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Kerr et al.

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(54) **METHOD AND APPARATUS FOR AN AEROSOL GENERATION DEVICE**

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A24B 15/167	(2020.01)
B05B 17/00	(2006.01)
B05B 17/06	(2006.01)

(52) **U.S. Cl.**
CPC ***A24F 47/002*** (2013.01); ***A24B 15/167*** (2016.11); ***B05B 17/06*** (2013.01); ***B05B 17/0607*** (2013.01); ***B05B 17/0646*** (2013.01)

(58) **Field of Classification Search**
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USPC 239/4, 102.1, 102.2, 332, 338; 128/200.14, 200.16; 131/275, 329
See application file for complete search history.

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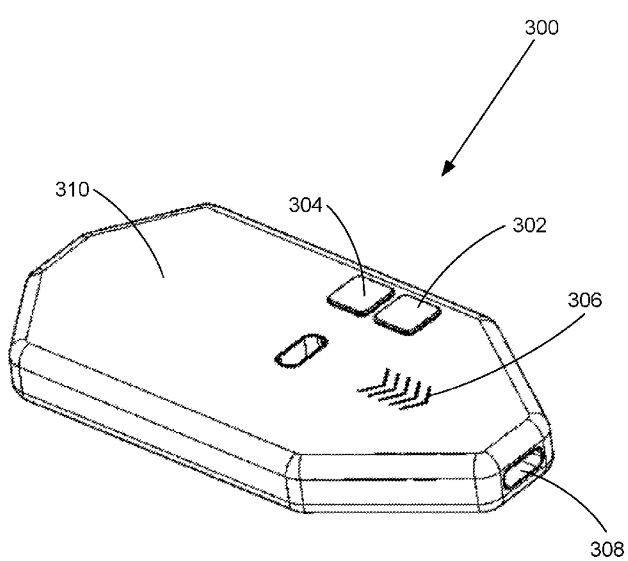
(57) **ABSTRACT**

An aerosol generation device includes an ergonomically correct unibody within which an aerosol generation device is enclosed. The unibody integrates components of the aerosol generation device into a sleek form factor designed for portability, whereby each component blends into the aesthetics defined by the unibody while providing reusable functionality. Airflow detection is used to activate aerosol generation and spacial orientation detection is used to activate status updates such as battery charge level and solution fill level. A user may define a rate of atomized solution that may be produced by the aerosol generation device through external control of the frequency of operation of the aerosol generation device. Use of medical-grade stainless steel and other hygienically correct components contribute to reusability and, therefore, the reduction of non-biodegradeable waste.

11 Claims, 8 Drawing Sheets



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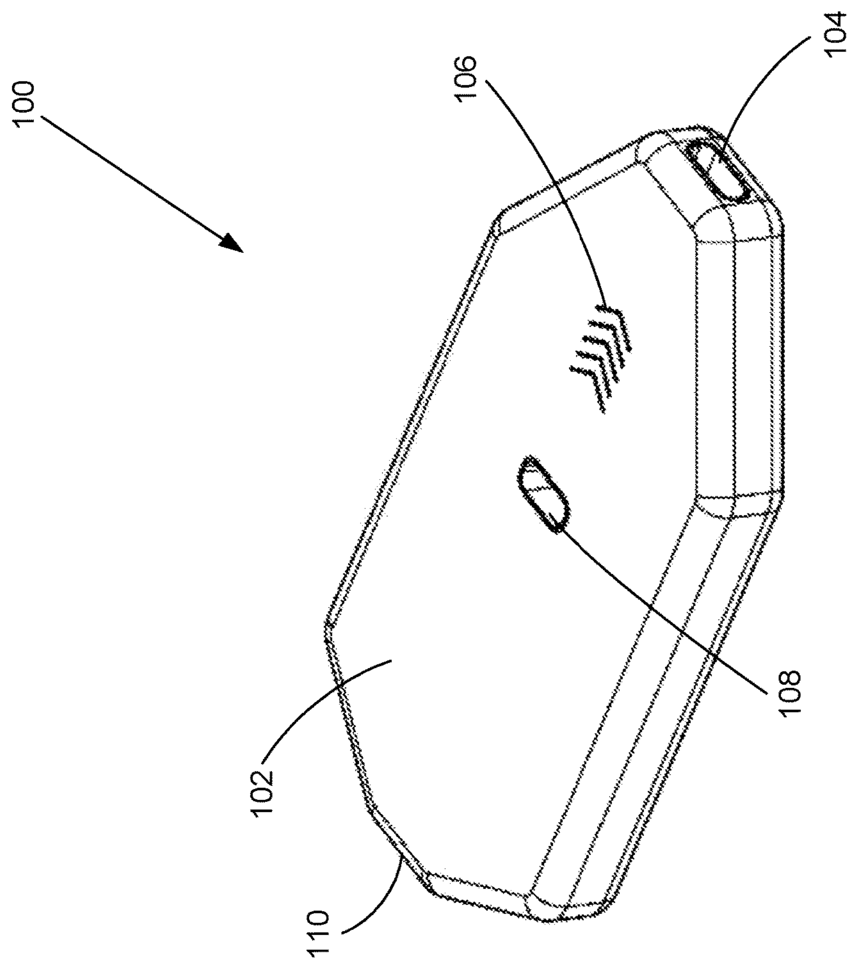

FIG. 1

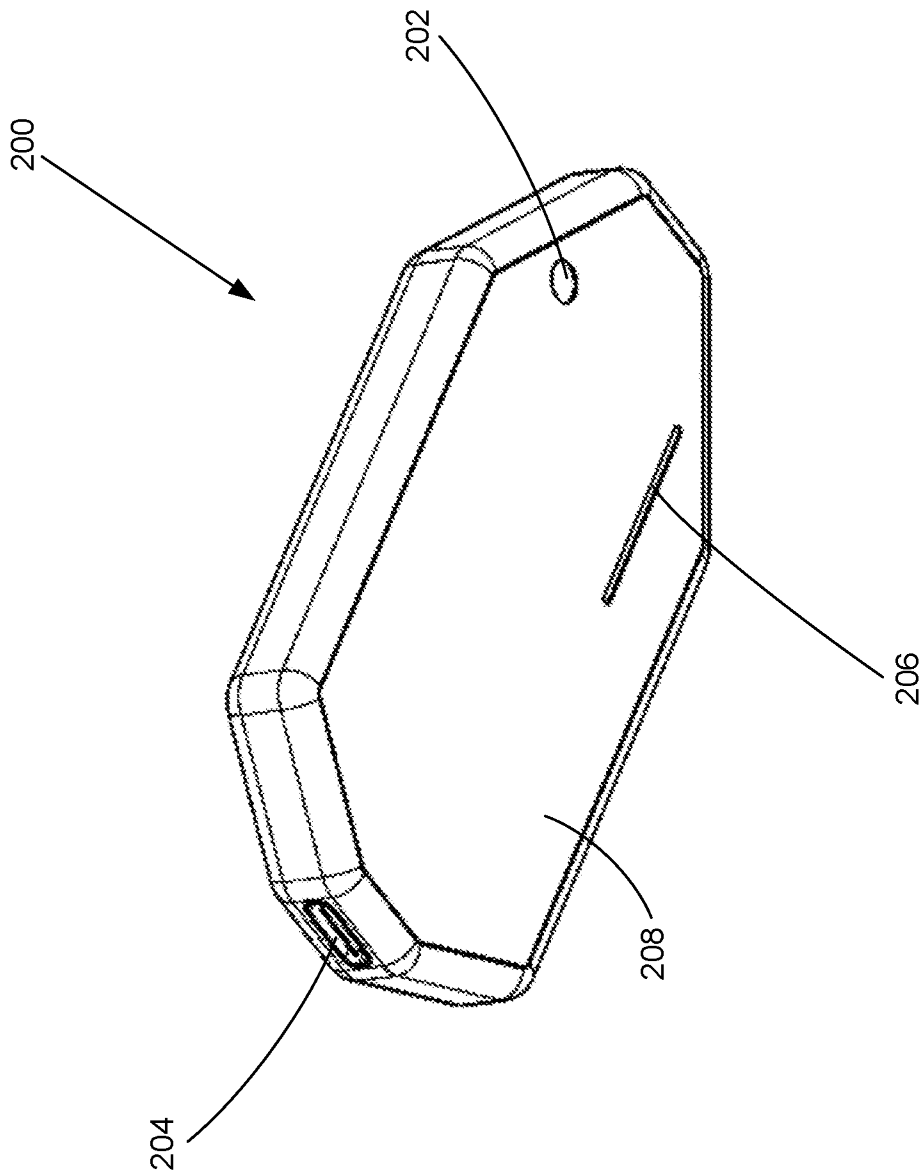

FIG. 2

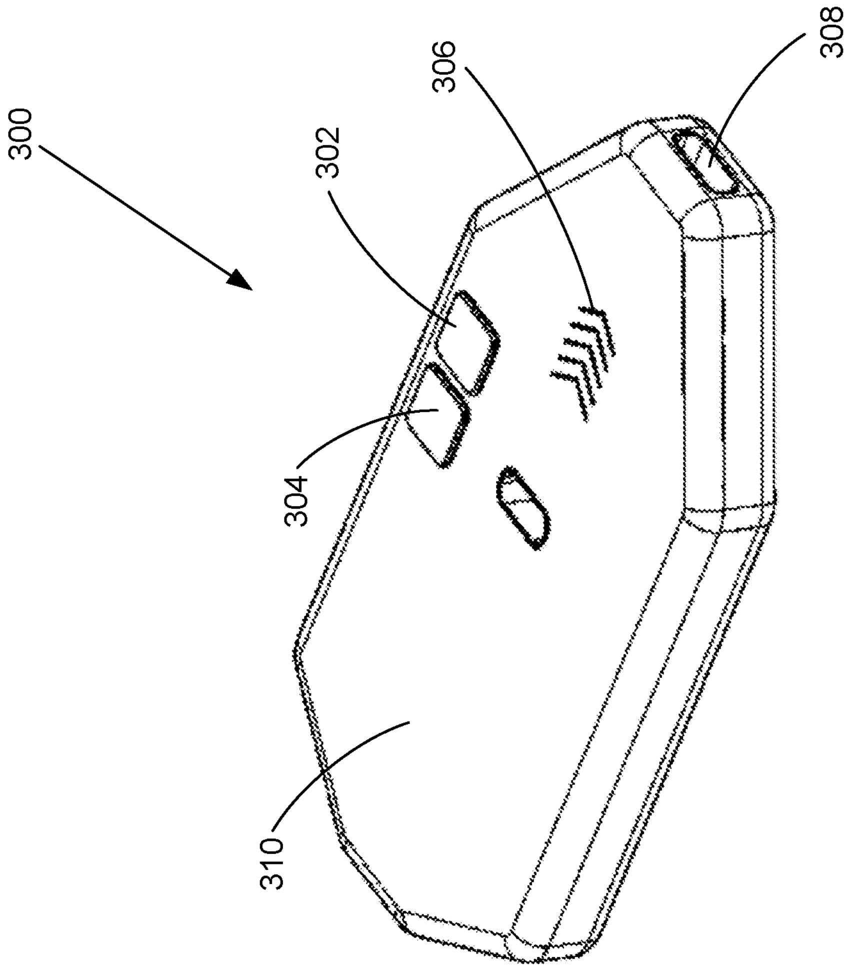

FIG. 3

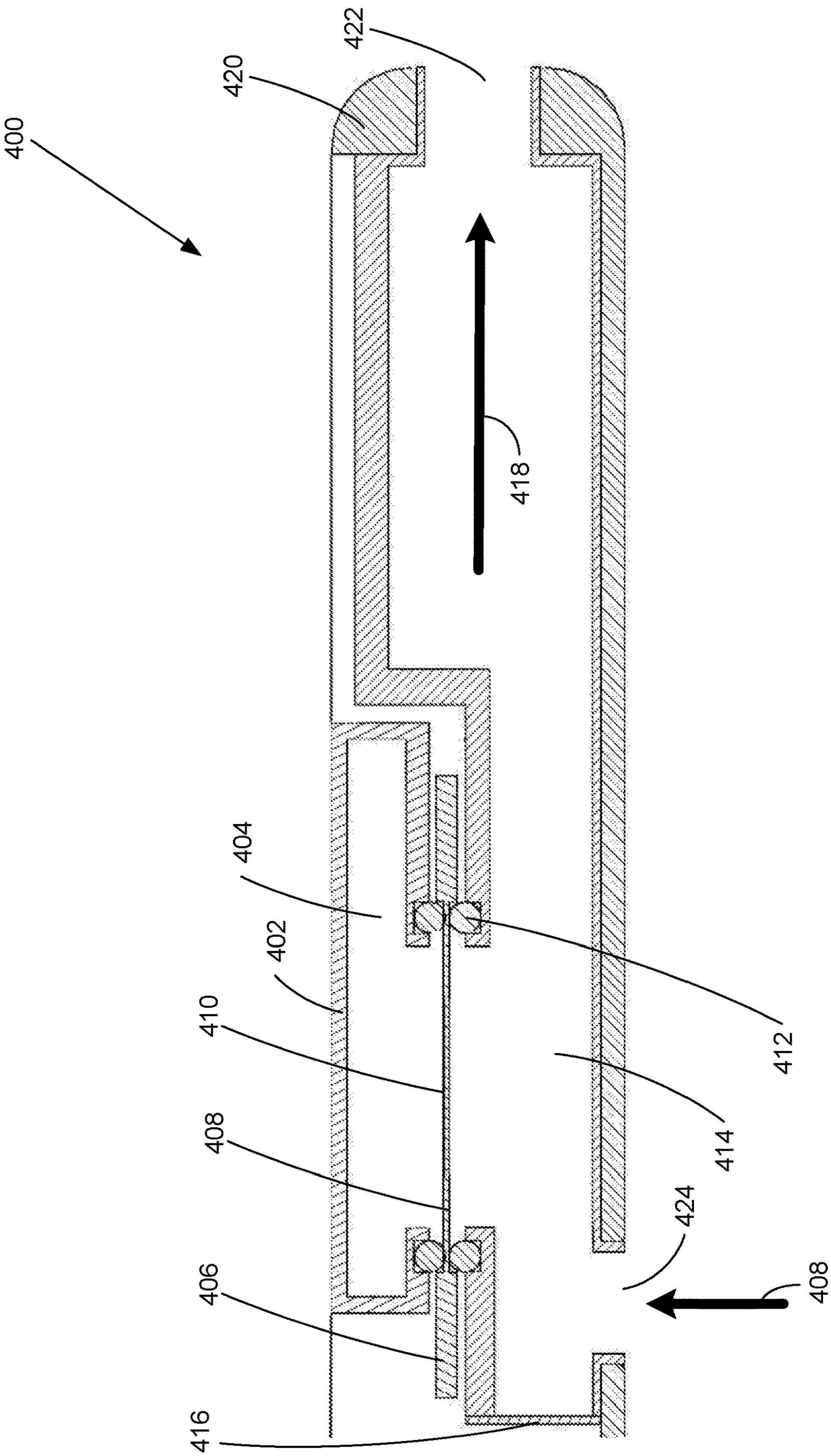

FIG. 4

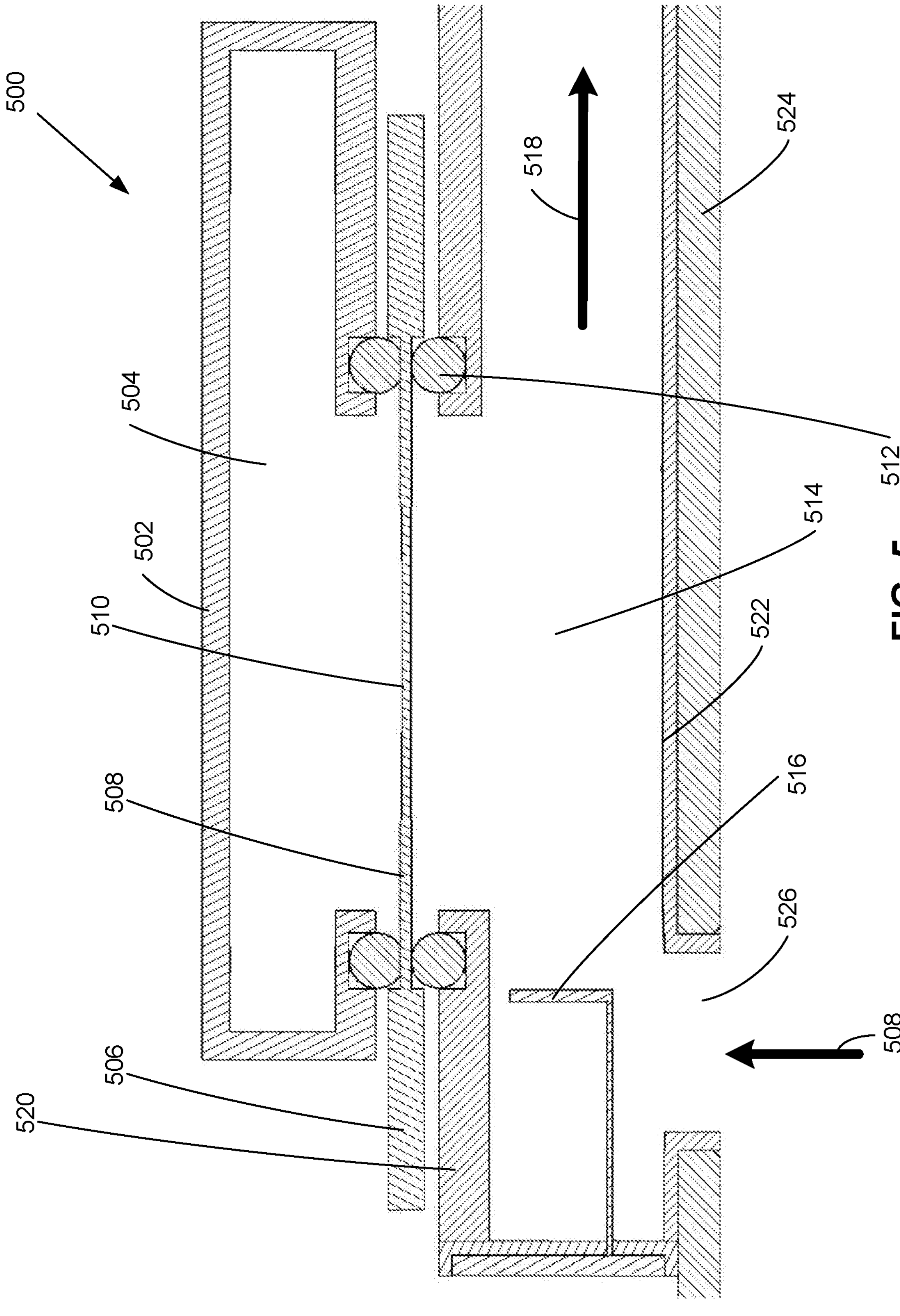

FIG. 5

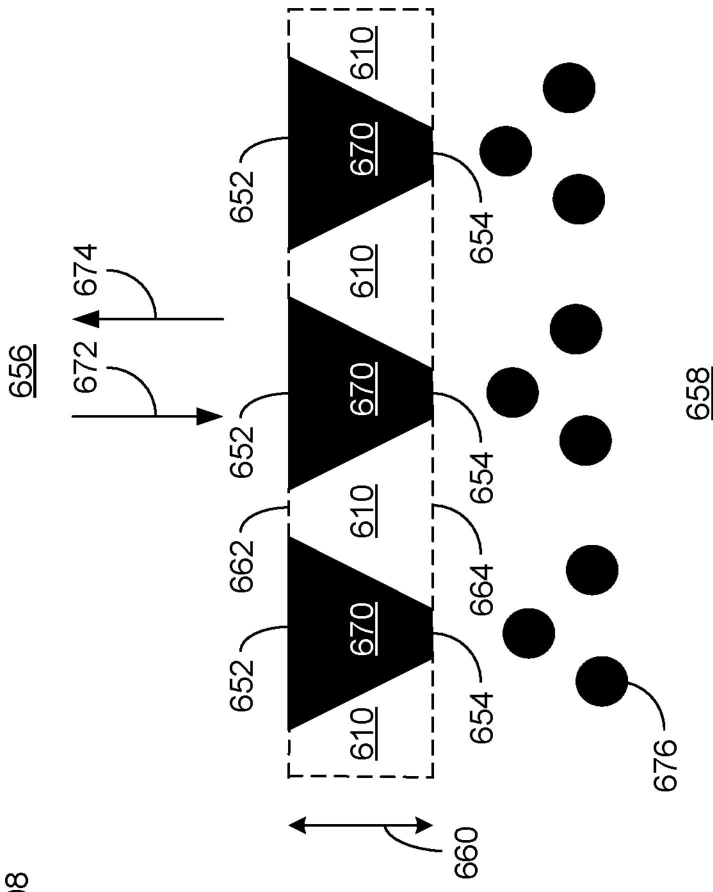
656
672
674
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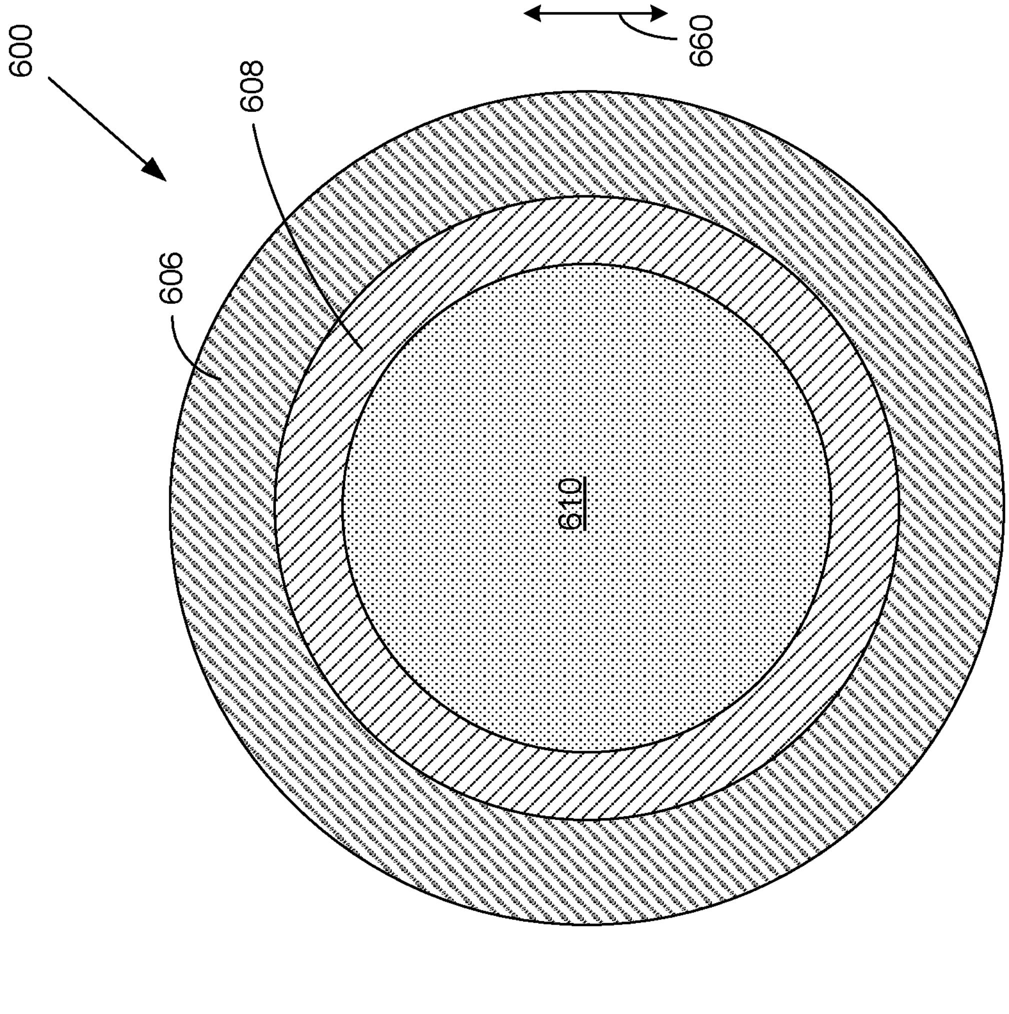
FIG. 6B


600
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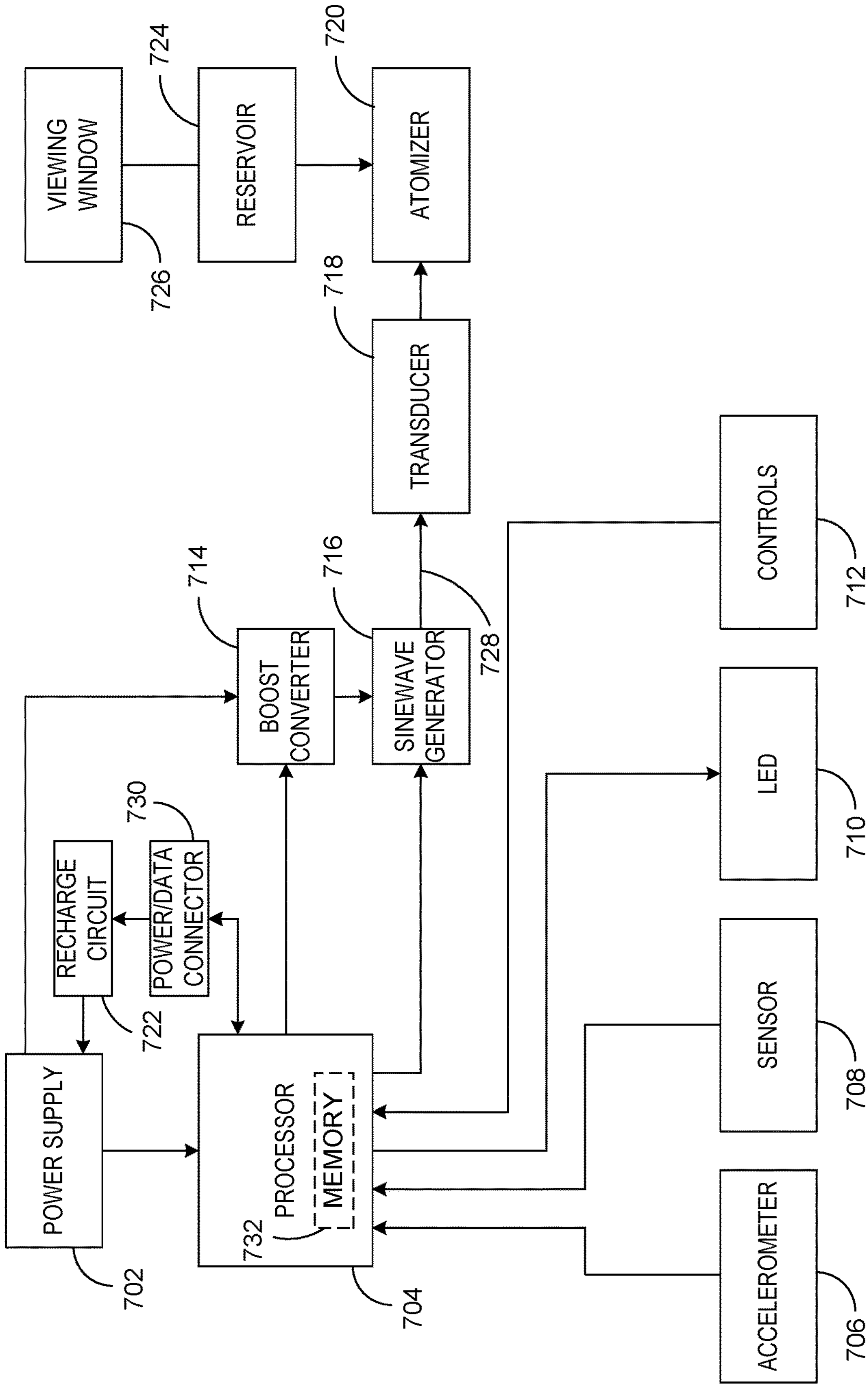
610

FIG. 6A

700



VIEWING WINDOW
726
RESERVOIR
724
ATOMIZER
720
718
TRANSDUCER
BOOST CONVERTER
714
SINEWAVE GENERATOR
716
728
CONTROLS
712
LED
710
SENSOR
708
ACCELEROMETER
706
RECHARGE CIRCUIT
722
POWER/DATA CONNECTOR
730
POWER SUPPLY
702
PROCESSOR
MEMORY
732
704

FIG. 7

800

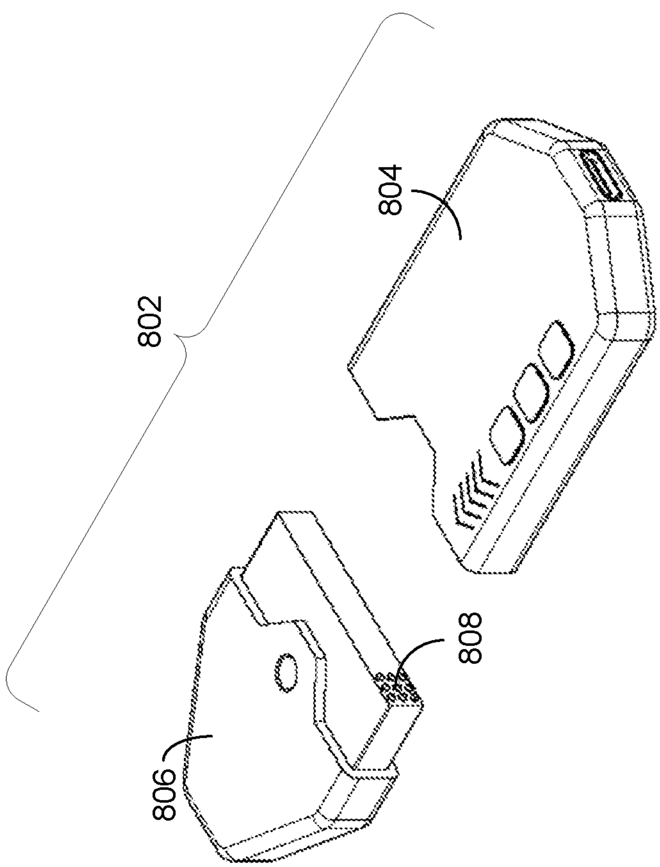


FIG. 8

METHOD AND APPARATUS FOR AN AEROSOL GENERATION DEVICE

FIELD OF THE INVENTION

The present invention generally relates to aerosol generation devices, and more particularly to electronic aerosol generation devices.

BACKGROUND

Aerosol generators have been utilized to atomize liquid solutions for ingestion into the human blood stream via the bronchial system. In particular, such liquid solutions may be formulated to contain a dissolved or suspended particulate that may be atomized into a fine mist for distribution to the respiratory organs of the body and to the other organs of the body via the interelated circulatory system.

One conventional technique that has been used to atomize a liquid solution includes the use of compressed air that may be circulated through the liquid solution at high velocity to generate an aerosol that may then be inhaled by a person. This so-called jet nebulizer, however, is not considered to be particularly portable due to the size and weight constraints of the concomitant compressor. Accordingly, jet nebulizers are traditionally employed by the user for stationary applications, such as treatments for asthma or other respiratory ailments at home.

Other more portable atomization devices include the use of ultrasonic wave technologies. Such devices, however, are considerably inefficient and produce unintended heating of the liquid to be atomized. Accordingly, such portable atomization devices are overly wasteful and potentially harmful.

Still other conventional atomization devices utilize heating elements for aerosol generation. Electronic cigarettes, so called e-Cigarettes for example, are battery operated and utilize a heating element to atomize a liquid that may contain varying amounts of nicotine, flavorings and/or other chemicals. Such heated atomization elements, however, generate aerosols much less efficiently than their counterpart technologies and further tend to create a residue throughout the inner-workings of the e-Cigarette.

Further disadvantages in common with most conventional atomization devices intended for portability include their manufacture as completely disposable devices and/or disposable sub-components (e.g., batteries, liquid storage tanks, cartridges and atomizing heads). Accordingly, their production and use contribute to the ever-growing, non-biodegradeable waste accumulation resulting in deleterious affects on marine life—not to mention the deleterious affects on the planet's landfills, forests, parks and fields.

Efforts continue, therefore, to develop simplified, reusable and planet-friendly aerosol generation devices that may be used safely and efficiently while remaining portable, ergonomically correct and aesthetically pleasing.

SUMMARY

To overcome limitations in the prior art, and to overcome other limitations that will become apparent upon reading and understanding the present specification, various embodiments of the present invention disclose methods and apparatus for simplified, reusable and planet-friendly aerosol generation devices that may be used safely and efficiently. Atomization devices in accordance with the present invention may be made to be ergonomically correct for the user while increasing adaptability to the user's needs. Portability

may be enhanced via a sleek form factor to facilitate stealthy stowage of the atomization device on the user's person for quick and easy retrieval when necessary.

In accordance with one embodiment of the invention, an aerosol generation device comprises a processor, an airway egress port, a user input device coupled to the processor, a generator configured by the processor to generate a signal having a frequency selected in response to a control signal from the user input device, and an atomizer in direct contact with a solution, the atomizer configured to provide atomized solution to the airway egress port at a rate proportional to the selected frequency.

In accordance with an alternate embodiment of the invention, an aerosol generation device comprises a processor including a memory, an airway egress port, a generator configured by the processor to generate a signal having a frequency, an atomizer in direct contact with a solution, the atomizer configured to provide atomized solution to the airway egress port at a rate proportional to the frequency. The processor selects the frequency to be equal to one of a plurality of resonance frequencies associated with the atomizer.

In accordance with an alternate embodiment of the invention, a method of using an aerosol generation device comprises storing a solution in direct contact with an atomizer, vibrating the atomizer at a frequency substantially equal to a resonance frequency of the atomizer and selecting the frequency of vibration in response to a desired rate of atomization. The vibration frequency is selected by a user of the aerosol generation device.

BRIEF DESCRIPTION OF THE DRAWINGS

Various aspects and advantages of the invention will become apparent upon review of the following detailed description and upon reference to the drawings in which:

FIG. **1** illustrates a top perspective view of an aerosol generation device in accordance with an embodiment of the present invention;

FIG. **2** illustrates a bottom perspective view of an aerosol generation device in accordance with an embodiment of the present invention;

FIG. **3** illustrates a top perspective view of an aerosol generation device in accordance with an alternate embodiment of the present invention;

FIG. **4** illustrates a cross-sectional view of an aerosol generation device in accordance with an embodiment of the present invention;

FIG. **5** illustrates a cross-sectional view of an aerosol generation device in accordance with an alternate embodiment of the present invention;

FIGS. **6**A and **6**B illustrate a mesh assembly in accordance with an embodiment of the present invention;

FIG. **7** illustrates a block diagram of an aerosol generation device in accordance with an embodiment of the present invention; and

FIG. **8** illustrates an exploded view of an aerosol generation device in accordance with an alternate embodiment of the present invention.

DETAILED DESCRIPTION

Generally, the various embodiments of the present invention are applied to an aerosol generation device that may be used to atomize a liquid (e.g., water) that may be infused with virtually any chemical composition (e.g., a cannabinoid (CBD) compound or a tetrahydrocannabinol (THC) compound). The atomized solution may include droplets that may be accurately sized by the aerosol generation device for efficient deposition within the user's bronchial system (e.g., at prescribed sites within the human lung).

In one embodiment, the aerosol generation device may deliver a substantially fixed rate of delivery of atomized solution such that the duration of the inhalation period may determine a volume of atomized solution that may be ingested by the user. In an alternate embodiment, the aerosol generation device may deliver a user-selectable, variable rate of delivery of atomized solution such that the user may select a volume of atomized solution that is to be ingested by the user for any given inhalation period.

A size of atomized droplets produced by the aerosol generation device may be determined by one or more attributes of the atomizing element (e.g., mesh) of the aerosol generation device. In one embodiment, for example, the mesh may be configured with a number of apertures that may exhibit a geometric shape (e.g., circular) and a geometric dimension (e.g., diameter) that may substantially define the size of atomized droplets produced by the mesh. As per one example, the diameter of each droplet produced by the aperture may be proportional (e.g., substantially equal) to the diameter of the aperture.

Further, the mesh may exhibit another geometric dimension (e.g., depth) such that the depth may define a thickness of the mesh, whereby each aperture may exhibit a substantially constant shape (e.g., circular) having a substantially constant dimension (e.g., diameter) throughout the thickness of the mesh, such that each aperture may exhibit a geometric shape (e.g., a cylindrical shape). In alternate embodiments, each aperture may exhibit a substantially constant shape (e.g., circular), but may also exhibit a varying dimension (e.g., a decreasing diameter) throughout the thickness of the mesh, such that each aperture may exhibit a geometric shape (e.g., conical) having a larger diameter on one side of the mesh relative to a smaller diameter on the opposite side of the mesh. Other geometric shapes may also be formed by each aperture, such as square, rectangular, trapezoidal, etc.

The aerosol generation device may be arranged such that the atomizing element (e.g., mesh) may be placed into direct contact with the solution to be atomized. In one embodiment, for example, the mesh may be comprised of medical-grade stainless steel such that corrosion of the mesh may be substantially eliminated despite being in constant contact with the solution. The stainless steel mesh may be further processed (e.g., electropolished) to reduce surface roughness thereby decreasing the mesh's proclivity for residue buildup. All surfaces of the aerosol generation device that may be in direct contact with the atomized solution (e.g., the airway) may also be comprised of electropolished, medical-grade stainless steel to further reduce, or eliminate, any/all required maintenance (e.g., cleaning) that may be required.

The solution to be atomized may contain a non-hydrophobic compound (e.g., a non-hydrophobic CBD compound) such that the propensity for residue buildup onto the mesh and airway may be further reduced. The solution may further be devoid of excipients, such as polyethylene glycol (PEG) or polyethylene oxide (PEO), to further minimize residue within the aerosol generation device for substantially maintenance free operation.

An encasement for the aerosol generation device may include aesthetically pleasing components (e.g., a culinary-grade anodized aluminum body) to reduce weight and the likelihood of corrosion while minimizing cost. The encasement may provide ultimate simplicity, for example, through the elimination of external activation controls and may instead monitor activity (e.g., airflow) at the air ingress and/or air egress ports of the aerosol generation device to activate the atomization process and may further construe spacial orientation changes (e.g., via a three-axis accelerometer) to allow the user to change other aspects of operation (e.g., rate of atomization) of the aerosol generation device simply by altering its spacial orientation in a particular manner.

In other embodiments, external controls (e.g., buttons) may be included within the aerosol generation device's encasement to facilitate the user's control of certain operational characteristics (e.g., rate of delivery of atomized solution) that may be delivered by the aerosol generation device. In other embodiments, the encasement may include input/output (I/O) features, such as a power/data port (e.g., USB-C), a wireless power/data port and a visual indicator (e.g., viewing window) so that the user may monitor a volume of solution that may be contained within the aerosol generation device's liquid reservoir.

The aerosol generation device may include a power supply (e.g., one or more rechargeable batteries) that may be completely encapsulated within its encasement. In one embodiment, the battery may be recharged wirelessly (e.g., via magnetic induction) or recharged via wired access (e.g., via USB-C). A visual indication of the charge level of the power supply may be provided within the encasement and may be activated any number of ways (e.g., movement detection via accelerometer, tactile excitation or detected airflow activity within the airway of the aerosol generation device).

The encasement of the aerosol generation device may include a refillable reservoir within which a solution may be stored until needed for atomization. In one embodiment, the refillable reservoir may be fully encapsulated within the encasement and may include a sealed fill port having a hygienically-suitable surface capable of receiving solution from an external source. The sealed fill port may be self-sealing (e.g., via a spring-loaded door covering the fill port) to prevent egress of the solution once stored. In an alternate embodiment, the refillable reservoir and/or other components (e.g., the atomizing component) may be included within a reusable cartridge that may engage the encasement in such a way that the cartridge may be secured into the encasement during operation, yet removable from the encasement for maintenance (e.g., solution refill).

As discussed above, the solution may be kept in direct contact with the mesh at all times, whether the aerosol generation device is activated or not. Further, the mesh may be sandwiched between the reservoir and the airway of the aerosol generation device such that a geometric configuration of the mesh may be used to facilitate the atomization of the solution into the airway of the aerosol generation device when activated and to prevent leaking of the solution into the airway when deactivated.

In one embodiment, for example, apertures may be arranged within the mesh such that a magnitude of surface tension of solution present at each opening of each aperture may be sufficient to prevent the solution from exiting the mesh and leaking into the airway when the aerosol generation device is deactivated (e.g., when the mesh is not vibrating). Conversely, excitation of the mesh (e.g., via vibration) may exert a force sufficiently larger than the surface tension of the solution so as to force portions (e.g., droplets) of the solution into the airway when the aerosol generation device is activated. Further, a geometric dimension (e.g., diameter) of each aperture may determine the size of droplets formed during atomization.

A transducer (e.g., piezoelectric transducer) may be used to excite (e.g., vibrate) the mesh at one or more amplitudes and one or more frequencies sufficient to atomize the solution during activation of the aerosol generation device. In one embodiment, atomized solution produced by the aerosol generation device may be fixed at a volume that may not be selectable by the user. In such an instance, a particular volume of atomized solution that may be ingested by the user may be determined by the duration of the inhalation period utilized by the user. In an alternate embodiment, a volume of atomized solution to be ingested by the user may be selected by the user through modulation of the amplitude and/or frequency of vibration of the mesh (e.g., via a control mechanism configured within the encasement of the aerosol generation device or a spacial orientation measurement device configured to detect spacial orientation changes).

The aerosol generation device may be configured such that at least a portion of the solution and at least a portion of the mesh may be in direct contact at all times no matter the spacial orientation of the aerosol generation device. Accordingly, the aerosol generation device may atomize the solution once activated whether placed into a normal, inverted or sideways orientation.

Turning to FIG. **1**, a top perspective view of aerosol generation device **100** is exemplified, which may include unibody **102** that may exhibit a single molded unit that may form both the body of aerosol generation device **100** as well as a housing for its integral components. As per one example, area **104** may form a portion (e.g., leading edge) of unibody **102**, but may also include and integral component (e.g., airway egress port **104**) that may facilitate the expulsion of atomized solution meant for ingestion by a user of aerosol generation device **100** as discussed in more detail below. It should be noted that airway egress port **104** may be integrated anywhere within unibody **102**, such as along trailing edge **110** of unibody **102**.

An additional component (e.g., airway ingress port **108**) may also be integrated within unibody **102**, which may be utilized by aerosol generation device **100** to draw ambient air into the interior portion (not shown) of unibody **102**. The ambient air may then be mixed with the atomized solution within an airway (not shown) of aerosol generation device **100** prior to expulsion via airway egress port **104**. It should be noted that airway ingress port **108** may be integrated anywhere within unibody **102**, such as along a bottom portion of unibody **102**.

Visual indicators may further be integrated within unibody **102**, such as visual indicator **106**. Depending upon the operation of an internal processor (not shown) of aerosol generation device **100**, visual indicator **106** may be indicative of a number of operational parameters. As per one example, the individual components of visual indicator **106** (e.g., each individual arrowhead of visual indicator **106**) may be individually backlit by a light emitting diode (LED) (not shown) arranged along an underlying printed circuit board (not shown) in proximity to each arrowhead, such that once illuminated, the light projected by each LED may be viewed by the user and construed in a manner that may be indicative of an operational parameter of aerosol generation device **100**.

In one embodiment, visual indicator **106** may be indicative of the charge level of a rechargeable battery (not shown) that may be included in an interior of unibody **102**. Full charge may, for example, be indicated by the illumination of all arrowheads of visual indicator **106** in a color (e.g., green) that may be indicative of normal operation. Any less than full charge may, for example, be indicated by the number of arrowheads illuminated and may further be indicated by a color of the illumination. Eighty percent charge may, for example, be indicated by the illumination (e.g., green illumination) of 4 out 5 arrowheads, sixty percent charge may, for example, be indicated by the illumination (e.g., amber illumination) of 3 out 5 arrowheads and forty percent charge may, for example, be indicated by the illumination (e.g., red illumination) of 2 out 5 arrowheads and so on.

In addition, the meaning of visual indicator **106** may be determined by the operational state of aerosol generation device **100** as may be determined by firmware/machine code executed by an internal processor (not shown) of aerosol generation device **100**. As per one example, aerosol generation device **100** may include an accelerometer (not shown) that may constantly measure the spacial orientation of unibody **102**. Upon the measurement of a particular change in spacial orientation (e.g., trailing edge **110** oriented around 45 degrees below airway egress port **104**) by the accelerometer (not shown) as detected by the processor (not shown), visual indicator **106** may initially provide a visual indication of an operational state of aerosol generation device **100** and may then power off. As per one example, the battery charge state as discussed above may be temporarily indicated (e.g., for five seconds) after detection of a spacial orientation change and may then power off.

As per another example, upon the measurement of a particular change in spacial orientation (e.g., trailing edge **110** oriented directly above airway egress port **104**) by the accelerometer (not shown) as detected by the processor (not shown), visual indicator **106** may provide a visual indication of a selected rate of atomization. Further, a user of aerosol generation device **100** may increase or decrease the selected rate of atomization through successive spacial orientation changes of aerosol generation device **100** and may be updated as to the selected rate of atomization via visual indicator **106**.

In one embodiment, for example, a user may incrementally increase the rate of atomization through successive half rotations of aerosol generation device **100** first in a clockwise direction to invert aerosol generation device **100** and next in a counter-clockwise direction to return aerosol generation device **100** to its original position. In an alternate embodiment, for example, a user may incrementally decrease the rate of atomization through successive half rotations of aerosol generation device **100** first in a counter-clockwise direction to invert aerosol generation device **100** and next in a clockwise direction to return aerosol generation device **100** to its original position.

Turning to FIG. **2**, a bottom perspective view of aerosol generation device **200** is exemplified, which may include unibody **208** (e.g., as discussed above in relation to unibody **102** of FIG. **1**), which may further include additional integrated components. As per one example, aerosol generation device **200** may include an internal reservoir (not shown) that may contain a solution to be atomized by aerosol generation device **200** as discussed in more detail below. Sealable fill door **202** may, for example, be in direct fluid communication with the internal reservoir (not shown). Once opened, sealable fill door **202** may provide a direct fluid communication path between an external container (not shown) and the internal reservoir (not shown), thereby allowing the internal reservoir (not shown) to be refilled. Once refilled, sealable fill door **202** may automatically close (e.g., via spring actuation) to seal the opening to the internal reservoir (not shown).

Viewing window **206** may, for example, be included to allow a user of aerosol generation device **200** to visually determine a volume of solution that may be contained within the internal reservoir (not shown). As per one example, viewing window **206** may be backlit by a light emitting diode (LED) (not shown) arranged along an underlying printed circuit board (not shown) in proximity to viewing window **206**, such that once illuminated, the light projected by the LED may allow the user to more easily determine a volume of solution that may be contained within the internal reservoir (not shown). In one embodiment, viewing window **206** may be temporarily backlit (e.g., for five seconds) after the internal processor/accelerometer (not shown) detects a spacial orientation change.

Aerosol generation device **200** may further include a power/data interface (e.g., USB-C **204**). The power/data interface may, for example, be used to receive operational power to charge a rechargeable battery (not shown) that may be included within aerosol generation device **200** and may further be used to receive firmway/machine code that may be executed by an internal processor (not shown) within aerosol generation device **200**.

Turning to FIG. **3**, a top perspective view of an alternate embodiment of aerosol generation device **300** is exemplified, which may include unibody **310** (e.g., as discussed above in relation to the unibodies of FIGS. **1** and **2**), which may further include additional integrated I/O components (e.g., buttons **302** and **304**) that may be used by the user to select operational parameters associated with aerosol generation device **300**.

In one embodiment, for example, aerosol generation device **300** may allow the user to select a volume of atomized solution that is to be expelled via air egress port **308** (e.g., as discussed above in relation to airway egress port **104** of FIG. **1**). Activation (e.g., via capacitive sense or tactile depression) of button **302** may, for example, cause aerosol generation device **300** to expel an increased volume of atomized solution through actuation of an increased rate of atomization. Conversely, activation (e.g., via capacitive sense or tactile depression) of button **304** may, for example, cause aerosol generation device **300** to expel a decreased volume of atomized solution through actuation of a decreased rate of atomization.

Visual indicator **306** (e.g., as discussed above in relation to visual indicator **106** of FIG. **1**) may indicate the user-selected rate of atomization. A maximum atomization rate may, for example, be indicated by the illumination of all arrowheads of visual indicator **306**. Any less than a maximum atomization rate may, for example, be indicated by the number of arrowheads illuminated. Eighty percent of maximum atomization rate may, for example, be indicated by the illumination of 4 out 5 arrowheads, sixty percent of maximum atomization rate may, for example, be indicated by the illumination of 3 out 5 arrowheads and forty percent of maximum atomization rate may, for example, be indicated by the illumination of 2 out 5 arrowheads and so on.

Activation of I/O components (e.g., buttons **302** and **304**) may cause varied reactions based upon the operational state of aerosol generation device **300**. As per one example, simultaneous activation (e.g., capacitive sense or tactile depression) of both buttons **302** and **304** during an idle state of aerosol generation device **300** may cause aerosol generation device **300** to commence solution atomization and a subsequent simultaneous activation (e.g., capacitive sense or tactile depression) of both buttons **302** and **304** during an active state of aerosol generation device **300** may cause aerosol generation device **300** to cease solution atomization. Alternately, activation of either button **302** or **304** during an idle state of aerosol generation device **300** may cause aerosol generation device **300** to report a charge state at visual indicator **306** (e.g., as discussed above in relation to visual indicator **106** of FIG. **1**) of the rechargeable battery (not shown) contained within unibody **310** (e.g., as discussed above in relation to the unibodies of FIGS. **1** and **2**) of aerosol generation device **300**.

Turning to FIG. **4**, a cross-sectional view of aerosol generation device **400** is exemplified. Aerosol generation device **400** may include unibody **420** (e.g., as discussed above in relation to the unibodies of FIGS. **1**, **2** and **3**) and components **422** and **424** (e.g., as discussed above in relation to the airway egress and airway ingress ports of FIGS. **1** and **3**) integrated within unibody **420**. Aerosol generation device **400** may further include reservoir **402** and solution **404** contained within reservoir **402** both of which may be fully integrated within unibody **420**. It should be noted that while solution **404** may be in direct contact with mesh **410** as shown, non-atomized solution **404** may neverthess be prevented from leaking into airway **414** due to the configuration of mesh **410** as discussed in more detail below. It should be further noted that sealing devices (e.g., hygienic gaskets **412**) may restrict solution **404** from access to transducer **406**, thereby constraining solution **404** to direct contact with mesh **410** and annular ring **408** only.

In operation, the lips of a user may engage aerosol generation device **400** at airway egress port **422** and the user may then begin inhaling through the user's mouth. In response, ambient air **408** may be caused to enter aerosol generation device **400** at airway ingress port **424**, continue as airflow **418** through airway **414**, exit aerosol generation device **400** at airway egress port **422** and then traverse the user's bronchial system. In response to airflow **418** being created by the user, airflow **418** may create a slight low pressure system within airway **414**, which may then cause pressure sensor **416** to slightly deflect toward airway **414**. A processor (not shown) may detect airflow **418** (e.g., through a detection of the deflection of pressure sensor **416**) and in response, may then cause atomization of solution **404** into airway **414** (e.g., via vibration of mesh **410**) as discussed in more detail below.

In one embodiment, for example, a processor (not shown) may be in electrical communication with a transducer (e.g., piezoelectric transducer **406**) and may cause an electrical drive signal to be transmitted to piezoelectric transducer **406** in response to the detection of airflow **418**. Piezoelectric transducer **406** may then be caused to deflect rapidly (e.g., vibrate) which may then cause tiny droplets of solution (not shown) to appear within airway **414**, which may then be swept into the user's bronchial system when mixed with airflow **418** during the user's inhalation period. It should be noted that pressure sensor **416** may be positioned as shown within aerosol generation device **400** so that pressure sensor **416** may avoid contact with atomized solution that may be contained within airway **414**.

Turning to FIG. **5**, a cross-sectional view of an alternate aerosol generation device **500** is exemplified. Aerosol generation device **500** may include unibody **524** (e.g., as discussed above in relation to the unibodies of FIGS. **1**, **2** and **3**) and component **526** (e.g., an airway ingress port as discussed above in relation to FIGS. **1** and **3**) integrated within unibody **524**. Aerosol generation device **500** may further include reservoir **502** and solution **504** contained within reservoir **502** both of which may be fully encapsulated within unibody **524**. It should be noted that while solution **504** may be in direct contact with mesh **510** as shown, non-atomized solution **504** may neverthess be prevented from leaking into airway **514** due to the configuration of mesh **510** as discussed in more detail below. It should be further noted that sealing devices (e.g., hygienic gaskets **512**) may restrict solution **504** from access to transducer **506**, thereby constraining solution **504** to direct contact with mesh **510** and annular ring **508** only.

In operation, the lips of a user may engage aerosol generation device **500** at an airway egress port (not shown) and the user may then begin inhaling through the user's mouth. In response, ambient air **508** may be caused to enter aerosol generation device **500** at airway ingress port **526**, continue as airflow **518** through airway **514**, exit aerosol generation device **500** at an airway egress port (not shown) and then traverse the user's bronchial system. In response to airflow **518** being created by the user, airflow **518** may cause a flap (e.g., conductive flap **516**) to rotate within airway **514**. As per one example, airflow **518** may cause flap **516** to become electrically communicative with conductive portion **520**, thereby effecting a break-before-make connection between flap **516** and conductive portion **520**. As per another example, airflow **518** may cause flap **516** to be electrically discommunicative with conductive portion **522**, thereby effecting a make-before-break connection between flap **516** and conductive portion **522**. A processor (not shown) may detect airflow **518** (e.g., through a detection of the break-before-make and/or the make-before-break connection of flap **516** with conductive portions **520** and/or **522**, respectively) and in response, may then cause atomization of solution **504** into airway **514** (e.g., via vibration of mesh **510**) as discussed in more detail below.

In one embodiment, for example, a processor (not shown) may be in electrical communication with a transducer (e.g., piezoelectric transducer **506**) and may cause an electrical drive signal to be transmitted to piezoelectric transducer **506** in response to the detection of airflow **518**. Piezoelectric transducer **506** may then be caused to deflect rapidly (e.g., vibrate) which may then cause tiny droplets of solution (not shown) to appear within airway **514**, which may then be swept into the user's bronchial system when mixed with airflow **518** during the user's inhalation period. It should be noted that flap **516** may be positioned as shown within aerosol generation device **500** so that flap **516** may avoid contact with atomized solution that may be contained within airway **514**.

Turning to FIG. **6**A, a top view of mesh assembly **600** is exemplified, which may include transducer portion **606** (e.g., as discussed above in relation to transducer **406** and **506** of FIGS. **4** and **5**, respectively), ring portion **608** (e.g., as discussed above in relation to annular ring **408** and **508** of FIGS. **4** and **5**, respectively) and mesh portion **610** (e.g., as discussed above in relation to mesh **410** and **510** of FIGS. **4** and **5**, respectively). Top and bottom portions of transducer portion **606** may include electrical leads (not shown) so that an electrical stimulus may be applied to cause transducer portion **606** to deflect rapidly (e.g., vibrate). As transducer portion **606** vibrates, vibrations may also be imparted to mesh portion **610** via ring portion **608**.

Turning to FIG. **6**B, a cross-sectional view of mesh portion **610** is exemplified, which may include apertures **652** and **654**. In one embodiment, apertures **652** may exhibit a larger diameter as compared to the diameter of apertures **654**. In an alternate embodiment, the diameter of apertures **652** and **654** may be substantially equal. Portions **610** may, for example, be comprised of a medical-grade stainless steel and portions **670** may represent voids within mesh **610**, such voids **670** being created by an etching process (e.g., laser-etching process).

A dimension (e.g., depth **660**) may represent a height of mesh portion **610**, whereby voids **670** may be formed as geometrically shaped (e.g., conically shaped) channels extending from top portion **652** to bottom portion **654** of channels **670**. Mesh assembly **600** may be sandwiched between a volume of solution (not shown) that may occupy space **656** (e.g., reservoirs **402** and **502** as discussed above in relation to FIGS. **4** and **5**, respectively) and space **658** (e.g., airway **414** and **514** as discussed above in relation to FIGS. **4** and **5**, respectively).

In operation, channels **670** may be filled with solution (e.g., as shown in black), but due to the surface tension of the solution at apertures **654**, no solution may drop into space **658** while transducer portion **606** is not vibrating. Once transducer portion **606** begins to vibrate, cyclical force vectors **672** and **674** may be created to pump solution from space **656** into channels **670** via apertures **652** and then through apertures **654** to ultimately produce droplets **676** within space **658**.

During a phase of vibration (e.g., as indicated by force vector **674**), for example, droplets **676** may be "pinched" off of apertures **654** from a volume of solution occupying channels **670**. During a phase of vibration (e.g., as indicated by force vector **672**), on the other hand, solution present within channels **670** may adhere to the sidewalls of mesh **610** and apertures **654** (e.g., through capillary action and surface tension) and no droplets **676** may be produced during this phase.

A rate at which the magnitude of cyclical force vectors **672** and **674** may be modulated may determine a number of droplets **676** that may be formed within space **658** over a given time period. Furthermore, a dimension (e.g., diameter) of droplets **676** pinched off from apertures **654** may be selected by appropriate selection of a dimension (e.g., diameter) of apertures **654**. As per one example, a diameter of apertures **654** may be selected between about 0.01 μm and about 10 μm (e.g., approximately 4 μm) thereby producing droplets **676** having a diameter between about 0.01 μm and about 10 μm (e.g., approximately 4 μm). Accordingly, a size of droplets **676** may be selected for optimum deposition within the user's bronchial system.

Turning to FIG. **7**, a block diagram of aerosol generation device **700** is exemplified, which may include power supply **702**, processor **704**, various I/O devices **706-712**, boost converter **714**, sinewave generator **716**, transducer **718**, atomizer **720**, reservoir **724**, viewing window **726**, recharge circuit **722** and power/data connector **730**. Processor **704** may execute firmware/machine code received from power/data connector **730** (e.g., as discussed above in relation to power/data connector **204** of FIG. **2**) so as to control the operational states of aerosol generation device **700** as exemplified below. In addition, processor **704** may capture historical data as to the operation of aerosol generation device **700** over time. For example, the user's historical selection of atomized volume control, the user's operational history (e.g., number of hits per day and average length of a user's hit) and the number of refill operations in a given time period may be stored within a memory (e.g., memory **732**) of processor **704** and uploaded into a computer (not shown) via power/data connector **730** for future reference.

In one embodiment, power supply **702** may include one or more rechargeable batteries that may be included within a unibody (e.g., as discussed above in relation to the unibodies of FIGS. **1-5**). Recharge circuit **722** may accept any of a direct current (DC) signal, alternating current (AC) signal or magnetic signal and convert such signal as appropriate to recharge power supply **702** to achieve adequate operational power levels (i.e., voltage and current) in order to operate aerosol generation device **700** for a period of time (e.g., several days).

Processor **704** may both receive operational power from power supply **702** and may monitor such operational power to determine whether the operational characteristics (e.g., DC voltage magnitude and/or current capacity) of the operational power signal are adequate for operation. Results of such monitoring may be visually indicated (e.g., as discussed above in relation to the visual indicators of FIGS. **1** and **3**).

In operation, accelerometer **706** may measure a spacial orientation (e.g., along each of three axes) of aerosol generation device **700** and may report such measurements to processor **704**. In response, processor **704** may initiate an operational sequence and/or operational state depending upon the current operational state of aerosol generation device **700**.

As per one example, a particular change in spacial orientation may wake processor **704** from a sleep state, in which case processor may then report operational characteristics (e.g., reservoir **724** fill level, power supply **702** charge level) to a user of aerosol generation device **700**. In one embodiment, a fill level of reservoir **724** may be visually confirmed with viewing window **726** (e.g., as discussed above in relation to viewing window **206** of FIG. **2**) as may be enhanced through illumination of one or more LEDs **710** that may be placed in proximity to viewing window **726** (e.g., via a PCB, not shown, placed in proximity to viewing window **726**).

As per another example, a particular change in spacial orientation may wake processor **704** from an idle state, which may then cause processor **704** to monitor sensor **708**. In one embodiment, sensor **708** may include a pressure sensor (e.g., as discussed above in relation to pressure sensor **416** of FIG. **4**) the activation of which may be indicative of an airflow (e.g., as discussed above in relation to airflow **418** of FIG. **4**). In response, processor **704** may begin atomization of the solution contained within reservoir **724** by transducer **718** and atomizer **720** (e.g., as discussed above in relation to mesh assembly **600** of FIGS. **6**A and **6**B). In an alternate embodiment, sensor **708** may include an airflow indicator (e.g., as discussed above in relation to flap **516** of FIG. **5**) the activation of which may be indicative of an airflow (e.g., as discussed above in relation to airflow **518** of FIG. **5**). In response, processor **704** may begin atomization of the solution contained within reservoir **724** by transducer **718** and atomizer **720** (e.g., as discussed above in relation to mesh assembly **600** of FIGS. **6**A and **6**B).

As per other examples, accelerometer **706** may be omitted from aerosol generation device **700** altogether. In such instances, processor **704** may instead monitor controls **712** (e.g., as discussed above in relation to buttons **302** and **304** of FIG. **3**) to determine a commanded operation from any of a sleep or idle state as discussed above or to determine a commanded operation in relation to an operational state of aerosol generation device **700**. For example, controls **712** may be used by the user to select an adjustable volume of solution to be atomized and/or select a rate of atomization. In yet other examples, controls **712** may be omitted from aerosol generation device **700** altogether and accelerometer **706** may instead be used to select an adjustable volume of solution to be atomized and/or select a rate of atomization as discussed in more detail below.

In one embodiment, for example, boost converter **714** and sinewave generator **716** may combine to generate a sinewave signal (e.g., signal **728** of FIG. **7**) having an amplitude between approximately 20V peak-to-peak (P-P) and approximately 90 V P-P (e.g., about 70 V P-P) and a variable frequency sufficient to adequately excite transducer **718** across a frequency band (e.g., between about 15 KHz and 150 KHz) that may include multiple resonance frequencies that may be inherent to the operation of transducer **718**. The frequency of sinewave signal **728** may be varied by processor **704** in response to user input at controls **712** (e.g., as discussed above in relation to buttons **302** and **304** of FIG. **3**) or in response to spacial orientation change data (e.g., as may be generated by accelerometer **706** when the orientation of aerosol generation device **700** is changed in such a manner as to signal a request from the user to change the frequency of sinewave signal **728**).

In one embodiment, for example, activation of button **302** may cause the frequency of sinewave signal **728** to change (e.g., increase) and activation of button **304** may cause the frequency of sinewave signal **728** to change (e.g., decrease). In an alternate embodiment, for example, rotation of aerosol generation device **700** in a clockwise direction may cause the frequency of sinewave signal **728** to change (e.g., increase) and rotation of aerosol generation device **700** in a counter-clockwise direction may cause the frequency of sinewave signal **728** to change (e.g., decrease).

Variation of the frequency of sinewave signal **728** may activate one of several resonance frequencies that may be inherent to the operation of transducer **718**. As per one example, transducer **718** (e.g., as discussed above in relation to transducer portion **606** of FIG. **6** and transducers **406** and **506** of FIGS. **4** and **5**, respectively) may include a piezo-electric vibrator (e.g., a ceramic vibrator) that may be caused to vibrate at at more than one resonance frequency. In addition, as the resonance frequency is increased, so may the volume of atomized solution and/or the rate of atomization as generated by atomizer **720**.

Accordingly, a first frequency of sinewave signal **728** may be selected to be the lowest resonance frequency that may be associated with transducer **718** and in response, may cause the lowest rate of atomized solution to be produced by atomizer **720**. A second frequency of sinewave signal **728** may be selected to be the second lowest resonance frequency that may be associated with transducer **718** and in response, may cause the second lowest rate of atomized solution to be produced by atomizer **720**. A third frequency of sinewave signal **728** may be selected to be the third lowest resonance frequency that may be associated with transducer **718** and in response, may cause the third lowest rate of atomized solution to be produced by atomizer **720** and so on.

Transducer **718** may exhibit multiple (e.g., **5**) discrete resonance frequencies stored within memory **732** and by operation of controls **712** and/or accelerometer **706**, a user may toggle between each discrete resonance frequency to generate discrete variations in a rate of atomized solution that may be produced by aerosol generation device **700**. The user may then be apprised of the selected rate of atomization via appropriate illumination of LEDs **710** by processor **704** (e.g., as discussed above in relation to the visual indicators of FIGS. **1** and **3**). In the absence of controls **712** and accelerometer **706**, processor **704** may select a resonance frequency (e.g., one of many resonance frequencies as may be stored within memory **732** of processor **704**) as a default frequency of operation.

Turning to FIG. **8**, an alternate embodiment of aerosol generation device **800** is exemplified, whereby exploded view **802** exemplifies body **804** that may include removable head **806**. Head **806** may, for example, may be removably attached to body **804** via a mechanical latching mechanism (e.g., via magnets not shown) that may cause mechanical communication between head **806** and body **804** and may further cause electrical communication between connector **808** of head **806** and a corresponding connector (not shown) of body **804**. As such, aerosol generation device **800** may be configured for operation while head **806** may be removably attached to body **804**.

In one embodiment, head **806** may be configured with components (e.g., components **708**, **718**, **720**, **724** and **726** as discussed above in relation to FIG. **7**) so that various heads **806** may be interchanged with body **804** under certain circumstances. As per one example, a user may possess multiple heads **806** each containing a different solution within a reservoir (e.g., as discussed above in relation to reservoir **724** of FIG. **7**) so that the user may change attributes of aerosol generation device **800** (e.g., a flavor of atomized solution, a medicine contained within the atomized solution and/or liquid contained within the reservoir) on demand.

Furthermore, head **806** may be exchanged with replacement heads if/when components (e.g., transducer **718** and atomizer **720** as discussed above in relation to FIG. **7**) of head **806** become worn and/or inoperable. In such instances, head **806** may be replaced to accommodate reuse of the electrical components (e.g., processor **704**, power supply **702**, recharge circuit **722**, power/data connector **730**, accelerometer **706**, LEDs **710**, controls **712**, boost generator **714** and sinewave generator **716** as discussed above in relation to FIG. **7**) of body **804**.

Other aspects and embodiments of the present invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. For example, the aerosol generation device may be implemented with virtually any form factor (e.g., cigarette shaped) so as to facilitate portability. It is intended, therefore, that the specification and illustrated embodiments be considered as examples only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. An aerosol generation device, comprising:

a processor;

an airway egress port;

a user input device coupled to the processor and configured to generate a control signal that is indicative of one of a plurality of frequencies;

a generator configured by the processor to generate a signal having a frequency selected from the plurality of frequencies in response to the control signal from the user input device; and

an atomizer in direct contact with a solution, the atomizer configured to provide atomized solution to the airway egress port at a rate proportional to the selected frequency.

2. The aerosol generation device of claim **1**, wherein the user input device includes a plurality of buttons.

3. The aerosol generation device of claim **2**, wherein the plurality of buttons are configured to generate the control signal in response to sensed capacitance.

4. The aerosol generation device of claim **2**, wherein the plurality of buttons are configured to generate the control signal in response to tactile depression.

5. The aerosol generation device of claim **1**, wherein the processor is configured to select from the plurality of frequencies stored within a memory of the processor.

6. The aerosol generation device of claim **5**, wherein each of the plurality of frequencies correspond to a resonance frequency associated with the atomizer.

7. An aerosol generation device, comprising:

a processor including a memory containing a plurality of resonance frequencies;

an airway egress port;

a generator configured by the processor to generate a signal having a frequency selected by a user from the plurality of resonance frequencies;

an atomizer in direct contact with a solution, the atomizer configured to provide atomized solution to the airway egress port at a rate proportional to the selected frequency; and

wherein the processor selects the frequency to be equal to one of the plurality of resonance frequencies associated with the atomizer.

8. The aerosol generation device of claim **7**, further comprising a user input device configured to generate a control signal, the control signal being used by the processor to select the frequency.

9. The aerosol generation device of claim **8**, wherein the user input device includes a plurality of buttons.

10. The aerosol generation device of claim **9**, wherein the plurality of buttons are configured to generate the control signal in response to sensed capacitance.

11. The aerosol generation device of claim **9**, wherein the plurality of buttons are configured to generate the control signal in response to tactile depression.

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