Abstract: An apparatus comprises a reservoir, and first and second electrodes. Each electrode may comprise a generally curved section. The curved section of the first electrode is positioned below the curved section of the second electrode. The electrodes may define a gap comprising an input and outlet openings. The input opening may be immersed into liquid in the reservoir. An upper part of the curved section of the second electrode may define at least one aperture configured to allow a gas to enter into the gap. The apparatus may be configured to form an electrical field and allow a predetermined portion of the liquid in the gap to flow out of the outlet opening.
ELECTRO-HYDRODYNAMIC DOSING

CROSS REFERENCE TO RELATED APPLICATIONS

[01] This application claims priority to U.S. Provisional Application No. 61/695,156, filed August 30, 2012, entitled "Electro-Hydrodynamic Dosing," the entire disclosure of which is hereby incorporated by reference in its entirety and for all purposes.

FIELD OF THE INVENTION

[02] This disclosure relates generally to dosing device for a liquid, in particular for the dosing of highly concentrated liquid micro components, such as flavors and acidulants.

BACKGROUND

[03] Various beverage dispensers, such as those at cafeterias, restaurants, theatres, and other entertainment and/or food service venues, typically have either a "drop in" dispenser apparatus or a counter top type dispenser apparatus. In a drop in dispenser apparatus, the dispenser apparatus is self-contained and may be dropped into an opening of a counter top. In a counter top type dispenser apparatus, the dispenser apparatus is placed on a counter top. In conventional beverage dispensers, a dispensing head is coupled to a particular drink syrup supply source via a single pipe dedicated to supply the particular drink syrup to that dispensing head, wherein the particular drink syrup supply source is typically located near the counter top, i.e., directly under the counter top, or directly over the counter top.

[04] A user will typically place a cup under the signage of the selected beverage and either press a button or press the cup against a dispensing lever to activate the dispenser so that the selected beverage is delivered from the dispensing head corresponding to the selected beverage and into the cup until pressure is withdrawn from the button or lever.
Conventional dispensing machines may dispense a number of beverages. Each of dispensed beverages may consist of a number of components, such as flavors, acidulants, sweeteners, and diluents (e.g., water). In conventional dispensing machines, the required components of a beverage are dispensed via a common dispensing nozzle and each component is typically delivered to the dispensing nozzle via a separate delivery pipe. As the variety of the dispensed beverages increases, correspondingly the number of various beverage components also increases. As a result, it becomes problematic to fit and lay out all the required delivery pipes within a dispensing machine as well as to connect all of them to the dispensing nozzle. In addition, the design of the dispensing nozzle becomes more complicated.

Conventional beverage dispensers are typically limited to dispensing drinks having flavoring supply sources located at their respective counters. Thus, a limited number of drinks are typically available at a conventional beverage dispenser. For example, drinks typically available at a conventional beverage dispenser are a regular cola beverage, a diet cola beverage, perhaps one or several non-cola carbonated beverages, such as a lemon-lime flavored carbonated beverage or some other fruit-flavored drink (e.g., orange flavored carbonated beverage, and/or root beer), and perhaps one more non-carbonated beverage(s), such as a tea and/or a lemonade.

Conventional dispensers are not typically configured to permit a user generate or receive from a single dispensing head a custom-ordered beverage that a consumer may wish to purchase, e.g., a cola flavored with cherry, vanilla, lemon, or lime, etc., or a tea flavored with lemon, orange, peach, raspberry, etc., or a tea having one or more teaspoons of sweetener (sugar, or some other nutritive sweetener or non-nutritive sweetener).

Conventional dispensers typically require servicing and resupply of flavoring sources at the counter.

Conventional dispensers typically require a dedicated dispensing head for each particular beverage.
To increase efficiency of beverage dispensing, more concentrated components may be desirable. A reconstruction ratio for a beverage composition may become as high as 1000:1 and higher (i.e., beverage component to a diluent). For such a high concentration the dose of the component(s) typically amount to a fraction of a milliliter with the required accuracy of several percent, i.e., several micro-liters.

Conventional technologies for macro-dosing are typically based on mechanical metering pumps or on a combination of a flow control system with a valve that opens the flow for a required period of time. Using such technologies in order to provide required accuracy may present a challenge due to the fundamental limitation of accuracy of a mechanical system.

Electro-hydrodynamic effect has been disclosed for micro-pumps to provide dosing of liquid in the micro-liter range. The productivity if such micro-pumps, however, is too low for a targeted dose size of about a fraction of a milliliter with the required accuracy of several percent, i.e., several micro-liters.

What is needed is a new dosing device that would meet the micro-dosing requirements specific for certain applications, including but not limited to beverage dispensing, and at the same time would be simple, responsive, and robust.

What is needed is a new beverage dispensing system that does not have the limitations and disadvantages of conventional beverage dispensers and methods.

SUMMARY

In an aspect of the disclosure, an apparatus comprises a reservoir, wherein the reservoir comprises the liquid. The apparatus further comprises a first electrode and a second electrode. Each electrode comprises a generally curved section. The generally curved section of the first electrode is positioned below the generally curved section of the second electrode. The electrodes define a gap. The gap comprises an input opening and an outlet opening. The input opening is immersed into liquid in the reservoir. An upper part of the generally curved section of the second electrode defines at least one aperture.
The at least one aperture is configured to allow a gas to enter into the gap. The apparatus is configured to apply a voltage from a voltage source and form an electrical field. The electrical field is configured to move a liquid edge of the liquid in the gap away from the input opening and towards the outlet opening. The apparatus is configured to allow a predetermined portion of the liquid that is positioned between the aperture defined by the upper part of the generally curved section of the second electrode and the outlet opening to flow out of the outlet opening.

[16] The above and other aspects, features and advantages of the present disclosure will be apparent from the following detailed description of the illustrated embodiments thereof which are to be read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[17] FIG. 1 illustrates a perspective view of an embodiment of a dosing device in accordance with various aspects of the disclosure.

[18] FIG. 2 illustrates a perspective view of an embodiment of a dosing device in accordance with various aspects of the disclosure.

[19] FIG. 3 illustrates a perspective view of an embodiment of a dosing device in accordance with various aspects of the disclosure.

[20] FIG. 4 illustrates an embodiment in accordance with various aspects of the disclosure.

[21] FIG. 5 illustrates a flow diagram of a method in accordance with various aspects of the disclosure.

[22] FIG. 6 illustrates a dosing control unit in accordance with various aspects of the disclosure.
DETAILED DESCRIPTION

[23] The embodiments discussed below may be used to form a wide variety of beverages, including but not limited to cold and hot beverages, and including but not limited to beverages known under any PepsiCo branded name, such as Pepsi-Cola®.

[24] Those of ordinary skill in the art will recognize that a transfer unit and/or portions thereof that feed a dispenser with a free flowing product may be located remotely from a counter, such as in a back room, or at the counter, such as below or over the counter.

[25] In an aspect of the disclosure an apparatus comprises a reservoir, wherein the reservoir comprises the liquid. The apparatus further comprises a first electrode and a second electrode. Each electrode comprises a generally curved section. The generally curved section of the first electrode is positioned below the generally curved section of the second electrode. The electrodes define a gap. The gap comprises an input opening and an outlet opening. The input opening is immersed into liquid in the reservoir. An upper part of the generally curved section of the second electrode defines at least one aperture. The at least one aperture is configured to allow a gas to enter into the gap. The apparatus is configured to apply a voltage from a voltage source and form an electrical field. The electrical field is configured to move a liquid edge of the liquid in the gap away from the input opening and towards the outlet opening. The apparatus is configured to allow a predetermined portion of the liquid that is positioned between the aperture defined by the upper part of the generally curved section of the second electrode and the outlet opening to flow out of the outlet opening.

[26] In an aspect of the disclosure the electrical field may be a non-homogenous electrical field. In an aspect of the disclosure the aperture may be gas permeable and impervious to liquid flow. In an aspect of the disclosure the aperture may be configured to allow a gas to enter into the gap through the aperture defined by the upper part of the generally curved section of the second electrode and replace liquid flowing out of the outlet opening. In an aspect of the disclosure the liquid may comprise a dielectric liquid.
In an aspect of the disclosure the gap may have an apex at a lower surface of the second electrode, and the aperture extends from an upper surface of the second electrode to the apex of the gap. In an aspect of the disclosure the aperture may comprise at least two apertures. In an aspect of the disclosure the liquid comprises an electro-conductive liquid.

In an aspect of the disclosure the apparatus may further comprise a layer of electrical insulating material on a portion of each surface of each electrode defining the gap. In an aspect of the disclosure the electrical insulating material may be configured to reduce electrical current in the liquid between the electrodes. In an aspect of the disclosure the electrical insulating material may be configured to substantially maintain the strength of the electrical field in the gap when voltage is applied to the electrodes.

In an aspect of the disclosure the apparatus may be configured to allow a predetermined portion of the liquid that is positioned between the aperture defined by the upper part of the generally curved section of the second electrode and the outlet opening to flow away from the inlet opening and out of the outlet opening by reducing the voltage from being applied. In an aspect of the disclosure reducing the voltage may comprise stopping the voltage from being applied. In an aspect of the disclosure the apparatus may be configured to allow a predetermined portion of the liquid that is positioned between the aperture defined by the upper part of the generally curved section of the second electrode and the outlet opening to flow away from the inlet opening and out of the outlet opening by sending a compressed gas into the gap through the aperture. In an aspect of the disclosure the apparatus may further comprise a compressed gas source for the compressed gas.

In an aspect of the disclosure the reservoir may comprise a first reservoir, the first reservoir comprising the liquid, and a second reservoir. The second reservoir may comprise an upper part and a lower part. The lower part of the second reservoir may be configured to receive a portion the liquid from the first reservoir through a channel until liquid in the first reservoir is lowered to a first level in the first reservoir and negative
pressure is formed in an upper part of the first reservoir above the liquid in the first reservoir. The input opening of the gap may be configured to be immersed into liquid in the second reservoir.

[31] In an aspect of the disclosure the apparatus may be configured to convey gas from the upper part of the second reservoir to the first reservoir through the channel. In an aspect of the disclosure the apparatus may be configured so that when liquid flows out of the outlet opening, a first liquid level of the second reservoir is lowered and gas moves through the channel from the second reservoir to the first reservoir. Further, negative pressure in the first reservoir may be released, and liquid from the first reservoir is allowed to move through the channel to the second reservoir until the liquid level in the second reservoir is restored to its first liquid level prior to liquid flowing out of the outlet opening.

[32] In an aspect of the disclosure a method is provided, the method comprising conveying a liquid from a reservoir through a gap defined by a first electrode and a second electrode, each electrode comprising a generally curved section. The generally curved section of the first electrode may be positioned below the generally curved section of the second electrode. The gap may comprise an input opening and an outlet opening, the input opening at a first end of the electrodes, and the outlet opening at a second end of the electrodes, the input opening configured to be immersed into liquid in the reservoir. The method may comprise providing access of a gas to enter into the gap through at least one aperture, the at least one aperture defined by an upper part of the generally curved section of the second electrode. The method may comprise applying a voltage and forming an electrical field, the electrical field configured to move a liquid edge of the liquid in the gap away from the input opening and towards the outlet opening. The method may comprise allowing a predetermined portion of the liquid that is positioned between the aperture defined by the upper part of the generally curved section of the second electrode and the outlet opening to flow out of the outlet opening.
In an aspect of the disclosure the method step of allowing may comprise reducing the voltage being applied. In an aspect of the disclosure the reducing the voltage being applied may comprise stopping the voltage. In an aspect of the disclosure the step of allowing may comprise sending a compressed gas through the aperture and into the gap.

In an aspect of the disclosure the method may further comprise receiving a request for a free flowing food product. In an aspect of the disclosure the step of allowing of the predetermined amount of liquid to flow out from the outlet opening corresponds to the request for the free flowing food. In an aspect of the disclosure the method may further comprise determining the amount of liquid to dose from the outlet opening based on the request for the free flowing food product.

In an aspect of the disclosure the method may further comprise combining the liquid that has flowed out from the outlet opening with a diluent to form a free flowing food product. In an aspect of the disclosure the method may further comprise monitoring a liquid level of the reservoir. In an aspect of the disclosure the method may further comprise reducing the voltage being applied when the liquid level of the reservoir reaches a level that corresponds to the predetermined portion of the liquid to be dosed from the outlet opening. In an aspect of the disclosure the method may further comprise sending a compressed gas into the gap through the aperture when the liquid level of the reservoir reaches a level that corresponds to the predetermined portion of the liquid to be dosed from the outlet opening.

In an aspect of the disclosure the method may further comprise automatically adding of liquid to the reservoir when the liquid level of the reservoir reaches a minimum lower threshold. In an aspect of the disclosure the method may further comprise activating an alert signal when the liquid level of the reservoir reaches a maximum lower threshold. In an aspect of the disclosure the method may further comprise stopping the automatically adding of liquid to the reservoir when the liquid level of the reservoir reaches a minimum upper threshold. In an aspect of the disclosure the method may further comprise...
activating an alert signal when the liquid level of the reservoir reaches a maximum upper threshold.

[37] In an aspect of the disclosure, an apparatus or dosing device 100 is provided, the apparatus 100 comprising a reservoir 101. The reservoir 101 may comprise a liquid 102 to be dosed, and two electrodes 103 and 104. Liquid 102 may comprise a component of a free flowing product, e.g., a free flowing food product, such as a beverage. Liquid 102 may comprise a dielectric liquid. Liquid 102 may comprise an electro-conductive liquid, e.g., an acid solution. Liquid 102 may comprise a micro component wherein the ratio by weight of the micro component to a diluent is about 1000: 1.

[38] Apparatus 100 may comprise dosing control unit 1203. Dosing control unit 1203 may comprise controller 1202. Controller 1202 may be operatively connected to voltage source 127 via two-way communications as shown in FIG. 1. Controller 1202 may further be operatively connected to valve 128 via two-way communications as shown in FIG. 1. Those of skill in the art will recognize that in accordance with the disclosure a controller, such as controller 1202, may control operation of devices. Thus, controller 1202 may control operation of device(s) in FIG. 1 to control the voltage applied to electrodes, and thus control dosing by apparatus 100, as well as control addition of liquid 102 to reservoir 101 to replenish reservoir 101 with liquid 102.

[39] Electrode 103 may comprise a generally curved section 122. Electrode 104 may comprise a generally curved section 123. Generally curved sections 122 and 123 may each compromise a generally semi-cylindrical shape. Generally curved sections 122 and 123 may be in spoon-like arrangement, e.g., as shown in FIG. 1. Section 122 of electrode 103 may comprise a first concave surface 107 and a second concave surface 108. Section 123 of electrode 104 may comprise a first concave surface 109 and a second concave surface 110. The second concave surface 108 of electrode 103 may face the first concave surface 109 of the second electrode 104. The second concave surface 108 of the first electrode 103 may have a radius 111. The first concave surface 109 of the second
electrode 104 may have a radius 112. As shown in FIG. 1, radius 112 may be larger than radius 111.

[40] Electrodes 103 and 104 may be insulated from each other, for example with an insulating layer(s) (not shown in FIG. 1). A gap 105 may be defined between the electrodes 103 and 104. A first end 114 of the first electrode 103 and a first end 115 of the second electrode 104 may be immersed into the liquid 102 in reservoir 101. As shown in FIG. 1, a second end 116 of the first electrode 103 and a second end 117 of the second electrode 104 may be positioned so that each of ends 116 and 117 is not immersed into the liquid 102. Ends 116 and 117 may define an output conduit 118 for the liquid to be dosed. Output conduit 118 may comprise an output opening 126.

[41] Ends 114 and 115 may define in input conduit 113 for the liquid to be dosed. Input conduit 113 may comprise an input opening 125. An upper part 119 of the second electrode 104 may define at least one aperture 106. Aperture(s) 106 may be configured to allow a gas, e.g., air, to pass through aperture(s) 106. Thus, aperture(s) 106 may be a gas permeable aperture. Aperture(s) 106 may be configured to be impervious to liquid flow through aperture(s) 106.

[42] The electrodes may have an initial state that is electrically neutral. When the electrodes are in electrically neutral state, liquid 102 may enter input conduit 113 and reach a level of liquid in the gap 105 that may be determined and/or be controlled by the level 124 of the liquid 102 in the reservoir 101. By controlling the level 124 of liquid 102 in reservoir 101, the level of liquid 102 in gap 105 may also be controlled. Level 124 may be monitored by a sensor 129. Those of skill in the art will recognize that in accordance with the disclosure sensor 129 may be any suitable liquid level sensor. In an aspect, pressure sensor 130 may monitor the pressure at location 131 in reservoir 101. The pressure at location 131 may correspond to an amount of liquid 102 in gap 105, including the amount of liquid 102 in gap 105.

[43] Apparatus 100 may be configured to apply a voltage from an electrical power or voltage source 127 to the electrodes 103 and 104, and form an electrical field in gap 105. The
electrical field may be a non-homogenous electrical field. Those of skill in the art will recognize that in accordance with the present disclosure, the voltage applied to the electrodes 103 and 104 may be a voltage that creates an electrical field that may move liquid 102 through gap 105 past an apex 120 of gap 105 and towards output opening 126. Thus, apparatus 100 may be configured to allow the liquid 102 to move along the gap 105 and past an apex 120 of gap 105, and further proceed along the gap 105 towards output opening 126. Apex 120 may be located where the at least one aperture 106 may be is defined by electrode 104. Input conduit 113 and output conduit 118 may meet at apex 120 of gap 105.

At a predetermined position of the liquid edge 121 of liquid 102 in gap 105, the voltage being applied may be reduced, stopped from being applied, or otherwise altered so that the portion of the liquid 102 that is in gap 105 between the at least one aperture 106 and the ends 116 and 117 of electrodes 103 and 104, may flow through output conduit 118 and towards and through output opening 126. Gas, e.g., air, may penetrate through the at least one aperture 106 and into the gap 105, and replace the portion of the liquid leaving output conduit 118 and output opening 126.

Thus, in accordance with aspects of the disclosure, an apparatus is provided, the apparatus comprising a reservoir. The reservoir may comprise a liquid to be dosed, and two semi-cylindrical or curved electrodes in a spoon-like configuration with respect to each other. The electrodes may be insulated from each other. A gap may be defined between curved sections of the electrodes. A first end of each electrode may in combination with the first end of the other electrode form an input conduit, and be immersed into the liquid to be dosed. A second end of each electrode may in combination with the second end of the other electrode form an output conduit for dosed liquid. An upper part of one of the electrodes may define at least one aperture, the at least one aperture configured to be a gas permeable aperture. The electrodes may have an initial state that is electrically neutral. The level of dosed liquid in the gap may be determined by the level of the liquid in the reservoir. The apparatus may be configured to apply a voltage from a voltage source, and form an electrical field, which may be a
non-homogeneous electrical field. The electrical field may be configured to pull liquid through the gap to allow a liquid edge of the liquid to move along the gap and past an apex of the gap, and further proceed along the gap and away from the apex. At a predetermined position of the liquid edge, the applied high voltage may be released or released or stopped from being applied. The portion of the liquid, which may be between the gas permeable aperture and the output opening of the electrodes, may flow out of the electrodes. Gas may penetrate through the gas permeable aperture and into the gap, and replace the leaving liquid.

FIG. 2 illustrates an apparatus or dosing device 200 for dosing of a liquid 202. Liquid 202 may be similar to or the same as liquid 102 previously described and shown in FIG. 1. Device 200 may be similar to device 100 shown in FIG. 1, and may be operated in a similar manner for the dosing of a liquid from reservoir 101. Apparatus 200 may comprise voltage source 127, valve 128, dosing control unit 1203 and controller 1202 as previously described with respect to FIG. 1. The above disclosure of controller 1202 with respect to FIG. 1 is incorporated herein by reference with respect to FIG. 2. Controller 1202 may be operatively connected to device(s) in FIG. 2 via two way communications (not shown in FIG. 2) to control operation of device(s). As shown in FIG. 2, the second surface 108 of electrode 103 and the first surface 109 of electrode 104 may each be covered by a thin layer of electrical insulating material 201. Those of skill in the art will recognize that, in accordance with the present disclosure, insulation material 201 may be any suitable insulation material that insignificantly reduces the strength of the electrical field in the gap 105, and which may reduce or eliminate electrical current in the liquid between the electrodes. Those of skill in the art will recognize that, in accordance with the present disclosure, using insulation material 201 as described herein may be particularly useful for dosing of an electro-conductive liquid, e.g., an acid solution(s) from a reservoir.

FIG. 3 illustrates an apparatus or dosing device 300. Apparatus 300 may be configured similar to apparatus 100 shown in FIG. 1, and apparatus 200 shown in FIG. 2. Apparatus 300 may comprise voltage source 127, valve 128, dosing control unit 1203 and controller
1202 as previously described with respect to FIG. 1. The above disclosure of controller 1202 with respect to FIG. 1 is incorporated herein by reference with respect to FIG. 3. Controller 1202 may be operatively connected to device(s) in FIG. 3 via two way communications (not shown in FIG. 3) to control operation of device(s). Apparatus 300 may be configured so that a predetermined portion of liquid 102 may be dosed or purged out of the electrodes by a compressed gas flow 301. Gas flow 301 may be applied through at least one aperture(s) 106, as previously described and shown in FIG. 1 and FIG. 2. Gas flow 301 may be supplied by a gas source(s) 302. Those of skill in the art will recognize that in accordance with the present disclosure, gas source 302 may be any suitable gas source, e.g., a gas compressor or compressed gas tank. The gas may be air. When gas flow 301 is supplied through aperture(s) 106 and into gap 105, the gas flow 301 may physically move the portion of liquid 102 that may be positioned between apex 120 of gap 105 and outlet opening 126 towards outlet opening 126. Thus, use of a compressed gas flow 301 to exert a force greater than the force exerted by an electrical field in gap 105 may allow for the dosing of a predetermined portion or amount of liquid 102 out of the outlet opening 126. Controller 1202 as previously described with respect to FIG. 1, may be configured to control gas flow 301, e.g., controlling operation of gas source 302 or a valve (not shown in FIG. 3) between gas source 302 and aperture(s) 106.

[48] The apparatus or dosing device of the present disclosure may include a cartridge for a liquid that provides constant level and constant hydrostatic pressure of the liquid in a reservoir, such as the reservoirs discussed herein.

[49] FIG. 4 illustrates an apparatus or cartridge design in accordance with aspects of the disclosure. Apparatus 400 may include two reservoirs - a main reservoir 401 and a buffer reservoir 402. Apparatus 400 may comprise voltage source 127, valve 128, dosing control unit 1203 and controller 1202 as previously described with respect to FIG. 1. The above disclosure of controller 1202 with respect to FIG. 1 is incorporated herein by reference with respect to FIG. 4. Controller 1202 may be operatively connected to device(s) in FIG. 4 via two way communications (not shown in FIG. 4) to control operation of device(s). Main reservoir 401 and buffer reservoir 402 may have fluid
communication with each other through a channel 403. The main reservoir 401 may be filled with a liquid 406 in a manner wherein a portion 405 of the main reservoir 401 may be free of the liquid 406 and may contain a gas, e.g., air. The buffer reservoir 402 may have an opening 404 in its upper part 407 so that the buffer reservoir 402 may be connected with the atmosphere through the opening 404 defined by the buffer reservoir 402. The lower part 408 of the buffer reservoir 402 may include a dosing device 409 with electrodes 103 and 104. Dosing device 409 may be similar to or the same as apparatus 100 shown in FIG. 1, apparatus 200 shown in FIG. 2, or apparatus 300 shown in FIG. 3. Thus, dosing device 409 may be operated in a manner similar to or the same as apparatus 100 shown in FIG. 1, apparatus 200 shown in FIG. 2, or apparatus 300 shown in FIG. 3, as described herein. Liquid 406 may be similar to or the same as liquid 102, or liquid 202 as described herein.

Apparatus 400 may be operated as follows. Liquid 406 from the main reservoir 401 may be conveyed to the buffer reservoir 402 through channel 403 until the liquid in the main reservoir 401 lowers to a level 408, and negative gas pressure in main reservoir 401 may be formed in portion 405 of the main reservoir 401. Atmospheric gas or air from the upper part 407 of the buffer reservoir 402 may move to the main reservoir 401 through channel 403 and, in a form of bubbles, reach the portion 405 of the main reservoir 401. This process may take place until the level of the liquid in the buffer reservoir 402 closes channel 403 and stops atmospheric gas flow. Negative pressure in the portion 405 of the main reservoir 401 may stop flow of the liquid from the main reservoir 401 into the buffer reservoir 402 through channel 403. After that, the liquid level in the buffer reservoir 402 may be set to remain constant.

As the liquid is taken by the dosing device 409 with electrodes 103 and 104 from the buffer reservoir 402, the liquid level in the buffer reservoir 402 may decrease. Lowering the liquid level in buffer reservoir 402 may open access of atmospheric gas or air through channel 403 into the main reservoir 401. Thus, gas bubbles may move through channel 403 to the upper part 405 of the main reservoir 401. The negative pressure in portion 405 may be released and the liquid 406 from the main reservoir 401 may move to the buffer
reservoir 402 through the channel 403. The liquid level in the buffer reservoir may thus be restored to its previous value. The above process may be repeated until all the liquid from the main reservoir 401 is consumed or used.

[52] The apparatus or dosing device of the present disclosure may include a cartridge for a liquid that provides constant level and constant hydrostatic pressure of the liquid in a reservoir, such as the reservoirs discussed herein.

[53] Benefits of the disclosure include the possibility for electrically controlled movement of the liquid through the gap between electrodes for the dosing of a predetermined amount of liquid. Those of skill in the art will recognize that in accordance with the disclosure, this can be accomplished by measuring electrical capacity of the electrode system. Electrical capacity can depend on the liquid volume between electrodes. Another benefit is the capability to dynamically control dosing based on feedback between the amount of liquid that fills the gap between the electrodes, and the voltage that is applied to the electrodes. A further benefit is that there are no moving parts in the design of the dosing device, and thus the dosing device may be more robust and responsive than a dosing device that has moving parts. In addition, there may be low power consumption in accordance with the design of the present disclosure, e.g., power consumption may be about 100 mW, which may be lower than power consumption of a device that has moving parts.

[54] FIG. 5 illustrates a flow diagram of a method in accordance with various aspects of the disclosure. FIG. 5 illustrates a method 500. In step 501 of method 500, conveying a liquid from a reservoir through a gap defined by a first electrode and a second electrode occurs, each electrode comprising a generally curved section. The generally curved section of the first electrode may be positioned below the generally curved section of the second electrode. The gap may comprise an input opening and an outlet opening, the input opening at a first end of the electrodes, and the outlet opening at a second end of the electrodes, the input opening configured to be immersed into liquid in the reservoir. In step 502, providing access of a gas to enter into the gap through at least one aperture
occurs, the at least one aperture defined by an upper part of the generally curved section of the second electrode. In step 503, applying a voltage and forming an electrical field occurs, the electrical field configured to move a liquid edge of the liquid in the gap away from the input opening and towards the outlet opening. In step 504, allowing a predetermined portion of the liquid that is positioned between the aperture defined by the upper part of the generally curved section of the second electrode and the outlet opening to flow out of the outlet opening occurs.

FIG. 6 illustrates a dosing control unit in accordance with various aspects of the disclosure. FIG. 6 illustrates an example of a dosing control unit 1203, as shown in FIG. 1, and incorporated by reference in connection with FIG. 2, 3, and 4. Dosing control unit 1203 may comprise a controller 1202 as shown in FIG. 1 and FIG. 6. Controller 1202 may comprise a processor. Dosing control unit 1203 may further comprise at least one non-transitory memory 1602, a display 1604, and a communication interface 1608. Controller 1202 may execute computer-executable instructions present in non-transitory memory 1602 such that, for example, dosing control unit 1203 may send and receive information via a network (not shown).

Dosing control unit 1203 may further include or be in communication with a system bus (not shown). A system bus may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. The structure of system non-transitory memory is well known to those skilled in the art and may include a basic input/output system (BIOS) stored in a read only memory (ROM) and one or more program modules such as operating systems, application programs and program data stored in random access memory (RAM). Dosing control unit 1203 may be configured to allow dosing control unit 1203 to communicate other devices, e.g., in apparatus 100 of FIG. 1, apparatus 200 of FIG. 2, apparatus 300 of FIG. 3, and apparatus 400 of FIG. 4. Dosing control unit 1203 may also include a variety of interface units and drives (not shown) for reading and writing data.
Those of skill in the art will recognize that, in accordance with the disclosure, any suitable network connections and other ways of establishing a communications link between dosing control unit 1203 and devices in apparatus 100 of FIG. 1, apparatus 200 of FIG. 2, apparatus 300 of FIG. 3, and apparatus 400 of FIG. 4. The existence of any of various well-known protocols, such as TCP/IP, Frame Relay, Ethernet, FTP, HTTP and the like, is presumed, and a central processor unit or computer may be operated in a client-server configuration to permit a user to retrieve web pages from a web-based server. Furthermore, any of various conventional web browsers may be used to display and manipulate data on web pages.

Those of skill in the art will recognize that, in accordance with the disclosure, dosing control unit 1203 may include an associated computer-readable medium containing instructions for controlling any of previously described apparatus 100, 200, 300, and 400, and implement the exemplary embodiments that are disclosed herein.

Dosing control unit 1203 may also include various input devices 1610. Input devices 1610 may include keyboards, track balls, readers, mice, joy sticks, buttons, and bill and coin validators.

Those of skill in the art will recognize that in accordance with the disclosure any of the features and/or options in one embodiment or example can be combined with any of the features and/or options of another embodiment or example.

The disclosure herein has been described and illustrated with reference to the embodiments of the figures, but it should be understood that the features of the disclosure are susceptible to modification, alteration, changes or substitution without departing significantly from the spirit of the disclosure. For example, the dimensions, number, size and shape of the various components may be altered to fit specific applications. Accordingly, the specific embodiments illustrated and described herein are for illustrative purposes only and the disclosure is not limited except by the following claims and their equivalents.
We claim:

1. An apparatus comprising:

   a reservoir, the reservoir comprising a liquid; and

   a first electrode and a second electrode, each electrode comprising a generally curved section, the generally curved section of the first electrode being positioned below the generally curved section of the second electrode, the first electrode and the second electrode defining a gap, the gap comprising an input opening and an outlet opening, the input opening at a first end of the electrodes, and the outlet opening at a second end of the electrodes, the input opening configured to be immersed into the liquid in the reservoir;

   an upper part of the generally curved section of the second electrode defining at least one aperture, the at least one aperture configured to allow a gas to enter into the gap;

   the apparatus configured to apply a voltage from a voltage source and form an electrical field configured to move a liquid edge of the liquid in the gap away from the input opening and towards the outlet opening;

   the apparatus configured to allow a predetermined portion of the liquid that is positioned between the aperture defined by the upper part of the generally curved section of the second electrode and the outlet opening to flow out of the outlet opening.

2. The apparatus of claim 1, wherein the electrical field is a non-homogenous electrical field.

3. The apparatus of claim 1, wherein the aperture is gas permeable and impervious to liquid flow, the aperture configured to allow a gas to enter into the gap through the aperture.
defined by the upper part of the generally curved section of the second electrode and replace liquid flowing out of the outlet opening.

4. The apparatus of claim 1, wherein the liquid comprises a dielectric liquid.

5. The apparatus of claim 1, wherein the gap has an apex at a lower surface of the second electrode, and the aperture extends from an upper surface of the second electrode to the apex of the gap.

6. The apparatus of claim 1, wherein the aperture comprises at least two apertures.

7. The apparatus of claim 1, wherein the liquid comprises an electro-conductive liquid.

8. The apparatus of claim 7 further comprising a layer of electrical insulating material on a portion of each surface of each electrode defining the gap.

9. The apparatus of claim 8, wherein the electrical insulating material is configured to reduce electrical current in the liquid between the electrodes.
10. The apparatus of claim 9, wherein the electrical insulating material is configured to substantially maintain the strength of the electrical field in the gap when voltage is applied to the electrodes.

11. The apparatus of claim 1, wherein the apparatus is configured to allow a predetermined portion of the liquid that is positioned between the aperture defined by the upper part of the generally curved section of the second electrode and the outlet opening to flow away from the inlet opening and out of the outlet opening by reducing the voltage from being applied.

12. The apparatus of claim 11, wherein reducing the voltage comprises stopping the voltage from being applied.

13. The apparatus of claim 1, wherein the apparatus is configured to allow a predetermined portion of the liquid that is positioned between the aperture defined by the upper part of the generally curved section of the second electrode and the outlet opening to flow away from the inlet opening and out of the outlet opening by sending a compressed gas into the gap through the aperture.

14. The apparatus of claim 13 further comprising a compressed gas source for the compressed gas.

15. The apparatus of claim 1, wherein the reservoir comprises:

a first reservoir, the first reservoir comprising the liquid; and
a second reservoir, the second reservoir comprising an upper part and a lower part, the lower part of the second reservoir configured to receive a portion the liquid from the first reservoir through a channel until liquid in the first reservoir is lowered to a first level in the first reservoir and negative pressure is formed in an upper part of the first reservoir above the liquid in the first reservoir, and wherein the input opening of the gap is configured to be immersed into liquid in the second reservoir.

16. The apparatus of claim 15, wherein the apparatus is configured to convey gas from the upper part of the second reservoir to the first reservoir through the channel.

17. The apparatus of claim 16, wherein when liquid flows out of the outlet opening a first liquid level of the second reservoir is lowered and gas moves through the channel from the second reservoir to the first reservoir, negative pressure in the first reservoir is released, and liquid from the first reservoir is allowed to move through the channel to the second reservoir until the liquid level in the second reservoir is restored to its first liquid level prior to liquid flowing out of the outlet opening.

18. A method comprising:

conveying a liquid from a reservoir through a gap defined by a first electrode and a second electrode, each electrode comprising a generally curved section, the generally curved section of the first electrode being positioned below the generally curved section of the second electrode, the gap comprising an input opening and an outlet opening, the input opening at a first end of the electrodes, and the outlet opening at a second end of the electrodes, the input opening configured to be immersed into liquid in the reservoir;
providing access of a gas to enter into the gap through at least one aperture, the at least one aperture defined by an upper part of the generally curved section of the second electrode;

applying a voltage and forming an electrical field, the electrical field configured to move a liquid edge of the liquid in the gap away from the input opening and towards the outlet opening; and

allowing a predetermined portion of the liquid that is positioned between the aperture defined by the upper part of the generally curved section of the second electrode and the outlet opening to flow out of the outlet opening.

19. The method of claim 18 wherein the allowing comprises reducing the voltage being applied.

20. The method of claim 19 wherein the reducing the voltage being applied comprises stopping the voltage.

21. The method of claim 18 wherein the allowing comprises sending a compressed gas through the aperture and into the gap.

22. The method of claim 18 further comprising receiving a request for a free flowing food product.

23. The method of claim 22 wherein the allowing of the predetermined amount of liquid to flow out from the outlet opening corresponds to the request for the free flowing food.
24. The method of claim 22 further comprising determining the amount of liquid to
dose from the outlet opening based on the request for the free flowing food product.

25. The method of claim 18 further comprising combining the liquid that has flowed
out from the outlet opening with a diluent to form a free flowing food product.

26. The method of claim 18 further comprising monitoring a liquid level of the reservoir.

27. The method of claim 26 further comprising reducing the voltage being applied
when the liquid level of the reservoir reaches a level that corresponds to the predetermined
portion of the liquid to be dosed from the outlet opening.

28. The method of claim 26 further comprising sending a compressed gas into the gap
through the aperture when the liquid level of the reservoir reaches a level that corresponds to the
predetermined portion of the liquid to be dosed from the outlet opening.

29. The method of claim 18 further comprising automatically adding of liquid to the
reservoir when the liquid level of the reservoir reaches a minimum lower threshold.

30. The method of claim 29 further comprising activating an alert signal when the
liquid level of the reservoir reaches a maximum lower threshold.
31. The method of claim 29 further comprising stopping the automatically adding of liquid to the reservoir when the liquid level of the reservoir reaches a minimum upper threshold.

32. The method of claim 31 further comprising activating an alert signal when the liquid level of the reservoir reaches a maximum upper threshold.
CONVEYING A LIQUID FROM A RESERVOIR THROUGH A GAP DEFINED BY A FIRST AND SECOND ELECTRODE

PROVIDING ACCESS OF A GAS TO ENTER INTO THE GAP THROUGH AT LEAST ONE APERTURE

APPLYING A VOLTAGE AND FORMING AN ELECTRICAL FIELD


FIG. 5
FIG. 6

1610

INPUT DEVICES

1202

MEMORY

PROCESSOR

1203

DISPLAY

COMMUNICATION INTERFACE

1608

1604

1602