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[Continued on next page]

(54) Title: MODULAR CARTRIDGE SYSTEM FOR APPARATUS PRODUCING CLEANING AND/OR SANITIZING SOLUTIONS

FIG. 1a

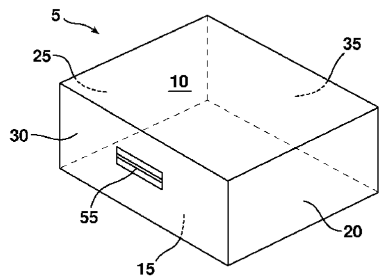
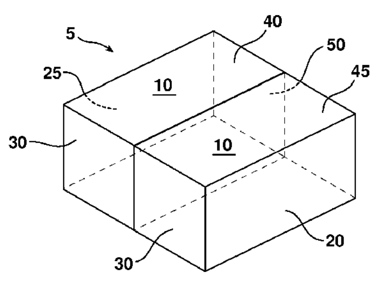


FIG. 1b



(57) Abstract: The presently disclosed subject matter comprises a method and system for producing cleaning and/or sanitizing solutions using a replaceable cartridge system. Particularly, the consumables needed to electrochemically or chemically produce the cleaning and/or sanitizing solutions can be supplied in a cartridge in a quantity measured to last for the chosen design life of the cartridge. Alternatively, the cartridge can comprise cleaning and/or sanitizing precursors that can be pre-prepared and supplied in a highly concentrated form.

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TITLE

MODULAR CARTRIDGE SYSTEM FOR APPARATUS PRODUCING CLEANING AND/OR SANITIZING SOLUTIONS

FIELD OF THE INVENTION

The presently disclosed subject matter relates to a method and system for producing cleaning and/or sanitizing solutions using a replaceable cartridge.

BACKGROUND

Sterilizing and cleaning solutions are commonly used on a wide variety of surfaces when microbial action against spores, viruses, fungi, and/or bacteria is required. Such sterilizing and cleaning solutions have a broad range of applications in medical, commercial, and household environments to eliminate further microbial growth. For example, sterilizing solutions are commonly used in the preservation of poultry and fish, general agricultural and petrochemical uses, breaking down of biofilms, produce conditioning, water treatment, general medical disinfection, and any application where there is a desire to free a surface from living organisms.

In some embodiments, sterilizing and cleaning solutions can be produced electrochemically using an electrolytic cell. However, there are several disadvantages associated with the electrolytic production of these solutions in the prior art. Particularly, the production of corrosive chemicals inside the electrolytic cell can damage the electrodes, thereby limiting cell life. In addition, scale can build up on the electrodes and cell internals. Further, the life of the ion exchange membranes is limited.

Alternatively, in some embodiments, sterilizing and cleaning solutions can be produced chemically by reacting two or more reagents. For example, a chlorine dioxide solution can be produced by chemically reacting sodium chlorite and citric acid in the presence of water or water vapor. However, there are several disadvantages associated with the chemical production of such solutions in the prior art. For example, some solutions (such as chlorine dioxide solutions) must be produced on-site because of instability and short shelf-life. In addition, transport and storage of chemically produced cleaning and/or sterilizing solutions has been found to be limiting.

The presently disclosed system addresses the disadvantages associated with prior art methods and devices for producing sterilizing and cleaning solutions. Particularly, the presently disclosed subject matter employs a cartridge system to facilitate the easy replacement of consumables and wear components. For example, when using the cartridge to electrochemically produce a sanitizing solution, electrolyte supply, water filter, water conditioner, additives, the electrolyzing cell, cleaning and sanitizing concentrates, and the like can be supplied in a cartridge in a quantity measured to last for the chosen design life of the cartridge. When the cartridge reaches the end of its service life, it is easily removed and replaced. In this manner, none of the consumables are wasted, since all will expire at approximately the same time. In addition, there will be minimal downtime of the device. The disclosed system virtually eliminates the cost and time necessary for service and maintenance of the system as a result of the rapid and simple replacement of the cartridge, and the longevity of the non-cartridge elements.

Thus, the presently disclosed subject matter addresses the problems present in the prior art by disclosing a system and method for producing a cleaning and/or sterilizing solution by providing consumables in a quick-change cartridge.

SUMMARY

In some embodiments, the presently disclosed subject matter is directed to an apparatus for the preparation of a cleaning, sanitizing, or sterilizing solution. In some embodiments, the apparatus comprises at least one modular component.

In some embodiments, the presently disclosed subject matter is directed to an electrolyzing cell comprising an anode, a cathode, electrolyte, and at least one ion exchange membrane. In some embodiments, the cell is packaged in a replaceable cartridge. In some embodiments, the cell functions

for a pre-determined, limited duration. In some embodiments, the cartridge comprises at least one cleaning, sanitizing, or sterilizing solution concentrate.

In some embodiments, the presently disclosed subject matter is directed to a method of electrolytically producing cleaning, sanitizing, or sterilizing solutions. In some embodiments, the method comprises providing an apparatus comprising at least one modular component, wherein the modular component comprises an electrolyzing cell. In some embodiments, the method also comprises connecting the electrolyzing cell to at least one power structure, whereby a cleaning, sanitizing, or sterilizing solution is produced.

In some embodiments, the presently disclosed subject matter is directed to a method of chemically producing a cleaning, sanitizing, or sterilizing solution, said method comprising providing an apparatus comprising at least one modular component, wherein the modular component comprises a sachet comprising the chemical precursors required to generate the solution. The disclosed method further comprises providing an initiating agent and contacting the chemical precursors with the initiating agent to generate a gas.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1a-1b and 2a-2c are perspective views of some embodiments of cartridges that can be used in accordance with the presently disclosed subject matter.

Figure 3a is rear elevation view of one embodiment of a cartridge that can be used with the presently disclosed subject matter.

Figure 3b is a schematic representation of one embodiment of the interior of a cartridge that can be used in accordance with the presently disclosed subject matter.

Figure 4a is a perspective view of one embodiment of an electrolyzing cell that can be used in accordance with the presently disclosed subject matter.

Figure 4b is a perspective sectional view taken along line 4b-4b of Figure 4a.

Figures 5a and 5b are schematic representations of embodiments of electrolyzing cells that can be used in accordance with the presently disclosed subject matter.

Figure 6a is one embodiment of an anode electrode that can be used in accordance with the presently disclosed subject matter.

Figures 6b and 6c are top plans views of an anode and cartridge interaction in some embodiments of the presently disclosed subject matter.

Figure 7 is a perspective view of one embodiment of an electrolytic cell that can be used in accordance with the presently disclosed subject matter.

Figure 8 is a perspective view of one embodiment of an electrolytic cell that can be used in accordance with the presently disclosed subject matter.

Figure 9 is a front elevation view of one embodiment of an anode compartment of an electrolyzing cell that can be used in accordance with the presently disclosed subject matter.

Figures 10a-10c are top plan views of flow control means that can be used in some embodiments of the presently disclosed electrolyzing cell.

Figure 11 is a front elevation view of one embodiment of an anode compartment of an electrolyzing cell that can be used in accordance with some embodiments of the presently disclosed subject matter.

Figure 12a is a schematic representation of one embodiment of an electrolyzing cell that can be used in accordance with the presently disclosed subject matter.

Figure 12b is a schematic representation of one embodiment of an electrolyzing cell that can be used in accordance with the presently disclosed subject matter.

Figure 13a is a schematic representation of one embodiment of an electrolyzing cell that can be used in accordance with the presently disclosed subject matter.

Figure 13b is a schematic representation of one embodiment of an electrolyzing cell that can be used in accordance with the presently disclosed subject matter.

Figure 13c is a sectional view of one embodiment of a cathode chamber of an electrolyzing cell that can be used in accordance with the presently disclosed subject matter.

Figure 14a is a schematic representation of one embodiment of an electrolytic cell that can be used in accordance with the presently disclosed subject matter.

Figure 14b is a schematic representation of one embodiment of an electrolytic cell that can be used in accordance with the presently disclosed subject matter.

Figure 15a is a front elevation view of one embodiment of a sachet that can be used in accordance with the presently disclosed subject matter.

Figures 15b-15d are perspective sectional views of some embodiments of the sachet of Figure 5a taken along line 15b-15b.

Figure 16a is one embodiment of a sachet that can be used with the presently disclosed subject matter.

Figure 16b is a perspective view of one embodiment of a cartridge that can be used with the presently disclosed subject matter.

Figure 16c illustrates one embodiment of a cartridge that can be used in accordance with the presently disclosed subject matter.

Figure 17a is a perspective view of one embodiment of a blister pack sachet that can be used in accordance with the presently disclosed subject matter.

Figure 17b is a sectional front elevation view taken along line 17b-17b of Figure 17a.

Figures 17c and 17d illustrate one embodiment of the blister pack sachet of Figure 17b during use.

Figure 18a illustrates one embodiment of a two compartment blister pack sachet in accordance with the presently disclosed subject matter.

Figure 18b illustrates one embodiment of the sachet of Figure 18a during use.

Figure 19a illustrates one embodiment of a two compartment blister pack sachet in accordance with the presently disclosed subject matter.

Figure 19b illustrates one embodiment of the sachet of Figure 19a during use.

Figure 20 is a schematic representation of one embodiment of a system that can be used to chemically produce a cleaning and/or sanitizing solution.

Figure 21 is a schematic representation of one embodiment of a system that can be used to chemically produce a cleaning and/or sanitizing solution.

Figure 22 is a schematic representation of one embodiment of a system that can be used to chemically produce a cleaning and/or sanitizing solution.

Figure 23 is a perspective view one embodiment of an apparatus employing the presently disclosed cartridge.

Figures 24a and 24b are cutaway views of one embodiment of a connection that can be used in the disclosed cartridge system.

DETAILED DESCRIPTION

I. General Considerations

Unlike prior art systems that require significant user interaction, the presently disclosed subject matter is directed to a cartridge system that facilitates the easy replacement of consumables and wear components to reliably produce one or more cleaning and/or sanitizing solutions. The disclosed cartridge can in some embodiments comprise the components needed to electrochemically generate a sanitizing solution (such as, for example, an electrolyzing cell). Alternatively or in addition, the disclosed cartridge can comprise the chemical precursors used to generate at least one cleaning and/or sanitizing solution. Alternatively or in addition, the disclosed cartridge can comprise highly concentrated chemicals that can be diluted or rehydrated into cleaning and/or sanitizing solutions. The disclosed system can employ individual cartridges, cartridges with multiple elements, or a single cartridge that contains all of the consumables. The quantity of each consumable supplied in the cartridge is only enough to last for the chosen design life of the cartridge.

When the cartridge reaches the end of its service life, it is easily removed and replaced. In this manner, there is no wasting of the consumables since all will expire at approximately the same time. As a result, there will be minimal downtime of the disclosed system. Thus, the disclosed cartridge system eliminates the cost and time necessary for service and maintenance of the apparatus used to electrochemically and/or chemically generate cleaning and/or sanitizing solutions.

II. Definitions

While the following terms are believed to be well understood by one of ordinary skill in the art, the following definitions are set forth to facilitate explanation of the presently disclosed subject matter.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which the presently disclosed subject matter belongs.

Following long standing patent law convention, the terms “a”, “an”, and “the” refer to “one or more” when used in the subject application, including the claims. Thus, for example, reference to “a package” includes a plurality of such packages, and so forth.

Unless indicated otherwise, all numbers expressing quantities of components, reaction conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term “about.” Accordingly, unless indicated to the contrary, the numerical parameters set forth in the instant specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by the presently disclosed subject matter.

As used herein, the term “about”, when referring to a value or to an amount of mass, weight, time, volume, concentration, percentage, and the like can encompass variations of, and in some embodiments, ±20%, in some embodiments ±10%, in some embodiments ±5%, in some embodiments ±1%, in some embodiments ±0.5%, and in some embodiments ±0.1%, from the specified amount, as such variations are appropriated in the disclosed package and methods.

As used herein, the term “adjacent” refers to be being near or adjoining. Objects that are adjacent can be spaced apart from one another or can be in actual or direct contact with one another. In some embodiments, objects that are adjacent can be coupled to one another and/or can be formed integrally with one another.

The term “anode” or “anode electrode” as used herein refers to the electrode in the electrolytic cell at which oxidation occurs when current is passed through the electrolytic cell.

The term “apparatus” as used herein refers to equipment for generating cleaning, sterilizing, and/or sanitizing solutions.

The term “blister pack” as used herein refers to a package that includes a rupturable or peelable sealing film of plastic, paper, aluminum foil and the like. The blister pack further comprises a rigid or semi-rigid well joined to form a sealed cavity that houses a dose of an active agent. The individual blisters of the blister pack can be arranged in any fashion, such as (but not limited to) a linear series of blisters or a matrix of blisters, and can be evenly spaced out or randomly positioned. Blister packs are generally known in the art. See, for example, U.S. Patent Nos. 7,784,250; 7,704,583; 7,623,040; and 7,489,594, the entire content of which is hereby incorporated by reference.

As used herein the term “cartridge” refers to a container comprising at least one compartment for housing one or more components. The cartridge can be, in some embodiments, designed for a single use after which it is discarded. In some embodiments, one or more compartments in a cartridge comprise a reagent, precursor, electrolytic cell, additive, water softening means, and the like, as set forth in more detail herein below.

As used herein, the term “catalyst” refers to any substance that increases the rate of a chemical reaction and is not itself consumed in an overall chemical or biological reaction. In some embodiments, the catalyst can include (but is not limited to) metal oxides and heat.

The term “cathode” or “cathode electrode” as used herein refers to the electrode in the electrolytic cell at which reduction occurs when current is passed through the electrolytic cell.

The term “chemical precursors” as used herein refer to any combination of chemicals that can react to produce a desired chemical product. For example, in some embodiments, the chemical precursors sodium chlorite and citric acid can generate chlorine dioxide gas in the presence of water or water vapor.

The term “cleaning solution” as used herein refers to an aqueous solution that is employed in the cleaning of one or more products. Exemplary cleaning solutions and their uses are known in the art and can include (but are not limited to) chlorine dioxide solution, hypochlorous acid solution, sodium hydroxide solution, and the like. For the sake of convenience, when the term “cleaning solution” is used herein, it can refer to cleaning solutions, sterilizing solutions, produce conditioning solutions, and/or sanitizing solutions.

As used herein, the term “concentrate” refers to relatively condensed form of a product (such as a cleaning, sterilizing, and/or sanitizing solution) that can be diluted with a diluent to form a solution of desired concentration. In some embodiments, the diluent can be water.

As used herein, the term “consumable” refers to anything that is used or consumed by an electrochemical or chemical reaction, or diluted or hydrated to produce a cleaning and/or sanitizing solution. For example, such consumables can include (but are not limited to) electrolyte supply, electrolytic cell, additives, chemical precursors, and the like.

The term “desiccant” as used herein refers to any material that absorbs, adsorbs, or reacts with water vapor and is thereby able to reduce the moisture in the air. In some embodiments, a desiccant can be used to prevent premature initiation of a reaction initiated by water vapor. The desiccant can be in film or paper form, and in some embodiments can be used to separate the reactants to a chemical reaction.

The term “electrolytic solution” or “electrolyzing solution” as used herein refers to an aqueous composition capable of being electrolyzed by the electrochemical cell and/or electrolyzing device described herein. In its broadest use, an aqueous electrolytic solution can be any chemically compatible solution that can flow through the passage of the electrochemical cell, and that contains sufficient electrolytes to allow a measurable flow of electricity through the solution. Water, except for de-ionized water, can include electrolytic solution, and can include: sea water; water from rivers, streams, ponds, lakes, wells, springs, cisterns, etc., mineral water; city or tap water; rain water; and brine solutions. An aqueous electrolytic solution of the present invention can be chemically compatible if it does not chemically explode, burn, and/or rapidly evaporate when placed inside the cell and/or device, or if it does not rapidly corrode, dissolve, or otherwise render the cell and/or device unsafe or inoperative, in its intended use.

The term “electrolytic cell,” “electrolyzing cell,” or “electrochemical cell” as used herein refers to a composite comprising an anode, a cathode, and an ion-conducting electrolyte interposed therebetween.

The term “envelope” as used herein to is meant to be construed broadly to include any type of container. In some embodiments, an “envelope” refers to a closed receptacle sealed about its perimeter that houses a sachet. In some embodiments, the envelope can be constructed from selectively permeable materials.

The term “filter” as used herein refers to any substance that allows liquid to flow through to remove suspended particles, impurities, gases, and the like. In some embodiments, the filter can comprise cloth, paper, porous porcelain, charcoal, polymeric material, and the like.

As used herein, the term “frangible” refers to the characteristic of being breakable, and generally refers to a seal that can be compromised by a force or pressure to deliver a supply of material from a location on one side of the seal to a location on the other side of the seal.

The term “impermeable,” “nonpermeable” or “barrier” as used herein refers to articles not permitting the passage of a liquid, gas, or solid therethrough.

The term “initiator” as used herein refers to a substance that initiates a chemical reaction. In some embodiments, suitable initiators can include (but are not limited to) water and water vapor.

The term “modular” is used herein to collectively designate the plurality of components of any embodiment of the modular cartridge of the presently disclosed subject matter, such as additives, electrolytic cell, and the like.

The term “package” as used herein is meant to be construed broadly to include any type of container. As set forth herein, in some embodiments, the package can be constructed from impermeable materials.

The term “produce conditioning solution” as used herein refers to a solution that can be used to wash and rehydrate produce while also controlling microorganisms and cross-contamination. For example, in some embodiments, a produce conditioning solution can be used to wash and disinfect fruits or vegetables, which can become contaminated with *salmonella* or other microorganisms in the field or elsewhere. The produce conditioning solution can reduce or eliminate populations of microorganisms and can prevent cross-contamination. Exemplary produce conditioning solutions are known in the art and will not be described in detail.

As used herein, the term “pump” includes all means of causing a controlled fluid flow, including controlled pumps or pressure sources and regulators. For example, in some embodiments, suitable pumps that can be used with the presently disclosed subject matter include peristaltic pumps, gear pumps, syringe pumps, electrokinetic pumps, gravity, compressed gas, controlled gas evolving devices, spring pumps, centripetal pumps, hand activated pumps, or any similar system known to those of ordinary skill in the art.

The term “replaceable” as used herein is used with reference to an item designed to be used and discarded or recycled (such as a cartridge). In some embodiments, the replaceable item can be easily removed from an apparatus without requiring disassembly of the apparatus and/or without the need for tools.

The term “sachet” as used herein refers to a closed receptacle containing one or more components that can be used to produce a sterilizing solution. The sachet is closed in the sense that the chemical precursors used to generate the sterilizing solution are retained within the interior cavity of the sachet and the sachet volume is sealed around its perimeter.

As used herein, the term “sanitize” or “sanitizing” refers to the elimination of nearly all microbial forms, but not necessarily all.

The term “sanitizing solution” as used herein refers to a solution that can be used to sanitize one or more products or surfaces. For example, in some embodiments, the sanitizing solution can comprise (but is not limited to) chlorine dioxide solution, hypochlorous acid solution, sodium hydroxide solution, and the like. For the sake of convenience, when the term “sanitizing solution” is used herein, it can refer to cleaning solutions, sterilizing solutions, produce conditioning solutions, and/or sanitizing solutions.

The term “selectively permeable” refers to the ability of a selected membrane or other material to allow desired liquids, gases, and the like to migrate through the membrane, but not other materials. For example, in some embodiments, water vapor can pass through a selectively permeable membrane, but water will not. In some embodiments, the ability to be selectively permeable is based upon the size, surface charge, hydrophilicity, hydrophobicity, topology, or other considerations.

The term “sheet” as used herein can be used interchangeably to describe articles that are processed into generally planar forms, either monolayer or multilayer. The term “sheet” can be used interchangeably with the term “film” in some embodiments.

As used herein, the term “sterilize” or “sterilization” refers to the destruction of all microbial life, including bacterial spores.

As used herein, the term “sterilizing solution” refers to a solution that can be used to sterilize one or more products. For example, exemplary sterilizing solutions and can include (but are not limited to) chlorine dioxide solution, hypochlorous acid solution, sodium hydroxide solution, and the like. For the sake of convenience, when the term "sterilizing solution" is used herein, it can refer to cleaning solutions, sterilizing solutions, produce conditioning solutions, and/or sanitizing solutions.

As used herein, the term "valve" is broadly construed to include any apparatus that can be opened or closed to control the flow of a liquid or gas.

The term "well" as used herein refers to any shape of a recessed portion capable of housing a chemical precursor, water, and the like within the interior thereof.

III. Cartridge **5**

As illustrated in Figure 1a, cartridge **5** can comprise top face **10** and bottom face **15**. In some embodiments, top face **10** and bottom face **15** can be parallel in relation to each other. Cartridge **5** can further comprise side faces **20**, **25**, front face **30**, and rear face **35**. In some embodiments, side faces **20** and **25** can be parallel in relation to each other. Similarly, in some embodiments, front and rear faces **30** and **35** can be parallel in relation to each other. Cartridge **5** contains a closed body having a confined space within the body to enclose one or more consumable components (such as, in some embodiments, an electrolyzing cell). Thus, cartridge **5** comprises at least one compartment within its interior. To this end, Figure 1b illustrates one embodiment of a cartridge comprising more than one compartment. Particularly, compartments **40** and **45** are separated by wall **50**.

As depicted in Figure 1a, in some embodiments, cartridge **5** can comprise gripping means **55** that can function as a handle for gripping the cartridge. Any of a wide variety of gripping means known in the art can be incorporated into cartridge **5**, including (but not limited to) notches, rods, handles, pull rings, bars, knobs, and the like. One of ordinary skill in the art would recognize that the presently disclosed subject matter also includes embodiments wherein cartridge **5** is configured without a gripping means.

As depicted in Figures 1a and 1b, cartridge **5** can be rectangular in shape, although the presently disclosed subject matter is by no means limited to the embodiments illustrated in the Figures. To this end, cartridge **5** can take any shape and form, limited only by its ability to be placed within the disclosed apparatus without interfering with the components housed within the cartridge, as discussed in more detail herein below. Thus, cartridge **5** can be of any size or shape (*e.g.*, square, rectangular, circular, ovoid, elongate, triangular, amorphous, and the like). To this end, the compartments housed within cartridge **5** can likewise take any shape or form.

Cartridge **5** can be constructed from any of a wide variety of materials known in the art, including (but not limited to) plastics (including PVC, polyethylene, polypropylene, other polyolefins, foam plastics, rubberized plastics, and the like), metals (including stainless steel and the like), wood, composite materials (including carbon/graphite, Kevlar®, and fiberglass with an epoxy resin), and the like. For example, in some embodiments, cartridge **5** can be constructed from durable, resilient plastic material that can help to protect the internal components from external impact and forces that might otherwise cause damage.

Cartridge **5** can be constructed in a wide variety of ways. For example, in some embodiments, cartridge **5** can be constructed from molded plastic and can be attached to a housing through the use of adhesives, ultrasonic welding, or mechanical fasteners (such as screws). One of ordinary skill in the art would be familiar with the methods that can be used to construct cartridge **5**, and such methods will not be described in detail herein.

In some embodiments, cartridge **5** can comprise a label or other identifier **120** printed or affixed to one or more faces. For example, the identifier can identify the cartridge contents, intended use of the cartridge, and the like. Identifier **120** can include any of a wide variety of identification aids, including (but not limited to) colored tags, labels, bar codes, radio frequency identification (RFID) tags, and the like. For example, the cartridges of Figures 2a, 2b, and 2c are identified as a food contact rinse cartridge, H1N1 sanitation cartridge, and a general disinfecting cartridge, respectively.

IV. Electrochemical Embodiments

IV.A. Generally

As set forth above, the presently disclosed subject matter is directed to a cartridge system that facilitates the easy replacement of consumables and wear components to reliably produce one or more sanitizing solutions. In some embodiments, the disclosed cartridge can be used to electrochemically produce one or more sanitizing solutions. Particularly, the disclosed cartridge can comprise some or all of the components necessary to electrolytically produce a sanitizing solution. The components can be supplied in the form of individual cartridges, cartridges with multiple elements, or a single cartridge that contains all of the consumables. The quantity of each consumable supplied in the cartridge is only enough to last for the chosen design life of the cartridge.

In some embodiments (such as, for example, when housing an electrolyzing cell) cartridge **5** comprises at minimum, an inlet to supply fresh water, an electrical inlet to power the electrodes, and outlets for the solutions produced. Particularly, Figure 3a illustrates one possible layout of cartridge **5**, comprising fresh water inlet **60**, electrical power inlet **65**, and product outlets **70** and **75**. In some embodiments, the layout depicted in Figure 3a can be located on rear face **35** of the cartridge. In some embodiments, product outlets **70** and **75** can comprise hypochlorous acid and sodium hydroxide solutions. As would be apparent to those of ordinary skill in the art, the use of additives could require one or more additional electrical inputs unless a passive injection system (such as a venturi) is used. Further, if a recirculating electrolyte supply is employed, additional electrical and/or water connections could be required. Such embodiments are also included within the scope of the presently disclosed subject matter.

Figure 3b illustrates a schematic of one embodiment of the interior of the cartridge depicted in Figure 3a. Fresh water inlet **60** can optionally pass through filter **80** to remove particulates from the water, as discussed in more detail herein below. Fresh water can then be split into three passages and enter electrolyzing cell **85**, which is powered by electricity supplied to electrode connections **90**, **95**. The output solutions leave electrolyzing cell **85** and optionally pass by additive compartments **100**, **105** where additive is drawn into the stream by suction attributable to venturis **110**, **115**. The output solutions then exit the cartridge at outputs **70**, **75**. One of ordinary skill in the art would appreciate that the presently disclosed subject matter is not limited to the schematic set forth in Figure 3b.

<u>IV.B.</u> <u>Electrolyzing Cell **85**</u>

As set forth herein, in some embodiments, an electrolyzing cell can be housed within cartridge **5**. Electrolytic cells are understood by those of ordinary skill in the art. <u>See</u>, for example, U.S. Patent Nos. 4,214,958; 4,443,316; 5,106,465; 5,593,554; 5,616,221; 5,900,127; 6,294,073; 7,090,753; and 7,238,272, the entire disclosures of which are incorporated herein by reference. Electrolyzing cell **85** can take any shape or form that can be conducive to efficient electrolysis to produce sanitizing solutions. As depicted in the Figures, electrolyzing cell **85** can be rectangular in shape, although the presently disclosed subject matter is by no means limited to the embodiments depicted in the Figures. To this end, electrolyzing cell **85** can take any shape or form that can be conducive to efficient electrolysis. Thus, electrolyzing cell **85** can be of any size or shape (*e.g.*, square, rectangular, circular, ovoid, elongate, triangular, amorphous, and the like).

Figures 4a and 4b illustrate one embodiment of an electrolyzing cell that can be used with the presently disclosed subject matter. Particularly, electrolyzing cell **85** comprises top wall **125**, bottom wall **135**, front wall **145**, rear wall **150**, and side walls **130** and **140**. The external walls can be constructed from any electrically non-conductive material known to those of ordinary skill in the art. For example, in some embodiments, molded plastic (such as acrylonitrile butadiene styrene ((“ABS”)) or polycarbonate), ceramics, composite materials, and/or metals (with a non-conductive coating) can be employed.

As illustrated in Figure 4b, in some embodiments, electrolyzing cell **85** comprises three chambers including anode chamber **155**, cathode chamber **160**, and intermediate chamber **165**. Anode chamber **155** comprises inlet **170** for fresh water and outlet **175** for acidic electrolyzed water (which in some embodiments can be hypochlorous acid solution). Likewise, cathode chamber **160** comprises inlet **180** for fresh water and outlet **185** for alkaline electrolyzed water (which in some embodiments can be sodium hydroxide solution). Intermediate chamber **165** comprises inlet **190** for the input of fresh replenishment water. The electrolytic chambers can be constructed from any of a wide variety of materials that are resistant to the acidic and alkaline electrolyzed water solutions. For instance, the chambers can be constructed from organic materials (such as polyvinyl chloride, polypropylene, and/or acrylic resin), inorganic materials (such as ceramics and glass), or metal with surfaces lined with rubber or coated with a coating material.

Anode electrode **195** and anion exchange membrane **196** separate anode chamber **155** from intermediate chamber **165**. Similarly, cathode electrode **200** and cation exchange membrane **201** separate cathode chamber **160** from intermediate chamber **165**. In some embodiments, the electrodes and the exchange membranes are optionally adhered together. Anion exchange membrane **196** allows anions (such as chlorine ions) to pass therethrough, thus supplying anions for the production of acid electrolyzed water. Such anion exchange membranes are well known in the art. One example of a suitable anion exchange membrane can be a gel polystyrene cross linked with divinylbenzene in a chlorine ionic form, such as AMI-7001 Anion Exchange Membranes (available from Membranes International, Inc. of Ringwood, New Jersey, United States of America). Similarly, cation exchange membrane **201** allows cations (such as sodium ions) to pass therethrough, thus supplying cations for the production of alkaline electrolyzed water. Such cation exchange membranes are well known in the art. One example of a suitable cation exchange membrane is a gel polystyrene cross linked with divinylbenzene in a sodium ionic form, such as CMI-7000 Cation Exchange Membrane (available from Membranes International, Inc. of Ringwood, New Jersey, United States of America).

Figure 5a is a schematic representation of one embodiment of electrolyzing cell **85**. Specifically, fresh water enters the cell through common port **205** and is split three ways. One flow enters anode chamber **155**, one flow enters cathode chamber **160**, and one flow enters intermediate chamber **165**. Intermediate chamber **165** houses electrolyte and is kept full of water by the pressure of the fresh water. A power supply (not shown) applies a DC voltage to the positive and negative terminals that power the electrodes (also not shown).

Electrolytic solution **211** is a liquid that is electrolyzed into cations and anions by the application of electrolytic voltage. Preferred electrolytic solutions contain at least some halogen ions, including (but not limited to) chloride, chlorite, bromide, bromite, iodide, and iodite, and mixtures thereof. Thus, in some embodiments, electrolyte solution **211** can comprise sodium chloride, potassium chloride, calcium chloride, or combinations thereof. One of ordinary skill in the art would appreciate that electrolyte solution **211** can comprise a wide variety of electrolytes. The electrical current supply provides a flow of electrical current between the electrodes and across the passage of electrolytic solution passing across the anode. Two outputs are produced which in some embodiments can be cleaning and/or sanitizing solutions. For example, in some embodiments, the cleaning and/or sanitizing solutions can be hypochlorous acid solution **215** and sodium hydroxide solution **220**. However, the electrolytically-produced cleaning and/or sanitizing solutions are not limited to hypochlorous acid and sodium hydroxide solutions and can include any solution that can function in sanitizing and/or cleaning applications.

Figure 5b illustrates an alternate schematic representation of an electrolytic cell that can be used with the presently disclosed subject matter. Particularly, in the electrolyzing cell of Figure 5b, before fresh water enters intermediate chamber **165**, it enters a saline circulation system through flow control means **225** that adds fresh water to the replenish the system as needed. In addition, electrolyte supply is housed in electrolyte chamber **226**. Pump **230** circulates the electrolyte solution through intermediate chamber **165** that supplies the electrolytes for the electrochemical reaction. The circulation system ensures that electrolyte solution is consistent and homogenous and that there is no stratification of solution density that could change the output. A power supply (not shown) applies a DC voltage to positive and negative terminals **235** and **240** that power the electrodes.

By the application of the electrolytic voltage, the electrolyte solution is electrolyzed. In this process, an anion (for example, a chloride ion) is transferred to anode chamber **155** through anion exchange membrane **196**, and a cation (for example, a sodium ion) is transferred to cathode chamber **160** through cation exchange membrane **201**. Accordingly, water in the anode chamber becomes acidic and water in the cathode chamber becomes alkaline to produce acidic and alkaline ionized water solutions **215**, **220**, which can be used as sterilizing solutions.

Any suitable anode can be employed in anode chamber **155**, including those that are available commercially as dimensionally stable anodes. In some embodiments, anode **195** can include (but is not limited to) porous or high surface area anodes. To this end, Figure 6a illustrates one embodiment of anode **195**. Particularly, the anode comprises a plurality of pores **245** to provide passages for electrolytic water passing over the electrode surface to utilize the electrolysis product more efficiently. As a result, the electrolytic water flows not only on the electrode surface but also thorough the pores in the electrode. Thus, in some embodiments, anode **195** can be a porous or flow-through anode that has a large surface area and a large pore volume sufficient to pass a large volume of electrolytic solution therethrough. However, it is to be understood that anode **195** of the presently disclosed subject matter is not limited to the structure set forth in Figure 6a and can include any anode electrode so long as it can effectively conduct electricity through the aqueous electrolytic solution between itself and another electrode. In some embodiments, anode **195** comprises tab **246** that provides the electrical connection to the power supply.

Anode **195** can be constructed from any of a wide variety of electrically conductive materials known in the art, including (but not limited to) titanium, tantalum, aluminum, zirconium, tungsten, stainless steel, platinum, iridium, ruthenium, iron, nickel, chromium, and alloy and metal oxides thereof. In some embodiments, anode **195** requires a material without iron content. In some embodiments, anode **195** can be coated with a catalyst. Any of a wide variety of catalysts known in the art can be used, such as (but not limited to) platinum, iridium, ruthenium, and/or oxides, alloys and mixtures thereof. In some embodiments, the anode can be coated with a catalyst having a thickness of at least 0.1 micron.

In some embodiments, electrolyzing cell **85** is incorporated as an integral part of cartridge **5**. When the cartridge reaches the end of its life, it is removed from the apparatus and replaced with a new cartridge comprising a new electrolyzing cell and therefore eliminating the need for maintenance. However, in some embodiments, anode **195** can be built as a robust piece that lasts indefinitely and remains with the apparatus as a member that enters the cartridge when replaced. For example, as illustrated in Figures 6b and 6c, in some embodiments, anode **195** can be attached to apparatus **330**. In these embodiments, cartridge **5** comprises opening **331** sized to fit anode **195**. In use, a user would simply insert anode **195** into opening **331** as depicted in Figure 6c.

Any suitable cathode can be employed in cathode chamber **160**, including those that are available commercially as dimensionally stable cathodes. In some embodiments, cathode **200** can be a porous or high surface area cathode. To this end, cathode **200** can take the form of anode **195** as illustrated in Figure 6a, including pores **245** and tab **246**. However, it is to be understood that a cathode of the presently disclosed subject matter is not limited to the structure set forth in Figure 6a and can include any cathode so long as it can effectively conduct electricity through the aqueous electrolytic solution between itself and another electrode.

Cathode **200** can be constructed from any of a wide variety of electrically conductive materials known in the art, including (but not limited to) titanium, tantalum, aluminum, zirconium, tungsten, stainless steel, platinum, iridium, ruthenium, iron, nickel, chromium, and alloy and metal oxides thereof.

Figure 7 illustrates one embodiment of the electrolyzing cell of Figures 4a and 4b in use. Particularly, intermediate chamber **165** is partially filled with electrolyte solution **211**. Electrolyte chamber **165** is filled with electrolyte when the cartridge is new. In use, electrolyte chamber **165** is flooded with water and is replenished with fresh water as the electrolyte and water are consumed by the electrochemical process. The amount of electrolyte, and therefore the dimensions of electrolyte chamber **165** can be sized to last the design life of the cartridge. For example, in some embodiments, 1 gram of electrolyte and 1 mL of water can be used for each 10 gallons of solution produced. In some embodiments, the minimum electrolyte chamber volume is 2.8 in^3 (to produce 1,000 gallons), and the electrolyzing cell can be designed accordingly.

As illustrated in Figure 8, in some embodiments electrolyzing cell **85** can comprise separator **250** positioned on both sides of intermediate chamber **165** (*i.e.,* in the intermediate chamber, adjacent to anion and cation exchange membranes **196** and **201**). Separator **250** functions to contain electrolyte within the intermediate chamber. As a result, undissolved electrolyte is prevented from coming into direct contact with anion and cation exchange membranes **196** and **201**. In this manner, the entire surfaces of the exchange membranes are in contact with a constant electrolytic solution. Separator **250** can be constructed from any material with pores large enough to allow electrolytic solution to pass through, but small enough to prevent crystalline salt from passing through. Thus, separator **250** can be constructed from open cell elastomer foam, mesh screens, porous diaphragms, and the like, as would be readily apparent to those having ordinary skill in the art. For example, in some embodiments, separator **250** can include Scotch-Brite™ Ultra Fine Pad #7448 (available from 3M Corporation, St. Paul, Minnesota, United States of America). It is to be understood that the presently disclosed subject matter includes embodiments wherein electrolyzing cell **85** lacks separator **250**.

In some embodiments, electrolyzing cell **85** can comprise flow control unit **255**, as depicted in Figure 9. Particularly, Figure 9 illustrates anode chamber **155** of an electrolyzing cell configured with a flow control unit. One of ordinary skill in the art would recognize that although anode chamber **155** is depicted in the Figures, flow control unit **255** can easily be configured in cathode chamber **160**, both anode and cathode chambers, or in neither chamber. Flow control unit **255** is a porous device that functions to impede the passage of water in a controlled fashion. When installed, water flow velocity in the vicinity of electrode **195** is restricted and electrolyzed at a higher concentration. Particularly, since water outboard **256** (water that is not within the flow control means) is unrestricted, it will flow at a higher rate. Specifically, the reduced velocity and higher concentration near the electrode mimics a narrow, low flow chamber and increases electrolyzing efficiency. The concentration of the output will be controllable by adjusting flow rate and/or electrical current.

Flow control unit **255** can be constructed from any of a wide variety of materials known in the art. For example, as depicted in Figure 10a, in some embodiments, the flow control unit can comprise mesh pad **260** constructed from nylon or other suitable material. As illustrated in Figure 10b, in some embodiments flow control means **255** can be configured as porous block **265** constructed from materials that range from cellulose to stone. Figure 10c illustrates that in some embodiments, flow control unit **255** can be constructed from mesh screen material **270** that can be used on its own or stacked to obtain a desired flow control means thickness. The porosity of flow control unit **255** can be selected to adjust the resistance to flow and therefore "tune" the flow to the preferred concentration. For example, in some embodiments, 300 micron woven thermoplastic mesh sheet #9318T45 (available from McMaster Carr Supply Company, Santa Fe Springs, California, United States of America) can be used.

However, in some embodiments, electrolyzing cell **85** can be configured without a flow control unit, as depicted in Figure 11. Particularly, fresh water enters anode chamber **155** through inlet port **170** and electrolyzed water exits the chamber through outlet port **175**. Electrolysis only occurs in the vicinity of electrode **195**, with the highest concentration in area **197** nearest the electrode and the lowest concentration in area **198** along the outer wall. Because there is no obstruction to flow inside the chamber, the flow velocity is substantially consistent across width **199** of the electrolyzing cell.

IV.C. Filter **80**

In some embodiments, cartridge **5** can comprise one or more filters **80**. For example, as illustrated in Figure 12a, filter **80** can be positioned as a pre-filter which can be desirable in environments where the fresh water supply comprises sediment and/or other contaminants that can cause premature deterioration of the electrolyzing cell performance. Particularly, as depicted in Figure 12a, fresh water enters cartridge **5** at common port **205** and passes through filter **80** before being separated into three inlet supplies. The water then enters electrolyzing cell **85** and exits the cell as acidic and alkaline electrolyzed water solutions **215** and **220** (which can be, in some embodiments, hypochlorous acid and sodium hydroxide solutions).

Alternatively or in addition, in some embodiments, filter **80** can be positioned in an output location. In some embodiments, excess chlorine gas can be produced in anode chamber **155** of electrolyzing cell **85**. As illustrated in Figure 12b, the excess chlorine gas can be eliminated by positioning filter **80** on the output of the system. Particularly, fresh water enters cartridge **5** at common port **205** and is separated into three inlet supplies before entering electrolyzing cell **85**. The electrolyzed water exiting from the anode side of the electrolyzing cell can then pass through filter means **80** before exiting the cartridge.

The shape or form of filter **80** is not limited and can take any shape or form known to those of ordinary skill in the art. In some embodiments, filter **80** can comprise, for example, activated charcoal, although any suitable filtering means known in the art can be used. For example, in some embodiments, filter **80** can be constructed from paper, cellulose, polypropylene, activated carbon, and the like. The filter medium can be selected to correct water quality problems on a regional basis, for an individual type of water issue, and/or for general filtering. As with the previous elements, filter means **80** can be sized for the life of the cartridge.

Filters suitable for use with the presently disclosed subject matter are known in the art, and can include the following: U.S. Patent Nos. 6,234,184; 6,182,674; 5,909,743; 5,345,957; 4,038,103; 5,711,326; 5,601,660; 4,998,548; 4,468,333; and 3,575,185, the entire disclosures of which are hereby incorporated by reference in their entireties.

IV.D. Water Softener **280**

Hard water can cause the build-up of scale on the electrodes, as well as the production of calcium that can block passageways, particularly in the cathode chamber of electrolyzing cell **85**. Accordingly, in some embodiments, cartridge **5** can comprise water softener **280** to reduce the dissolved calcium, magnesium, manganese, and/or ferrous iron ion concentration in hard water. Figure 13a illustrates one embodiment of an electrolyzing cell comprising water softener **280**. Particularly, the input water enters cartridge **5** at common port **205** and can optionally be filtered using filter **80** prior to routing through water softener **280**. Water is then separated into three inlet supplies before entering electrolyzing cell **85**. The electrolyzed water exits the electrolyzing cell as acidic and alkaline electrolyzed water solutions **215** and **220** (which can be, in some embodiments, hypochlorous acid and sodium hydroxide solutions).

Since the calcium problem is predominantly an issue on the cathode side of the electrolyzing cell, in some embodiments it may not be necessary to soften all of the water passing through the system. Thus, in some embodiments, water softener **280** can be positioned in the cathode chamber supply after the water supply is split, as illustrated in Figure 13b. In this manner, only the water entering the cathode chamber is softened, and therefore can be approximately half the size needed to soften the entire water supply. Alternatively or in addition, in some embodiments, water softener **280** can be positioned inside cathode chamber **160**, as illustrated in Figure 13c. Particularly, in some embodiments, water softener **280** can comprise an exchange resin constructed from a synthetic or natural sand-like material coated with positively charged sodium ions, although the presently disclosed subject matter includes any of a wide variety of water softening means known in the art. The choice of softening media and quantity necessary for a given application would be apparent to those of ordinary skill in the art.

As illustrated in Figures 13a-13c, water softener **280** can be supplied as a separate cartridge or as an element in a combined cartridge, and the amount of media can be calculated for the chosen design life to keep it as small and inexpensive as possible. Water softener **280** can optionally be used in conjunction with the filtering means described herein above.

IV.E. Additional Additives

In some embodiments, cartridge **5** can comprise one or more additional additives. Particularly, various additives can be added to the acidic and alkaline electrolyzed water solutions produced by the electrolyzing cell. For example, such additives can include (but are not limited to) scents (such as citrus, herbal, and the like), colorants (such as dyes, food colorings, and the like), gelling agents, surfactants (which can include foaming agents, emulsifiers, dispersants, and the like), and/or anti-biological agents.

As illustrated in Figure 14a, additives **285** can be configured on the outputs of electrolyzing cell **85**. Alternatively or in addition, in some embodiments, additives **285** can enter on the input side as illustrated in Figure 14b. As with the electrolyte, filtering means, and water softening elements discussed herein above, only enough additive is included to last for the design life of cartridge **5**.

The additives can be positioned in separate cartridges, or in a combination cartridge with any or all of the previously disclosed components. Unlike the electrolyte, filter, and water softener (which are pass-through elements), additives **285** must be placed into the streams in a metered fashion, which can be accomplished in a number of ways, including the use of a metering pump or venturi suction device, as would be known to those of ordinary skill in the art.

V. Concentrated Precursor Embodiments

In some embodiments, cartridge **5** can comprise cleaning and/or sanitizing precursors that can be pre-prepared and supplied in a highly concentrated form. The quantity of concentrate is enough to last for the design life of the cartridge. The concentrates can be used in lieu of an electrolyzing cell, or used in conjunction with the cell to produce an alternate formulation of the cleaning and/or sanitizing solution. Thus, rather than have an electrolyzing cell as part of cartridge **5**, cleaning and/or sanitizing precursors can be supplied as a concentrate in a cartridge. The apparatus can mix water with the concentrated precursors to get a desired concentration.

For example, in some embodiments, the concentrate can be a commercially available concentrate, such as a quarternary ammonium product (for example, Sanibet™, available from Betco of Toledo, Ohio, United States of America). Quarternary ammonium is widely used as a cleaner and sanitizer at concentrations of about 200 parts per million ("ppm"). The Sanibet™ product requires one ounce of concentrate in 4 gallons of water to achieve 200 ppm. If the system batch size is 30 gallons, the cartridge will contain 7.5 ounces of concentrate to prepare one batch. Other chemical concentrates can be used to produce other solutions, such as degreasers and detergents. More highly concentrated precursors can be used to make the cartridge even smaller in size. If liquid concentrates are used, they can be added to the fresh water supply by various methods, including venturi suction devices, micro pumps, syringe devices, or other means known in the art. Solid or powdered concentrates can also be used with some form of metering means. Alternatively, the supply water can simply pass through the cartridge housing the concentrate and dissolve or absorb the concentrate along the way. As with the other solution preparing methods disclosed herein, additives can be included in the cartridge.

<u>VI.</u> <u>Chemical Embodiments</u>

<u>VI.A.</u> <u>Generally</u>

As set forth herein, the presently disclosed subject matter is directed to a cartridge system that facilitates the easy replacement of consumables and wear components to reliably produce one or more cleaning and/or sanitizing solutions. In some embodiments, the disclosed cartridge houses one or more chemical precursors that can be combined to produce one or more cleaning and/or sanitizing solutions. The quantity of each consumable supplied in the cartridge is only enough to last for the chosen design life of the cartridge.

In some embodiments, the sanitizing solution can be a chlorine dioxide solution. Chlorine dioxide is generally produced on site because it is an unstable compound with a short shelf life and is not practical to store or transport. To generate chlorine dioxide chemically, two or more chemical precursors and an initiator are required. For example, in some embodiments, the chemical precursors can be sodium chlorite and citric acid, although the presently disclosed subject matter is not limited and can include any reactants that can be combined in the presence of an initiator to generate chlorine dioxide or other sanitizing agents.

In some embodiments, the initiator can be water or water vapor. For example, as discussed in more detail herein below, when sodium chlorite and citric acid are combined in the presence of water or water vapor, chlorine dioxide gas is generated. The chlorine dioxide gas can then be absorbed by water to produce a chlorine dioxide solution. As discussed herein below, the reaction can be initiated when the chemical precursors are exposed to water, when a small amount of water is packaged with the chemical precursors, and/or when water is injected into the chemical precursors.

VI.B. Sachet **400**

In some embodiments, cartridge **5** comprises at least one sachet. Particularly, the sachet can house the chemical precursors needed to generate a sterilizing solution. Figures 15a and 15b illustrate one embodiment of sachet **400**. Specifically, sachet **400** is sealed on edges **401** using heat seal, adhesive, or any other method known in the art to enclose the sachet contents within its interior. Sachet **400** further comprises outer package **405**, inner envelope **410**, and chemical precursors **415**.

Outer package **405** is a hermetically sealed non-permeable package that houses inner envelope **410** within outer cavity **412**. One of ordinary skill would understand that outer package **405** can be constructed from any of a wide variety of non-permeable materials, including (but not limited to), aluminum foil, plastic foil, treated paper, and the like. Alternatively, outer package **405** can be a formed or molded part constructed from plastic and/or similar materials. One of ordinary skill in the art would also understand that outer package **405** can take any of a wide variety of shapes, such as rectangular, square, round, and the like and is not limited to the shape set forth in the Figures. In some embodiments, outer package **405** can comprise indicator **420**, which can include a bar code, RFID, or other identifying means that can be read by the apparatus.

As illustrated in Figure 15b, inner envelope **410** houses chemical precursors **415**. Inner envelope **410** is constructed from a selectively permeable material that allows water vapor to pass therethrough and contact chemical precursors **415** housed within inner cavity **411**. In addition, inner envelope **410** allows generated chlorine dioxide gas to pass therethrough and exit the envelope. In some embodiments, the inner envelope is impermeable to liquid water. Inner envelope **410** can be constructed from any of a wide variety of selectively permeable materials known in the art, including (but not limited to) polypropylene, polyethylene, and polysulfone membrane. For example, in some embodiments, inner envelope **410** can be constructed from polypropylene membrane filter material PP045 (available from Sterlitech Corporation, Kent, Washington, United States of America).

Chemical precursors are ultimately combined with an initiator (which in some embodiments can be water vapor) to generate chlorine dioxide gas. In some embodiments, the chemical precursors can be sodium chlorite and citric acid. One of ordinary skill in the art would recognize that the presently disclosed subject matter is not limited to the generation of chlorine dioxide by sodium chlorite and citric acid. Rather, the disclosed system includes the wide variety of metal chlorites and acids that can be used to generate chlorine dioxide. Chemical precursors **415** can be in tablet, capsule, or powder form and can be mixed or separated. The absolute and relative quantities of chemical precursors **415** can be selected based on the quantity and rate of chlorine dioxide production desired. Such routine experimentation is known to those of ordinary skill in the art.

In some embodiments, at least one additive can also be housed within inner cavity **411** of inner envelope **410**. Such additives can include (but are not limited to) desiccants, scents, surfactants, colorants, gelling agents, and the like and can be in pellet, powder, film, paper or other forms. Figure 15c illustrates one embodiment of sachet **400** wherein desiccant **425** is in paper form and is positioned within inner cavity **411** of inner envelope **410** to separate chemical precursors **415**. One of ordinary skill in the art would recognize that any additive can be substituted for desiccant **425** in the above description.

Figure 15d illustrates one embodiment of sachet **400** wherein outer cavity **412** comprises inner envelope **410** housing chemical precursors **415**, as well as frangible pouch **414** comprising water **413**. Frangible pouch can be any container comprising at least one frangible seal, as would be apparent to those of ordinary skill in the art. In use, a user or the apparatus disclosed herein can rupture the frangible seal of frangible pouch **414**, thereby releasing the water housed therein within outer cavity **412**. As a result, water vapor can pass through inner envelope **410** to initiate the reaction between chemical precursors **415**.

The chemical reaction used to generate chlorine dioxide gas can be contained within a reaction chamber to control the passage of water and absorption of chlorine dioxide. One of ordinary skill in the art would recognize that the presently disclosed subject matter is not limited to applications wherein chlorine dioxide is generated. Rather, the disclosed system can include other sanitizers, such as iodine-based or bromine-based solutions, as well as other forms of chlorine, if the correct reactants are used. Such sanitizers are well known to those of ordinary skill in the art.

To this end, in some embodiments, outer package **405** can function as the reaction chamber. For example, Figure 16a illustrates one embodiment wherein sachet **400** is used as the reaction chamber. Sachet **400** comprises entry port **440** and exit port **445** that are aligned with an attaching means, piercing cannula, or the like that makes a hydraulic connection. In use, as illustrated by arrow A, water passes through outer package **405** at entry port **440** into outer cavity **412** at a predetermined rate. As the water circulates in the area between the outer package and the inner envelope, water vapor passes through the selectively permeable membrane of the inner envelope to contact chemical precursors **415**. As a result, chlorine dioxide gas is generated and passes through the selectively permeable membrane of the inner envelope to outer cavity **412** and is absorbed by the water as it circulates. The water then exits outer cavity **412** as chlorine dioxide solution via exit port **445**, as depicted by Arrow B. Entry and exit ports **440**, **445** can be constructed using any means known in the art, including (but not limited to) needle puncture directly in outer package **405**. Alternatively or in addition, in some embodiments, entry and exit ports **440**, **445** can be valves (such as simple diaphragms or duckbills) that mate with the apparatus, sections of self-sealing material (such as the material used in medical syringe bottles), or other systems known in the art.

Figures 16b and 16c illustrate an alternate embodiment wherein outer package **405** is configured as a formed or molded part. In such embodiments, the interior of outer package **405** is divided into upper section **408** and lower section **407** by selectively permeable membrane **409**. Selectively permeable membrane **409** can be constructed from any selectively permeable material that allows water vapor and chlorine dioxide gas to pass therethrough. For example, in some embodiments, selectively permeable membrane **409** can be constructed from polypropylene membrane. In some embodiments, selectively permeable membrane **409** is impermeable to liquid water.

In some embodiments, chemical precursors **415** (and optionally additives **416**) are housed within lower section **407**. In such embodiments, upper section **408** comprises entry and exit ports **440**, **445**. However, one of ordinary skill in the art would appreciate that in some embodiments, upper section **408** can house the chemical precursors and lower section **407** can house the entry and exit ports. In use, water enters upper section **408** through entry port **440**, as depicted by Arrow A. Water then passes through the upper section and exits at exit port **445**, as illustrated by Arrow B. In the process, water vapor passes from upper section **408** through selectively permeable membrane **409** into lower section **407** to contact chemical precursors **415**. As a result, chlorine dioxide gas is generated in lower section **407** and passes through selectively permeable membrane **409** to upper section **408** and is absorbed by the water passing from entry port **440** to exit port **445**. Thus, water exits the unit as chlorine dioxide solution.

In some embodiments, water can be directly injected into lower section **407** by a user or by the apparatus. In these embodiments, water and/or water vapor contact the chemical precursors and chlorine dioxide gas is generated. The chlorine dioxide gas then passes through selectively permeable membrane **409** into upper section **408** and is absorbed by water to produce a chlorine dioxide solution, as described above with regard to Figure 16c.

<u>VI.C.</u> <u>Blister Sachet **460**</u>

In some embodiments, sachet **400** can be a blister pack sachet. Particularly, as illustrated in Figures 17a and 17b, blister sachet **460** includes forming sheet **465**, barrier sheet **470**, and selectively permeable sheet **475** positioned in a face-to-face relationship. Forming sheet **465** is of the type conventionally used in the production of blister packs and in some embodiments can be constructed from metallic foil, polymeric material, and the like. In some embodiments, forming sheet **465** can be produced by, for example, a thermal drawing process. As illustrated, forming sheet **465** is provided with at least one well **480** surrounded by flange **485**. Well **480** can assume any of a wide variety of shapes and is of sufficient size to house precursors **415** (and optionally one or more additives).

Selectively permeable sheet **475** is sealed to flange **485** via adhesive, heat seal, or any other method known in the art to enclose well **480**. Permeable sheet **475** can be constructed from any of a wide variety of selectively permeable materials known in the art, including (but not limited to) polypropylene membrane. Selectively permeable sheet **475** allows water vapor and chlorine dioxide gas to pass therethrough, as described in more detail herein below. In some embodiments, the selectively permeable sheet is impermeable to liquid water.

Barrier sheet **470** is sealed to selectively permeable sheet **475** using any method known in the art, including adhesive and heat seal technology. One of ordinary skill would understand that barrier sheet **470** can be constructed from any of a wide variety of non-permeable materials, including (but not limited to), aluminum foil, plastic foil, and the like.

As illustrated in Figure 17c, in use, barrier sheet **470** can be removed by a user or automatically by the apparatus to initiate production of the sterilizing solution. After barrier sheet **470** is removed, blister sachet **460** is then placed inside a chamber and the reaction is initiated by any of the methods previously disclosed such that the sachet becomes the reaction chamber (such as the method disclosed above for sachet **400**). For example, as illustrated in Figure 17d, in some embodiments supply water (represented by arrow W) can flow across the surface of permeable sheet **475**, absorbing chlorine dioxide as it passes, creating the sanitizing solution.

As would be apparent to those of ordinary skill in the art, multiple blister sachets can be supplied on a roll, sheet, linear package, concentric ring, strip, or any other preformed interconnection, wherein each sachet contains the quantity of chemical precursors needed for one batch of sanitizing solution. In some embodiments, the blister sachet can have perforations that allow one sachet (sized for one batch of sanitizing solution) to be separated from the other sachets by tearing it away from the rest of the blister sachets. The individual blister sachets can be separated prior to use or can be separated prior to bulk packaging.

In this manner, multiple sachets can be loaded into the apparatus, which then indexes them into and out of the location at which they are reacted. In these embodiments, the operator does not need to change the cartridge for each batch of solution, allowing the apparatus to run in a more automatic manner. Reacted sachets thus can remain in a protected location within the apparatus while the remaining sachets are used, ensuring that the chemicals are completely reacted, and the sachet is dry before the operator handles the pack.

VI.D. Two-Compartment Blister Sachet

In some embodiments, blister sachet **460** can be divided into two compartments by a selectively permeable membrane. The selectively permeable membrane can be constructed from any of a wide variety of selectively permeable materials known in the art, including (but not limited to) polypropylene membrane. The selectively permeable membrane allows water vapor and chlorine dioxide gas to pass therethrough. In some embodiments, the selectively permeable membrane does not allow water to pass therethrough.

Figure 18a illustrates one embodiment of a two compartment blister sachet that can be used with the presently disclosed subject matter. Particularly, selectively permeable membrane **490** divides well **480** into upper compartment **495** and lower compartment **500**. Upper compartment **495** can be a water supply compartment and lower compartment **500** can house chemical precursors **415** (and optionally additives). One of ordinary skill in the art would recognize that the presently disclosed subject matter also includes embodiments wherein the chemical precursors are housed in upper compartment **495** and the water supply compartment is the lower compartment. The two compartment blister sachet can be a formed blister, as illustrated in the embodiment of Figure 17 with a more complex shape that leaves a flat section between the upper and lower compartments. Membrane **490** can then be adhered to the flat section by any suitable method known in the art, including adhesive and/or heat sealing.

In use, water is passed through upper compartment **495** using any of a wide variety of methods known in the art. For example, as illustrated in Figure 18b, in some embodiments, upper compartment **495** can be pierced using a sharp instrument (such as a cannula **515**) or similar device. The cannula will deposit water into upper compartment **495** via input cannula **515a** and direct water out of the sachet as chlorine dioxide solution via exit cannula **515b**, as illustrated by the arrows. Particularly, water will flow from input cannula **515a** across selectively permeable membrane **490**. As a result, water vapor passes from upper compartment **495**, through selectively permeable membrane **490** to contact chemical precursors **415** in lower compartment **500**, thereby generating chlorine dioxide gas. The generated gas will pass through selectively permeable membrane **490** into upper compartment **495** and will be absorbed by the water flowing through the upper compartment. As a result, water leaving the sachet via exit cannula **515b** will be in the form of chorine dioxide solution.

In some embodiments, the two compartment blister sachet can be configured as set forth in Figure 19a. Specifically, in some embodiments, the sachet can comprise upper and lower wells **495**, **500**. The blister sachet of Figure 19a can be constructed by forming the upper and lower wells as separate blisters that are sealed together once the reactants and membrane are inserted. Alternatively, the blister can be of a clamshell design such that once the reactants and membrane are placed into one side, the clamshell is folded over and sealed using adhesive and/or heat sealing technology known in the art.

As illustrated in Figure 19a, selectively permeable membrane **490** separates upper and lower wells **495**, **500**. Selectively permeable membrane **490** can be constructed from any of a wide variety of selectively permeable materials known in the art. For example, in some embodiments, the selectively permeable membrane can allow water vapor and chlorine dioxide gas to pass therethrough. In some embodiments, the selectively permeable membrane can be constructed from polypropylene membrane.

In use, water is enters upper well **495** using any of a wide variety of methods known in the art. For example, in some embodiments, upper well **495** can be pierced using a sharp instrument (such as a cannula **515**) or similar device. As illustrated in Figure 19b, the cannula will deposit water into upper well **495** via input cannula **515a**. The water will flow from input cannula **515a** across membrane **490** and exit upper well **495** via exit cannula **515b**. As a result, water vapor passes through membrane **490** and enters lower well **500** to contact chemical precursors **415**, thereby generating chlorine dioxide gas. The generated gas will pass from lower well **500**, through membrane **490** and into upper well **495** and will be absorbed by the water. Thus, water that leaves the sachet via exit cannula **515b** will be in the form of chlorine dioxide solution.

VI.E. Catalyst

In some embodiments, a catalyst can be used to increase the rate and completion of the reaction. In some embodiments, the catalyst can be a chemical catalyst, such as (but not limited to) palladium, noble metals, transition metals, zeolites (aluminosilicate), electromagnetic energy, and ultraviolet light. Alternatively or in addition, in some embodiments, heat can be used as a catalyst to increase the rate of chlorine dioxide production. Particularly, the water that flows around the sachet can be heated, or the cartridge itself can be heated with a hot plate or other surface heater. In some embodiments, the heater can be included as part of the cartridge, or as an integral part of the apparatus. Alternatively or in addition, an exothermic chemical reaction that produces heat can be used, such as (but not limited to) Portland cement, or similar chemicals that can be intermixed to produce heat.

VII. Apparatus

The generating apparatus disclosed herein is an automatic or semi-automatic device into which cartridge **5** is inserted. The apparatus is attached to a source of water controlled through the cartridge to create the sanitizing solution. The apparatus then stores and dispenses the prepared sanitizing solution.

Figure 20 illustrates a schematic of the basic components of one embodiment of a system that can be used to produce a sanitizing solution (such as chlorine dioxide solution). Particularly, in system **501**, fresh water **550** enters the system and is controlled by valve **555**, which can be any of a wide variety of suitable valves known in the art. For example, in some embodiments, valve **555** can be an on/off valve or a flow control valve that adjusts the flow rate of the system. In some embodiments, valve **555** can be automatic, requiring no input from an operator. However, the presently disclosed subject matter also includes embodiments wherein valve **555** is controlled by an operator.

A cartridge or a sachet (not shown) is placed inside reaction chamber **560** by snap-fit, or other similar interlocking mechanisms. During operation, water passes through chamber **560** and then through, around, or adjacent to the sachet or cartridge. In some embodiments, chamber **560** can include retractable needles, mated fittings, or other devices to connect and conduct the water, as described herein above. The chemical reaction is initiated by any of the initiation methods described herein above. For example, in embodiments wherein the sachet comprises a frangible pouch housing water, the chamber can contain a device to rupture the frangible pouch. Alternatively or in addition, in some embodiments, water injector **565** can be used to supply water for initiation. Water injector **565** can comprise (but is not limited to) one or more retractable needles, needless syringes, mated fittings, bypass systems, and the like. In some embodiments, chamber **560** can comprise heater **570** to catalyze the reaction.

As fresh water passes through chamber **560**, the water absorbs chlorine dioxide generated by the chemical reaction. If RFID or other identification markings are used, chamber **560** can comprise a reading device (not shown), as are well known in the art. In some embodiments, chamber **560** can comprise a pressing device (not shown) to press the sachet after use to squeeze the water from it for drip-free disposal. In addition, heater **570** can be used after completion of the reaction to aid in drying cartridge **5**.

Generated chlorine dioxide solution passes from chamber **560** through conduit **575** and into reservoir **580** where it is stored until ready for use. In some embodiments, reservoir **580** can comprise level indicator **585** to monitor the amount of water present in the reservoir and the rate at which the reservoir is filling. Level indicator **585** can be any of a wide variety of level indicators known in the art, including (but not limited to) pressure transducers, level floats, and the like. An operator can use level indicator **585** to determine when reservoir **580** is full or empty and to determine how much chlorine dioxide solution remains in the reservoir to control the start/stop of the fresh water flow. If used to monitor the rate of fill, level indicator **585** can be used in conjunction with flow control valve **555** to control the rate of fresh water flow through chamber **560**. For example, if 30 gallons of water are passed through the chamber in 50 minutes (or at a rate of 0.6 gallons/minute), the output of solution entering the reservoir will remain at a relatively constant 3 ppm of chlorine dioxide. Alternatively or in addition, a fixed flow orifice can be used, and the inlet valve can be opened until the level indicator reads full and then closed.

In some embodiments, the system can comprise at least two dispenser outlets **590**, **591** which can be high pressure, low flow outlets for misting applications. Alternatively, in some embodiments, the dispenser outlets can be low pressure, high flow outlets to fill sinks. In some embodiments, the dispenser outlets can be a combination of high pressure, low flow and low pressure, high flow outlets. Dispenser outlets **590**, **591** can be fed by one or more pumps **595**, **596**. The presently disclosed subject matter can also include alternate dispensing options, such as the filling of detachable containers, spray bottles, and the like for hard surface cleaning and other similar applications.

In some embodiments, system **501** can comprise a water circulation means, as illustrated in Figure 21. Particularly, fresh water **550** enters chamber **560** and fills the reservoir as described above. However, once the reservoir is filled, water then flows through conduit **600** and is pumped (via pump **605**) back into the inlet of the chamber where it absorbs more chlorine dioxide and continues recirculating. In these embodiments, the water can be recirculated for as long as necessary to complete the reaction.

In some embodiments, system **501** can comprise a water accumulator. Specifically, as illustrated in Figure 22, water accumulator **615** can comprise a diaphragm or other device to compress and store the energy used to pump the water. Fresh water inlet valve **555** is opened to fill the accumulator and compress the diaphragm using the pressure of the fresh water source. In some embodiments, water accumulator **615** can hold the amount of water needed for one complete batch of solution. Once filled, inlet valve **555** is closed and outlet valve **620** is opened. The stored energy pushes the accumulated water through chamber **310** where it absorbs chlorine dioxide and then enters reservoir **580** and is ready for use. The system illustrated in Figure 22 provides a failsafe for the chlorine dioxide reaction. That is, if an electrical power or other failure occurs once the reaction has been initiated, the entire amount of water will pass through the chamber and no high concentration of chlorine dioxide gas will be generated. Alternatively, accumulator **615** can be a simple storage tank placed above the chamber and reservoir, using gravity to feed the water into the system once the tank has been filed by the fresh water inlet.

In some embodiments, system **501** can comprise two or more reservoirs (along with the necessary controls and plumbing) to generate a second (or more) batch of solution while the first batch is being used to ensure that there is always a solution prepared and ready for use.

VIII. Methods of Using the Presently Disclosed Subject Matter

Figure 23 illustrates one embodiment of apparatus **503** configured for commercial or other use. Particularly, apparatus **503** comprises base **295** containing a plurality of components, and can be used for mounting on a wall or other means. In some embodiments, controller **300** can house the electronics necessary to operate the components of cartridge **5** (such as, for example, electrolyzing cell **85**), and can include display panel **305**. Thus, in some embodiments, the presently disclosed subject matter comprises a means for communicating to the consumer when it can be time to refill or replace the cartridge **5**. For example, the communication means can comprise an indicator and optionally a timer and/or sensor. Suitable examples of communication means, communication devices, and methods of using communicating devices can include, but are not limited to, those found in the following: U.S. Pat. Nos. 6,295,004; 6,196,239; 5,839,458; 5,151,884; 4,653,423; 4,213,338; 4,164,197; 3,648,931; and 3,850,185, the entire disclosures of which are hereby incorporated by reference.

In some embodiments, plumbing controls can be enclosed in plumbing compartment **310**. The unit can be attached in some embodiments to a water supply and drain (not shown) and/or to a standard 120 or 240 volt electrical supply (also not shown). In some embodiments, storage tanks **315** hold a quantity of the cleaning and/or sanitizing solutions to be ready for dispensing. Refillable spray bottle **316** illustrates one method of dispensing, although any of a wide variety of dispensing means known in the art can be used.

Depending on the elements included in cartridge **5**, there can be provisions for hydraulic and/or electrical connections between the cartridge and system apparatus. In some embodiments, these can be quick-connect devices that will not require any intervention by the user other than the removal and replacement of the cartridge. For example, as is well known in the art, electrical connections such as plug-in contacts can be used. As would be apparent those skilled in the art, there are many ways to accomplish the hydraulic connections. For example, Figure 24a illustrates cartridge section **325** and apparatus **330**. Apparatus **330** comprises nipple **335** in fluid communication with its appropriate internal plumbing. In some embodiments, nipple **335** comprises o-ring **340** inserted into a groove. The cartridge includes receptacle **345** in fluid communication with its appropriate internal plumbing.

As depicted in Figure 24b, when the cartridge is inserted, nipple **335** enters receptacle **345**, and o-ring **340** is compressed, producing fluid-tight seal **350**. One of ordinary skill in the art would recognize that there are many connections that can be used and the presently disclosed subject matter is not limited to the fitting set forth herein.

IX. Advantages of the Presently Disclosed Subject Matter

The disclosed cartridge system facilitates the easy replacement of consumables and wear components housed within the cartridge. Particularly, the quantities of each consumable supplied are only enough to last for the chosen design life of the cartridge. For example, if the cartridge is designed to electrolytically make 1000 gallons of product at 10 gallons per hour, it will contain only enough electrolyte to produce 1,000 gallons of product. To this end, water filtering and conditioning elements can also be designed to last the same length of time.

When cartridge **5** reaches the end of its service life, it is easily removed and replaced by a user. In this manner, none of the consumables will be wasted, as all will run out at approximately the same time. In addition, there will be minimal downtime of the apparatus. The components that are not replaced with cartridge **5** are designed to last for an extended period of time. Thus, the disclosed system virtually eliminates the cost and time necessary for service and maintenance of the apparatus due to the rapid and simple replacement of the cartridge, and the longevity of the non-cartridge elements.

Further, the disclosed system comprises the ability to alter the sanitizing solution output and/or to compensate for input water quality by simply using a cartridge that contains different elements. Specifically, the contents of cartridge **5** can be tuned for regional or individual differences in water supply, or preferences in the desired outputs by adding, removing, or altering items such as filtering, water softening, or chemical additives.

Continuing, the flow of input water can be controlled and designed to produce a sanitizing solution of a desired concentration. As a result, cost is greatly reduced and the complexity of the cartridge can be decreased. Thus, in the disclosed system, a user can easily adjust flow rate or other variables to generate the desired concentration of sanitizing solution.

Further, in electrochemical applications, the presently disclosed subject matter is directed to a limited lifetime, low cost, and disposable electrolyzing cell that can be utilized in a cartridge system. Presently, developments in the industry are focused on longevity and efficiency, continually adding to the cost and complexity of the electrolyzing apparatus. The presently disclosed subject matter therefore significantly removes cost from the electrolyzing cell and purposefully gives it a designed life span.

An additional advantage to the presently disclosed subject matter is that the sanitizing solution can be prepared in a batch process in the chemical and precursor embodiments set forth herein. The reaction rate is more rapid at the beginning of the reaction, when there is the largest amount of unreacted precursors. As the precursors are consumed, the reaction rate slows. The fresh water flow rate can be controlled so that the reaction is complete before all of the water has been supplied. The remaining water acts to flush the cartridge after the reaction, leaving the cartridge benign, i.e. containing no reacting chemical. As the flushing water enters the reservoir, it mixes with the rest of the water and the resulting solution is at the correct concentration.

Also, for the concentrate and the reactive systems, only a small amount of highly or unreacted precursor is housed within the cartridge. There are no large quantities and minimal handling, and so is very safe to use. Even in the event of a failure, the small amount of chemical poses no danger.

Although several advantages of the disclosed system are set forth in detail herein, the list is by no means limiting. Particularly, one of ordinary skill in the art would recognize that there can be several advantages to the disclosed system that are not included herein.

CLAIMS

What is claimed is:

1. An apparatus for the preparation of a cleaning, sanitizing, or sterilizing solution, said apparatus comprising at least one modular component.

2. The apparatus of claim 1, wherein said cleaning, sanitizing, or sterilizing solution is selected from the group comprising: chlorine dioxide solution, hypochlorous acid solution, sodium hydroxide solution, and combinations thereof.

3. The apparatus of claim 1, wherein said modular component is a replaceable cartridge.

4. The apparatus of claim 3, wherein said cartridge comprises an electrolytic cell.

5. The apparatus of claim 4, wherein said electrolytic cell comprises:
   a. an anode chamber;
   b. a cathode chamber comprising a cathode; and
   c. an intermediate chamber comprising electrolyte.

6. The apparatus of claim 5, wherein said anode chamber comprises an anode.

7. The apparatus of claim 4, further comprising an anode, wherein said cartridge is adapted with an opening to accommodate said anode.

8. The apparatus of claim 3, wherein said cartridge comprises at least one chemical precursor.

9. The apparatus of claim 8, wherein said precursors is selected from the group comprising sodium chlorite, citric acid, and combinations thereof.

10. The apparatus of claim 3, wherein said cartridge comprises at least cleaning, sanitizing, or sterilizing solution concentrate.

11. The apparatus of claim 3, wherein said modular component is a sachet.

12. The apparatus of claim 11, wherein said sachet comprises:
    a. an outer impermeable package;
    b. an inner selectively permeable membrane housed within said package; and
    c. chemical precursors housed within said inner membrane.

13. The apparatus of claim 11, wherein said sachet is a blister pack sachet comprising:
    a. a forming sheet comprising at least one well;
    b. a selectively permeable sheet positioned adjacent to said forming sheet;
    c. a barrier sheet positioned adjacent to said selectively permeable sheet;

    wherein said well comprises chemical precursors.

14. The apparatus of claim 11, wherein said sachet is a blister pack sachet comprising:
    a. a forming sheet comprising at least one well;
    b. a selectively permeable sheet positioned adjacent to said forming sheet;

    wherein said well comprises chemical precursors; and

    wherein at least portion of said forming sheet functions as a barrier sheet.

15. The apparatus of claim 11, wherein said sachet comprises at least two compartments.

16. An electrolyzing cell comprising:
    a. an anode;

b. a cathode;
c. electrolyte; and
d. at least one ion exchange membrane;

wherein said cell is packaged in a replaceable cartridge; and
wherein said cell functions for a pre-determined, limited duration.

17. The cell of claim 16, wherein said cell comprises three chambers and electrolyte is supplied in the center chamber.

18. The cell of claim 16, wherein said duration is between about 10 and about 5000 running hours.

19. A method of electrolytically producing cleaning, sanitizing, or sterilizing solutions, said method comprising:
   a. providing an apparatus comprising at least one modular component, wherein said modular component comprises an electrolyzing cell;
   b. connecting said electrolyzing cell to at least one power source;

   whereby a cleaning, sanitizing, or sterilizing solution is thereby produced.

20. The method of claim 19, wherein said cell comprises three chambers and electrolyte is supplied in the center chamber.

21. The method of claim 19, wherein said quantity of electrolyte is sized to last for the pre-determined duration.

22. A method of chemically producing a cleaning, sanitizing, or sterilizing solution, said method comprising:
   a. providing an apparatus comprising at least one modular component, wherein said modular component comprises a sachet comprising the chemical precursors required to generate said solution;
   b. providing an initiating agent;

c. contacting said chemical precursors with said initiating agent to generate a gas;
d. contacting the gas with water to generate said solution.

23. The method of claim 22, wherein said quantity of chemical precursor is sized to last for the pre-determined duration.

24. A method of producing a cleaning, sanitizing, or sterilizing solution using a chemical concentrate, said method comprising:
a. providing an apparatus comprising at least one modular component, wherein said modular component comprises a chemical concentrate;
b. diluting said chemical concentrate with water to generate a cleaning, sanitizing, or sterilizing solution of desired concentration.

FIG. 1a

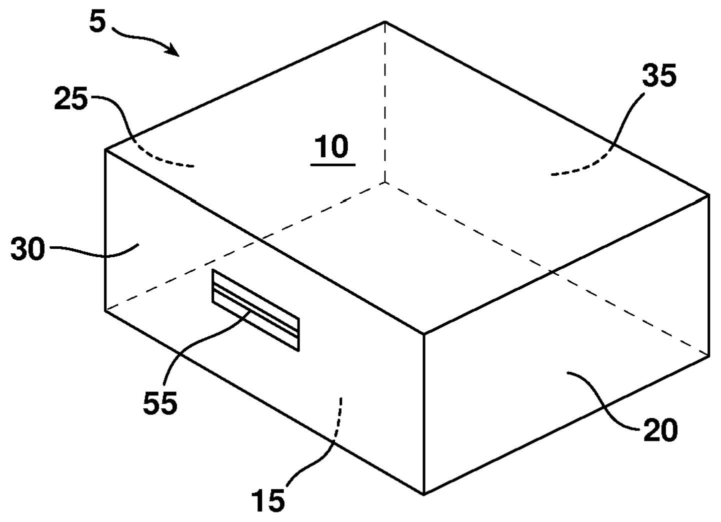


FIG. 1b

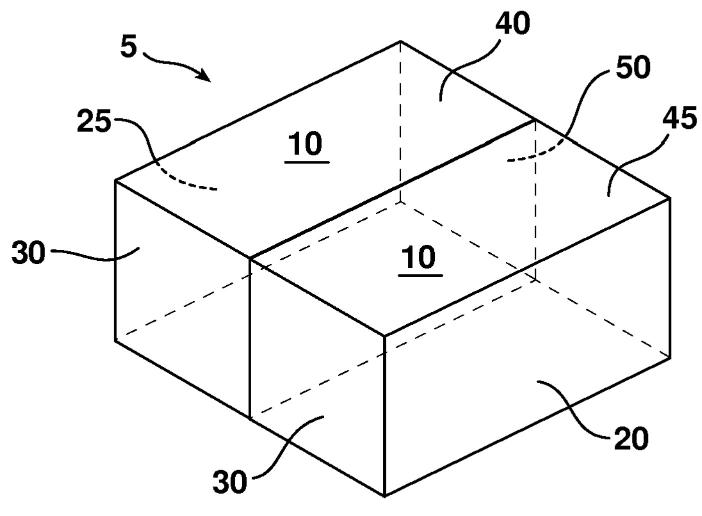


FIG. 2a

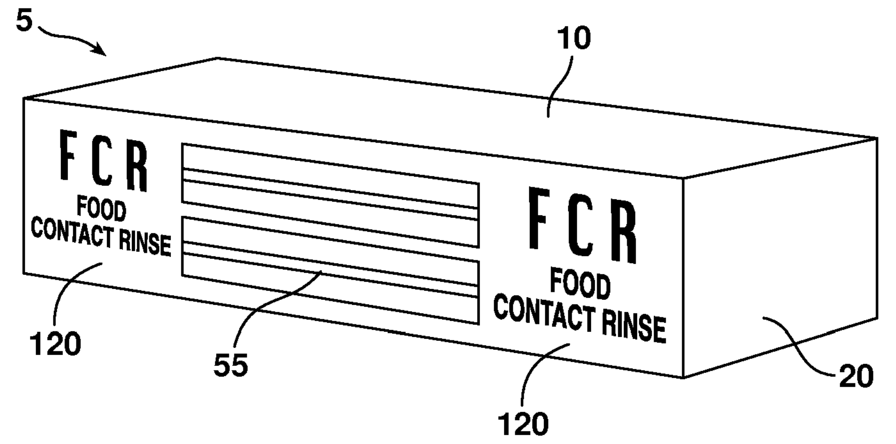


FIG. 2b

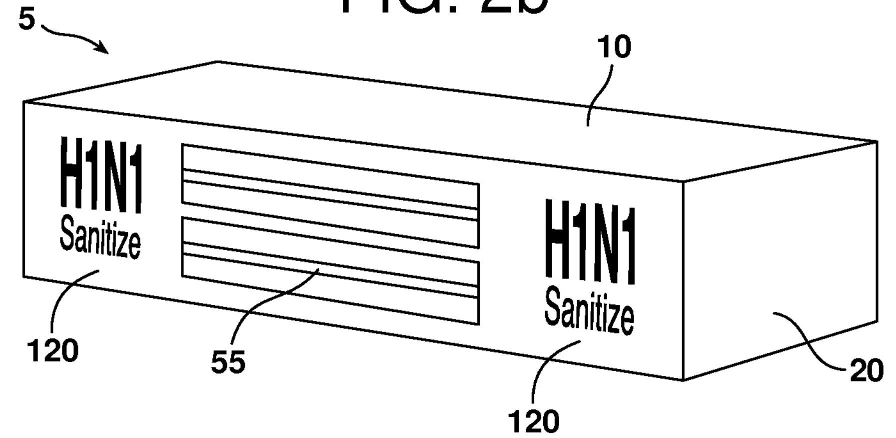


FIG. 2c

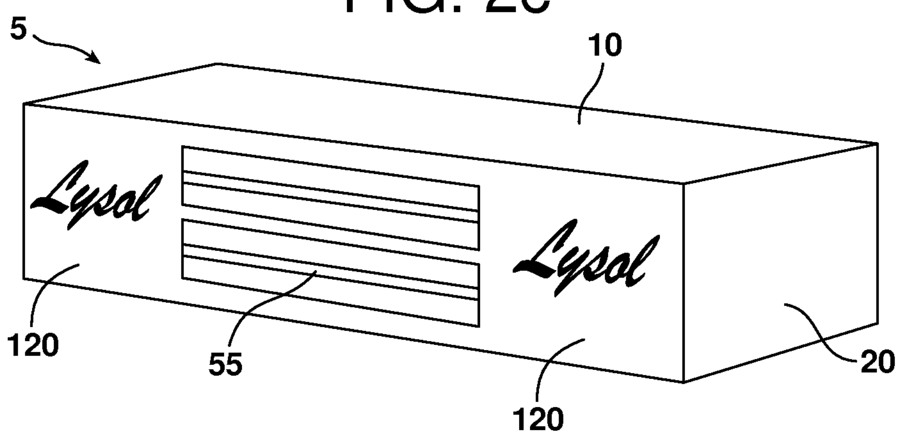


FIG. 3a

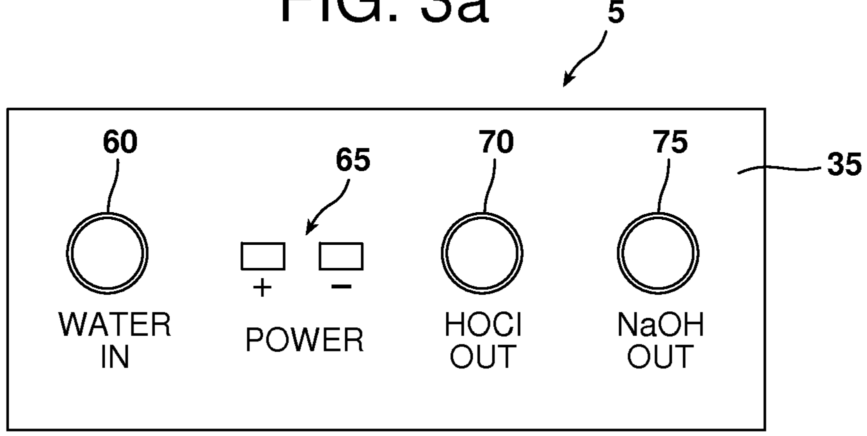

5
60
65
70
75
35
+
−
WATER IN
POWER
HOCI OUT
NaOH OUT

FIG. 3b

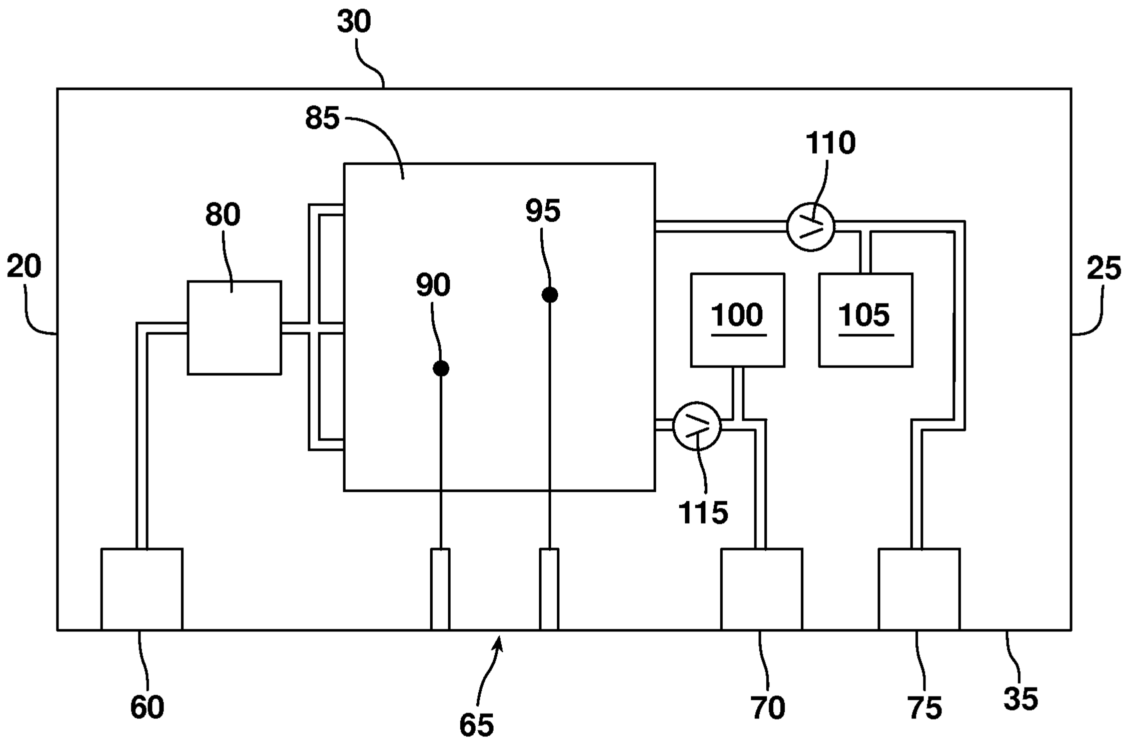
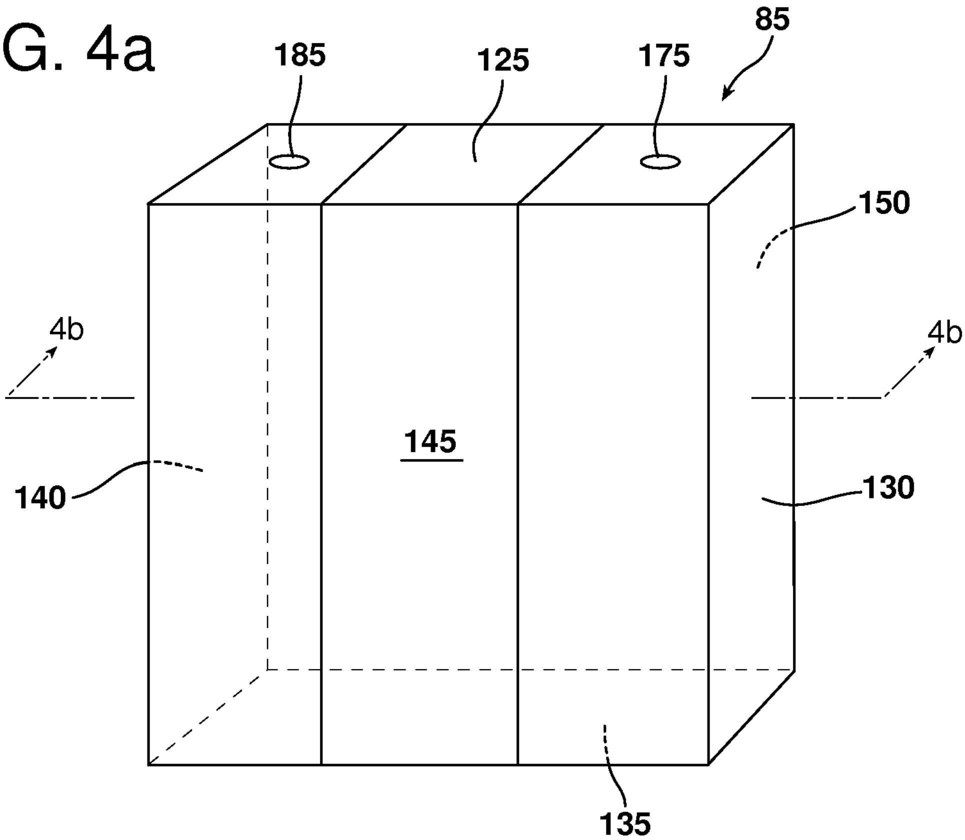
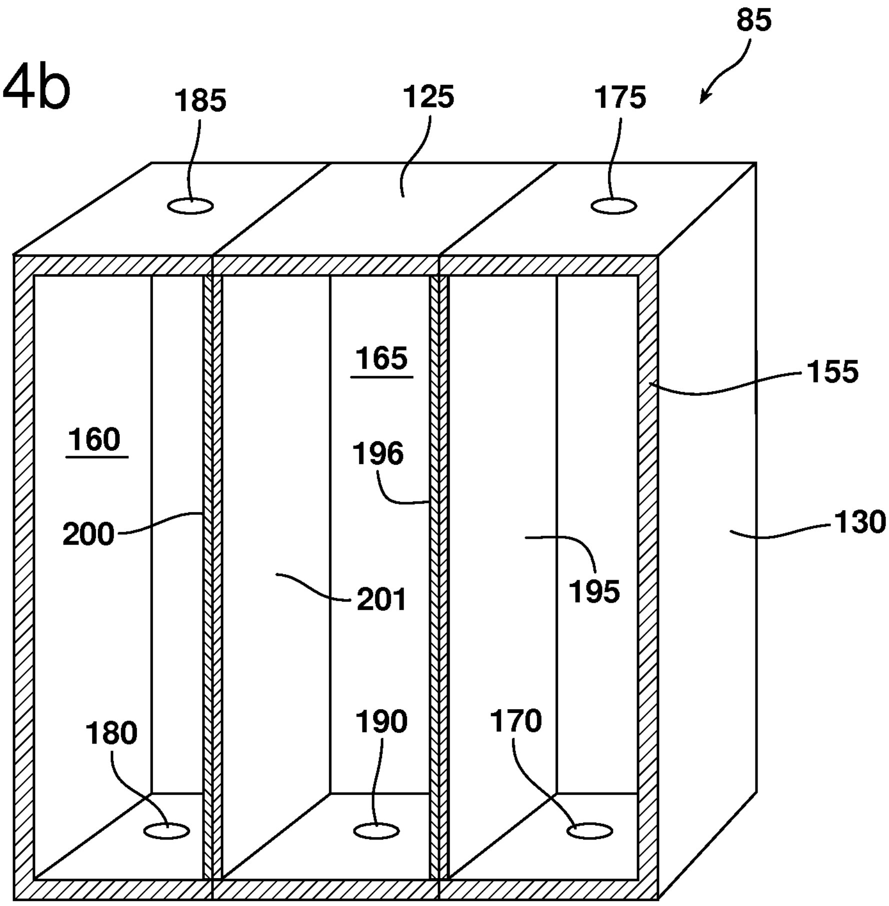

30
85
110
80
95
20
90
100
105
25
115
60
65
70
75
35

FIG. 4a



85
185
125
175
150
4b
4b
145
140
130
135

FIG. 4b



85
185
125
175
165
155
160
196
200
130
201
195
180
190
170

FIG. 5a

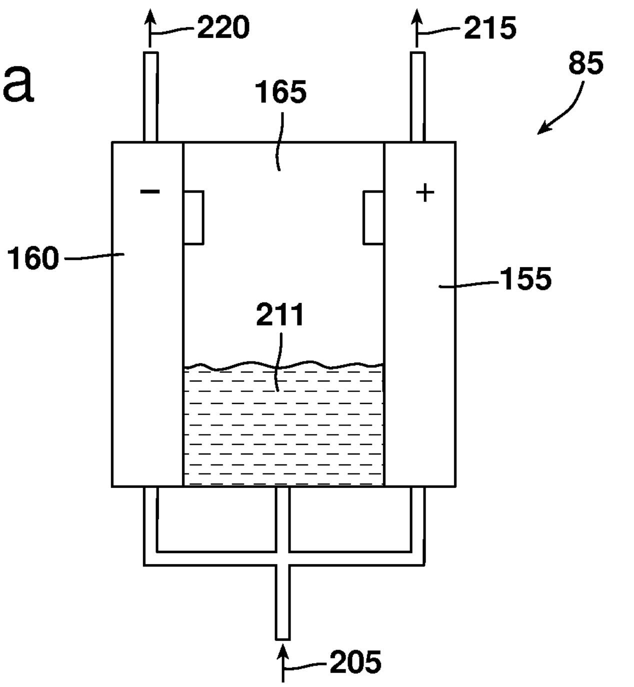
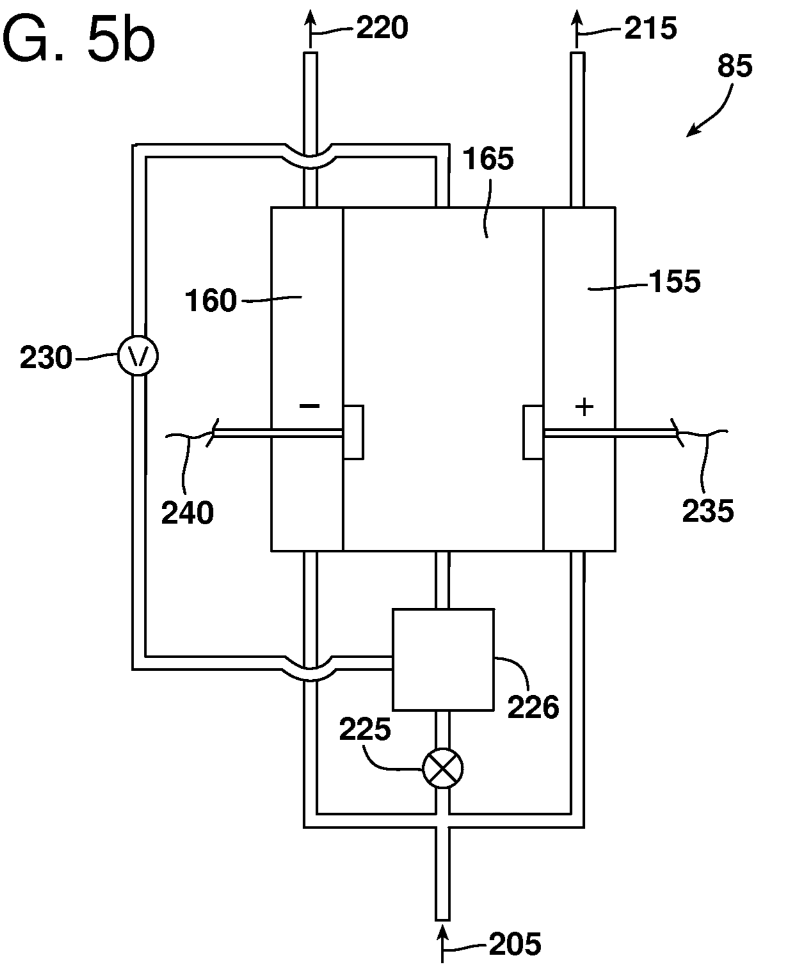

220
215
85
165
−
+
160
155
211
205

FIG. 5b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215
85
165
160
155
230
V
−
+
240
235
226
225
205

FIG. 6a

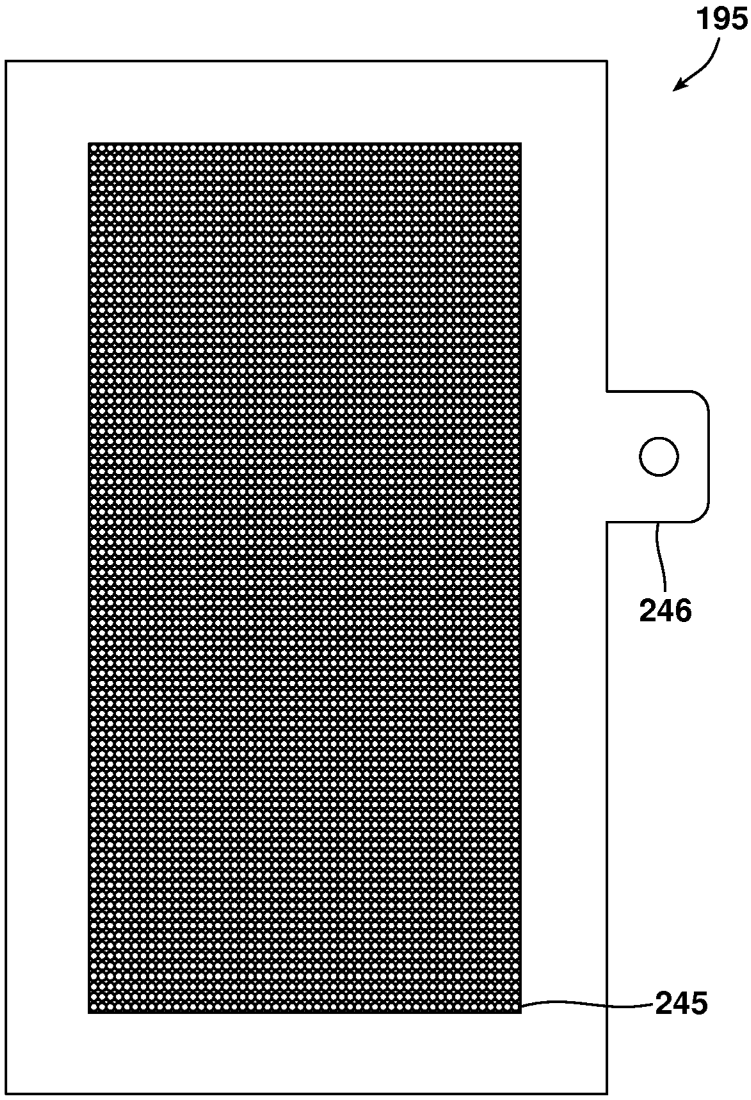


FIG. 6b

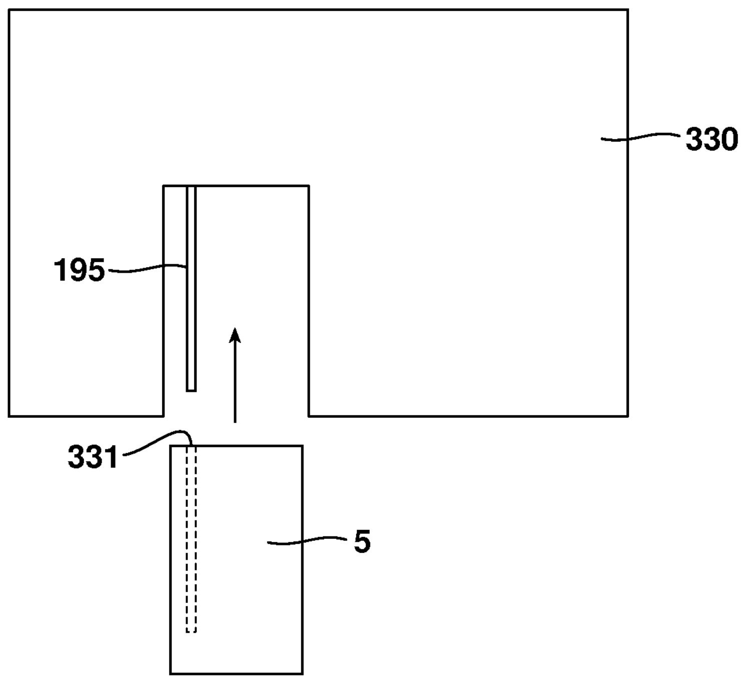


FIG. 6c

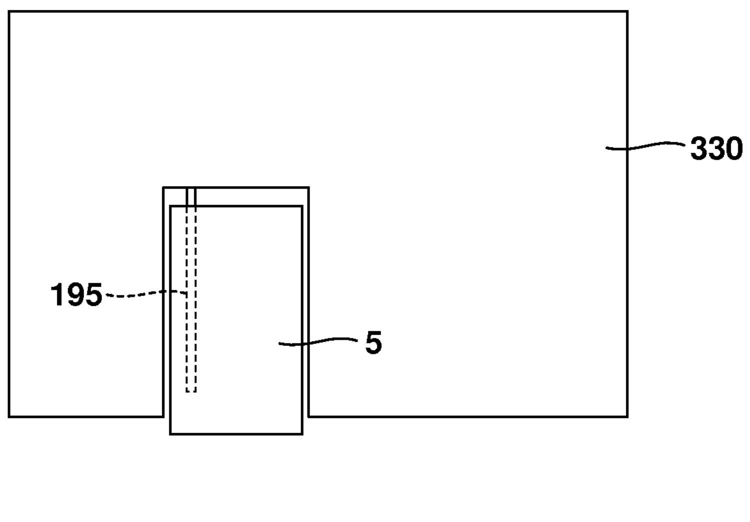


FIG. 7

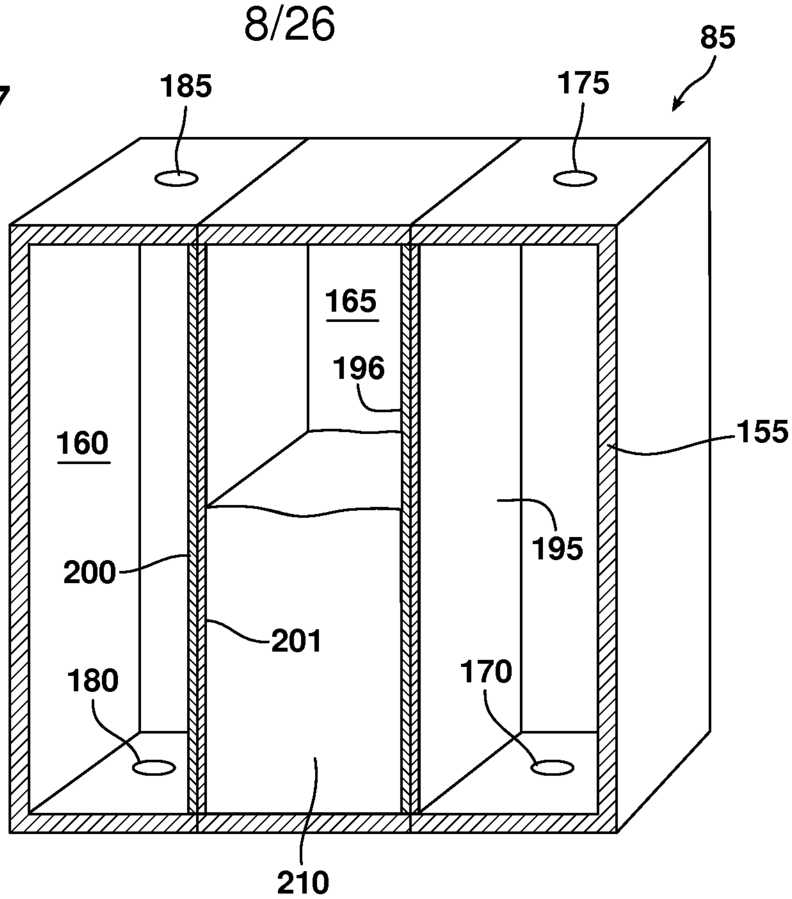

85
185
175
165
196
160
155
195
200
201
180
170
210

FIG. 8

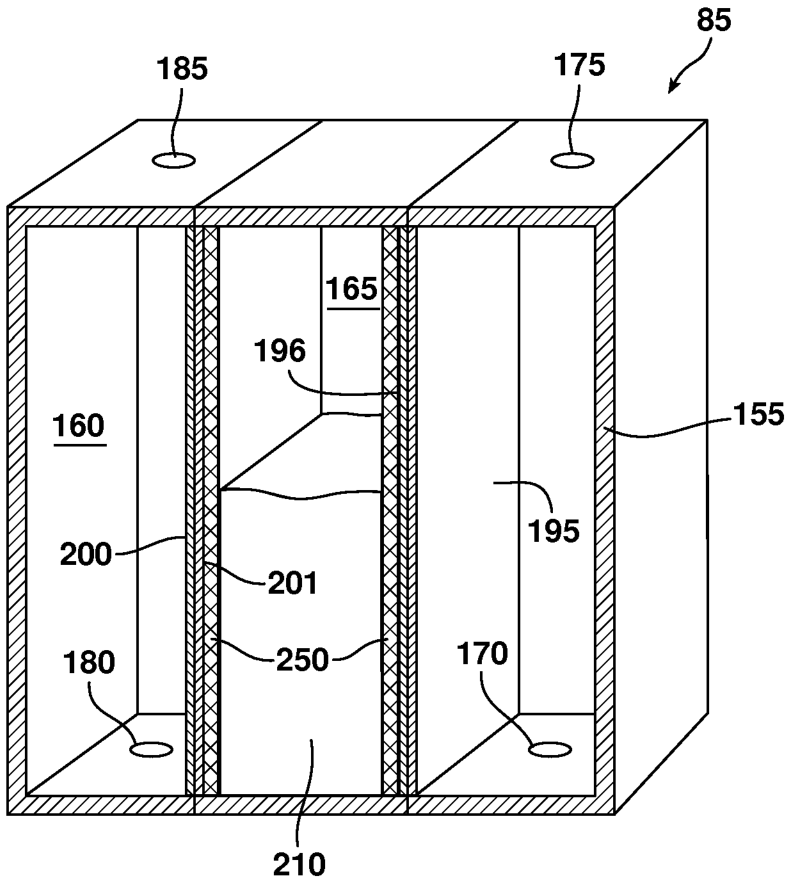

85
185
175
165
196
160
155
195
200
201
250
180
170
210

FIG. 9

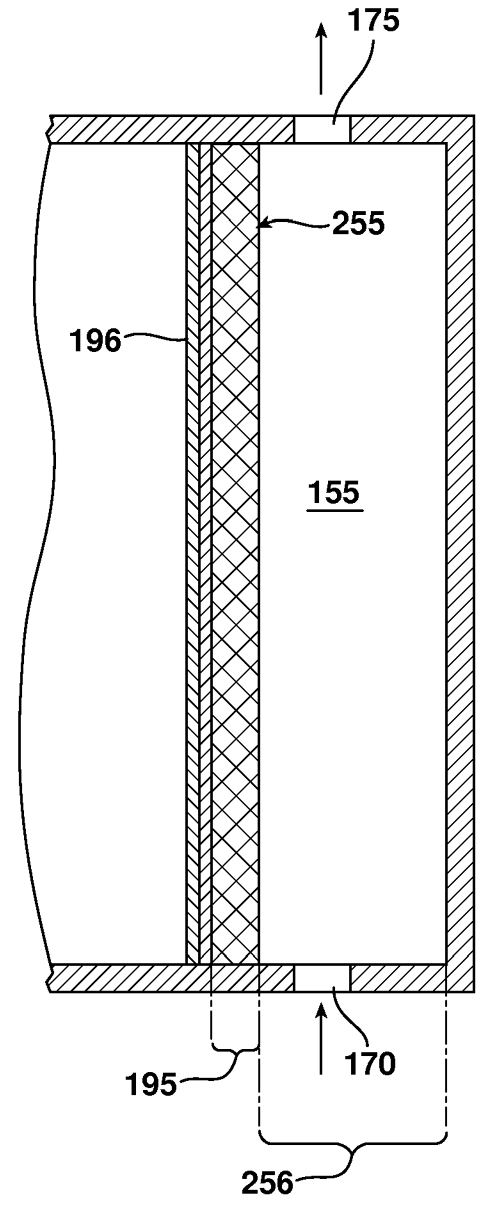


FIG. 10a

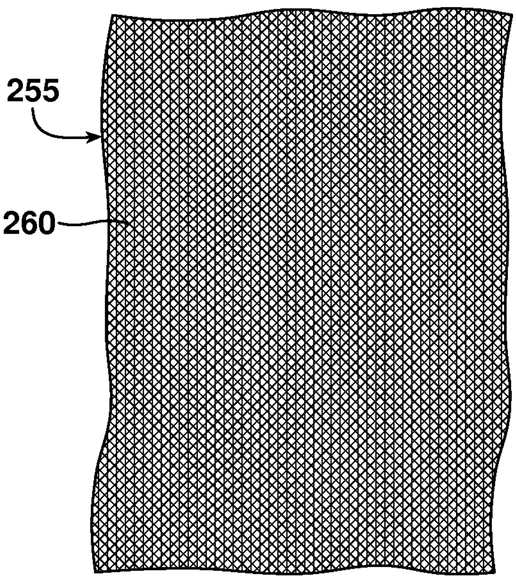


FIG. 10b

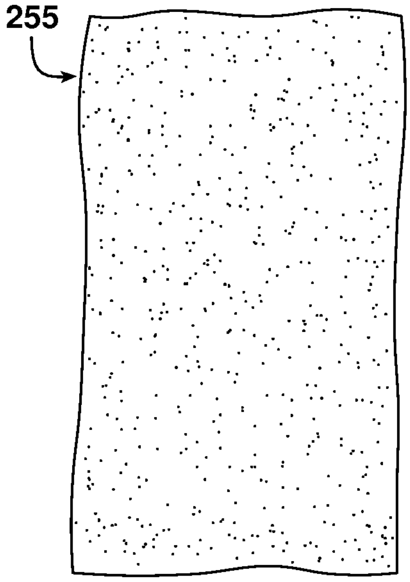


FIG. 10c

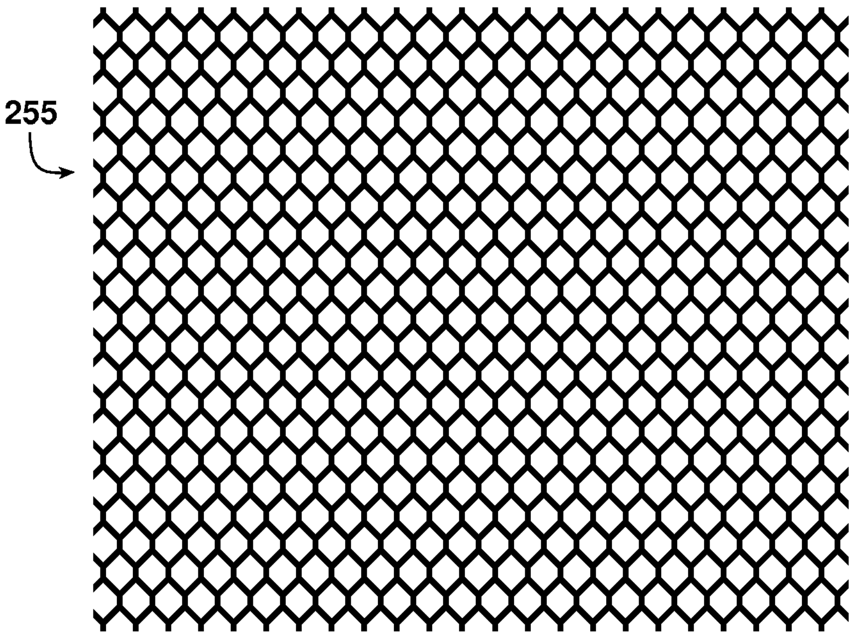
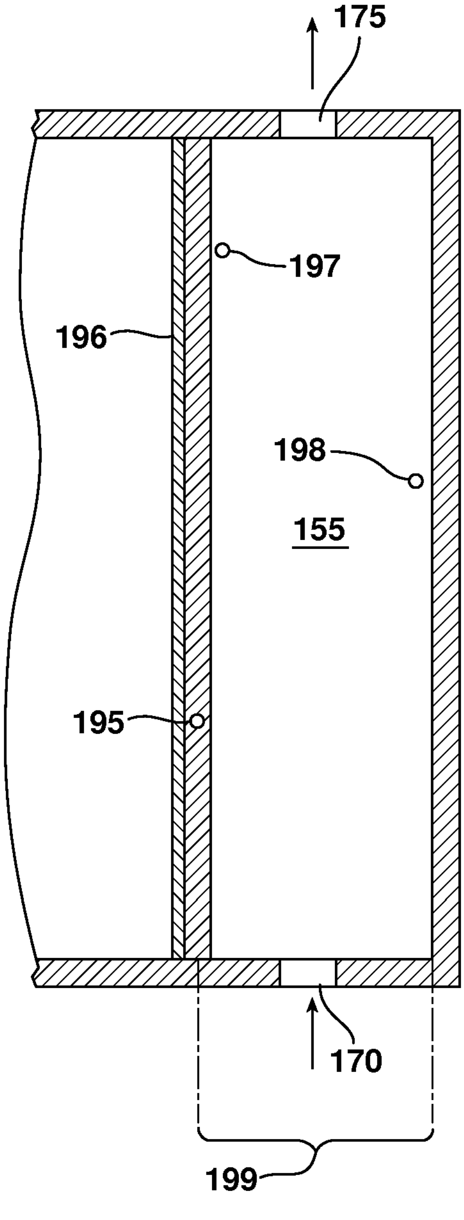


FIG. 11



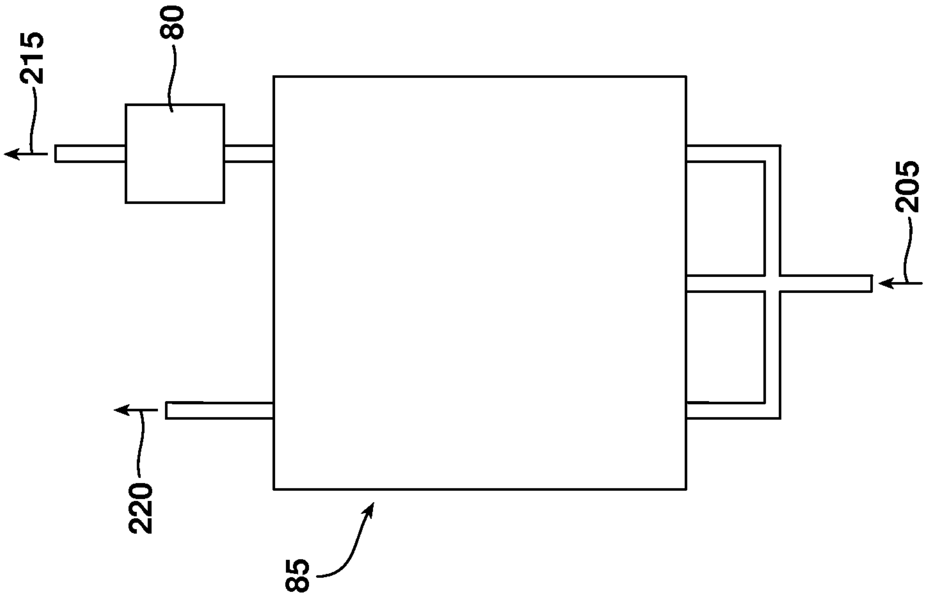


FIG. 12b

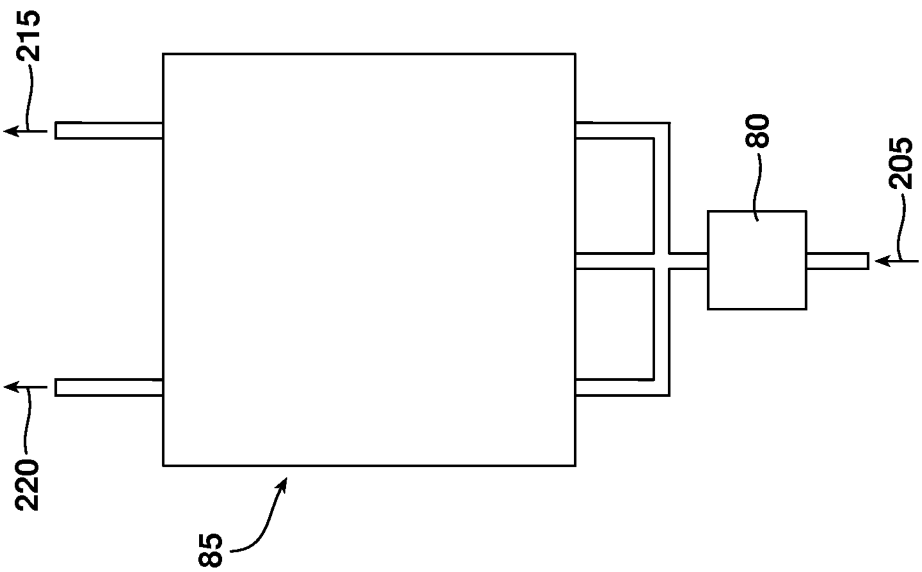


FIG. 12a

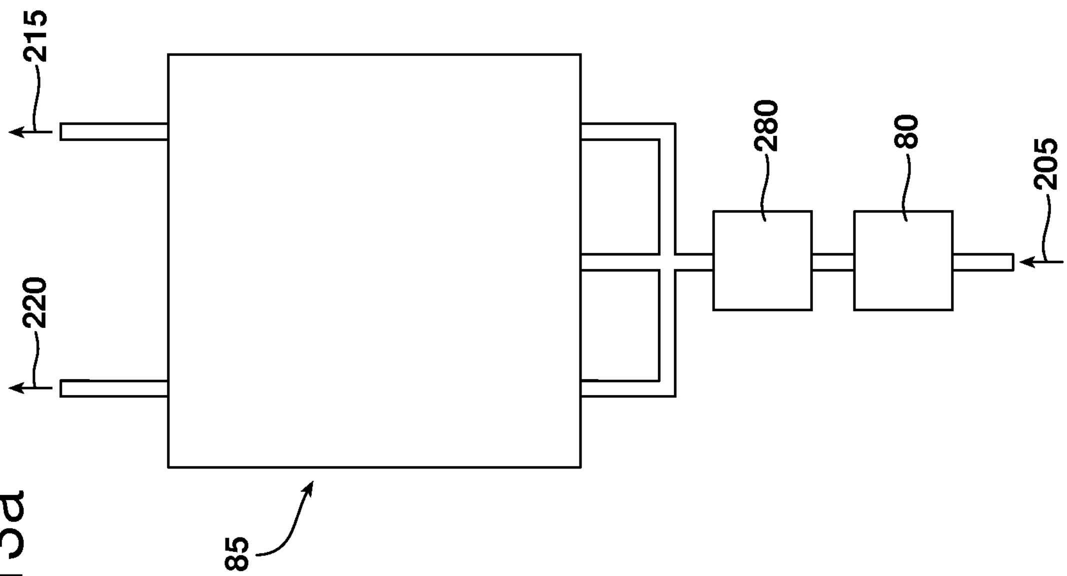


FIG. 13a

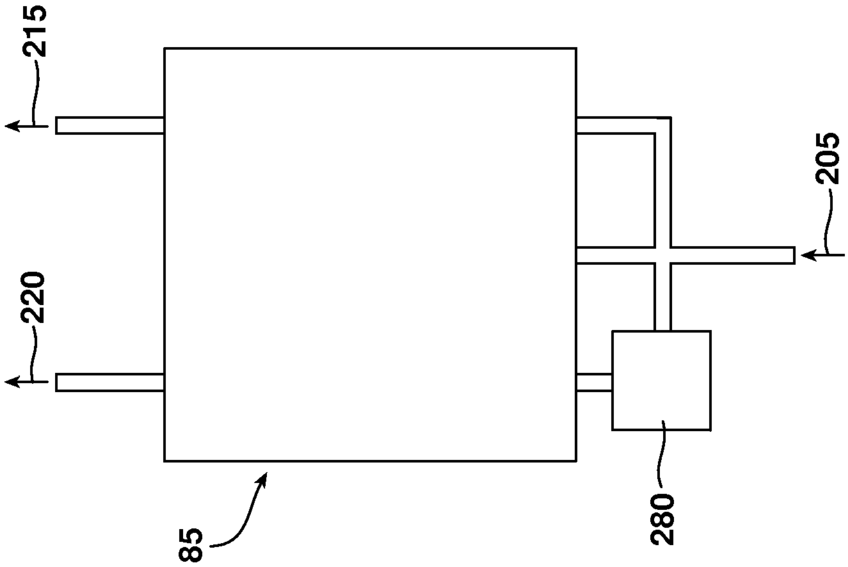
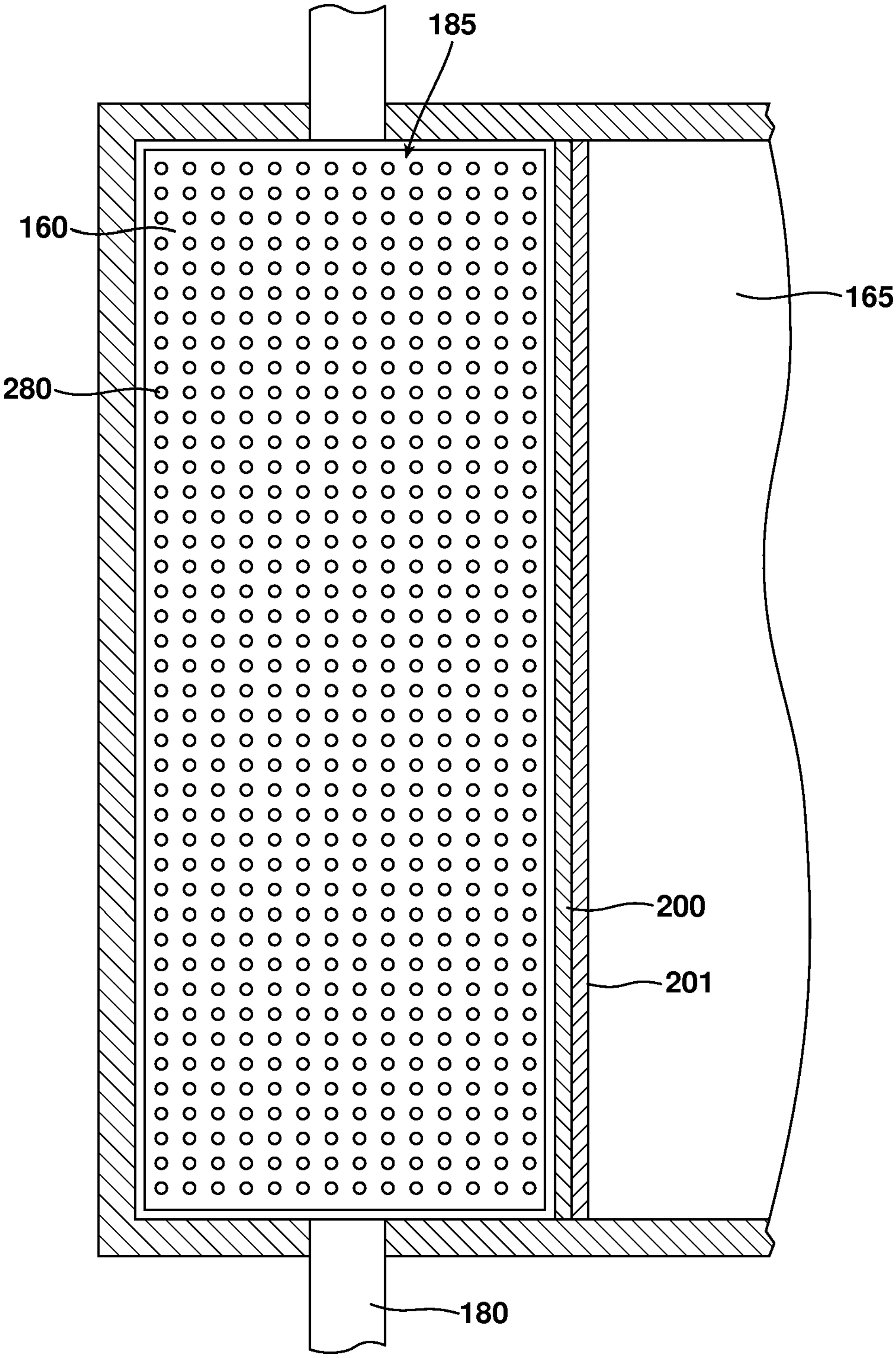


FIG. 13b

FIG. 13c



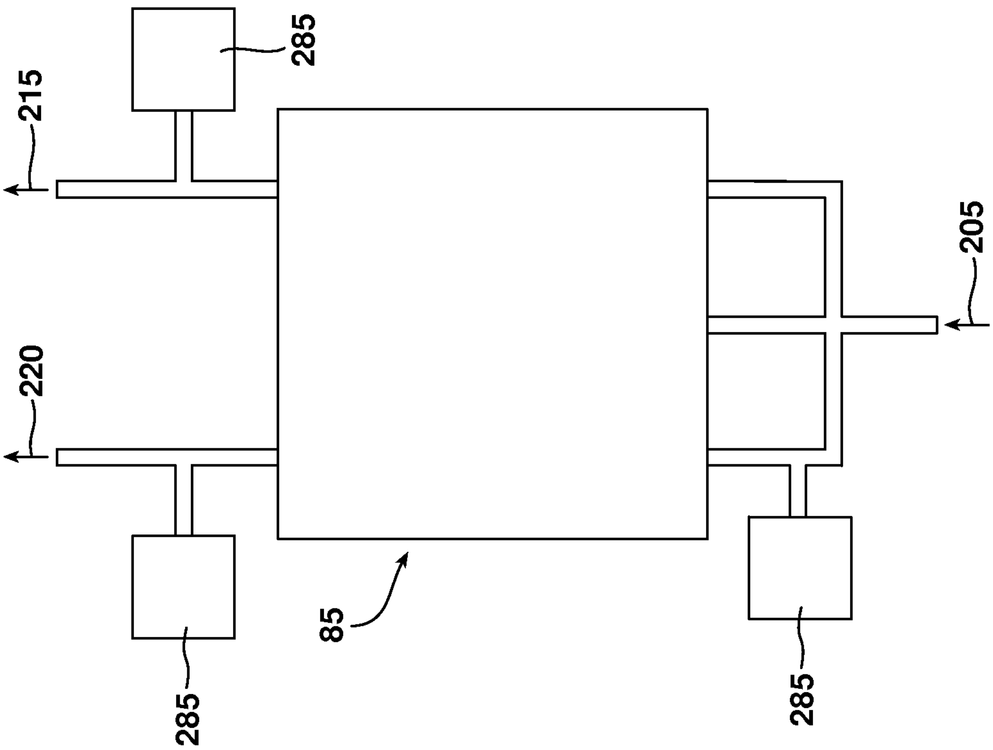


FIG. 14b

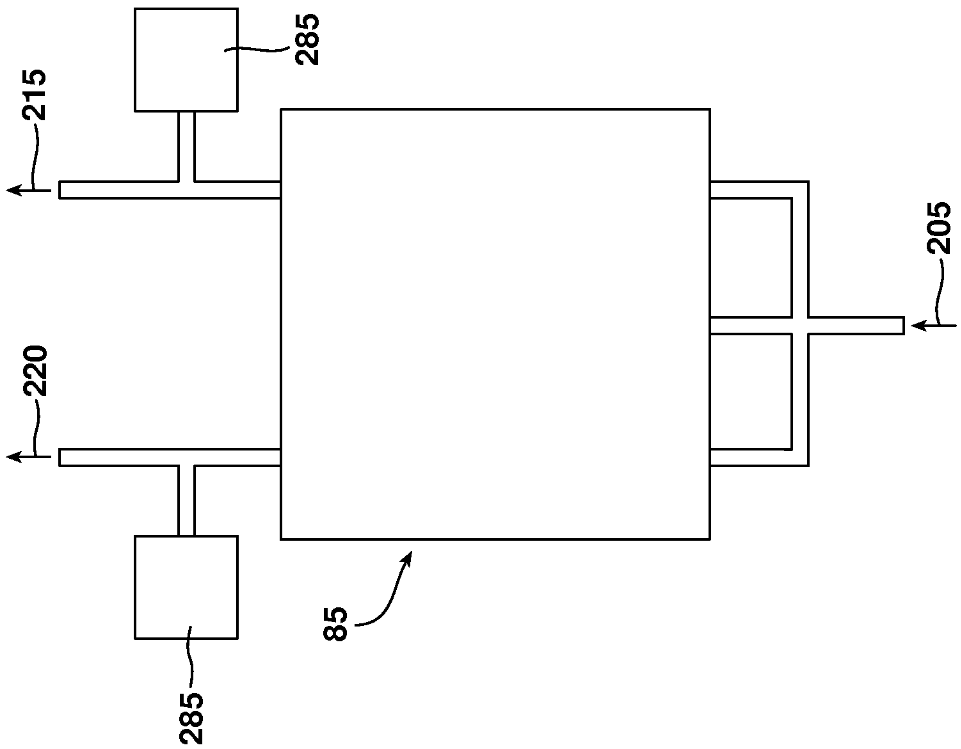


FIG. 14a

FIG. 15b

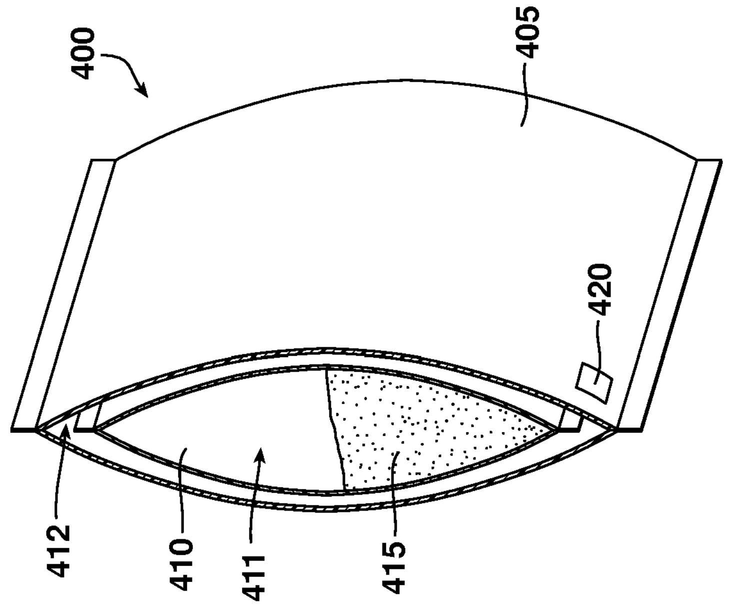
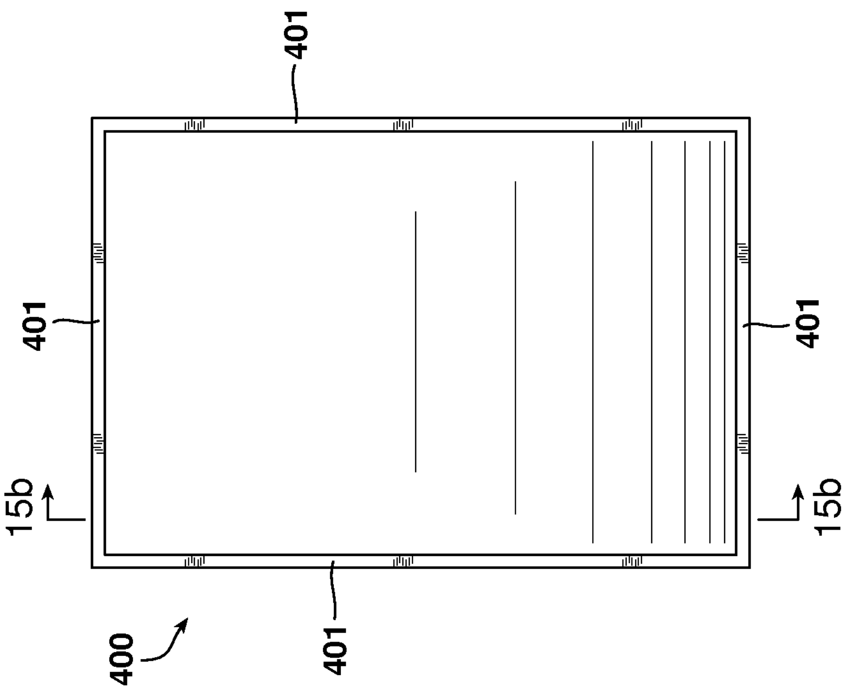


FIG. 15a



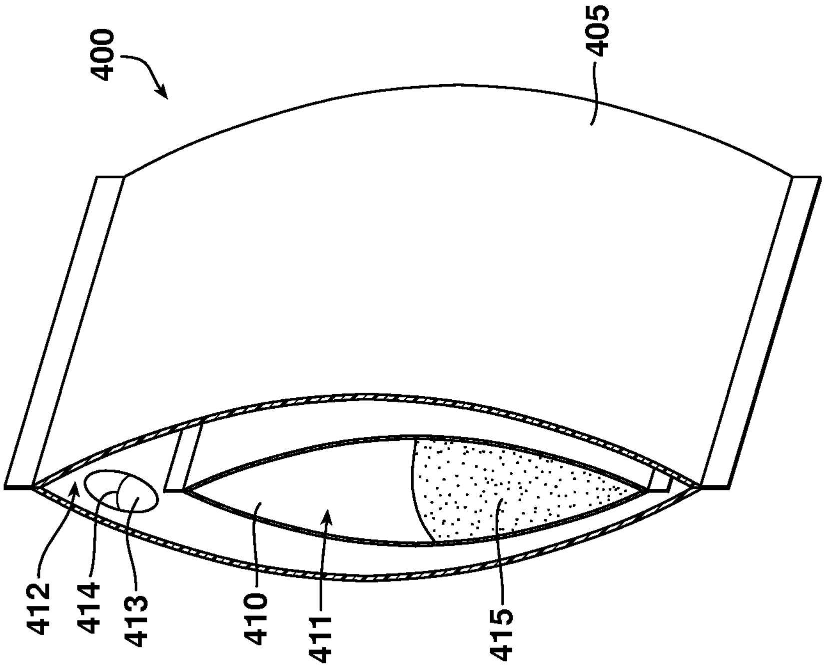


FIG. 15d

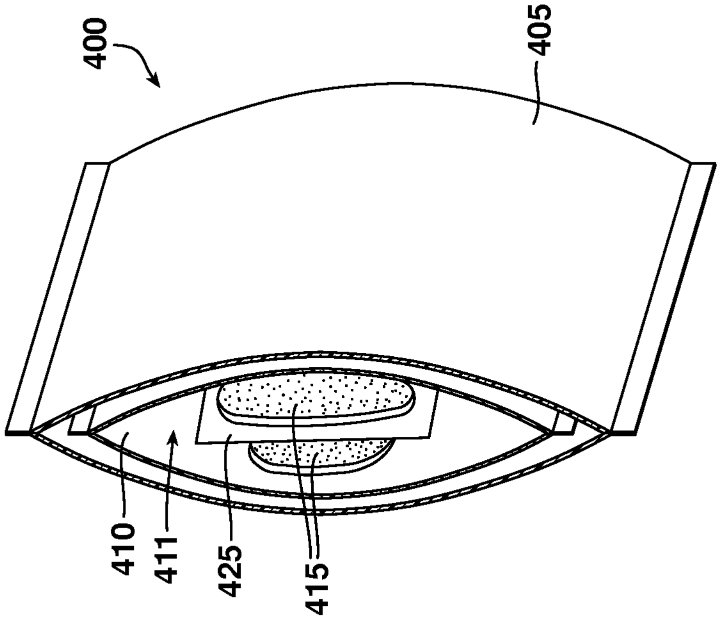


FIG. 15c

FIG. 16a

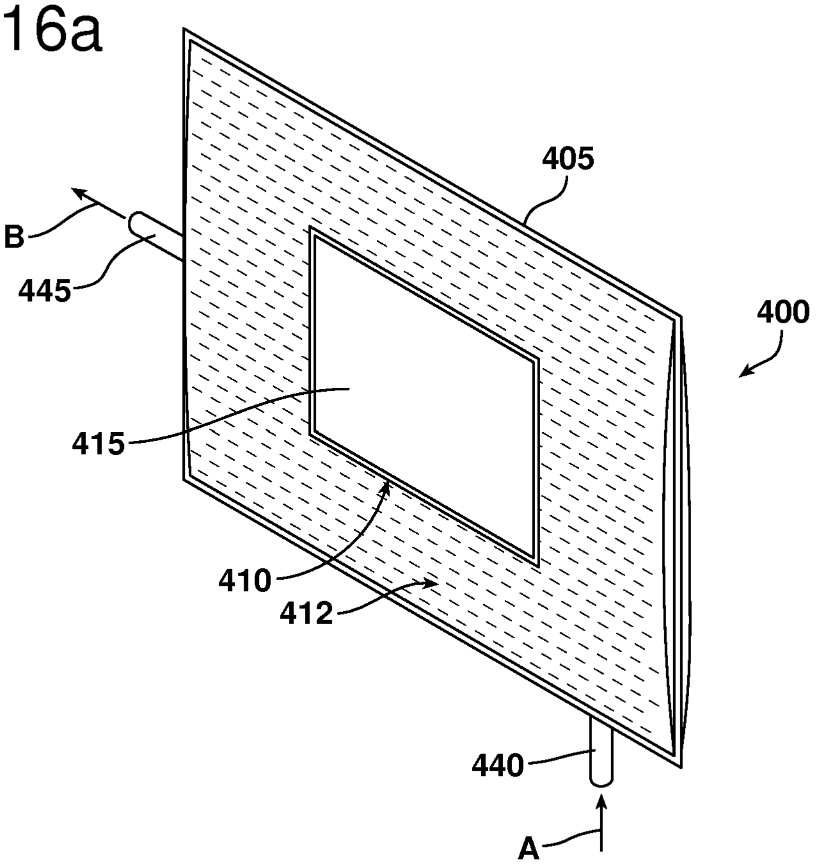


FIG. 16b

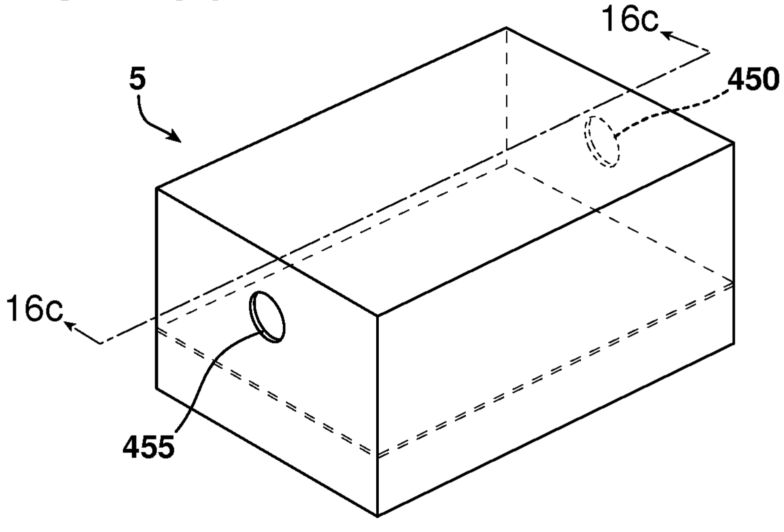


FIG. 16c

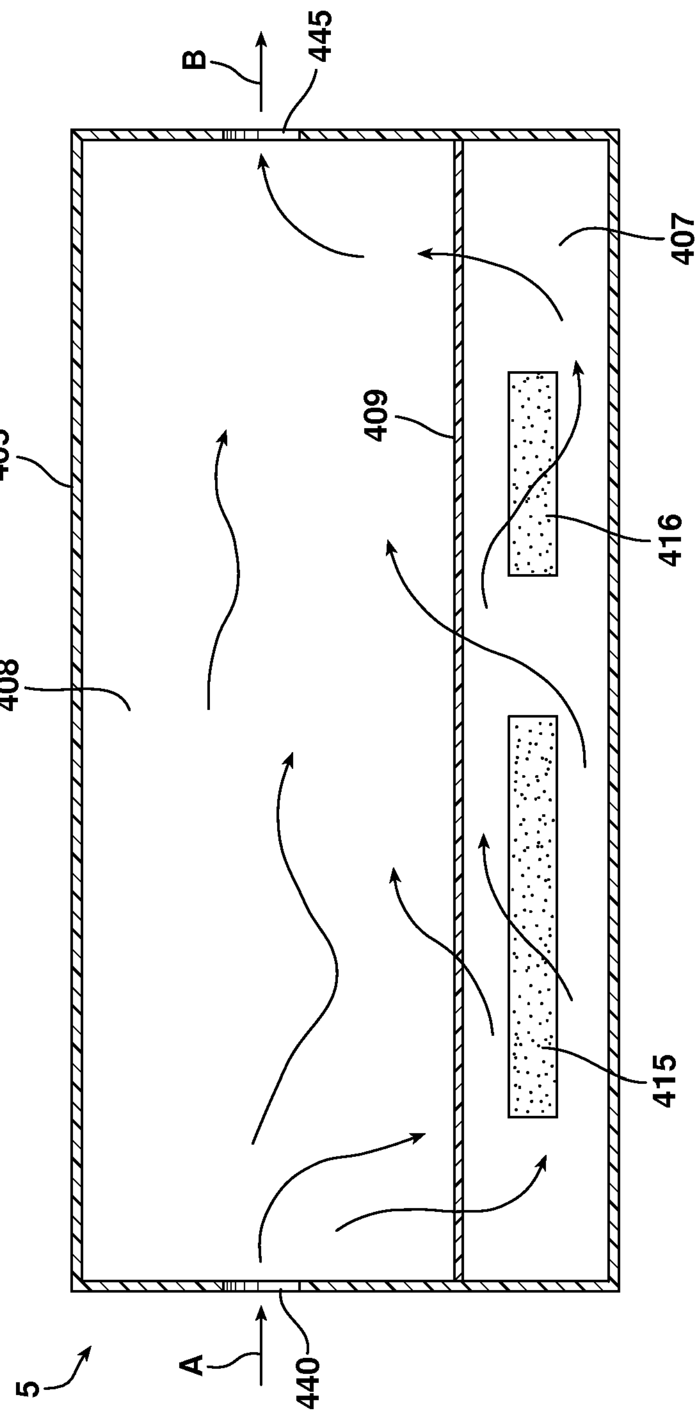


FIG. 17a

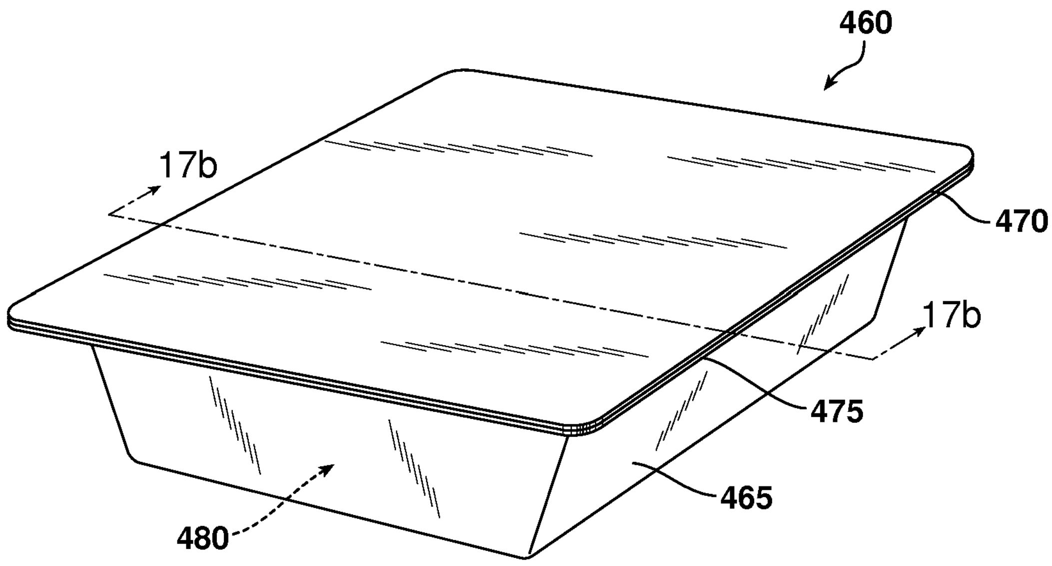


FIG. 17b

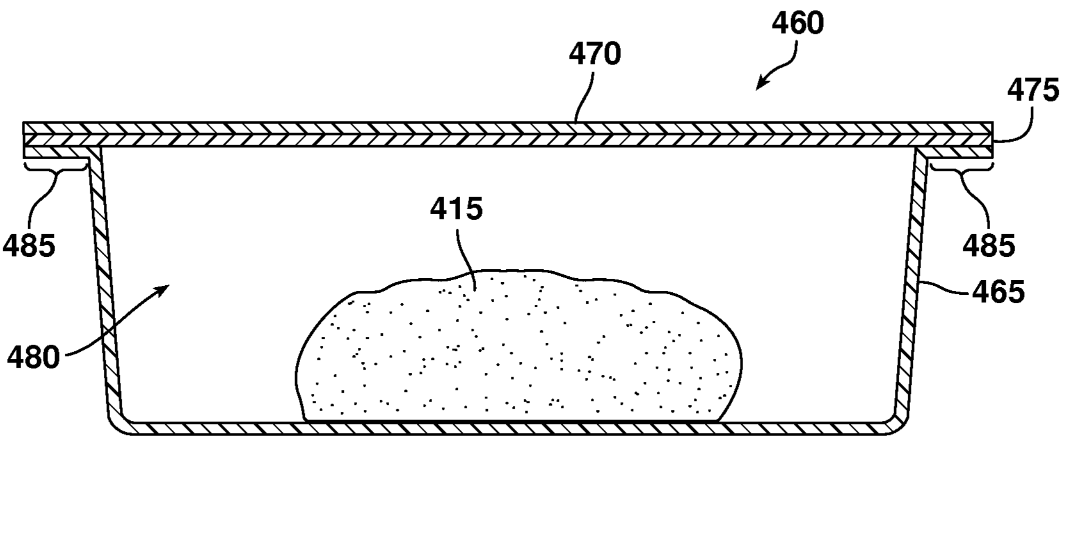


FIG. 17c

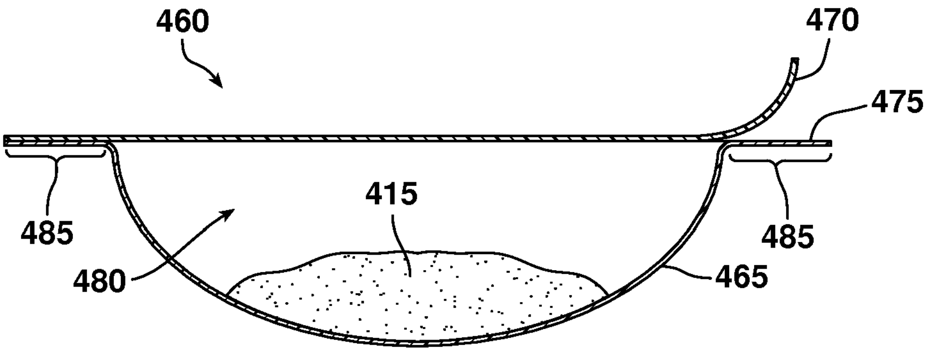


FIG. 17d

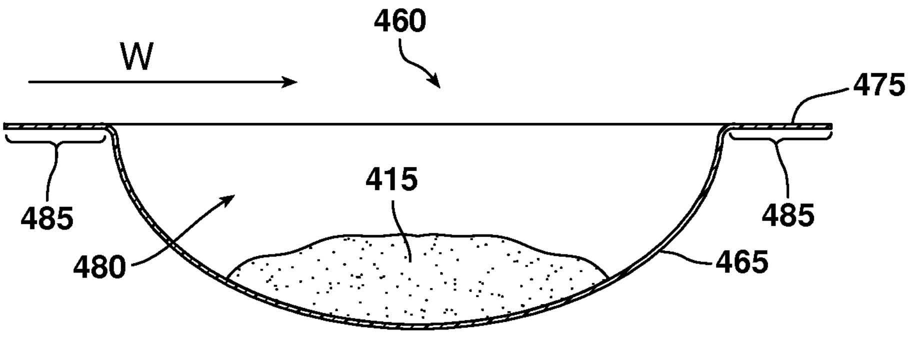


FIG. 18a

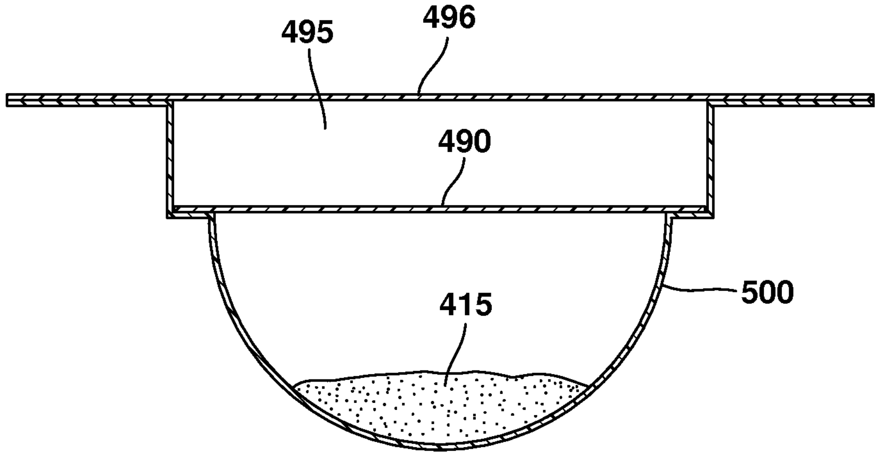


FIG. 18b

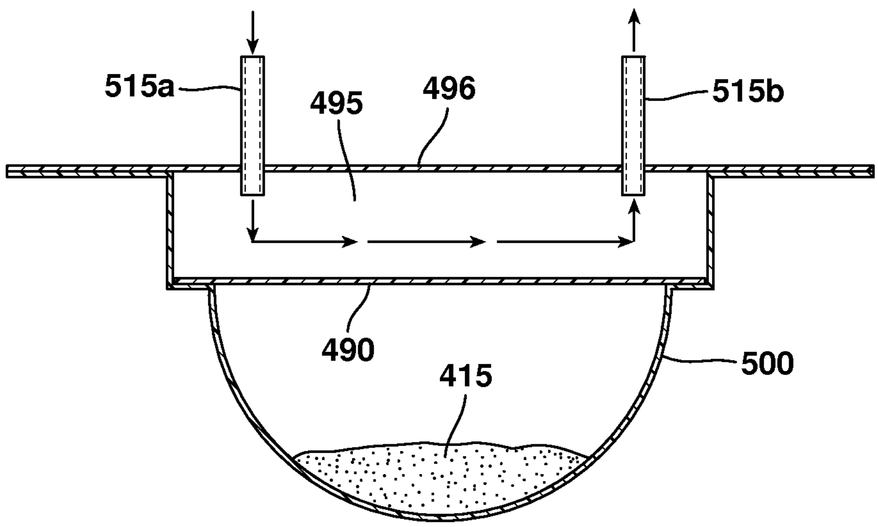


FIG. 19a

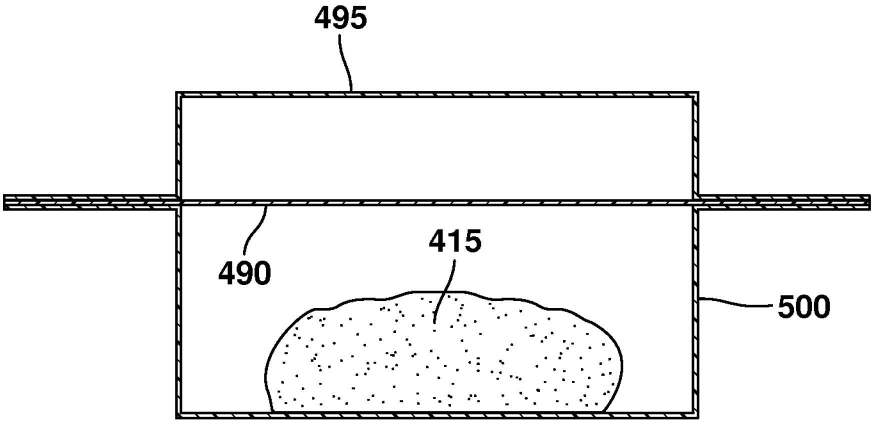


FIG. 19b

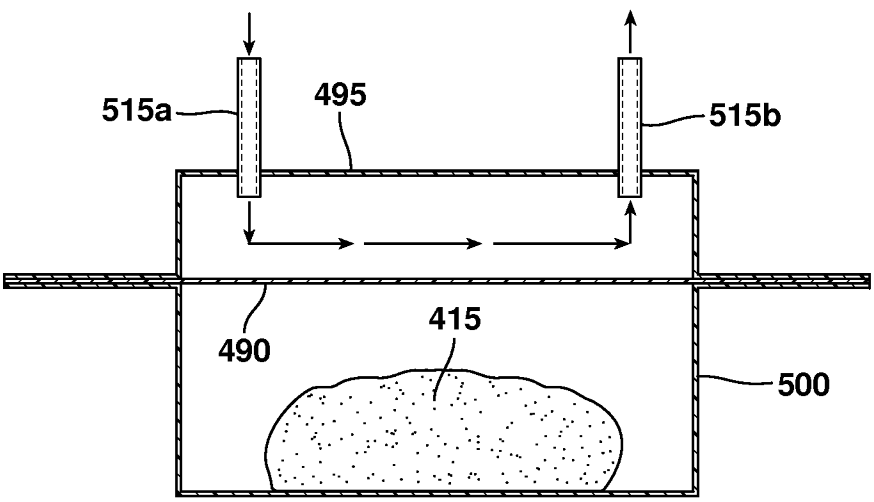


FIG. 20

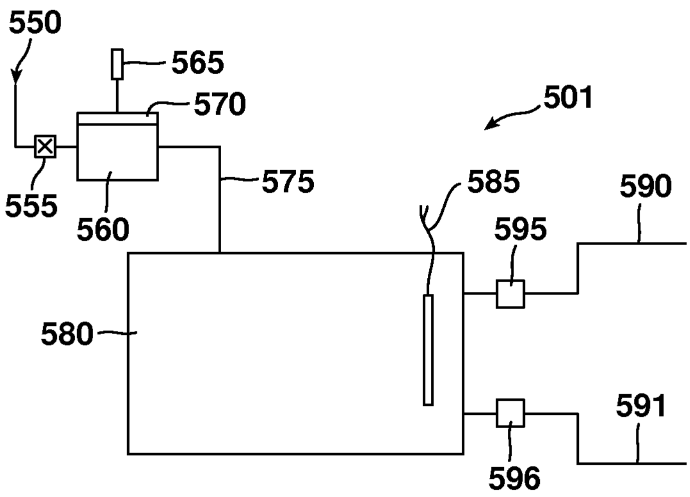


FIG. 21

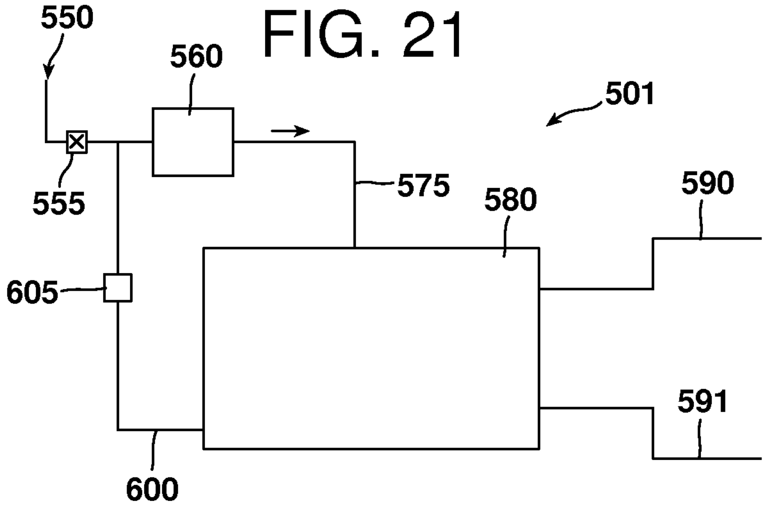


FIG. 22

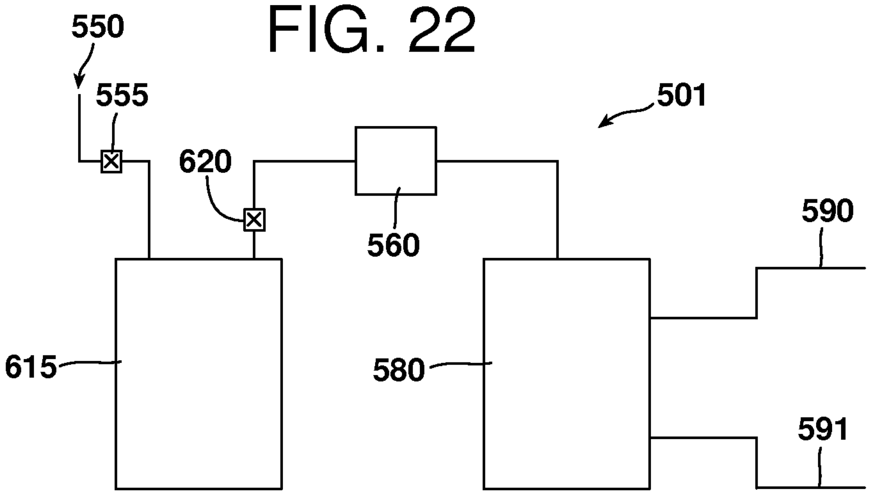


FIG. 23

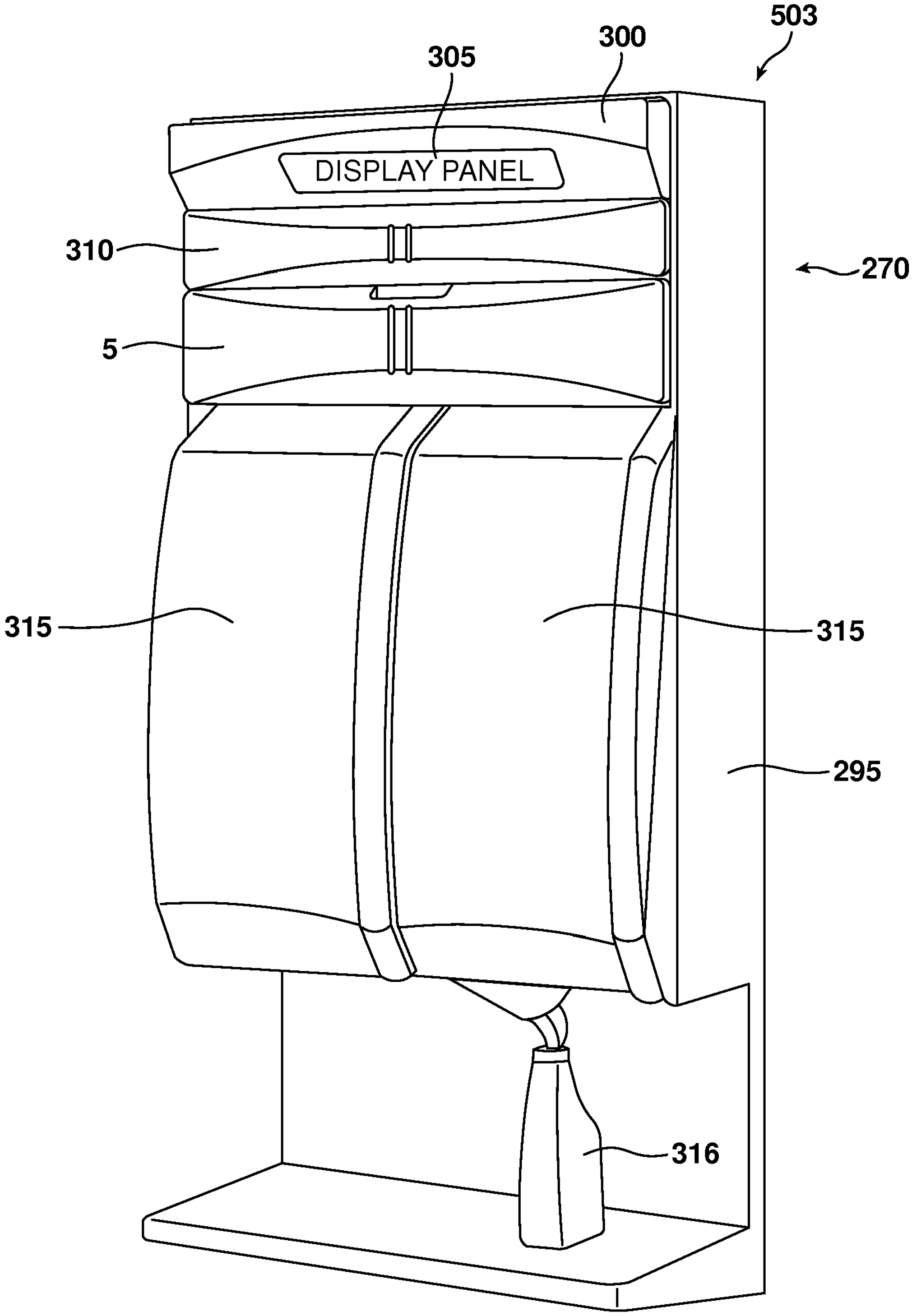


FIG. 24a

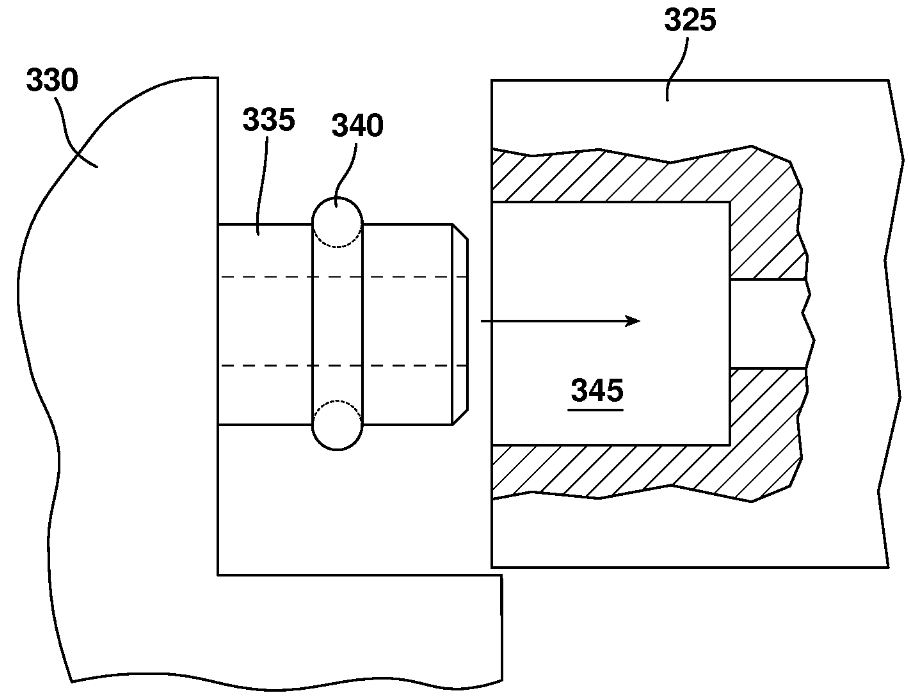


FIG. 24b