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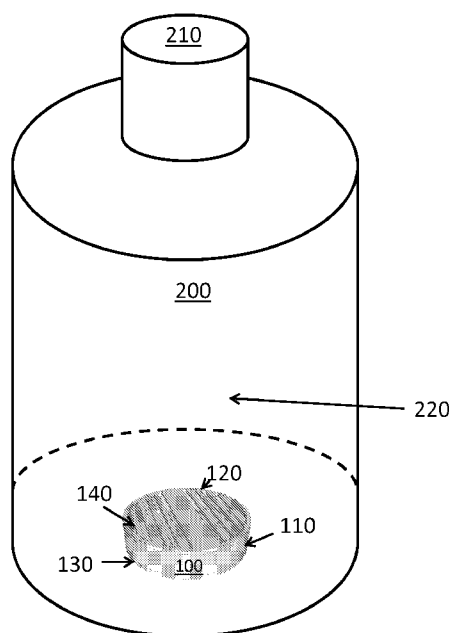
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(54) Title: UNIVERSAL DEVICE FOR MONITORING AND REPORTING FLUID CONSUMPTION AND METHOD USING SAME

FIGURE 2



(57) Abstract: A liquid intake tracking device for removable insertion into a beverage container in order to track an amount of liquid consumed, the rate of liquid consumption over time, and to provide alerts to the user. The device connects wirelessly to an application executing on an external electronic device which provides user with liquid consumption data and reports 5 concerning the user's interaction with the beverage container. Methods for tracking liquid intake are also disclosed.



5 **Universal Device for Monitoring and Reporting Fluid Consumption and
Method Using Same**

FIELD OF INVENTION

The present invention relates to liquid volume detectors, specifically for use in a container of liquid to be consumed by a user, in which a liquid volume is calculated by
10 measurements taken within the container, such as by measuring pressure with a pressure sensor with a piezo-resistive sensing element.

BACKGROUND OF THE INVENTION

Staying hydrated is important for health reasons, and it has become common for people to want to track their water and liquid consumption. The intake of specific volumes of
15 water throughout the day is important for many purposes, such as weight loss or weight maintenance, medical treatments, preventing dehydration, or to maintain a healthy lifestyle. The USDA and the medical community recommend that users consume at least eight eight-ounce glasses of water during a single day. Studies show that lack of sufficient liquid consumption by individuals could have adverse health effects.

20 One difficulty that people encounter with consuming enough water or liquids throughout the day is tracking how much they have consumed and how much they need to consume.

Some individuals attempt to track their intake of liquids themselves, either by counting the number of glasses they consume or entering consumption manually into a phone
25 application. This can lead to incorrect calculations as many individuals do not accurately track their consumption. Other individuals may use bottles currently on the market which

claim to track the amount of liquid consumed from that bottle alone. But at present there exists no product which can be inserted directly into any bottle or glass of the user's choosing and continually track the total consumption and the rate of consumption for that user, as well as provide alerts to users to consume enough throughout the day. What is needed in the art is

5 improvements in devices that track consumption and that can be used in a variety of containers.

SUMMARY OF THE INVENTION

The present invention is a liquid intake tracking device to be inserted into and remain within the main volume of a container.

10 In accordance with a broad aspect of the invention, a liquid volume is calculated within the container. In one implementation, the liquid volume is calculated by a pressure sensor residing within the interior region of the liquid intake tracking device. The pressure applied on the pressure sensor is communicated wirelessly to an external electronic device. The electronic device (e.g., a smartphone having an app executing on a processor thereof)

15 uses the data to determine the volume of liquid in the container, the amount of liquid consumed by the user, and the rate of liquid consumption.

In accordance with a more particular aspect of the invention, a liquid intake tracking device detects changes in a volume of liquid in a beverage container and wirelessly communicates detected information to an electronic device is provided. The tracking device

20 is sized to be received within the beverage container. The tracking device includes a pressure sensor with a piezo-resistive sensing element sized and shaped to be received within the beverage container and enclosed within the interior region of the liquid intake tracking device, the interior region being separated from any liquid within the beverage container by a housing. A portion of the housing further contains a flexible, fluid-impermeable membrane

capable of acting as a transfer medium between the external environment exposed to liquids within the beverage container and the pressure sensor within the interior region of the housing so as to ensure that the sensor does not come in direct contact with liquid. The liquid in the beverage container exerts a force on the flexible membrane, which causes a sealed
5 volume (e.g., air, CO₂, N₂, or other non-toxic fluid) located on the interior side of the housing beyond the membrane, or between the membrane and the pressure sensor, to compress or expand so as to cause the pressure to equalize with the liquid in the beverage container. The pressure imparted by the volume of liquid and air within the container is measured by the piezo-resistive sensing element of the pressure sensor. A liquid volume
10 detection circuit is connected to the pressure sensor and is operative to measure the pressure exerted on the pressure sensor as a function of the proportion of respective amounts of liquid and air within the volume contained by the container and to output a measurement value. The measurement value of the liquid volume detection circuit is indicative of a liquid volume in the beverage container. A wireless communication module is configured to communicate
15 one or more measurement values to an external device.

In accordance with further aspects of the invention as may be implemented in one or more embodiments, a tracking device can be further configured to include further circuitry and functionality. Thus, an accelerometer can be arranged to be operably coupled to the beverage container and to respond to changes in an orientation of the beverage container with
20 an orientation signal. An orientation sensor module can be configured to receive the orientation signal from the accelerometer and determine changes in an orientation of the beverage container between a non-vertical position and a vertical position. A control circuit can be connected to the orientation module and the liquid volume detection circuit and operates to inhibit the liquid detection circuit while the orientation of the beverage container
25 is in a non-vertical position. A temperature sensor module and a pH sensor module each can

be operably connected to the liquid intake tracking device to detect changes in temperature and pH, respectively, within the beverage container. One or more of these further circuits and devices can be included in a particular implementation of the invention.

In accordance with a further aspect of the invention, a method for tracking liquid intake using a device is provided in which the device is sized to be received within a beverage container and to remain at the bottom of the beverage container to detect changes in a volume of liquid in the beverage container. The method comprises the steps of generating an orientation signal from an accelerometer operably coupled to the beverage container to respond to changes in an orientation of the beverage container, determining changes in orientation of the beverage container between a non-vertical position and a vertical position based on the orientation signal, measuring a pressure on a pressure sensor having a piezo-resistive sensing element, the pressure being a function of a proportion of respective amounts of liquid and air within the beverage container while the beverage container is in a vertical orientation, and transmitting the measured pressure information to an electronic device for use by an input module (a) together with the orientation signal or information derived from the orientation signal, or (b) for only those measurements taken while the beverage container is in a vertical orientation.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

Figure 1 shows a perspective view of one embodiment of the invention.

Figure 2 shows a perspective view of the embodiment of Figure 1 disposed inside a container.

Figure 3A shows a perspective view of a second embodiment of the invention.

Figure 3B shows an exploded view of the embodiment of Figure 3A.

Figure 4 shows a cross-sectional view of the arrangement of Figure 1.

Figures 4A and 4B are detailed views showing further details of the cross-sectional view of Figure 4.

Figure 5 illustrates an exemplary external electronic device.

5 Figures 5A and 5B illustrate outputs on a display of the external electronic device that can be provided based on coordinated communication between the external electronic device and a liquid tracking device such as illustrated in Figures 1 through 4B.

Figure 6 is a flow diagram illustrating several aspects of the use of a liquid tracking device in accordance with one or more embodiments of the invention.

10 **DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS OF THE INVENTION**

By way of overview and introduction, the present invention comprises a liquid intake tracking device for the measurement of the amount of liquid in a beverage container. The device can be part of a system that includes an application that includes code that runs on a processor of an external device such as a smartphone or web-accessible server. The device
15 connects to the application and exchanges data with the application. In some arrangements, the device performs all calculations so as to communicate to the application a calculated amount of liquid consumed as well as the rate of consumption. In other arrangements, calculations can be performed within the application using raw information communicated from the device. In one implementation, a pressure measurement is taken by a pressure
20 sensor having a piezo-resistive sensing element and used to calculate the volume of liquid within the container, as described below. As such, there is a calibration process which precedes device use, using a coordination of information exchange between the device and the application executing in an external electronic device (see **Figure 5**), with the calibration

information being stored for use in making particular calculations. When such information is stored within a memory unit of the device, the device can make measurement calculations in an autonomous manner and send the computed measurement volumes to the application whenever a communication link is available, and otherwise store that information for

5 transmission when possible. The measurement calculations can be constrained to be made only at selected moments, such as not when motion of the container is detected or when the container is at certain inclinations. An accelerometer and an orientation sensor module are included in the device for at least this purpose.

The liquid intake tracking device resides at the bottom of the beverage container and
10 measures the pressure of the liquid above it. The pressure at the bottom of a volume at the bottom of a column h of water is calculated as follows:

$$P = P_{\text{atm}} + \rho gh$$

Where P is the measured pressure in Pascals, P_{atm} is the prevailing atmosphere pressure in Pascals, ρ is the density of the liquid in the beverage container (for water, this is 1000 kg/m^3),
15 g is the strength of Earth's gravity ($\sim 9.81 \text{ m/s}^2$), and h is the height of the water column in meters. Atmospheric pressure (P_{atm}) is nominally 101,000 Pascals at sea level, but varies with altitude and weather. To account for variations in atmospheric pressure, during calibration P_{atm} will be independently measured when no liquid is in the beverage container. When the beverage container is filled with a liquid, the water level is calculated as follows:

20

$$h = (P - P_{\text{atm}} - \Delta_P) / \rho g$$

Where P is the measured pressure in Pascals, P_{atm} is the prevailing atmospheric pressure in Pascals, Δ_P is calculated as the difference between the measured P_{atm} and P when there is no

liquid in the beverage container, ρ is the density of the liquid in the beverage container (for water, this value is 1000 kg/m^3), and g is the strength of Earth's gravity ($\sim 9.81 \text{ m/s}^2$).

For the purposes of this application, specific embodiments of the present invention are described and illustrated herein, but these embodiments are exemplary and are not limiting.

5 Additionally, terms that describe relative position refer to an embodiment of the invention as illustrated, but those terms do not limit the orientation in which the embodiments can be used.

As shown in in **Figure 1**, an embodiment of the liquid intake tracking device **100** has a housing **110** having a top cap **120** and a bottom cap **130**, and defines an interior region **320** (see **Figure 3B**) separated from any liquid in the beverage container. The housing **110** is
10 sealed and made of a non-permeable material so as to protect the electronic components within from liquid. The top cap **120** defines a series of apertures **140**. Liquid can flow in and out through the apertures **140**. In a particular environment, the outer dimension of the device is no larger than 37 millimeters at any point, to facilitate insertion and withdrawal from a variety of containers.

15 **Figure 2** shows the liquid intake tracking device **100** in position within a container **200**, having been received through top opening **210** and disposed within the main volume **220** of the container. The device remains within and at the bottom of the container **200** throughout use. A variety of container types can be used with the device **100**, such as bottles, glasses, and other containers that the device can be inserted into. For containers with a
20 closable top, the device remains secure within the closed container. For containers with an open top, the device can include a ballast (not shown) to secure it from movement as the container is tipped (e.g., when a user is taking a sip).

Figures 3A and **3B** show an illustrative embodiment of the liquid intake tracking device **100** with the top cap **120** not shown in order to provide a better view of the membrane

310 discussed below. As seen in **Figure 3A**, the liquid intake tracking device **100** has a housing **110** with a bottom cap **130**. In some embodiments, in lieu of a top cap **120**, a semi-flexible membrane **310** comprises at least a portion of the housing. In other embodiments, the semi-flexible membrane **310** is located directly below and is sealingly connected to the top cap **120** and in register with the apertures **140** of the top cap **120**, such that the liquid in the beverage container can flow through the apertures **140** in the top cap **120** to come in contact with the membrane **310**. The membrane **310** is made of a non-permeable material so as to protect the electronic components within from liquid. The membrane has a first side, which is exposed to the liquid within the beverage container, and a second side, which isolates any liquid within the beverage container from the components within the housing and which flexes into the interior region of the liquid intake tracking device and thereby changes the pressure within at least a portion of the housing. In some embodiments, the membrane **310** could be silicon molded with plastic. The membrane **310** flexes in response to the pressure imparted by liquid in the beverage container. **Figure 3B** shows an exploded view of the liquid intake tracking device **100** to better illustrate the arrangement of elements within the interior region **320** of the liquid intake tracking device **100**. The interior region **320** is separated from any liquid in the beverage container by the housing **110**. A circuit board **330** is located beneath the flexible membrane **310** such that a sealed volume **340** exists between the membrane **310** and the circuit board **330**, for example, a sealed volume of air. In an ideal embodiment, the ratio of the surface area of the membrane **310** to the volume **340** is large to reduce stress on the membrane **310**. A pressure sensor **410** (see **Figure 4**) is located within the sealed volume, preferably on the circuit board **330**. In some embodiments, the pressure sensor **410** is a barometric pressure sensor with a piezo resistive sensing element. The pressure sensor **410** can measure a force that is applied from an external environment upon the liquid intake tracking device **100**, such as by a liquid in a beverage container **200**. Unless

the pressure sensor is itself a sealed structure, it should not come in direct contact with liquid within the beverage container, but rather the pressure measurement should be taken indirectly. As liquid flows onto the membrane **310**, either directly or through the apertures **140** on the top cap **120**, the membrane **310** causes the volume **340** to compress or expand so as to cause the pressure of the volume **340** to equalize with the pressure of the surrounding liquid. The pressure sensor **410** measures the pressure exerted upon it by the volume **340**. The liquid level within the volume is calculated by a liquid volume detection circuit connected to the pressure sensor **410**. That circuit comprises a hardware processor **450** executing code that calculates a pressure measurement value from the pressure sensor. The value of the pressure changes as a function of the respective amounts of liquid and air in the container. In particular, different liquids have specific densities.

The respective pressure values measured when the container is empty and full can be captured during a calibration process in coordination with a software application that guides the user on capturing such data and which causes the information to be stored, as discussed further below. The pressure at the bottom of a column of water, for instance, can be calculated by the formula $P = P_{\text{atm}} + \rho gh$, where P is the measured pressure in Pascals, P_{atm} is the atmospheric pressure in Pascals, ρ is the density of the liquid in the container **200**, g is the strength of Earth's gravity ($\sim 9.81 \text{ m/s}^2$), and h is the height of the water column in meters. When the container **200** is filled with liquid, the liquid will exert a measured pressure upon the device **100** which can be used to calculate the volume of the liquid in the container **200** throughout changes as the liquid is being consumed.

In some embodiments, the initial calibration measurements of the empty container can be used to calculate any differences noted between the pressure sensor **410** in the device and a barometric pressure sensor included with an external electronic device **500** to calibrate the pressure value measured in the empty and full container in relation to the pressure sensed by

the electronic device **500**. The value of the P_{atm} can be sensed by a barometric pressure sensor on the external electronic device **500**, when such a sensor is available, and such information can be sensed each time a pressure reading is taken by the liquid intake tracking device **100**, at interval time periods set by the user, at the request of the user, or at some other interval, and the algorithm can include code implemented to utilize such readings in order to adjust the pressure measurements by the intake tracking device **100** in order to provide liquid intake reports that are adjusted to compensate for prevailing (including changed) atmospheric pressure values. The fluid volume can be reported as a percentage (3/4 full, or in units such as 600 ml left or 400 ml consumed).

The device **100** includes a source of electrical power, such as an electrical power storage device **350**. The electrical power storage device can be a battery for instance, a $LiFePO_4$ battery. A suitable battery has capacity to energize the device for one or more days of use. In a more particular embodiment, a wireless charging coil **360** can be provided and configured to charge the power storage device **350**. The wireless charging coil **360** can be located below the battery to minimize distance and obstructions between the charging coil and a wireless power transmitter. In that case, the container **200** and the device **100** disposed therein can be placed on a wireless power transmitter so as to charge the device without removal from the container. For example, the wireless charging can be performed according to the Qi standard. In some embodiments, the device includes an alert module comprising code that executes in the processor and causes an alert signal to be issued and drive a suitable alert device (e.g., a piezo, a speaker, a light, and so on) so as to indicate user when the charging of the electrical power storage device **350** is complete.

Figure 4 shows a cross-sectional view of the embodiment illustrated in **Figures 1, 3A, and 3B**. The device includes a wireless communication module **420** located on the circuit board **330** which is configured to enable communication of one or more measurement

values from the liquid volume detection circuit to an external electronic device **500** (see **Figure 5**) such as a smart phone. Communications can be in accordance with a variety of protocols. For instance, wireless communication can be accomplished through use of the Bluetooth 4.0 standard. The external electronic device **500** is capable of storing and tracking the data provided by the device. Among the data provided to the external electronic device **500** is information that enables presentation of the total consumption (as shown) and the average consumption over a period of time such as on a graph showing consumption amount plotted against days of the week or weeks of the year, and so on (not shown). Such information can be conveyed wirelessly from the device **100** or computed at the EED **500**.

The device **100**, in certain implementations, includes an accelerometer **430** and an orientation sensor module **440**. These components, as well as the wireless communication module **403**, can be located on the circuit board. The accelerometer **430** provides signals in response to changes in an orientation of the beverage container indicative of whether the device is in motion. In such embodiments, signals output by the accelerometer are provided to the processor **450** and are processed by code executing therein to determine whether the device **100**, and hence the container **200**, is in motion. Similarly, the orientation sensor module **440** provides signals to the processor **450** which are processed by code executing therein to determine whether the device **100**, and hence the container **200**, is in a vertical or non-vertical position, and optionally any particular angle in between. Changes in bottle orientation and any agitation of liquid within the container and can have an effect on the liquid volume in tracking devices which rely on distance measurements relative to a sensor (e.g., ultrasonic measurements) or in those that utilize column height measurements. In the embodiments described herein, the housing obtains measurements via a pressure sensor **410** and, as such, is relatively insensitive to sloshing or liquid movement as long as the device remains within the volume of fluid and not exposed to air within the beverage container **200**.

Nevertheless, in certain embodiments, the processor **450** is configured by the programmed code that it executes to determine, based on accelerometer and orientation sensor module information, whether to take a measurement at a given time based on the orientation and movement of the device. The orientation sensor **440** and the liquid volume detection circuit
5 are connected to a control circuit which includes the hardware processor **450** and memory **460** for storing information about one or more containers with which the device **100** has been associated during calibration (as discussed below), liquid volume measurements made by the processor, the time of such measurements, and other data. The control circuit can comprise further code which causes the processor to inhibit the liquid detection circuit from taking
10 liquid volume measurements while the container or its orientation are determined to be in a state of motion or in an undesired orientation. By constraining the detection circuitry, a higher percentage of the measurements have valid data and energy within the electrical power storage device is more efficiently preserved.

In one embodiment, the housing is covered with a silicone casing to reduce noise and
15 rattle when the device is inserted into the bottle.

In a more particular embodiment, a temperature sensor module **470** is connected as part of the control circuit to provide a temperature reading signal of the liquid temperature either in real-time or on-demand. The temperature readings can be communicated wirelessly to the EED **500** by the wireless communication module **420**. Alternatively, the reading
20 signals can be used by the processor **450** to account for variations of pressure measurements that occur with changes in temperature and inform an algorithm executing in the control circuit (as an input to the algorithm) so as to provide a more accurate determination of the liquid volume at the time of the measurement.

In some embodiments, a pH sensor module **470** can be provided to a pH reading of the liquid either in real-time or on-demand. The pH sensor module and the temperature sensor module can be located on the circuit board. Optionally, the sensor element of each of these modules has a face exposed to fluid in the container, such as through an opening in the housing **110**. The pH readings are communicated wirelessly to the EED **500** by the wireless communication module **420**. Alternatively, the pH readings can be used by the processor **450** to account for variations of pH level to inform an algorithm executing in the control circuit (as an input to the algorithm) so as to provide a more accurate determination of the liquid volume at the time of the measurement due to variations of pressure that occur with changes in pH.

Optionally, some embodiments of the invention can have a ballast (not shown) positioned within the body of the device to ensure the liquid intake tracking device stays disposed at the bottom of the beverage container throughout use. The ballast can be a heavy element or material, such as steel or sand.

In some embodiments, a porous compartment can be provided which has apertures that are in fluid communication with any liquid in the beverage container. The compartment can have a closeable access or otherwise be configured to receive a plurality of ceramic beads. For instance, the beads can be loose or included in a cartridge or pouch that fits into the compartment. The apertures are sized to not permit release of the beads into the liquid within the container, yet permit passage of the liquid into the compartment and across the beads. The beads have a combined surface area that interacts with the liquid for any one of a variety of purposes, such as to regulate the pH of water used as the liquid in the container. Such a compartment can attach to the device **100**, for example, by clipping onto it, or can be constructed as part of the device **100**. In one or more arrangements, the beads can be combined with a ballast material.

Some embodiments of the device can provide the user with alerts. One type of alert is an audible alert provided by a piezo buzzer **480** located on the circuit board. Another type of alert is a visual alert provided by an LED light **490** located on the circuit board. A third type of alert is a notification provided on or by the EED **500** (e.g., as a result of a Bluetooth push-
5 notification from the control circuit), on a display **510** thereof, rather than at the device **100**. The alert can take many forms, such as a visual “Alert” **530** on the display of the EED **500**, as shown in **Figure 5A**. Alert settings can be established in the user’s preferences, by interaction with an app executing on the EED **500**, and thereafter be uploaded to the memory **440**. One alert could be to drink more or less liquid to reach a target consumption rate **540**.
10 Thus, for instance, if the container is filled with water, the alert can be to consume more liquid. If the container is filled with an alcoholic drink, the alert can be to moderate consumption and consume less liquid (e.g., during the course of a party, etc.). Another user alert could be to refill the beverage container when the level of liquid in the container is determined to be empty. The target consumption can be a rate (liquid intake over time, as
15 calculated by the processor in the electronic device) or an amount. The amount can be a daily goal. The display can provide summaries of consumption during the present week, a daily average, whether consumption goals have been met and/or the degree to which a goal or prior goals have been met, and so on.

In operation, a user accesses a software application via a web browser or an app store,
20 such as Google Play or the Apple Store, and executes the application on a device such as the EED **500**. The machine executing the application provides a wireless interface to the control circuit to enable a user to establish environmental settings for the device **100**. The settings enable the device to be associated with one or more containers **550**, by interacting with one or more buttons **520** or other inputs (e.g., a touch-screen or a voice command module). A
25 beverage-container profile module stores and provides beverage container profile

information. Each container can have a different total liquid storage amount (volume) and shape, and that information can be input by the user directly or input by selecting an icon representative of the appropriate setting (as shown). Selections can be provided through the EED **500** and provided by wireless communication to the communication module **403** of the device, and from there to the control circuit for storage in the memory **440**. Thereafter, the device can operate substantially autonomously in collecting and storing information concerning use of the device with a selected container. In other words, the device **100** can take liquid volume measurements over time and store those measurements even if there is no connectivity to the EED. When communications are established again between the device and the EED, the measurements and other data such as temperature and pH, if available, can be uploaded to the EED for display on the screen. Among other information that can be displayed is the amount of fluid consumed **560** (e.g., as a percentage (as shown) or as a number of ounces or milliliters), whether the user is ahead of, behind, or on a target consumption rate **540**, and a variety of other information concerning the fluids consumed that day, that week, or over any other measuring period. The measurements and other information can be shared from the EED over a connection to a server in support of sharing via a social network or otherwise.

The software application on the EED further comprises an input module to receive the measured pressure from the liquid intake tracking device **100** via the wireless communication module **420**; a volume determination module executed in the processor to determine the volume of liquid in the beverage container as a function of the pressure measured by the pressure sensor **410**; a calculation module executed in the processor to calculate the amount of liquid intake as a function of the changes in the volume of liquid in the beverage container, the volume information from the beverage-container profile, and the liquid volume values calculated by the volume determination module; and an output module executed in the

processor to show on the EED display **510** information including the amount of liquid intake. Each of these modules comprises code that is implemented to provide the respective functionalities noted above, using algorithms, formulae, and steps understood from the foregoing description as well as by persons having ordinary skill in the art.

5 In one embodiment, all components of the liquid intake tracking device are heat resistant to at least 70 degrees Celsius to allow the device to be dishwasher safe and to be used in hot liquids. In another embodiment, the device has walls that have a continuous (e.g., smooth texture) for use with carbonated liquids to minimize bubble formation. This can be accomplished, for example, with PTFE coatings. In yet another embodiment, the device can
10 be used with inhomogeneous liquids, such as powder based solutions.

 In some embodiments, the device **100** can enter a deep sleep mode in order to conserve energy. During deep sleep, the processor **450** is put in a low power state by code implemented therein which prohibits communication between the device **100** and the EED **500** until it receives a prompt from either the accelerometer that the beverage container is in
15 use, the wireless communion module, or a timer.

Figure 6 illustrates certain processes that are performed by the liquid tracking device **100**. The processes illustrated in **Fig. 6** can be taken in a different order, or not in the same flow as illustrated. The flow diagram is an expedient for discussing operation of the device **100**, and is not meant to be restrictive of the particular order of steps or the number of steps
20 that need be taken in any given implementation. Rather, methods in accordance with the invention are defined by the claims that follow this description.

 Turning then to **Fig. 6**, as shown, for instance, after the initialization of memory and peripheral hardware at step **600**, which can include all of the calibration and set-up discussed above, a test is made at step **604** to determine, for a device already in the deep sleep state,

whether to wake to a fully-operative state. The deep sleep mode helps the device **100** to reduce the overall amount of power consumed, as the sensors consume power while performing measurements.

The device wakeup routine is implemented by the processor **450** and can be
5 programmed at step **604** to respond to the wireless communication module **420**. This can be detected by signals arriving at the wireless communication module **420**. As noted in step **612**, the programming comprises code that is implemented in the processor **450** to determine if a command was issued by the user. The processor can execute that command in step **616**. If the wakeup is a response to the wireless communication module **420**, at step **608** the EED
10 **500** first handles connection and disconnection events and client read events. If a command has been issued by the user in step **612**, the device **100** and the EED **500** executes the command in step **616**.

As noted at step **620** the device **100** wakeup can be programmed to respond to the accelerometer **430** or a timer, and, in that instance, the device **100** and EED **500** acquire
15 accelerometer and pressure sensor data (step **628**), determine if calibration is requested (step **644**), and calculate liquid volume (step **656**), as discussed in detail below, all in response to such programming.

If there is no wake up event, as determined at steps **604** and **620**, the process can resume at start, looping in this manner in a low power mode, as indicated by the connector
20 “A” back to start.

After the EED **500** powers on peripherals, as indicated at step **624**, the EED **500** implements step **628** to receive data from the pressure sensor **410** to determine the barometric pressure.

In certain embodiments, data is also received from the accelerometer **430**, when present, to determine the orientation and any movement of the device **100**. In one implementation in which an accelerometer is used, the device **100** can then reenter deep sleep until the accelerometer **430** determines that the device is in use, as shown in step **632**. When the accelerometer **430** activates the device **100**, at shown at step **632**, the devices sends sensor data from the temperature sensor module **460** and any pH sensor **470**, if present, to the EED **500**, at step **636**. Once the sensor data has been sent by the device **100** to the EED **500** at step **636**, embodiments that include the temperature sensor module **460** and the pH sensor **470** can have those elements powered off to further conserve energy.

At step **640**, the sensor data can be used to perform compensation calculations to adjust for variations in the pressure reading with respect to the temperature and pressure, as these parameters are sensitive to changes in temperature and pressure. In certain embodiments, adjustments are made for variations in either pressure or temperature. In still other embodiments, the calculation of fluid volume is made without regard to changes in pressure or temperature.

At step **644**, a calibration process is may be requested by the user such as when using the liquid tracking device **100** with a new container, or by programming in the processor configured to request recalibration after a time period or event. As indicated at step **648**, a calibration is performed at least prior to device use. An ambient pressure reading of the empty beverage container **200** is taken by the pressure sensor **410** and communicated via the wireless communication module **420** to the EED **500**. The readings taken of the empty beverage container can be used to calculate any differences noted between the device's pressure sensor **410** and any barometric pressure sensor included in the EED **500**, but certainly are used to calculate any difference between the measured atmospheric pressure and the prevailing atmospheric pressure to account for variations due to altitude or weather. The

temperature can be determined at this point in the calibration process by the temperature sensor module **460**, when available, and communicated via the wireless communication module **420** to the EED **500** for use in performing calculations to compensate for changes in pressure measured by the pressure sensor as a result of temperature. Likewise, the pH can be
5 determined by the pH sensor **470**, when present, and communicated via the wireless communication module **420** to the EED **500** for use in performing calculations to compensate for changes in pressure measured by the pressure sensor as a result of the now-known pH level.

The beverage container **200** is then filled to maximum capacity and a second pressure
10 reading is taken (optionally with further temperature or pH readings) and communicated wirelessly via the wireless communication module **420** to the EED **500**. The readings taken of the full beverage container are used to establish a pressure measured by the sensor when the bottle is at its maximum capacity. The measured pressure readings of the empty container and the full container are used together to determine the volume of the water in the container.
15 The water volume is calculated first as a linear quantity based on the measured pressure of the sensor; volume is computed using the calculations previously described herein. Any barometric pressure readings taken by the barometric pressure sensor on the EED **500** can also be used retroactively to account for variations in atmospheric pressure if the EED **500** and the liquid intake tracking device **100** are not in wireless communication with each other
20 during use.

Once calibration has been completed at step **652**, the volume of the liquid in the beverage container can be calculated at step **656**. During step **660**, the processor can be programmed to use information from any accelerometer to determine whether the data is valid based on the orientation and any movement of the beverage container. Data can be
25 marked as either valid (as noted in step **668**) or invalid (as noted in step **664**). During step

692, data that was marked as invalid in step **664** is recorded while data that was marked as valid in step **668** undergoes additional processing at steps **672** through **688**, as discussed next.

In the event that data is marked valid (or otherwise has been gathered in implementations in which the “validity” of the data is not tested), processing continues to
5 determine the volume of liquid in the beverage container at any given time at which the determination is being made, and, correspondingly, to determine the amount of liquid consumed by the user at that time.

If the liquid volume is above a threshold value, as determined during step **672**, a “fill” event is recorded at steps **676** and **692**, as this is indicative of the container having been filled
10 If the liquid volume is below a threshold value, as determined during step **680**, the liquid volume is calculated to determine if the volume of liquid in the beverage container had been emptied (step **684**). If the beverage container had been emptied, this data is recorded at step **692**. If the beverage container is not entirely empty, then a “drink” event is recorded at step **688** (which can be the same data recordation as indicated at step **692**). After the data is
15 recorded, the process can loop back to start, as indicated by the connector “A.”

It should be understood that various combinations, alternatives, and modifications of the present invention could be devised by those skilled in the art. The present invention is intended to embrace all such alternatives, modifications, and variances that fall within the scope of the appended claims.

20 While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

We Claim:

1. A liquid intake tracking device that detects changes in a volume of liquid within a beverage container and that wirelessly communicates detected information to an external electronic device, comprising:

5 a pressure sensor sized and shaped to be received within the beverage container and configured to emit a signal in response to pressure imparted on the pressure sensor by any liquid in the beverage container;

 a liquid level detection circuit connected to the pressure sensor and operative to measure the pressure of the sealed volume and output at least a first measurement value
10 concerning a first calibration, a second measurement value concerning a second calibration, and a current volume measurement value, wherein the first calibration measurement value is indicative of the beverage container being empty, the second calibration measurement value is indicative of the beverage container being filled, and the current volume measurement value is indicative of a current liquid volume in the
15 beverage container;

 a control circuit having a processor and a memory unit configured to receive and store the first calibration measurement value, the second calibration measurement value, and the current volume measurement value; and

 a wireless communication module configured to communicate at least the first
20 calibration measurement value, the second calibration measurement value, and the current volume measurement value to the external electronic device,

wherein the control circuit of the liquid intake tracking device is configured to provide at least the current volume measurement value to the external electronic device in an autonomous manner.

2. The liquid intake tracking device of claim 1, wherein the pressure sensor is disposed within a housing.

3. The liquid intake tracking device of claim 2, wherein the housing defines an interior region separated from any liquid within the beverage container.

4. The liquid intake tracking device of claim 3, wherein the housing further defines one or more apertures there through, and a semi-flexible membrane disposed in register with the one or more apertures and defining a flexible edge of a sealed volume comprising at least a portion of the interior region of the housing, the membrane flexing in the vicinity of the one or more apertures.

5. The liquid intake tracking device of claim 1, further comprising a ballast.

6 The liquid intake tracking device of claim 1, further comprising:

an accelerometer arranged to be operably coupled to the beverage container to respond to changes in an orientation of the beverage container with an orientation signal; and

an orientation sensor module configured to receive the orientation signal from the accelerometer and determine changes in an orientation of the beverage container between a non-vertical position and a vertical position,

wherein the wireless communication module communicates the one or more measurement values at a time after the orientation sensor module determines changes in the orientation of the beverage container from a non-vertical to a vertical position.

7. The liquid intake tracking device of claim 6, wherein the liquid level detection circuit, the accelerometer, the orientation sensor module, and the wireless communication module are disposed on a circuit board.

8 The liquid intake tracking device of claim 6, further comprising a control circuit
5 connected to the orientation module and the liquid level detection circuit and operative to inhibit the liquid detection circuit while the orientation of the beverage container is in a non-vertical position.

9 The liquid intake tracking device of claim 1, further comprising a housing sized and shaped to receive the pressure sensor, wherein the housing further comprises a top cap,
10 wherein the one or more apertures are included in the top cap.

10. The liquid intake tracking device of claim 9, wherein the pressure sensor is sealingly connected to the top cap.

11. The liquid intake tracking device of claim 1, further comprising a temperature sensor module disposed in relation to the pressure sensor so as to detect the temperature changes
15 within the beverage container, the temperature sensor module providing a temperature measurement signal as an output to the wireless communication module.

12. The liquid intake tracking device of claim 1, further comprising a pH sensor module disposed in relation to the pressure sensor so as to detect the pH of the liquid within the beverage container, the pH sensor module providing a pH measurement signal as an
20 output to the wireless communication module.

13. The liquid intake tracking device of claim 1 further comprising:

an electrical power storage device; and

a wireless charging coil configured to charge the electrical power storage device via an inductive coupling.

14. The liquid intake tracking device of claim 9, wherein the housing further comprising a porous compartment in fluid communication with the liquid in the beverage container, the porous compartment having a closeable access and being sized to receive a plurality of ceramic beads.

15. A liquid intake tracking device that detects changes in a volume of liquid within a beverage container and that wirelessly communicates detected information to an external electronic device, comprising:

a housing sized and shaped to be received within the beverage container and defining an interior region separated from any liquid within the beverage container;

a pressure sensor disposed within the housing;

a liquid level detection circuit connected to the pressure sensor and operative to measure the pressure of the sealed volume and output at least a first measurement value concerning a first calibration, a second measurement value concerning a second calibration, and a current volume measurement value, wherein the first calibration measurement value is indicative of the beverage container being empty, the second calibration measurement value is indicative of the beverage container being filled, and the current volume measurement value is indicative of a current liquid volume in the beverage container; and

a wireless communication module configured to communicate at least the first calibration, second calibration and current volume values to the external electronic device.

16. The liquid intake tracking device of claim 15, further comprising a membrane disposed within the interior region of the housing and providing a flexible edge of a sealed volume defined within at least a portion of the interior region of the housing, the membrane being in communication with and flexing in response to pressure imparted by any liquid in the beverage container.

17. A method for tracking liquid intake using a device being sized to be received within a beverage container to detect changes in a volume of liquid in the beverage container, comprising the steps of:

disposing the device within the beverage container, the device including:

a pressure sensor;

a wireless communication module configured to communicate one or more measurement values to an external electronic device;

calibrating the device relative to the beverage container by processing pressure readings while the beverage container is indicated by a user operating the external electronic device as being empty of any liquid and while the beverage container is indicated by the user operating the external electronic device as being full;

receiving atmospheric pressure data from at least one barometric sensor in communication with the external electronic device;

calculating the difference between the pressure reading obtained while the beverage container is empty and the received atmospheric pressure data,

adjusting the pressure reading obtained while the beverage container is full in response to the calculation;

detecting changes in pressure within the sealed interior volume using the pressure sensor, the pressure being a function of a proportion of amount of liquid within the beverage container at the time of detection; and

5 wirelessly transmitting the measured pressure information to the external electronic device using the wireless communication module.

18. The method of claim 17, wherein the device further includes: a housing having a flexible membrane overlying a sealed interior volume, the flexible membrane having a first side exposed to any liquid within the beverage container and a second side arranged to flex into the sealed interior volume.

10 19. The method of claim 17, further comprising:

providing an application for execution in a processor of the external electronic device, the application including code comprising one or more modules, including:

15 a beverage-container profile which stores and provides beverage container profile information including at least volume information concerning a volume of liquid that can be contained by the beverage container;

an input module which receives the measured pressure from the device over a wireless connection to the device;

a level determination module which executes in the processor to determine the level of the liquid in the beverage container as a function of the measured pressure;

20 a calculation module which executes in the processor to calculate an amount of liquid intake as a function of changes in the level of liquid in the beverage container

and the volume information in the beverage-container profile using liquid volume values determined by the level determination module; and

an output module which executes in the processor to display at least the amount of liquid intake on a display of the electronic device.

5 20. The method of claim 17, further comprising the steps of generating and providing an alert to a user, using an alert module executing in the processor of the electronic device, to consume more liquid.

21. The method of claim 17, further comprising the step of providing an alert to a user, using an alert module executing in the processor of the electronic device, to consume less
10 liquid.

22. The method of claim 17, further comprising the step providing an alert to the user, using an alert module executing in the processor of the electronic device, to refill the beverage container when the volume of liquid in the beverage container determined by the level determination module indicates that the beverage container is empty.

15 23. The method of claim 17, further comprising the step calculating a rate of liquid consumption as a function of the calculated liquid intake over time, using the processor in the electronic device.

24. The method of claim 17, further comprising the steps of:

detecting a temperature of the liquid in the beverage container using a temperature
20 sensor;

transmitting the detected temperature to the electronic device for use by the input module; and

calibrating the liquid level determined by the level determination module to compensate for changes in pressure measured by the pressure sensor as a result of any change in detected temperature of the liquid.

FIGURE 1

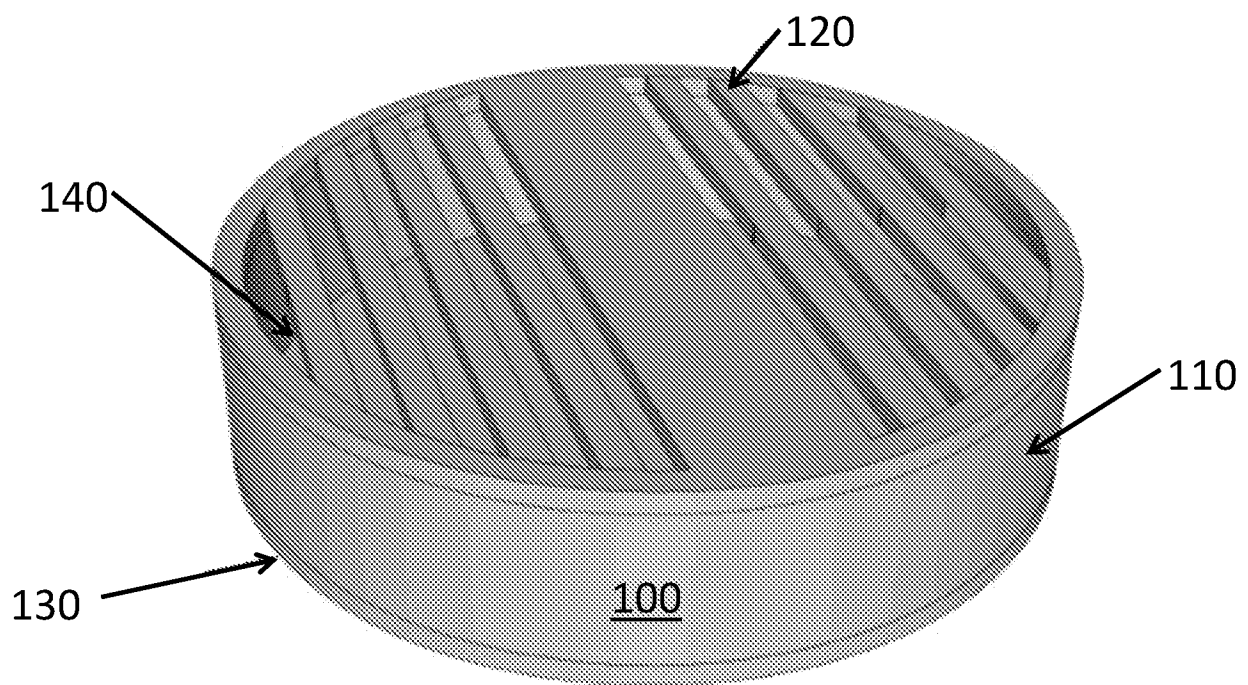
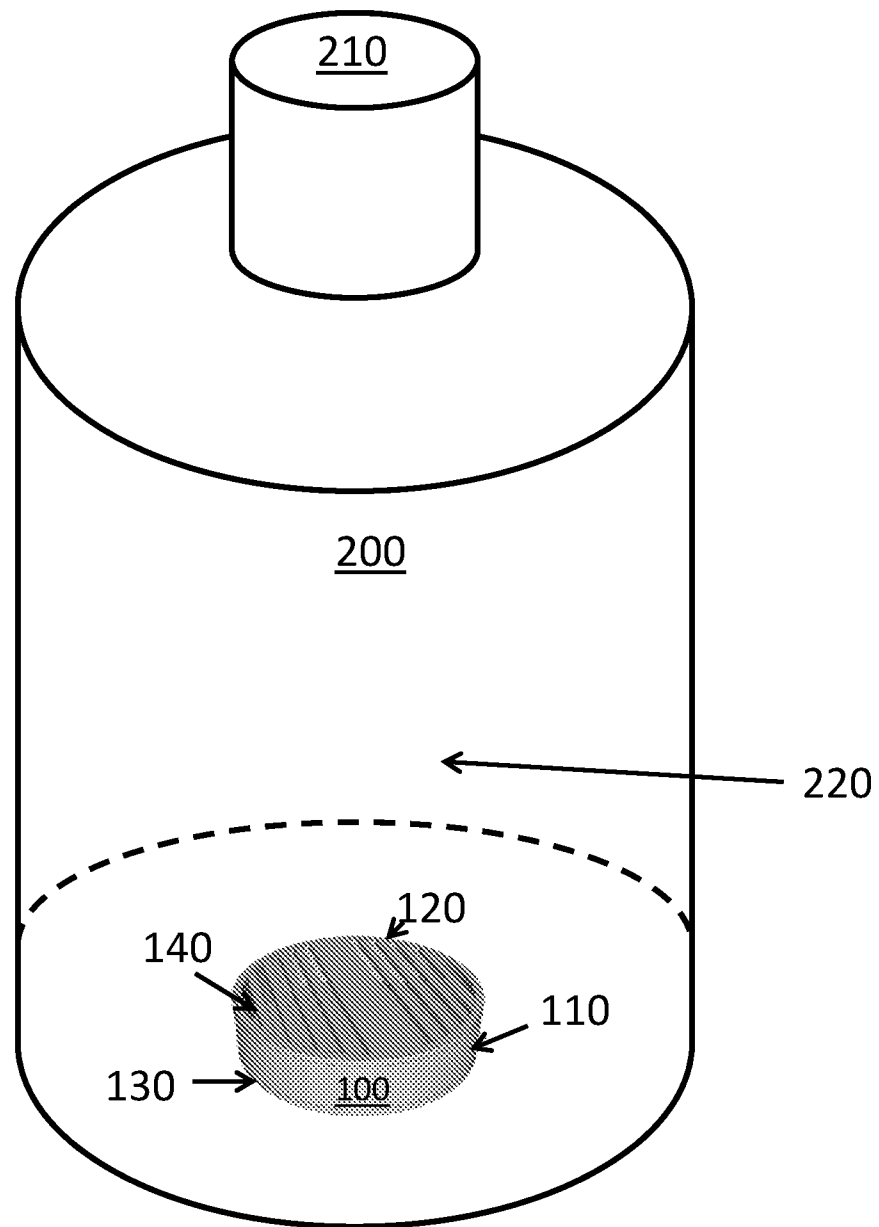


FIGURE 2



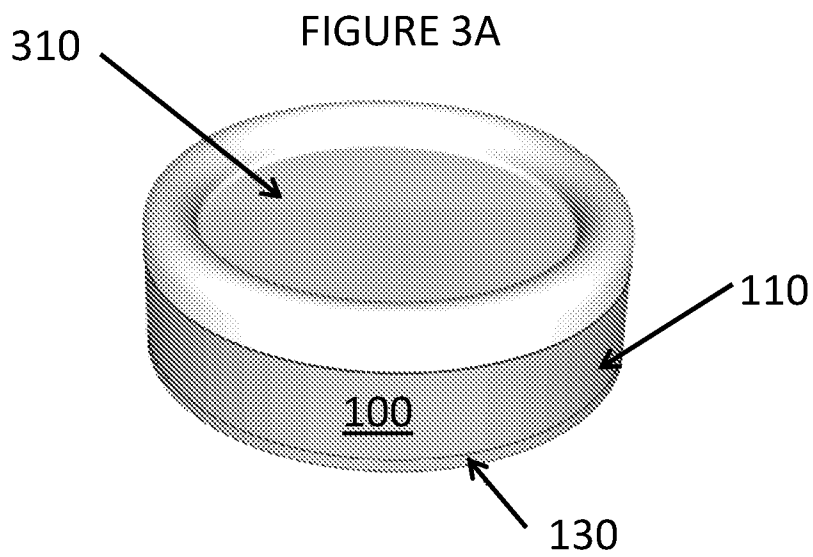
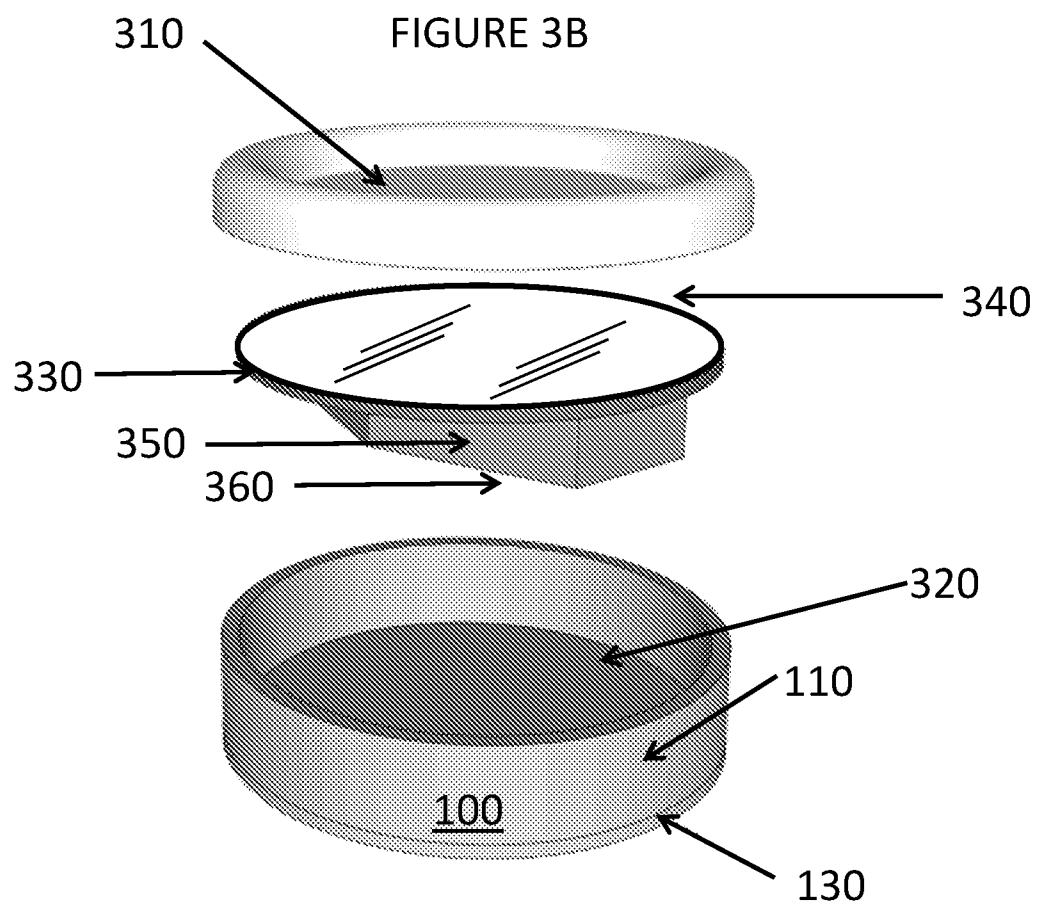


FIGURE 4

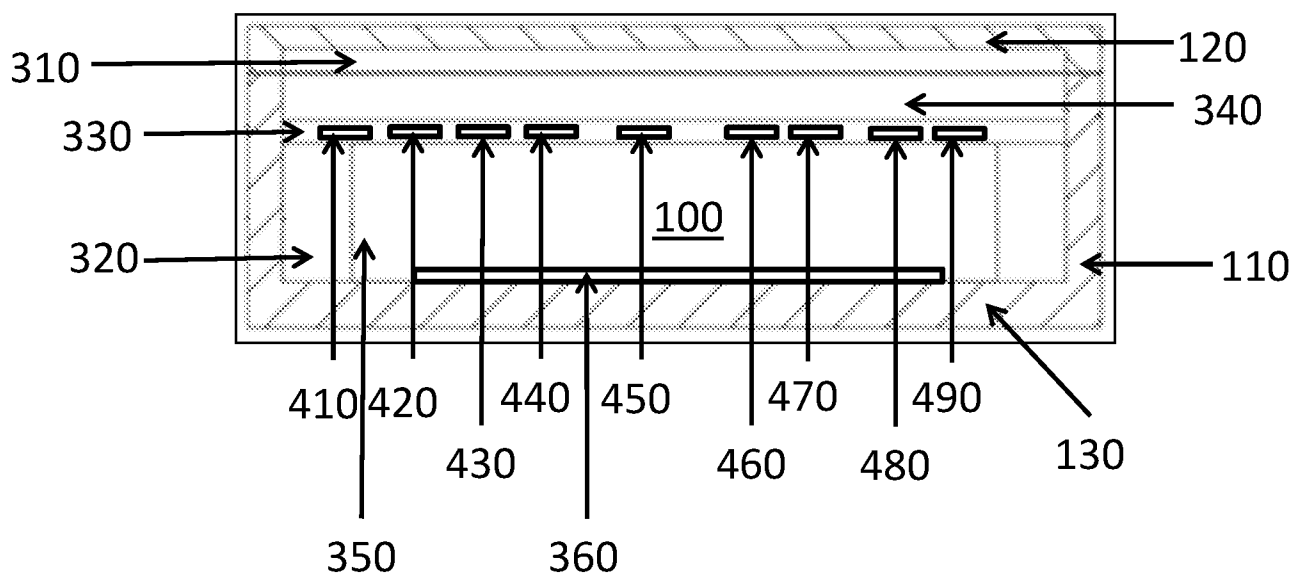


FIGURE 5

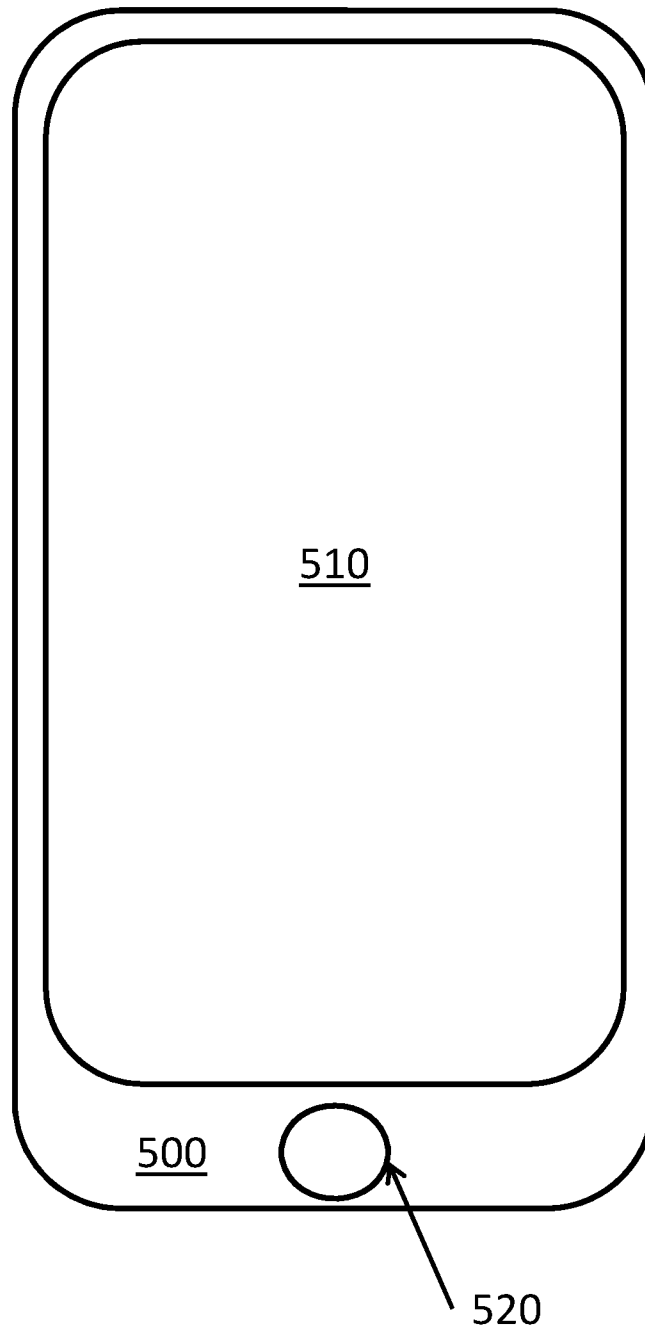


FIGURE 5A

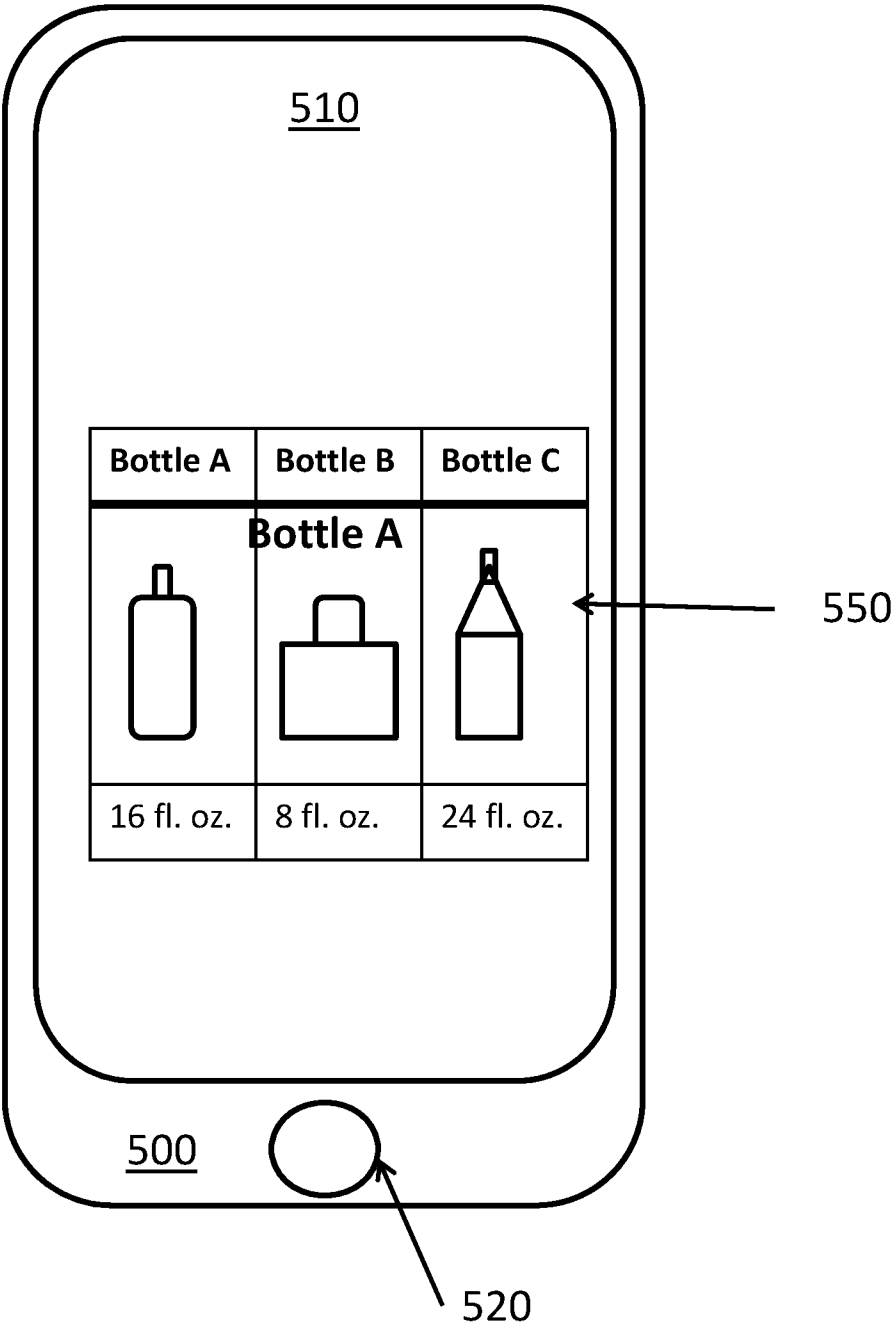


FIGURE 5B

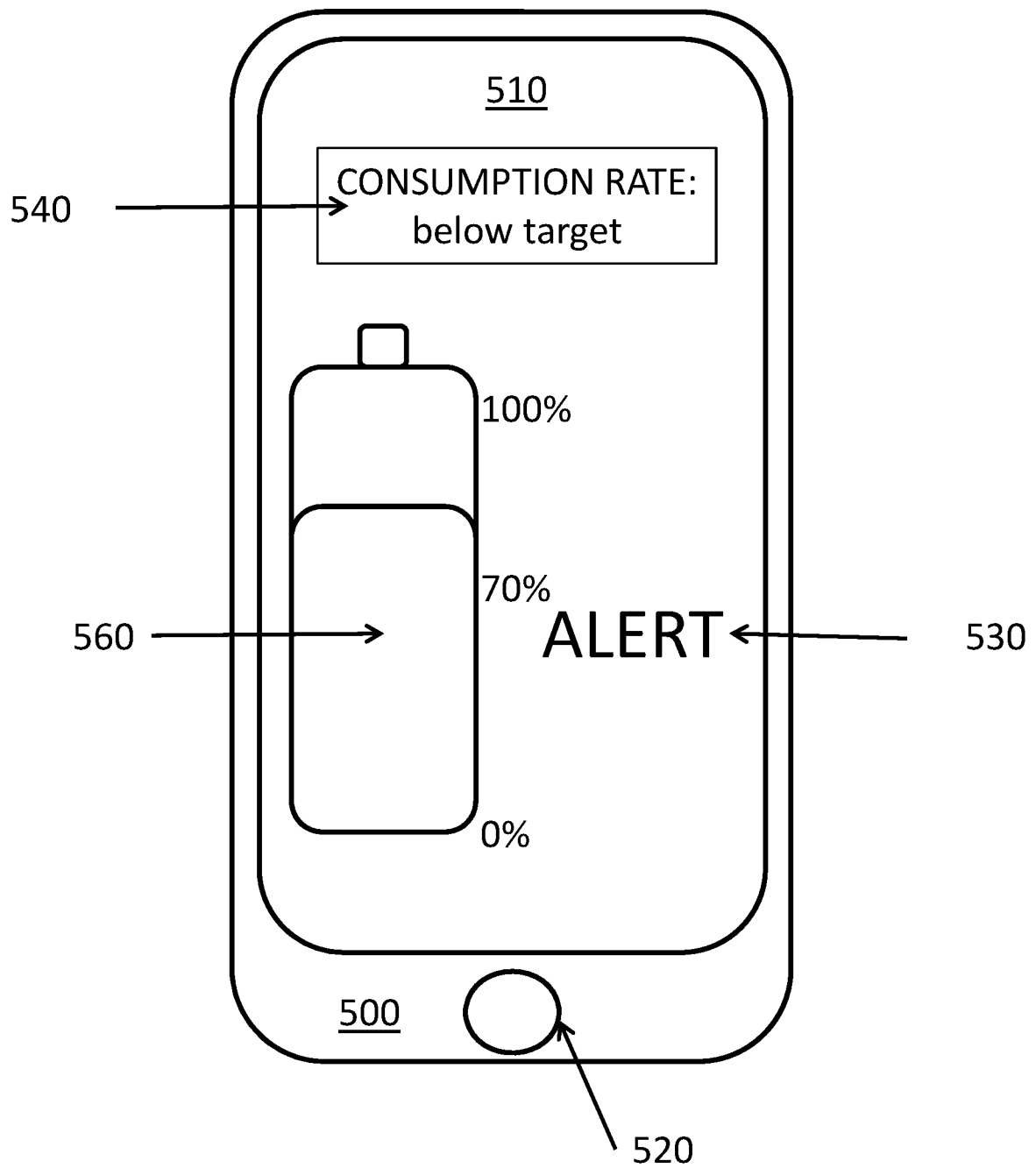
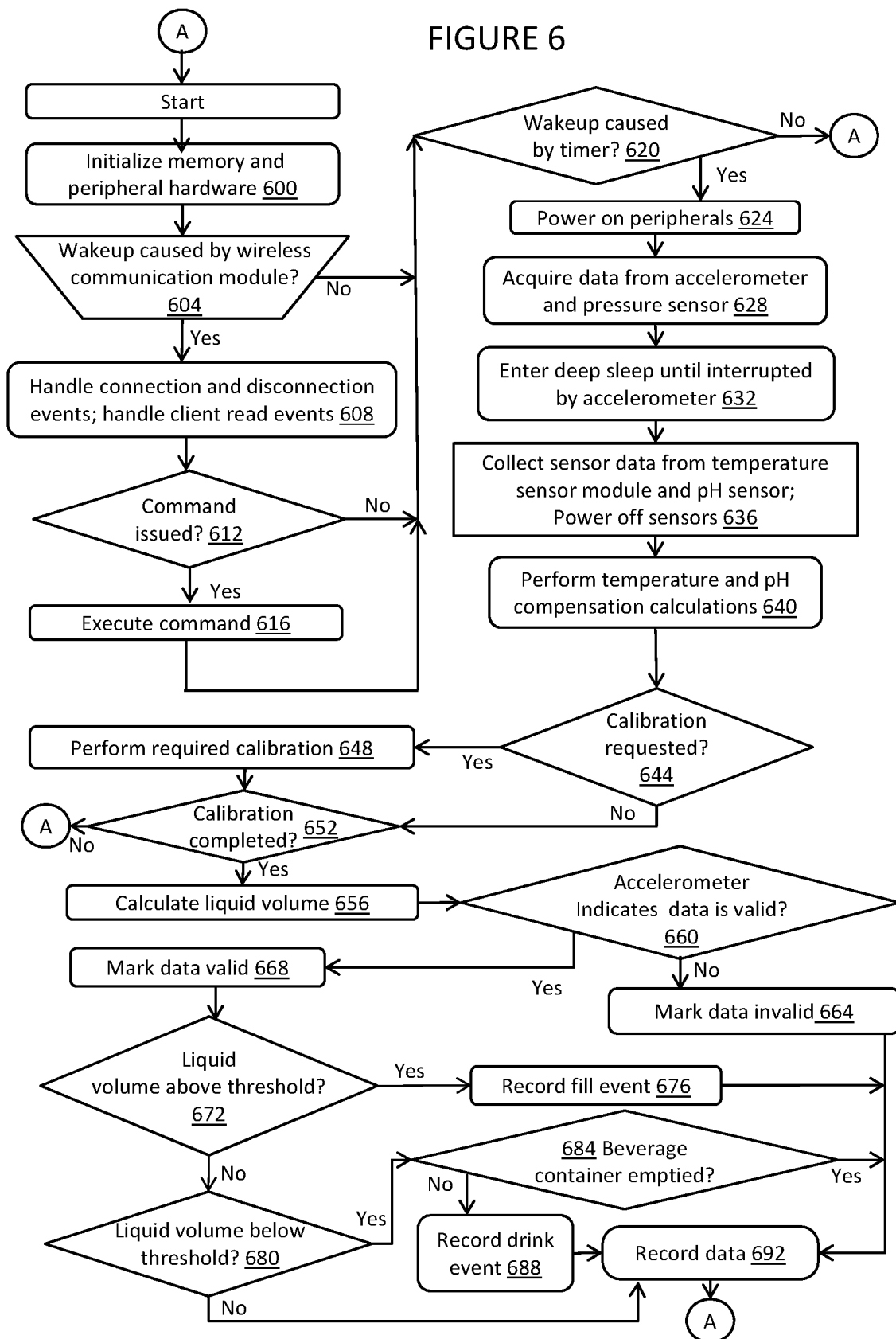


FIGURE 6



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/053010

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01F23/16
ADD. G01F25/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2015/200904 A1 (HYDR8 INC [US]) 30 December 2015 (2015-12-30)	1-3,5-8, 11,13, 15,17, 19-24
Y	figures 2A, 2B, 2C, 4 page 2, line 1 - line 8 page 9, line 1 - line 16 page 14, line 18 - page 15, line 3 page 15, line 8 - line 12 page 15, line 21 - line 25 page 15, line 29 - page 17, line 25 page 18, line 3 - line 18 page 27, line 7 - line 13 -----	4,9,10, 12,14, 16,18
Y	DE 327 063 C (HENRY G E WOCHE) 6 October 1920 (1920-10-06) figure 3 ----- -/--	4,9,10, 14,16,18

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

2 August 2017

Date of mailing of the international search report

09/08/2017

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INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2017/053010

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2008/106193 A1 (XCELLEREX INC [US]; MITCHELL PETER A [US]; FISHER MICHAEL [US]) 4 September 2008 (2008-09-04) page 8, line 12 - line 14 -----	12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2017/053010

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WO 2015200904 A1	30-12-2015	US 2016022209 A1 WO 2015200904 A1	28-01-2016 30-12-2015
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