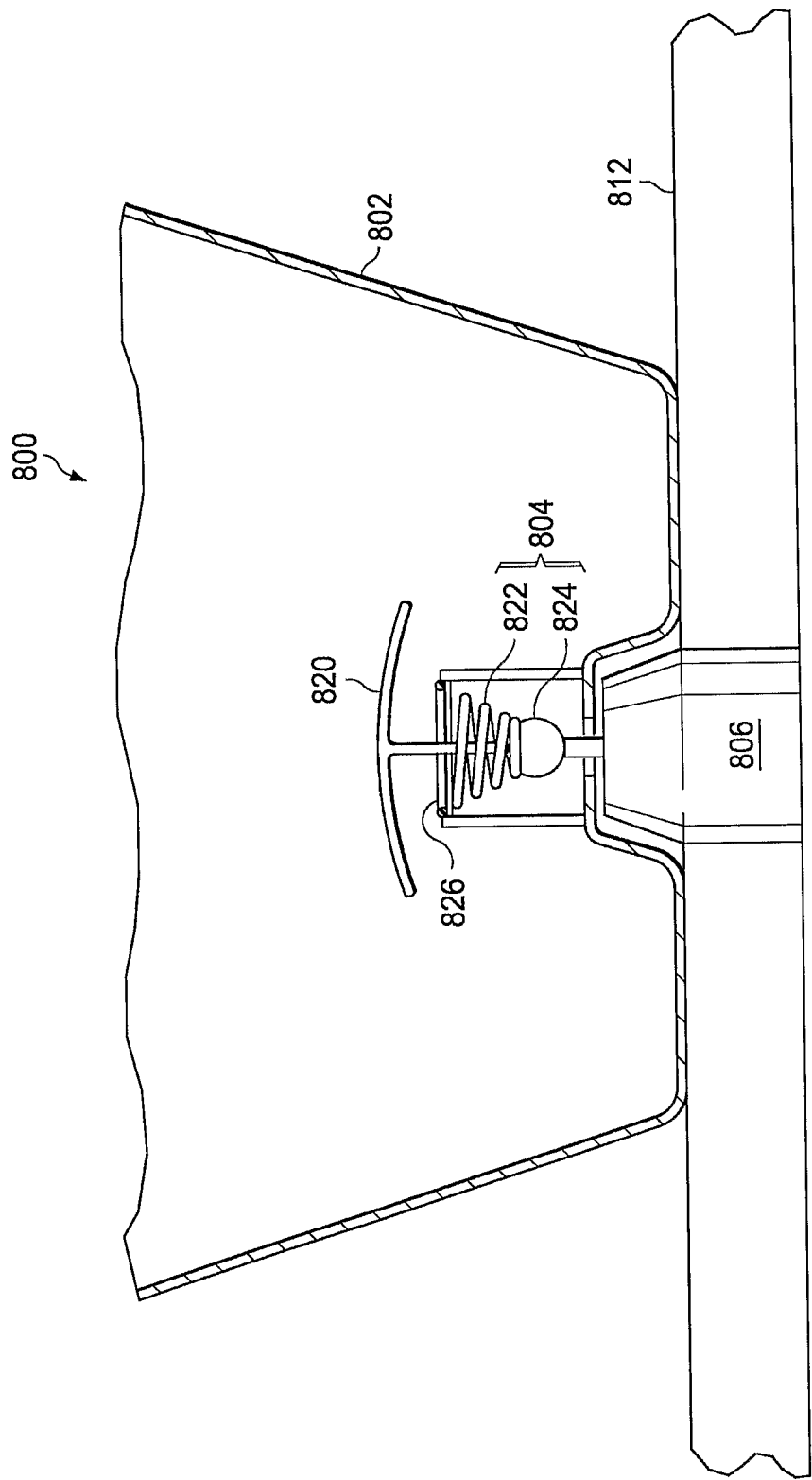
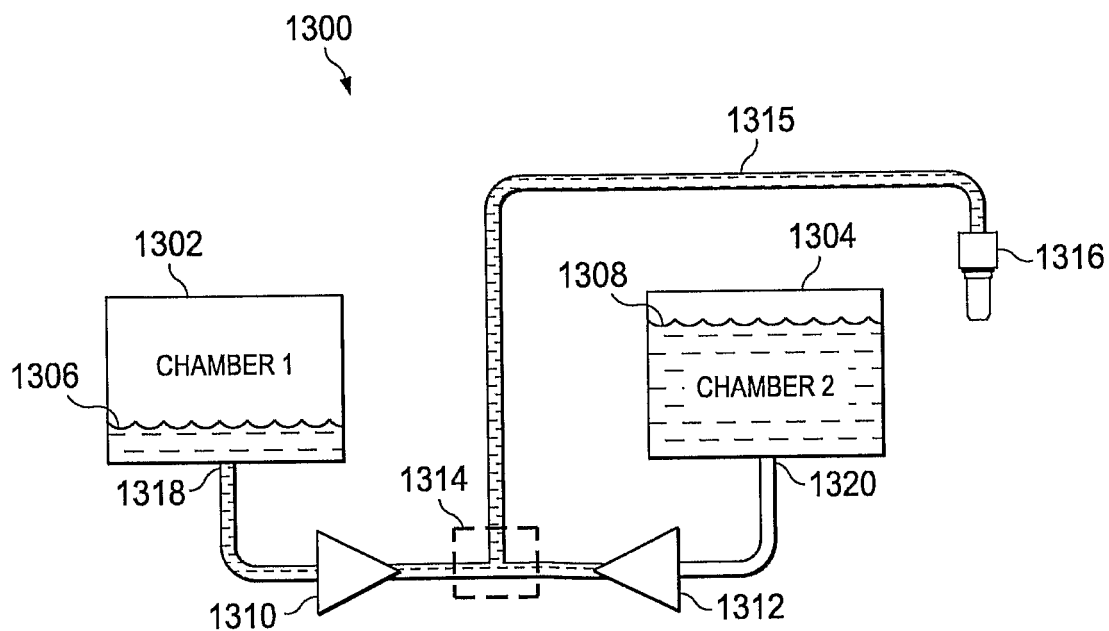
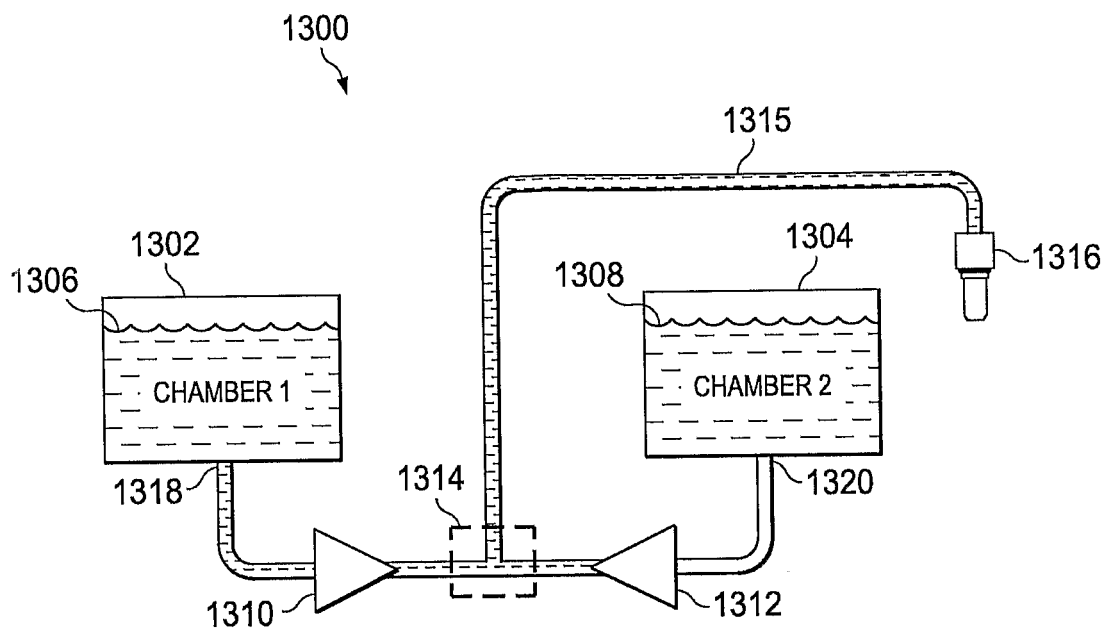


FIG. 25b

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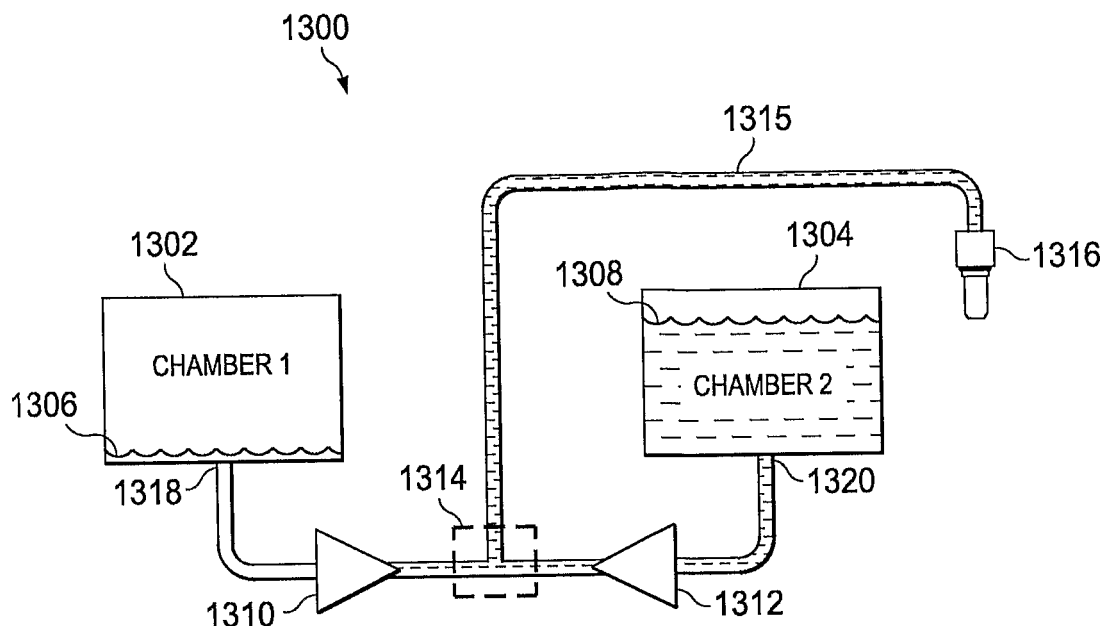


FIG. 26c

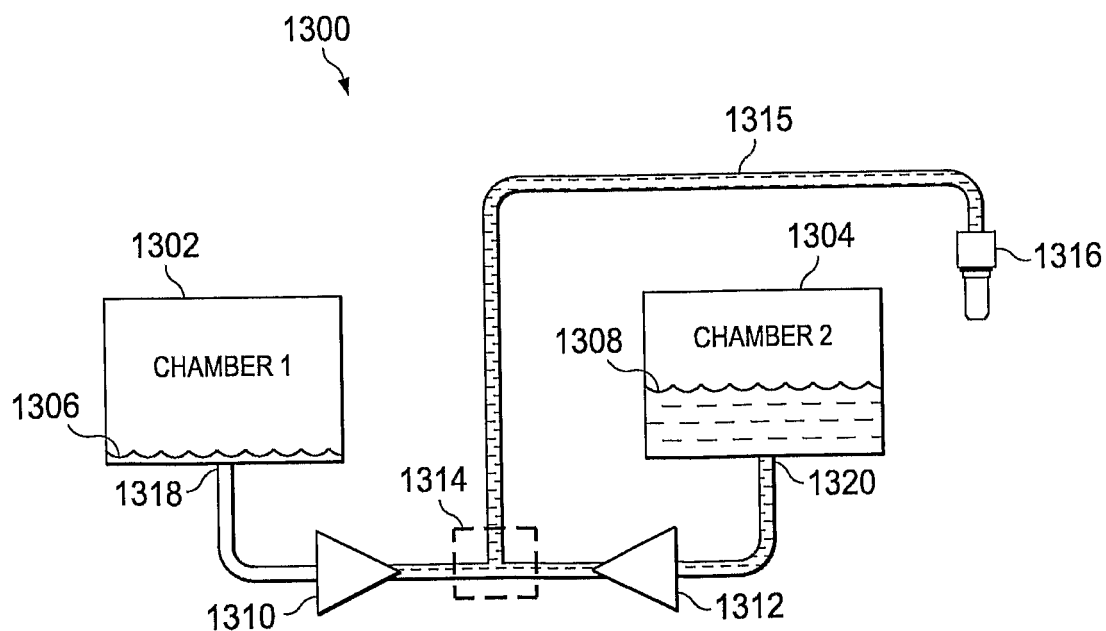
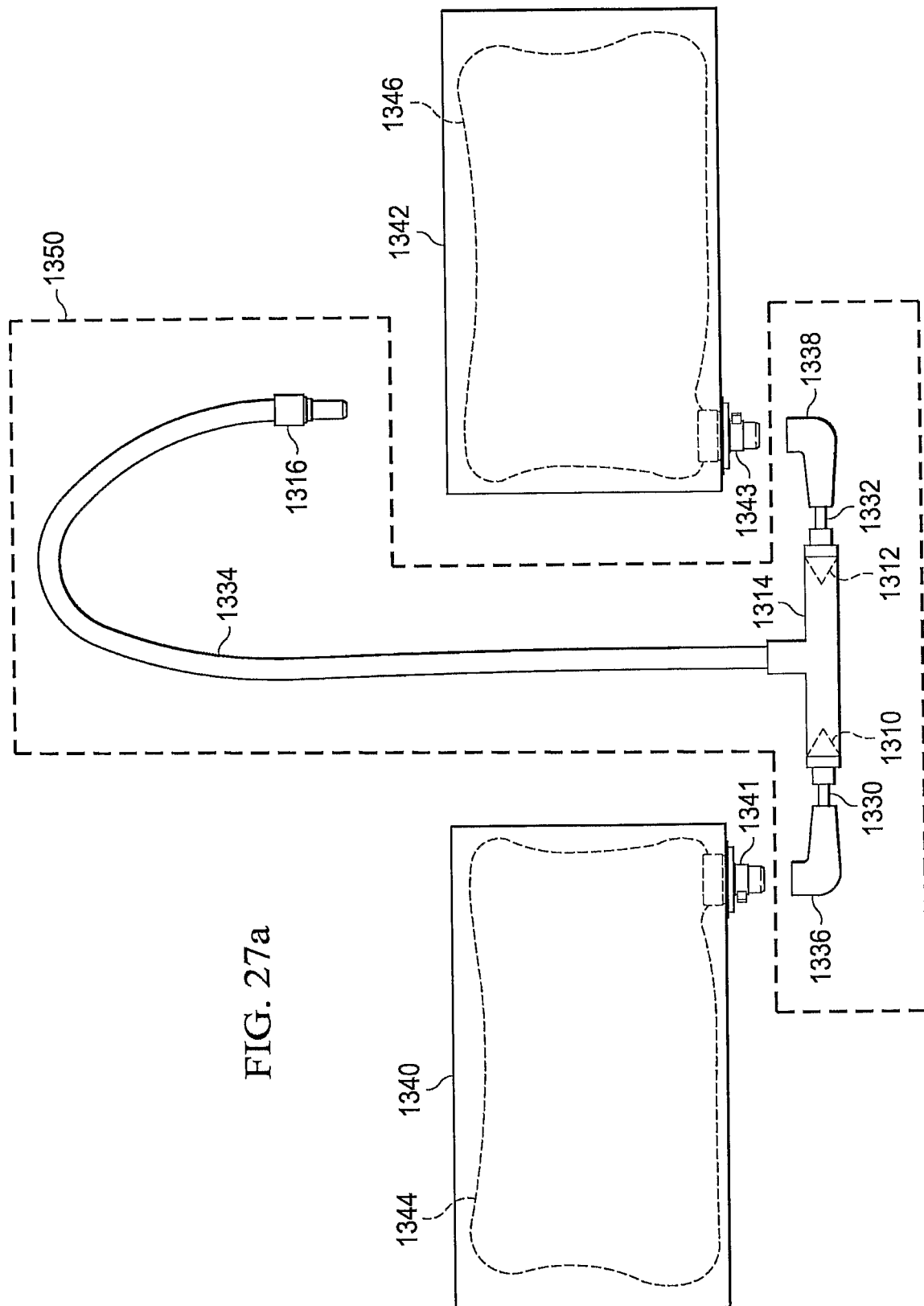


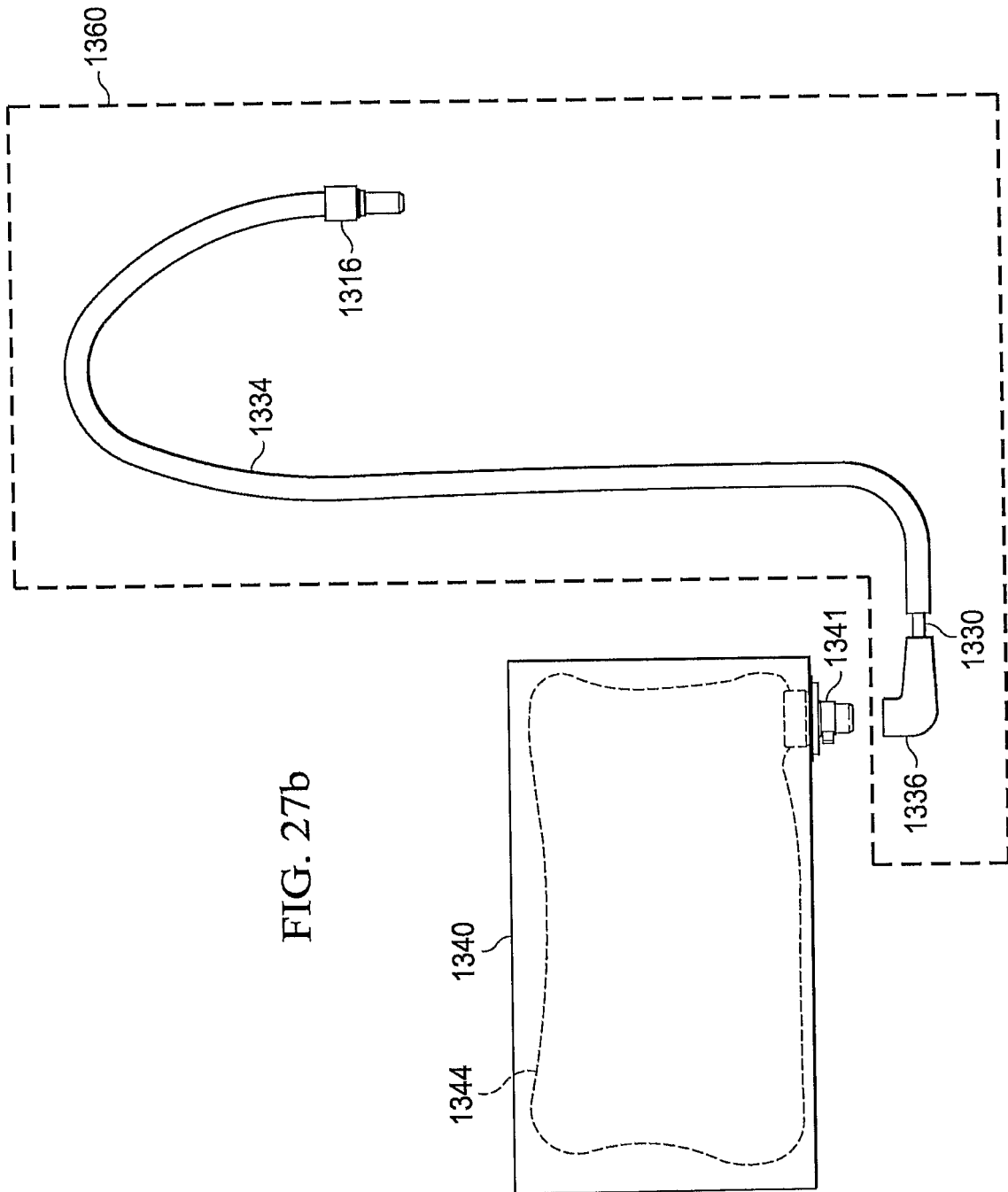
FIG. 26d

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FIG. 28a

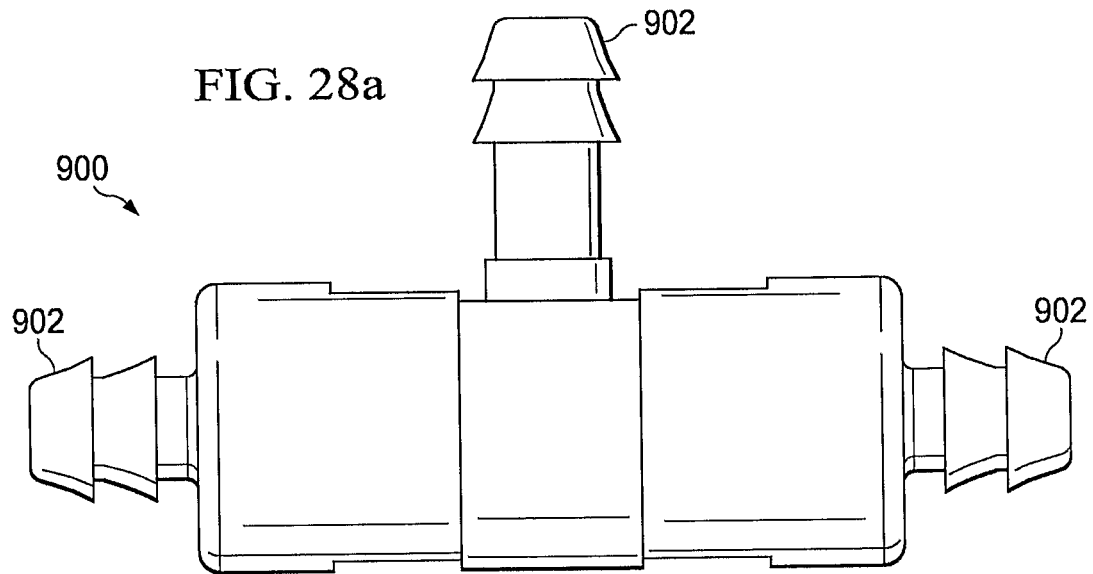


FIG. 28b

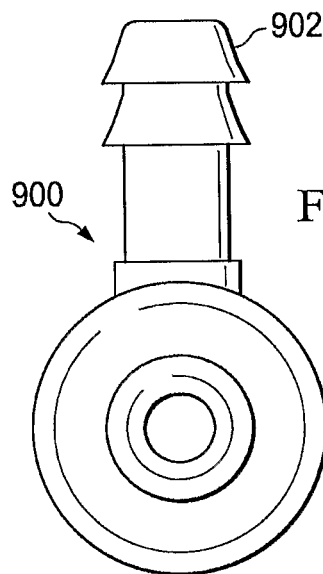
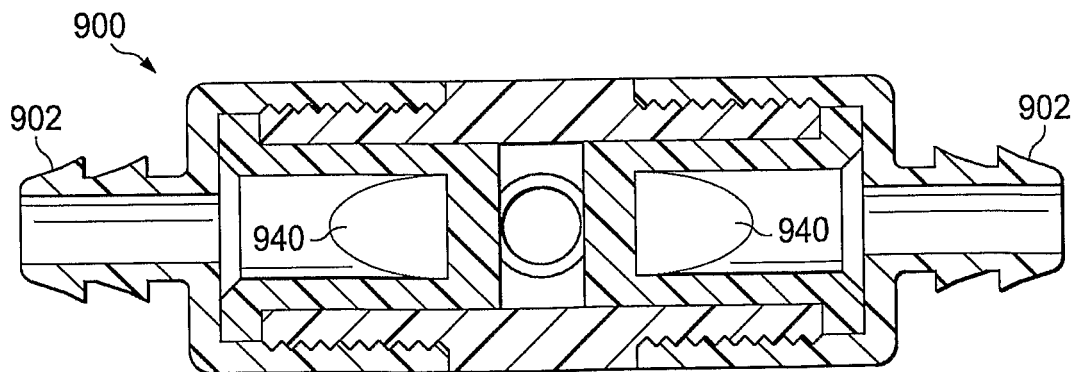


FIG. 28c



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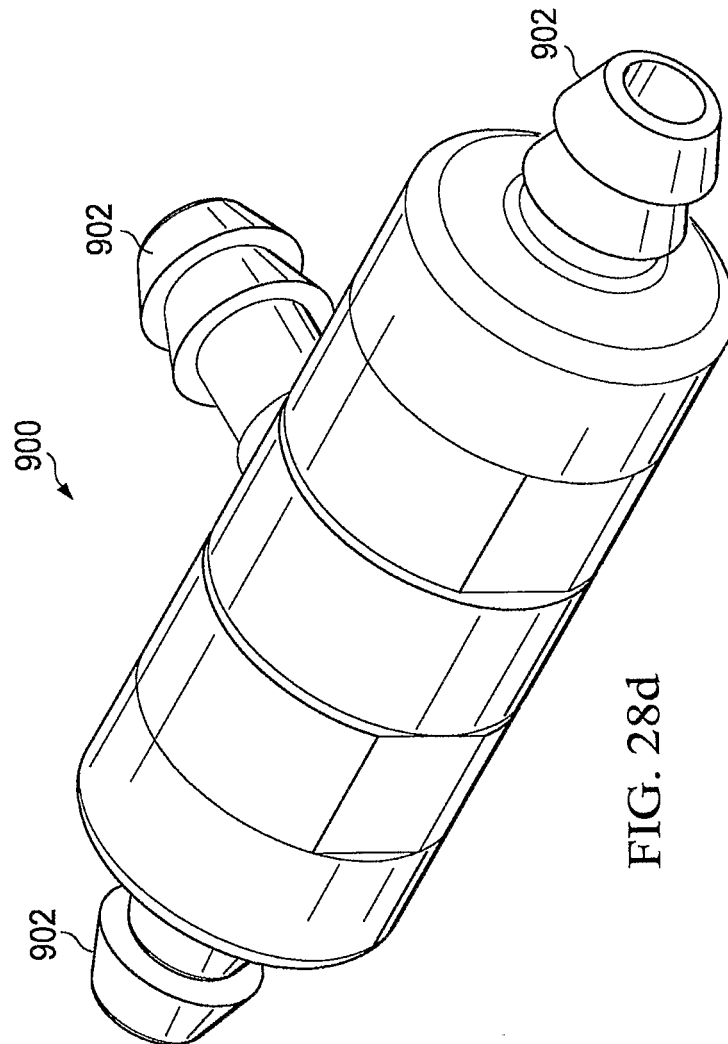
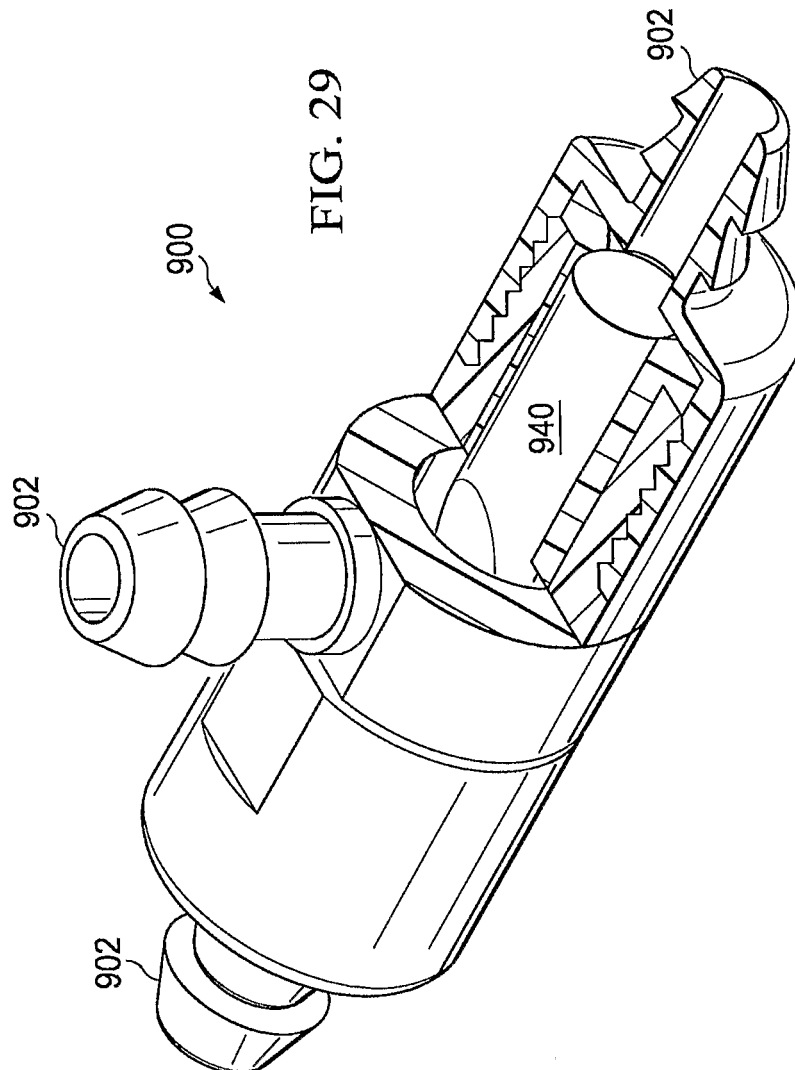
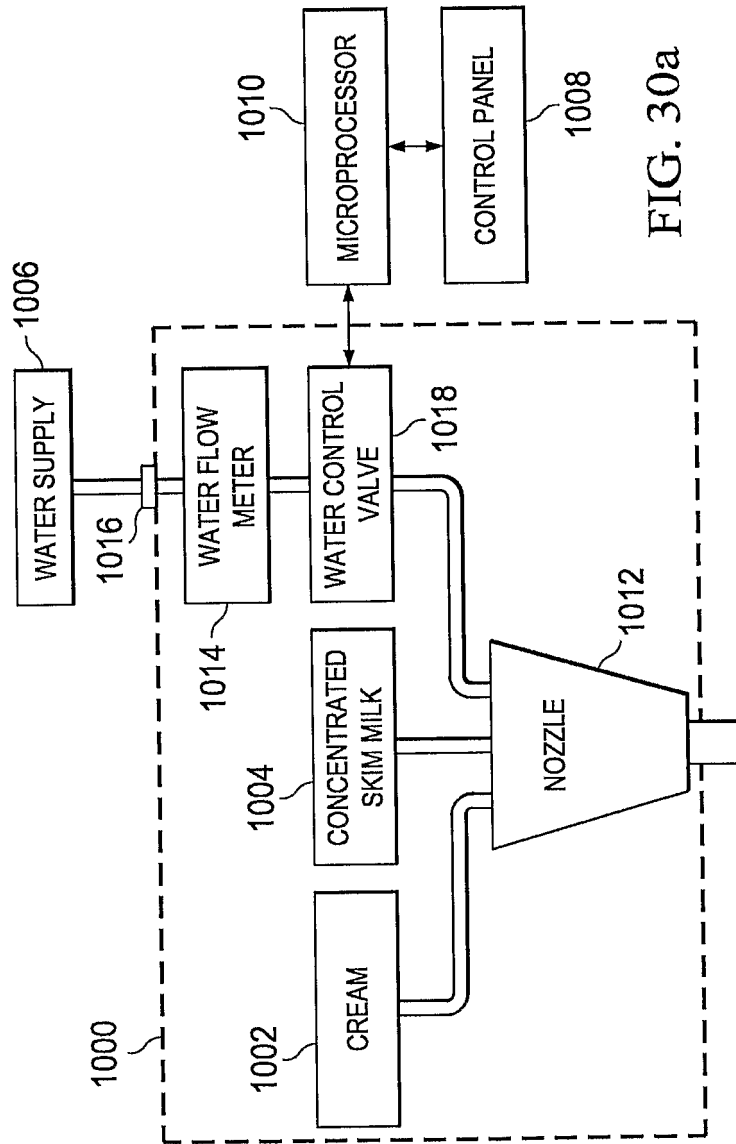


FIG. 28d



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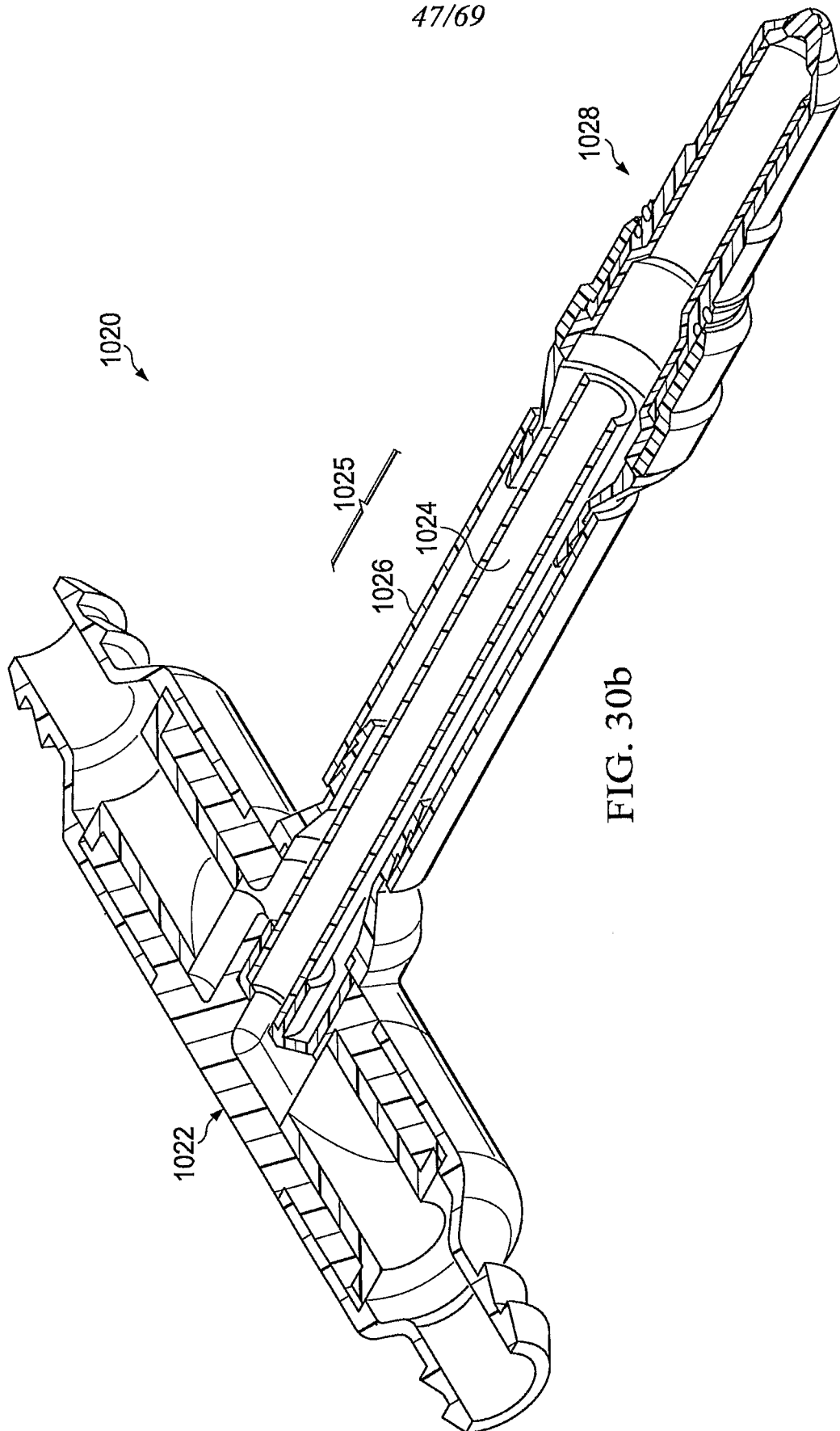
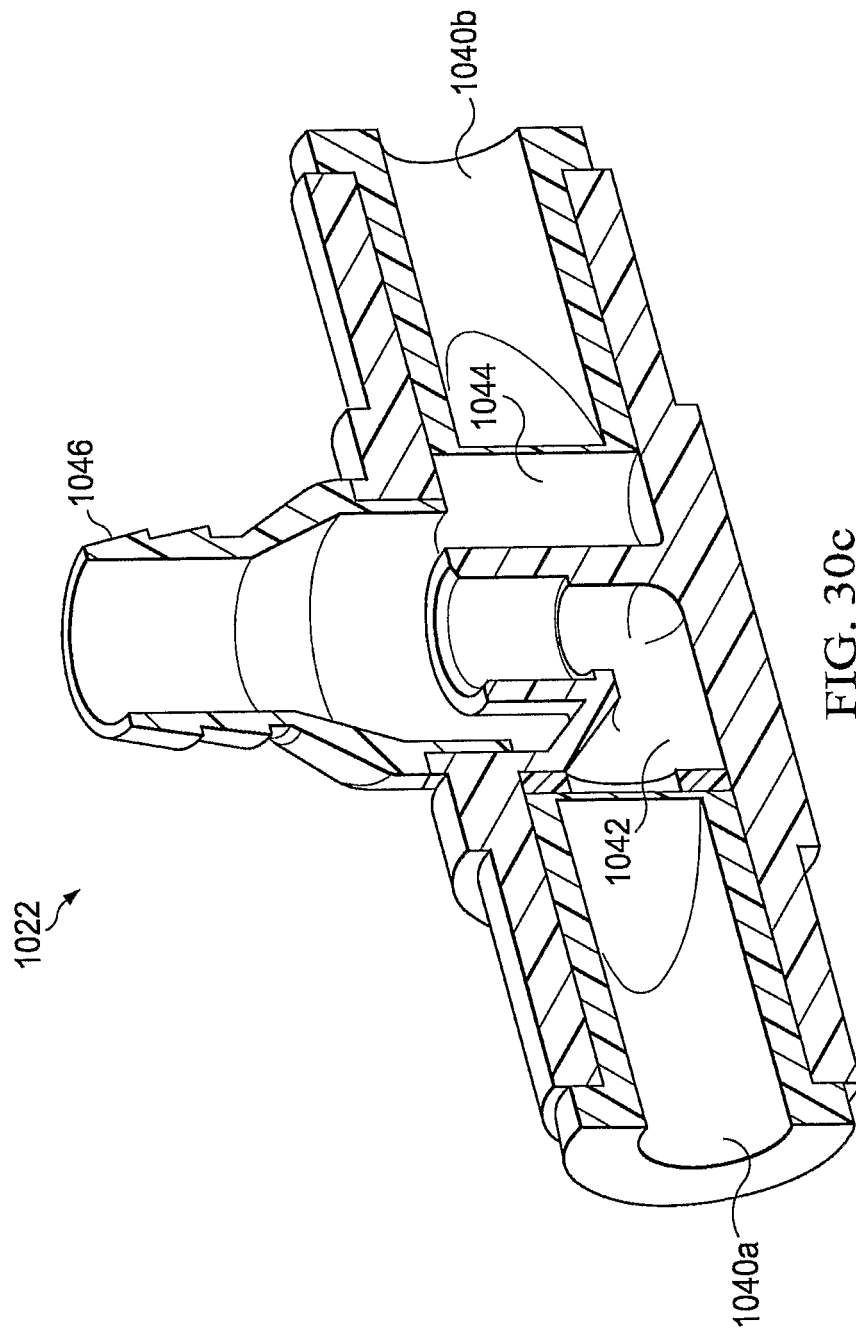


FIG. 30b

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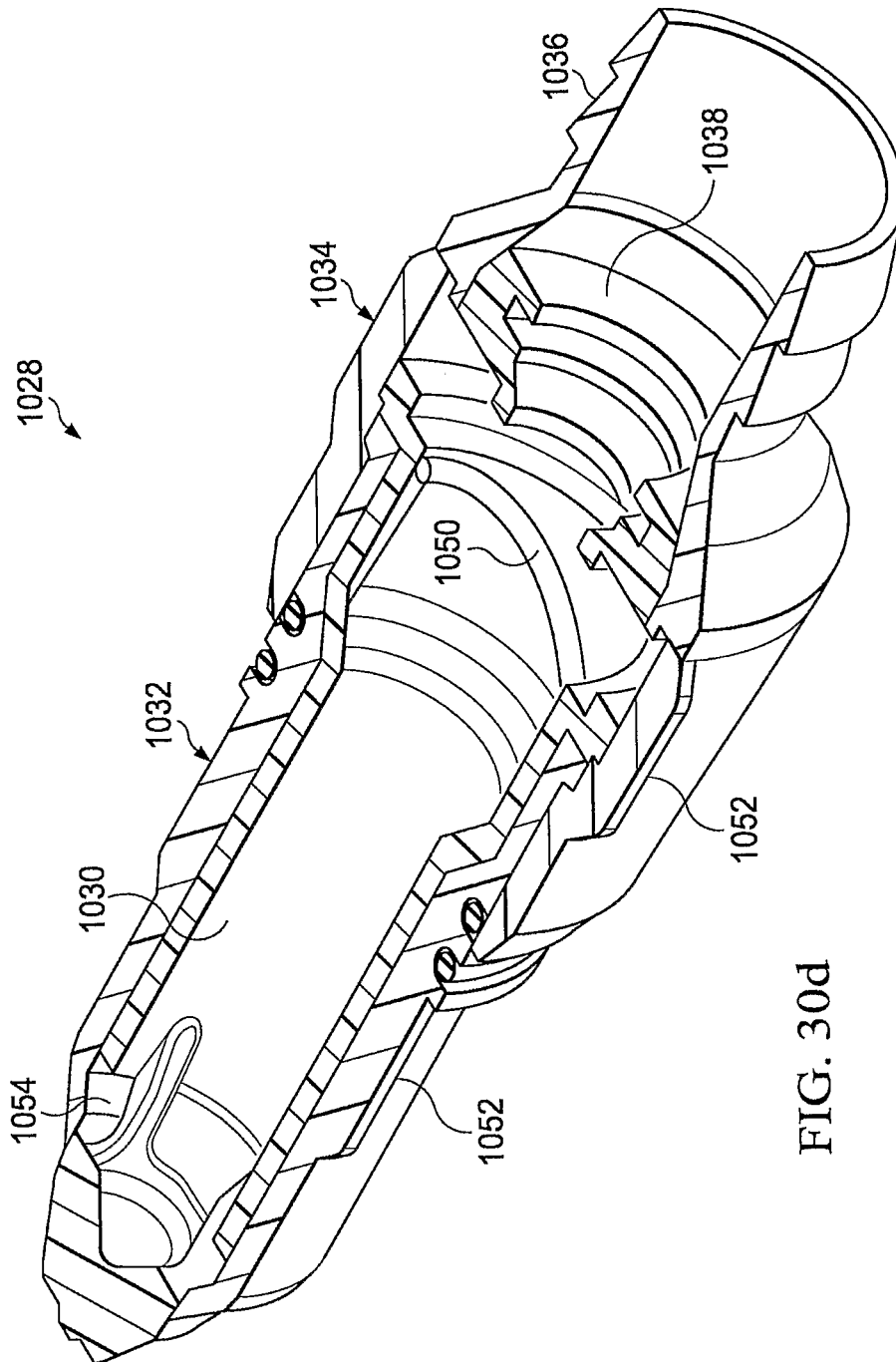
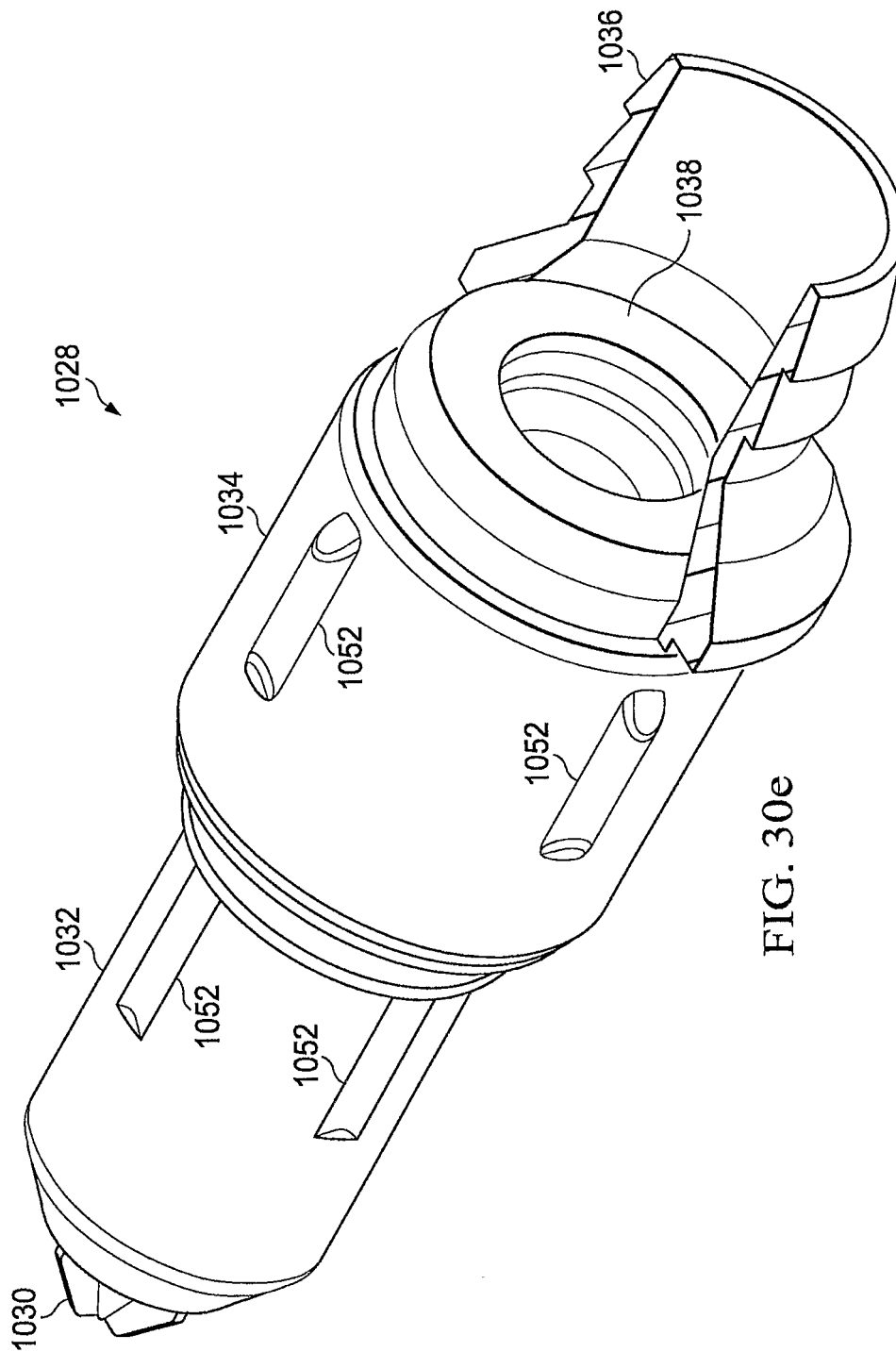


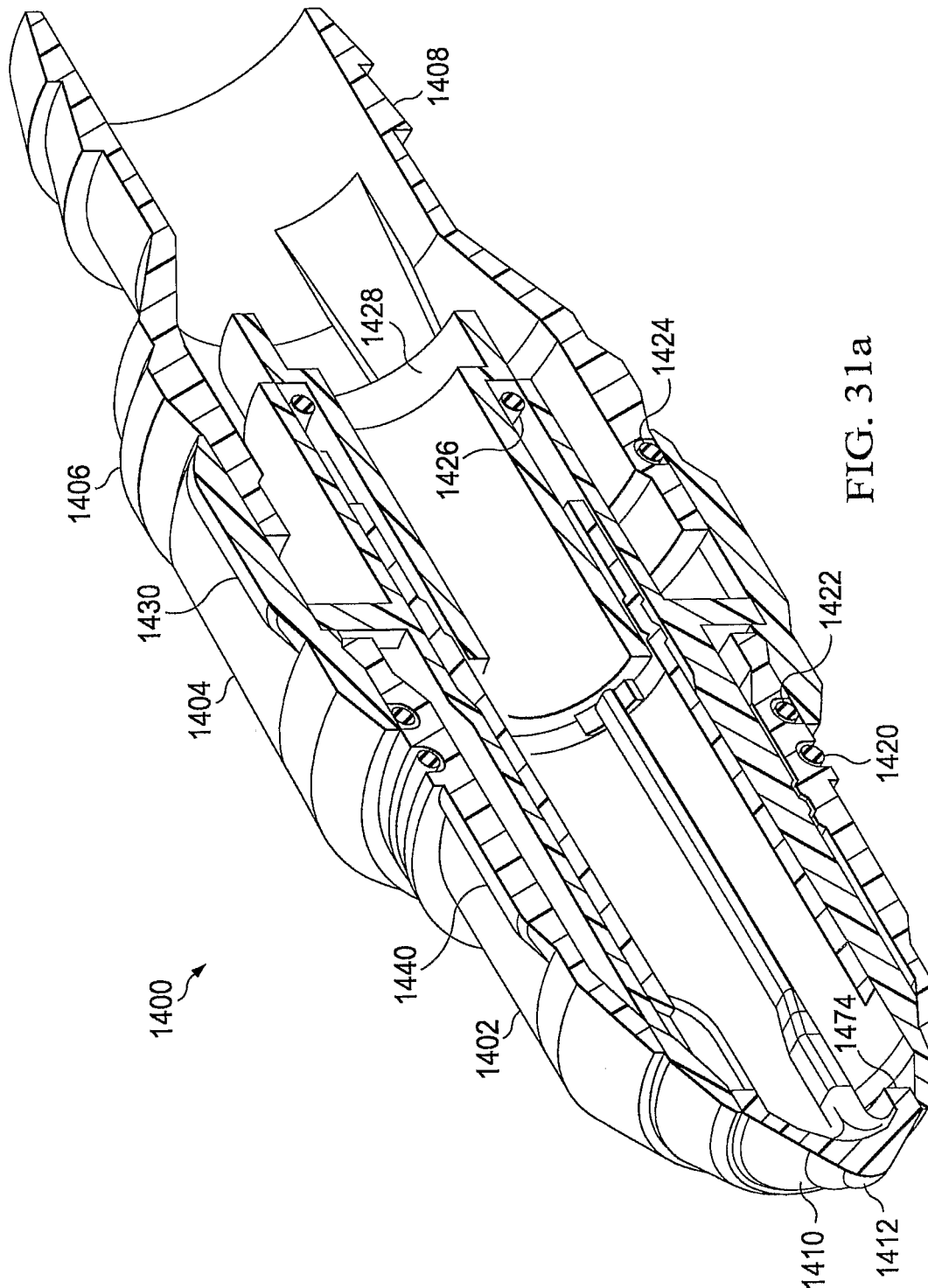
FIG. 30d



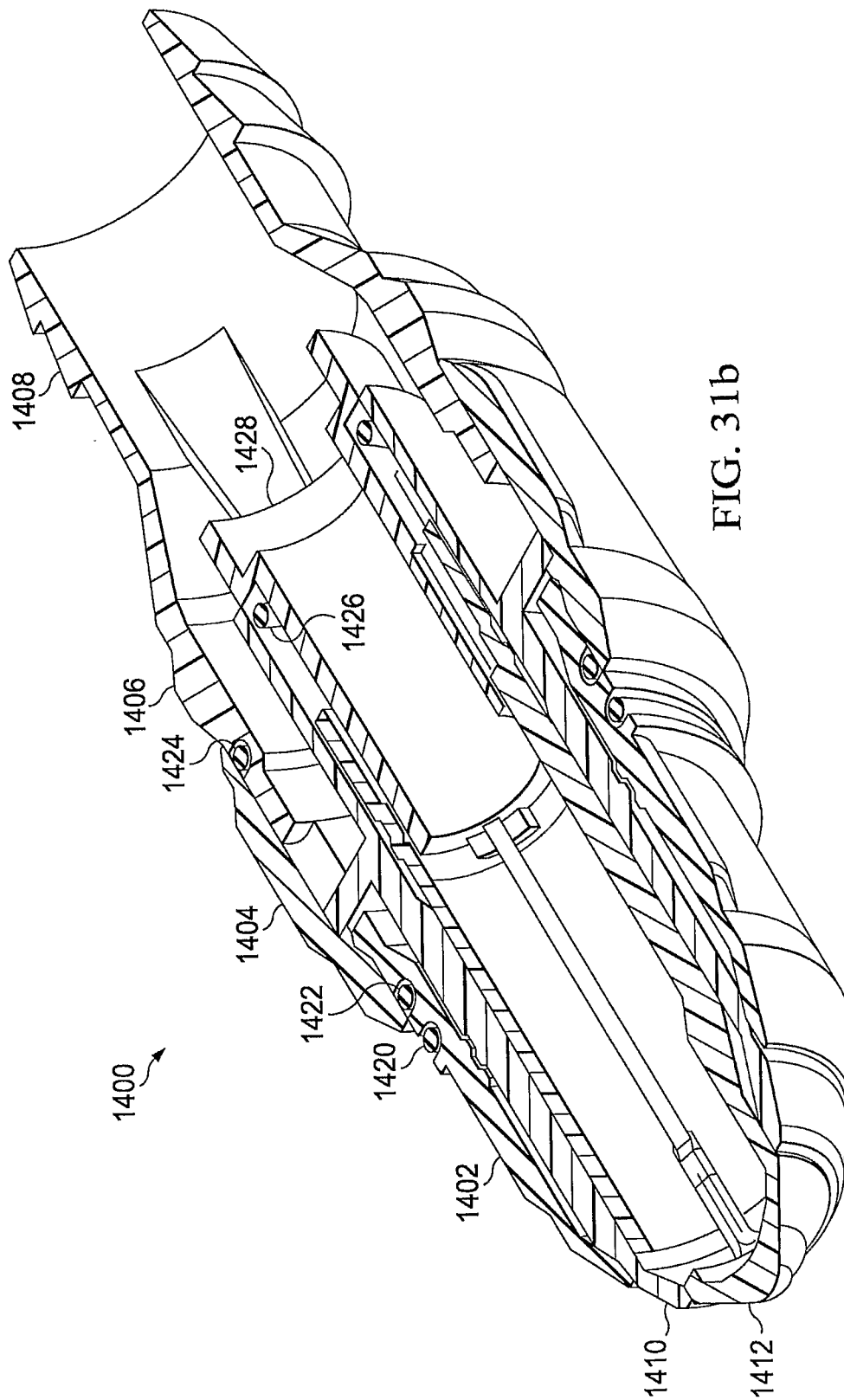
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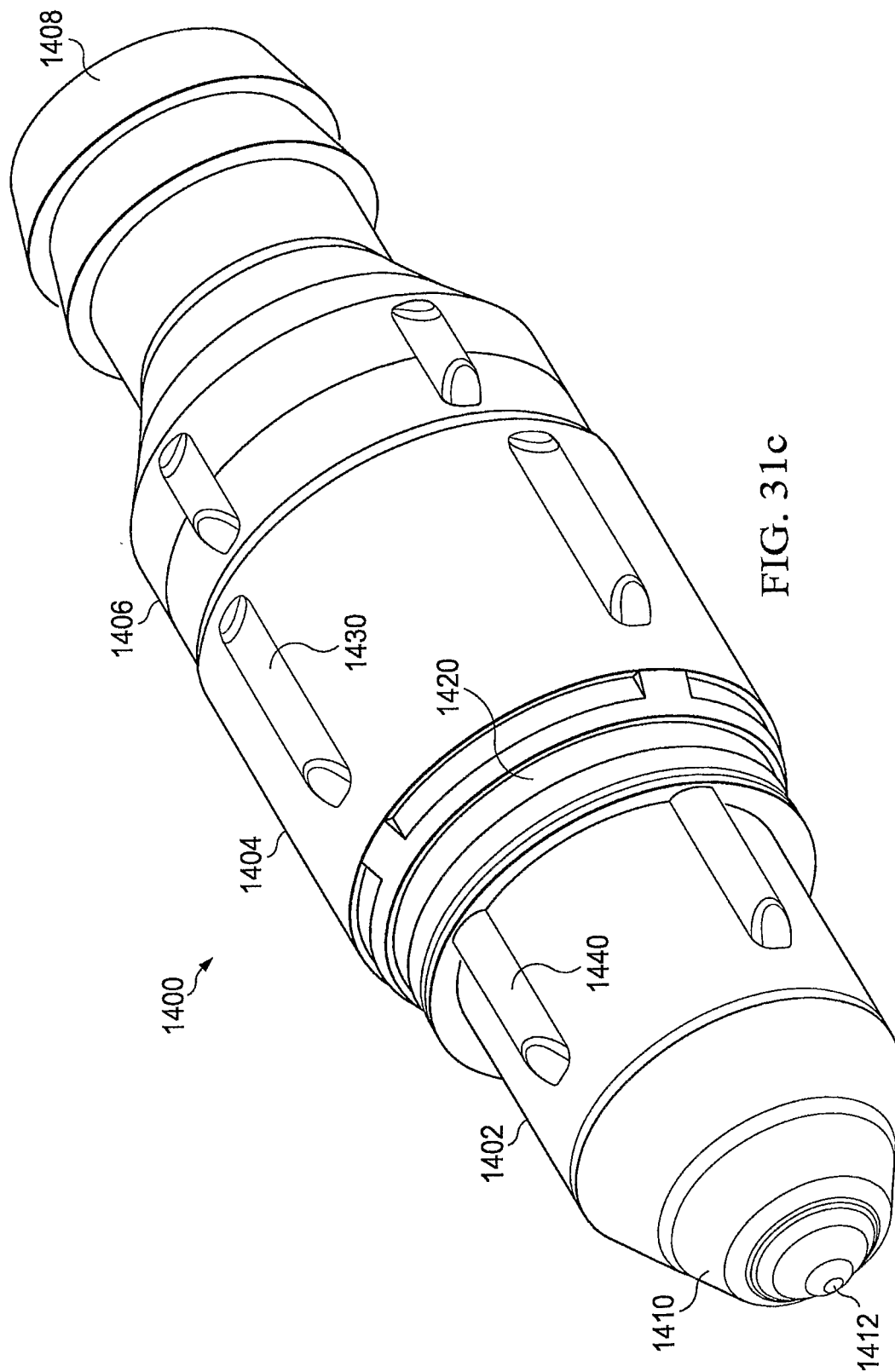
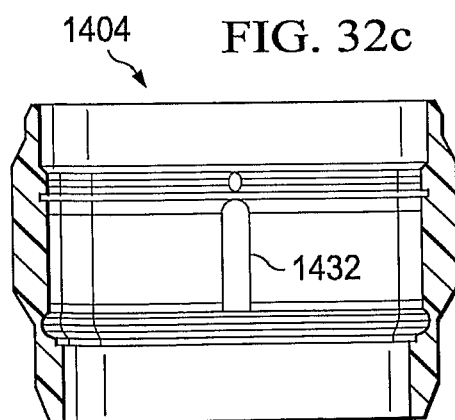
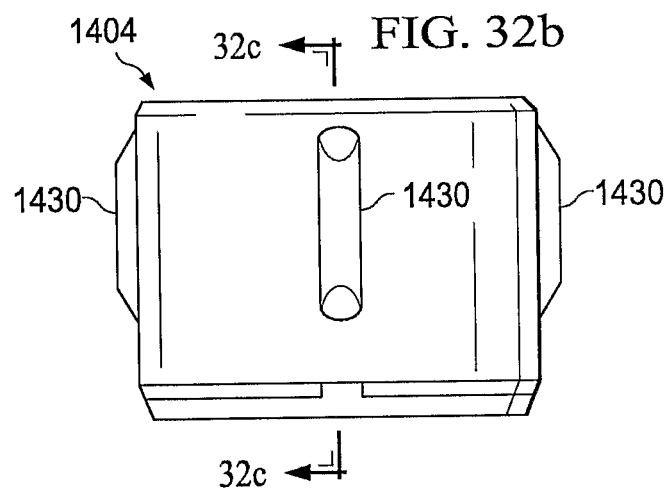
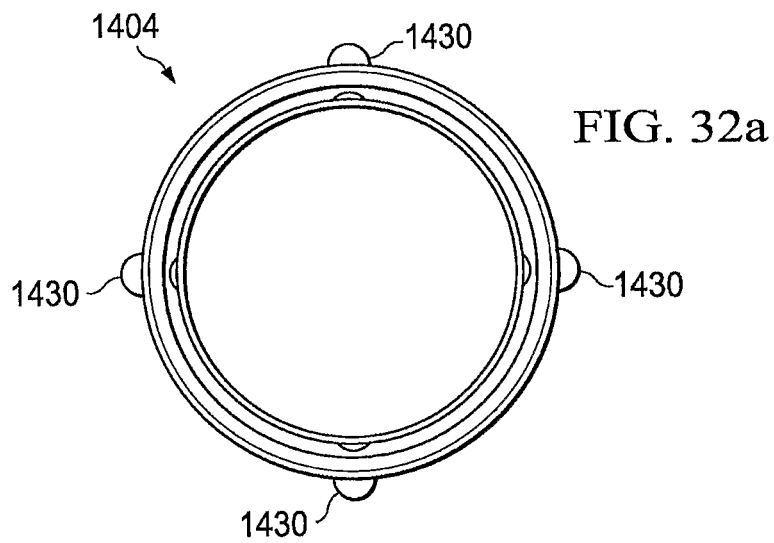
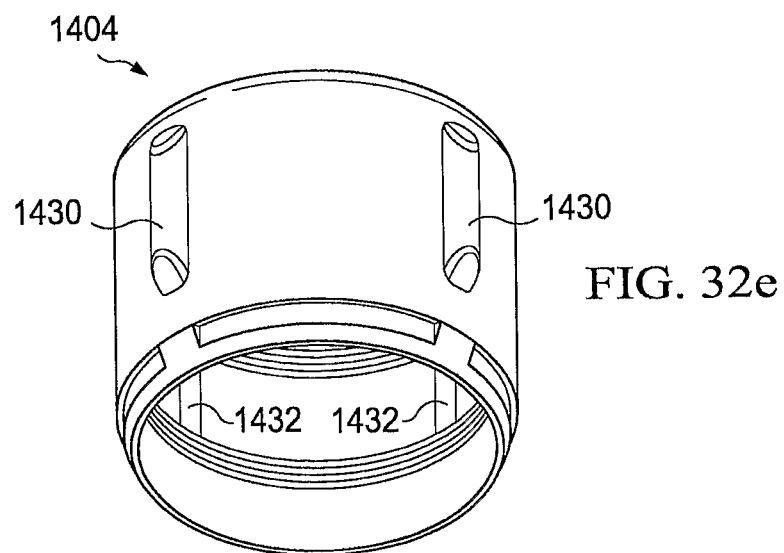
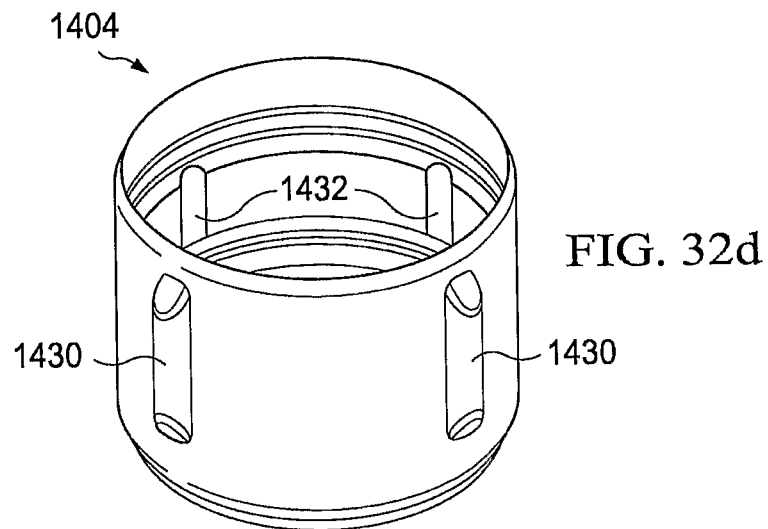


FIG. 31c

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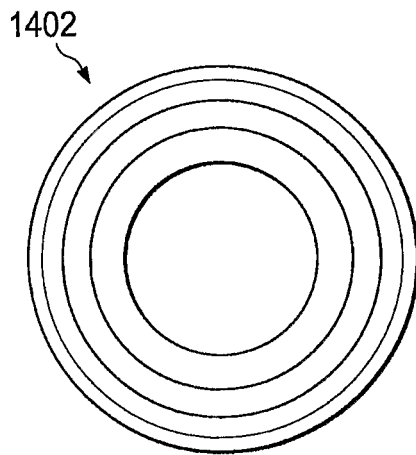


FIG. 33a

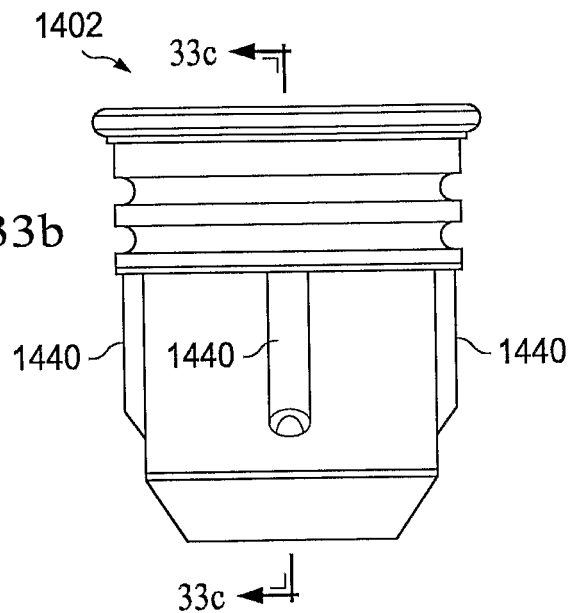


FIG. 33b

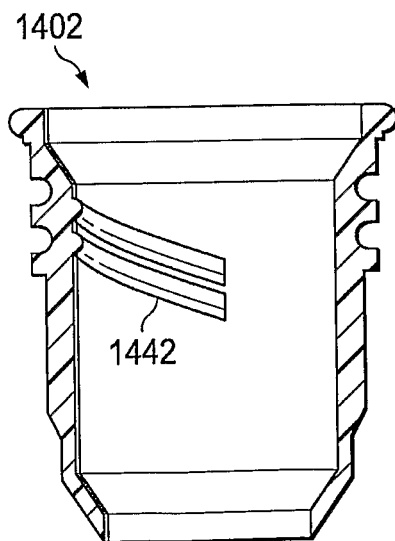


FIG. 33c

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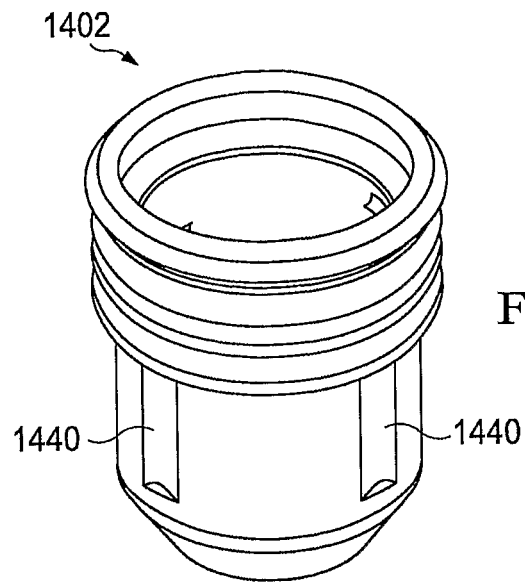


FIG. 33d

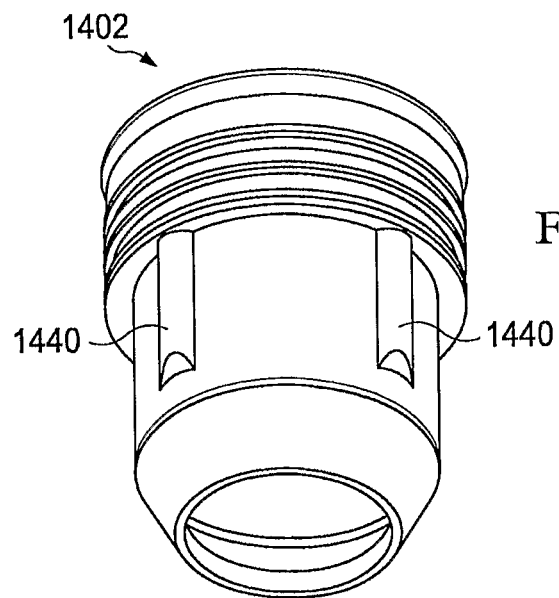


FIG. 33e



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FIG. 34a

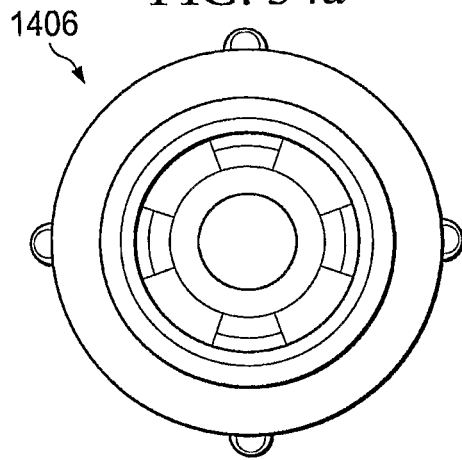


FIG. 34b

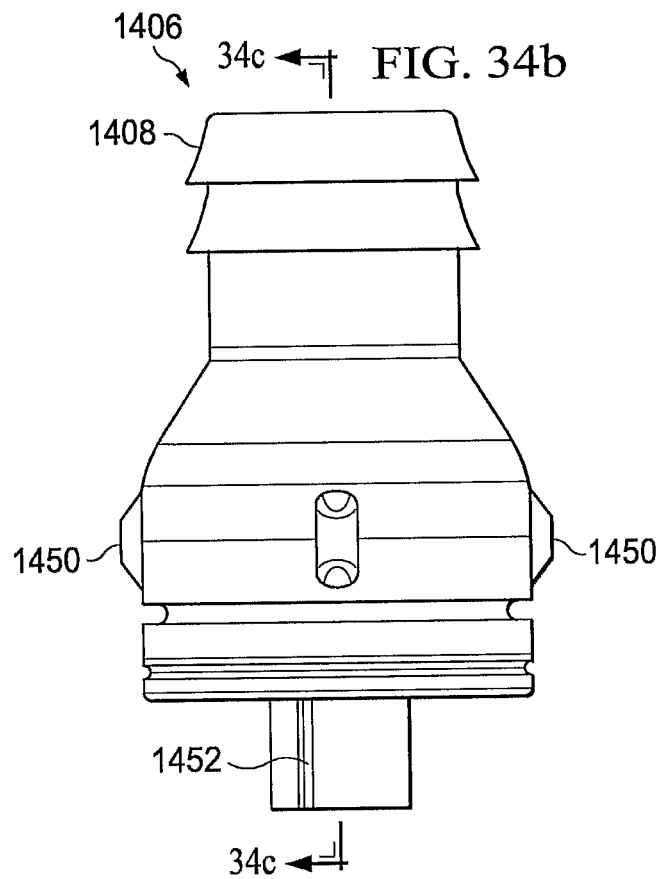
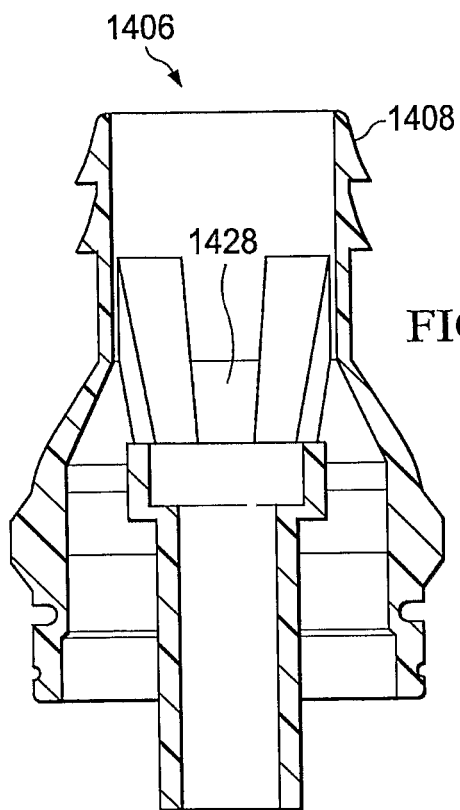
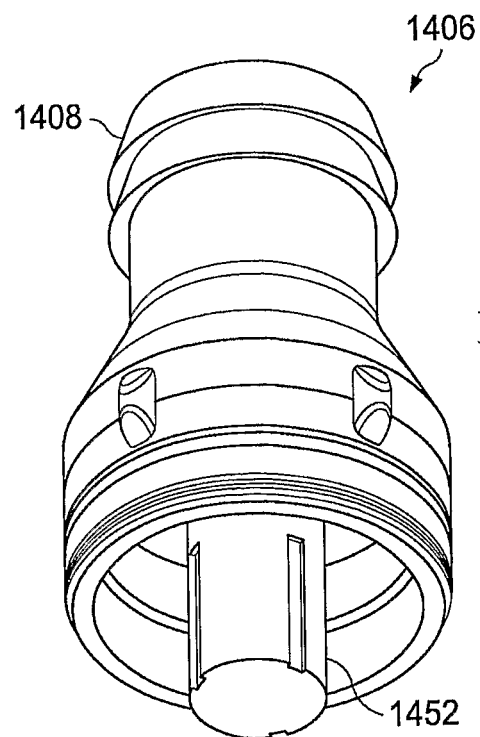
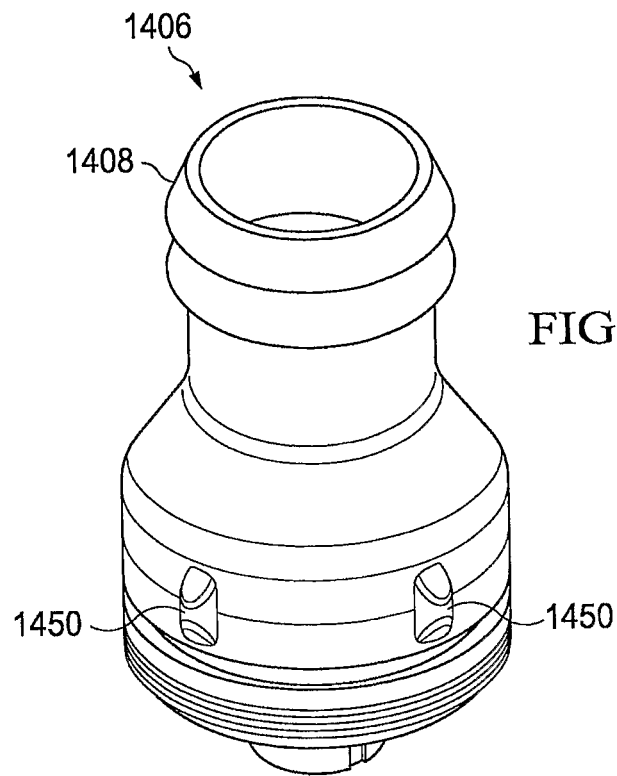


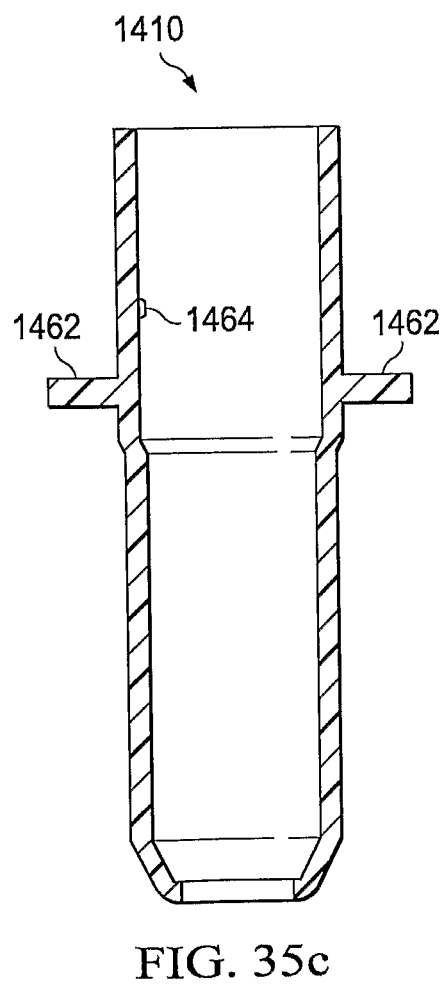
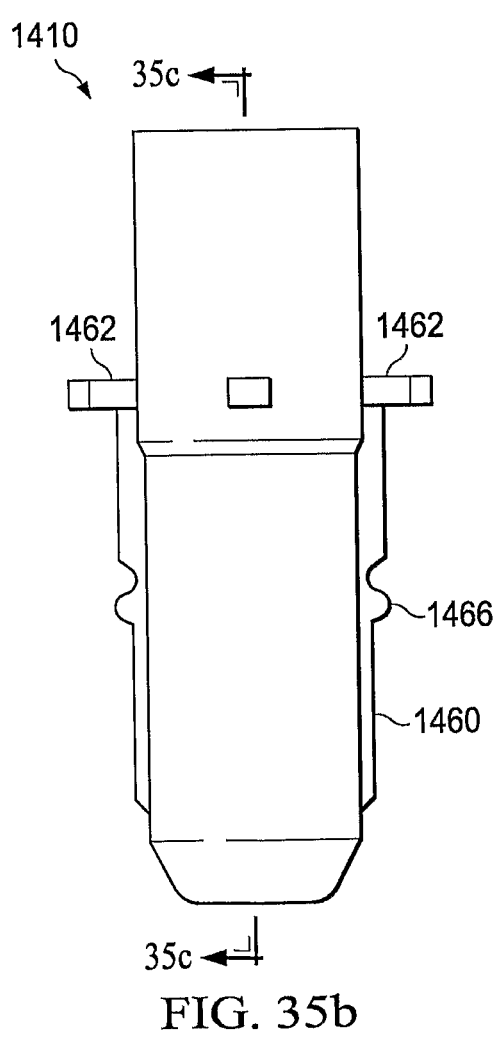
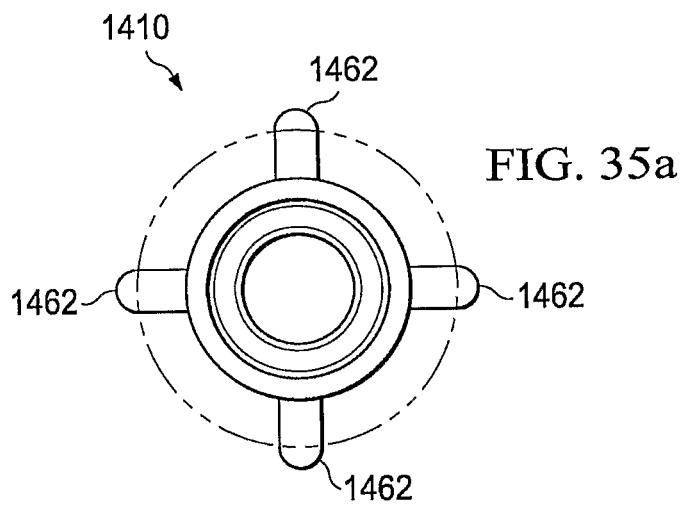
FIG. 34c



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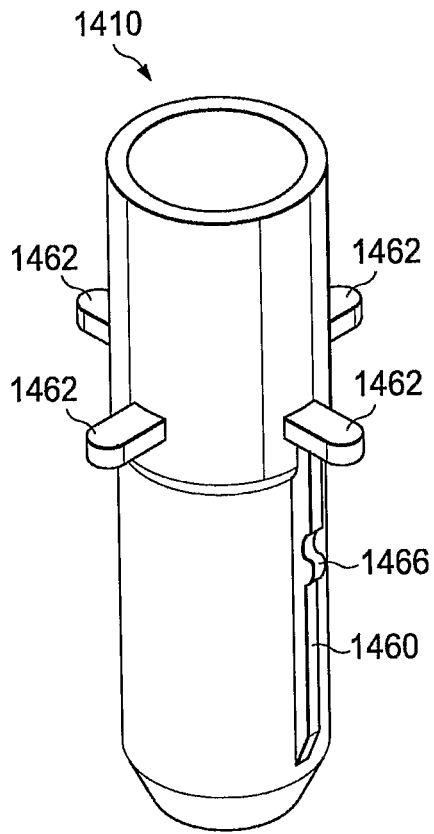


FIG. 35d

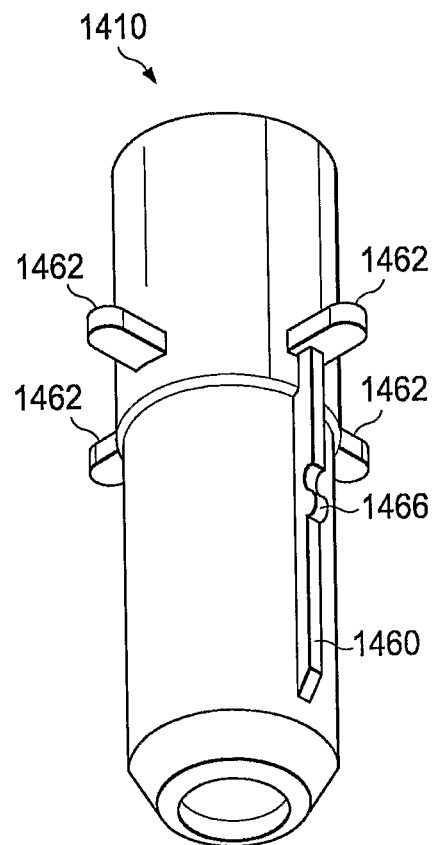


FIG. 35e

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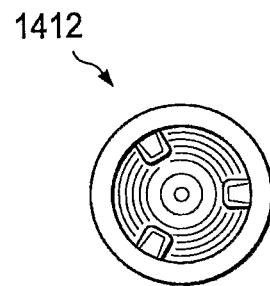


FIG. 36a

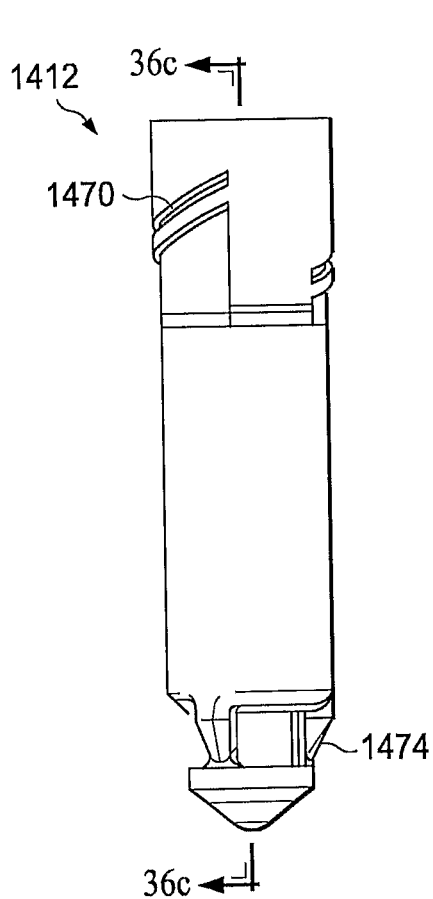


FIG. 36b

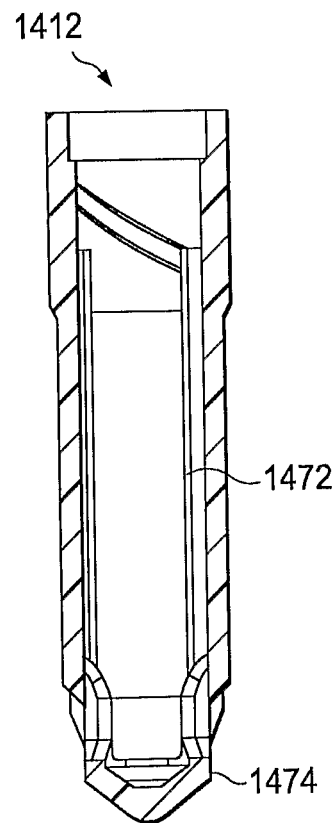


FIG. 36c

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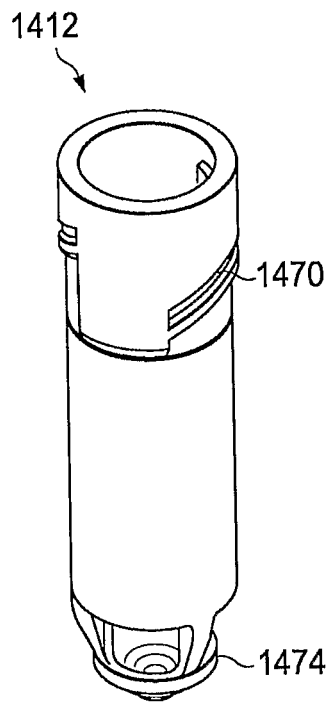


FIG. 36d

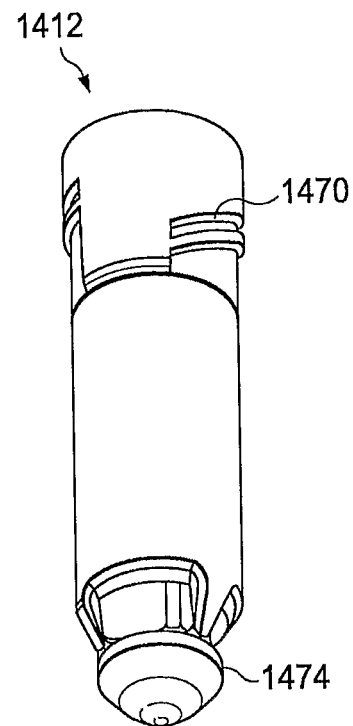
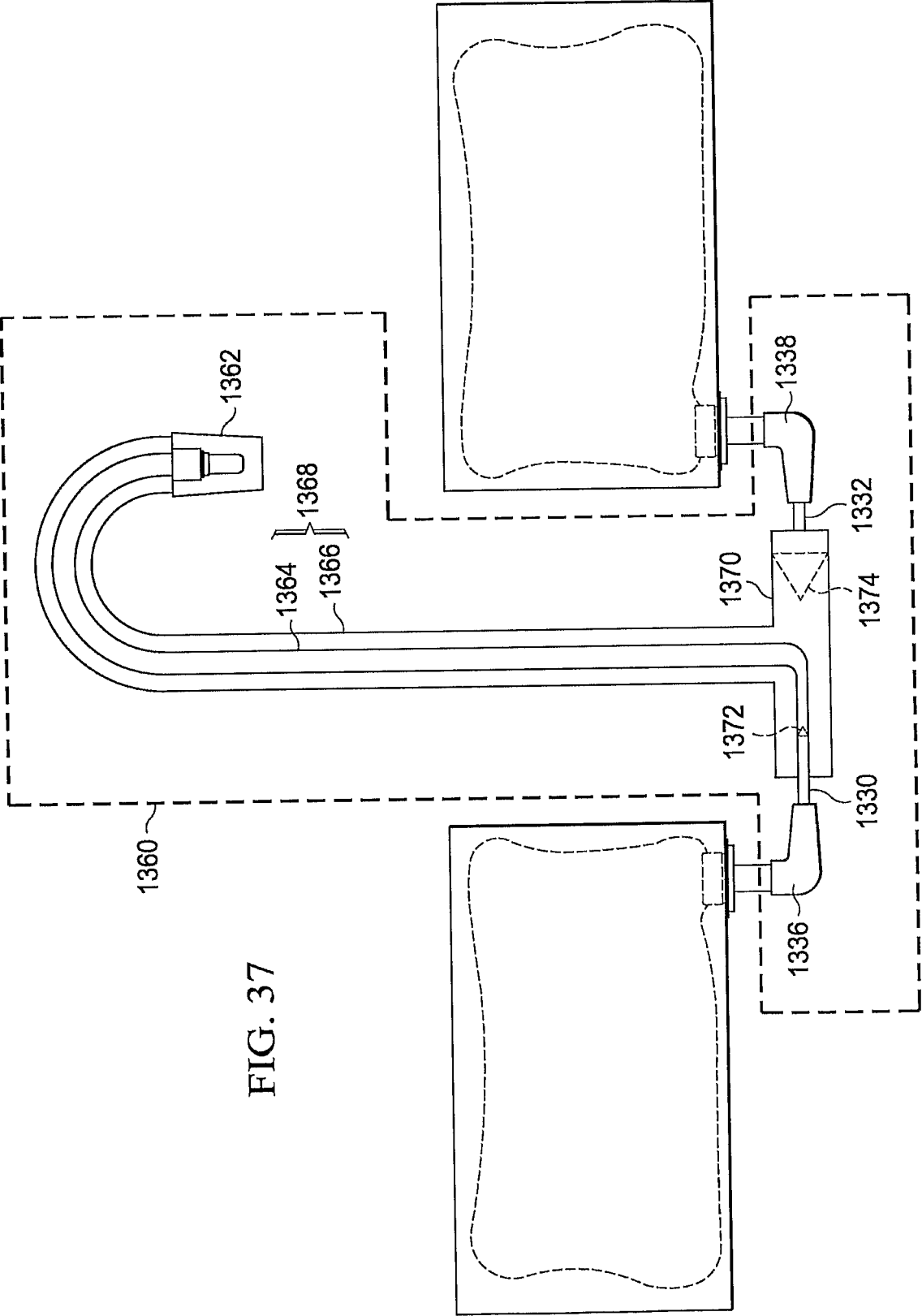


FIG. 36e



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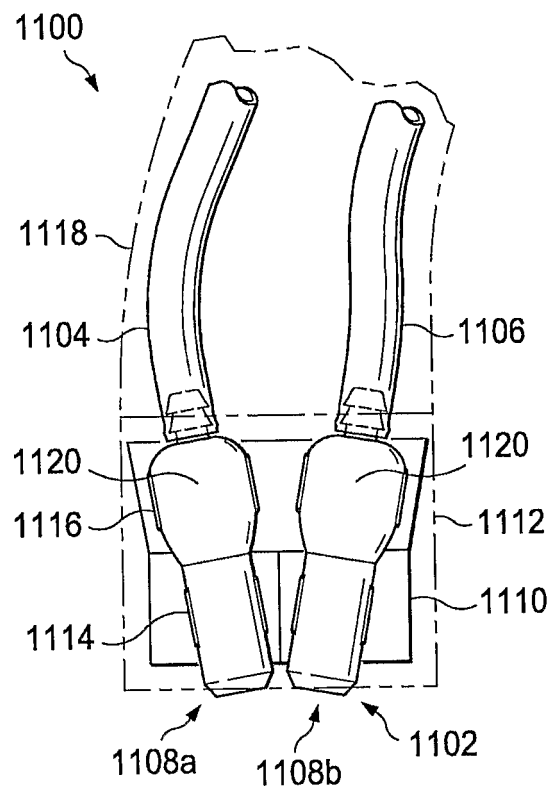


FIG. 38a

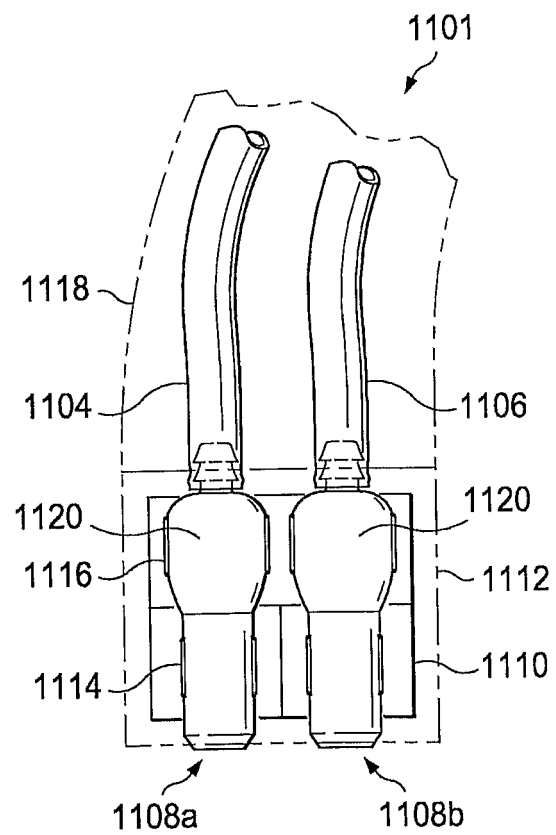
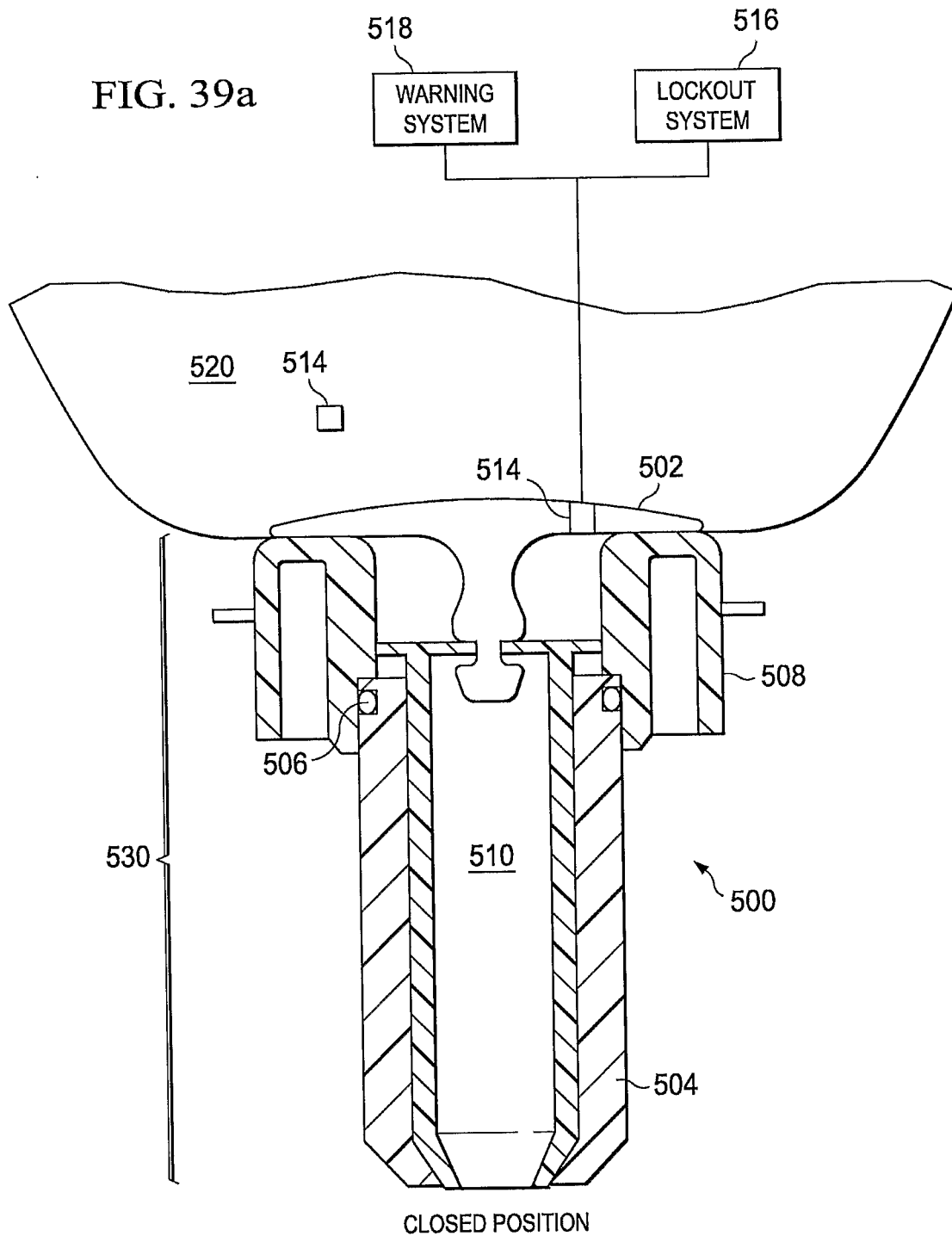


FIG. 38b



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FIG. 39a



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FIG. 39b

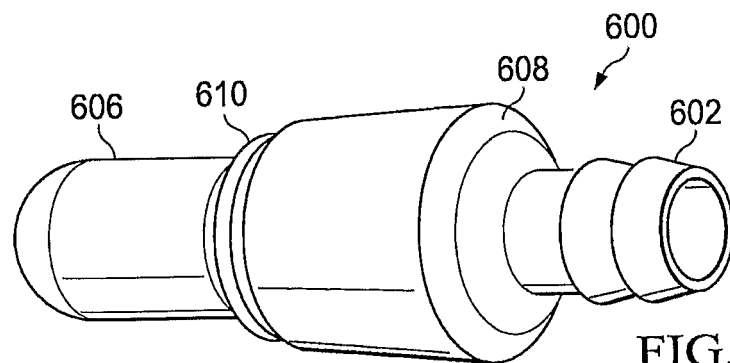
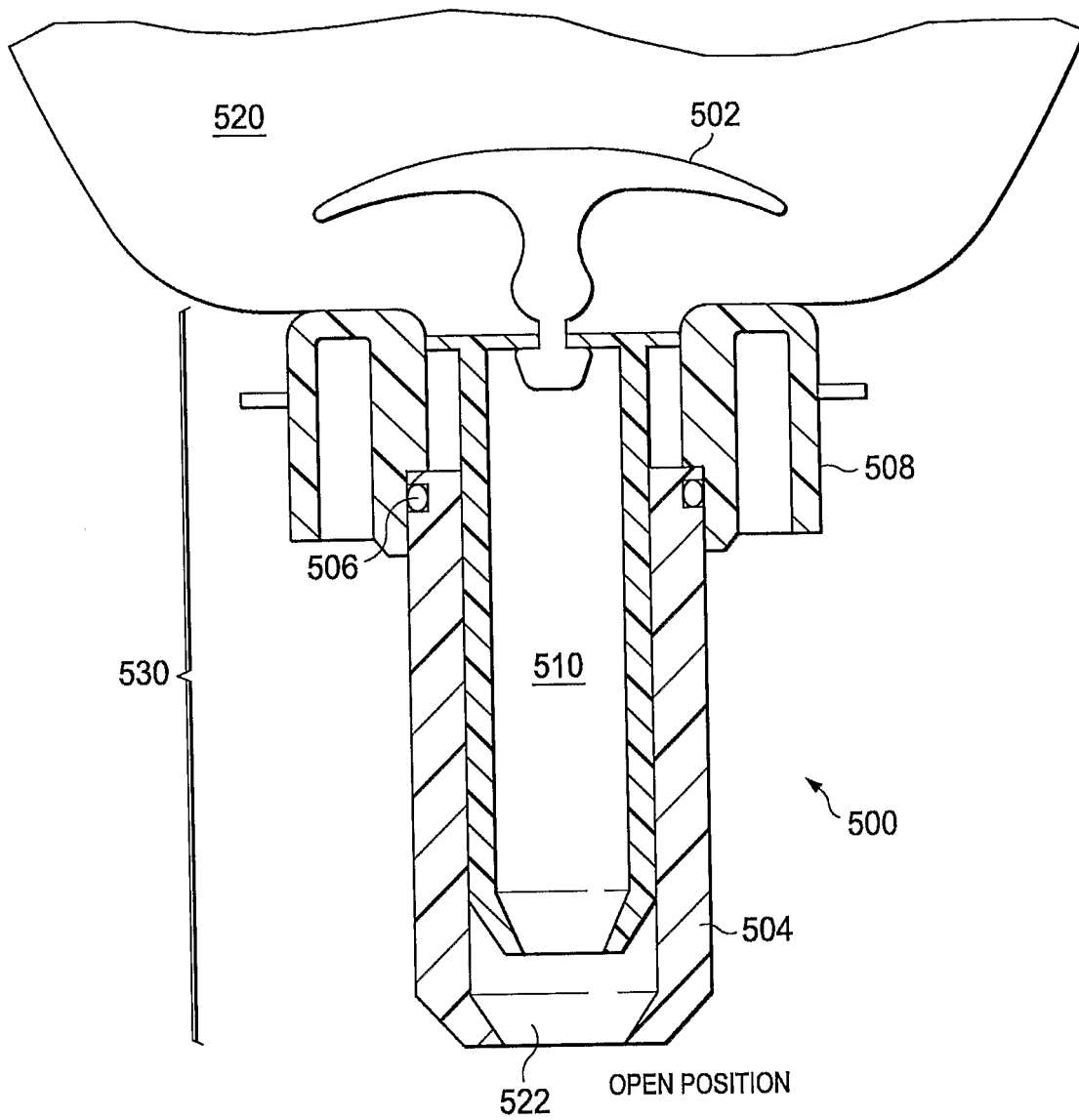
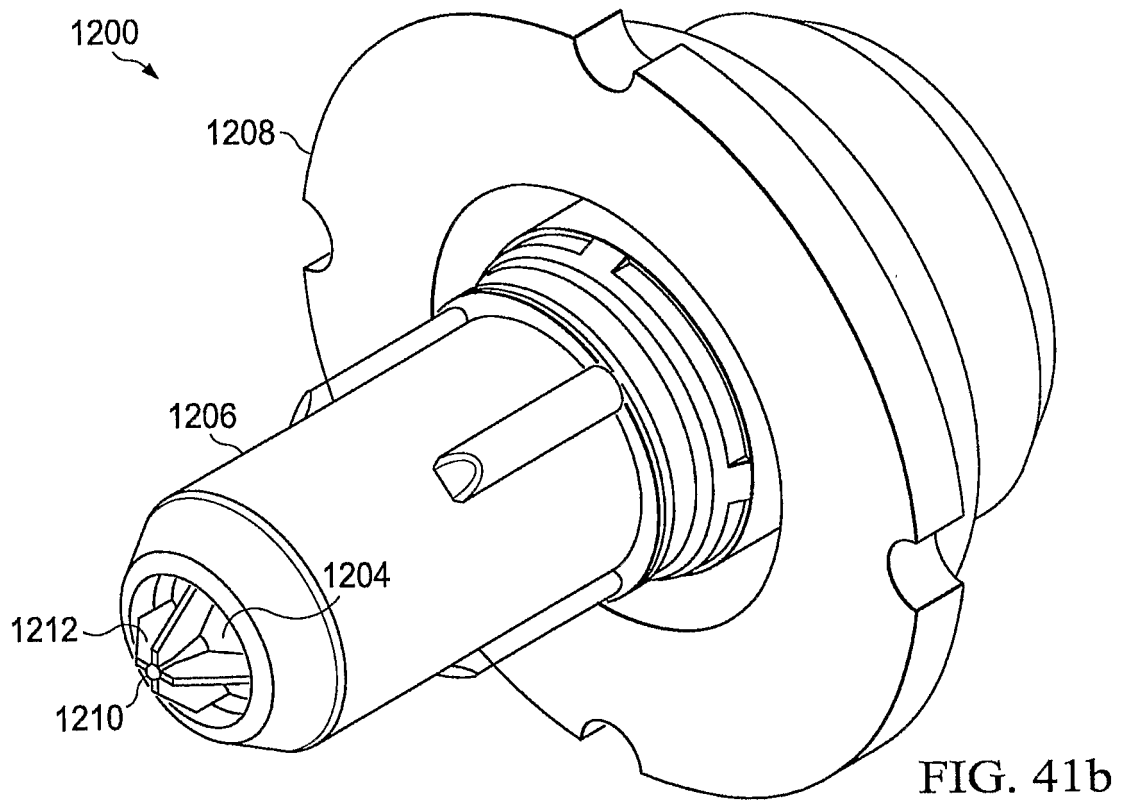
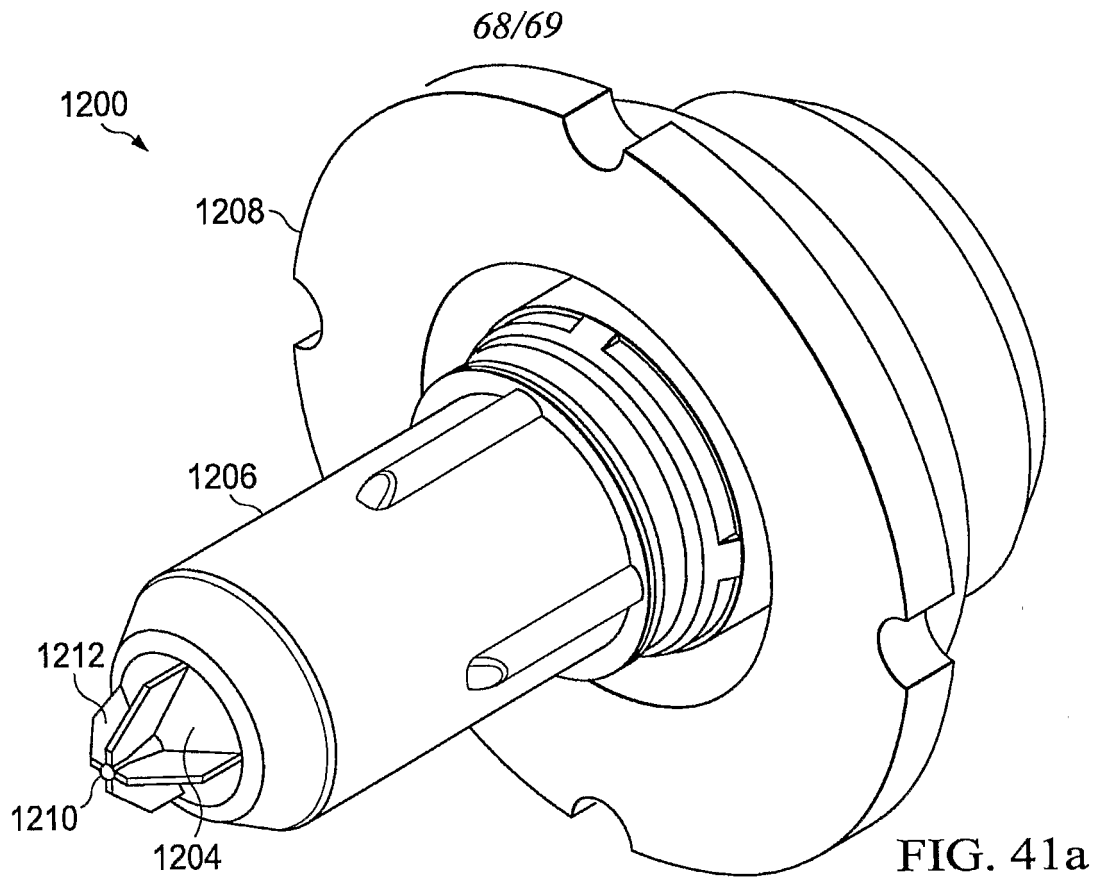


FIG. 40



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