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(54) **A SYSTEM AND METHOD FOR MANAGING A SMOKING SUBSTITUTE DEVICE**

(57) A smoking substitute device comprising a reservoir for containing a liquid, a liquid-level sensor for detecting a level of liquid in the tank, an orientation sensor for detecting an orientation of the smoking substitute device, and a control unit, wherein the control unit is con-

figured to determine an amount of liquid in the tank by modifying a liquid level measurement detected by the liquid-level sensor based on an orientation measurement detected by the orientation sensor.

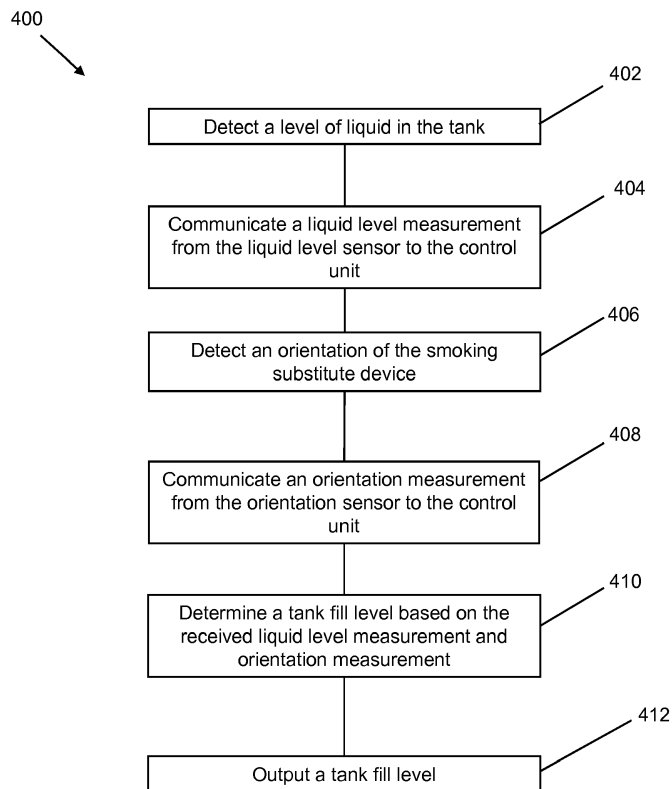


Fig. 4

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Description

TECHNICAL FIELD

[0001] The present invention relates to smoking substitute and particularly, although not exclusively, to monitoring an operational parameter of a smoking substitute device.

BACKGROUND

[0002] The smoking of tobacco is generally considered to expose a smoker to potentially harmful substances. It is generally thought that a significant amount of the potentially harmful substances are generated through the heat caused by the burning and/or combustion of the tobacco and the constituents of the burnt tobacco in the tobacco smoke itself.

[0003] Conventional combustible smoking articles, such as cigarettes, typically comprise a cylindrical rod of tobacco comprising shreds of tobacco which is surrounded by a wrapper, and usually also a cylindrical filter axially aligned in an abutting relationship with the wrapped tobacco rod. The filter typically comprises a filtration material which is circumscribed by a plug wrap. The wrapped tobacco rod and the filter are joined together by a wrapped band of tipping paper that circumscribes the entire length of the filter and an adjacent portion of the wrapped tobacco rod. A conventional cigarette of this type is used by lighting the end opposite to the filter, and burning the tobacco rod. The smoker receives mainstream smoke into their mouth by drawing on the mouth end or filter end of the cigarette.

[0004] Combustion of organic material such as tobacco is known to produce tar and other potentially harmful byproducts. There have been proposed various smoking substitute devices in order to avoid the smoking of tobacco.

[0005] Such smoking substitute devices can form part of nicotine replacement therapies aimed at people who wish to stop smoking and overcome a dependence on nicotine.

[0006] Smoking substitute devices may comprise electronic systems that permit a user to simulate the act of smoking by producing an aerosol (also referred to as a "vapour") that is drawn into the lungs through the mouth (inhaled) and then exhaled. The inhaled aerosol typically bears nicotine and/or flavourings without, or with fewer of, the odour and health risks associated with traditional smoking.

[0007] In general, smoking substitute devices are intended to provide a substitute for the rituals of smoking, whilst providing the user with a similar experience and satisfaction to those experienced with traditional smoking and tobacco products. Some smoking substitute systems use smoking substitute articles (also referred to as a "consumables") that are designed to resemble a traditional cigarette and are cylindrical in form with a mouth-

piece at one end.

[0008] The popularity and use of smoking substitute devices has grown rapidly in the past few years. Although originally marketed as an aid to assist habitual smokers wishing to quit tobacco smoking, consumers are increasingly viewing smoking substitute devices as desirable lifestyle accessories. Some smoking substitute devices are designed to resemble a traditional cigarette and are cylindrical in form with a mouthpiece at one end. Other smoking substitute devices do not generally resemble a cigarette (for example, the smoking substitute device may have a generally box-like form).

[0009] There are a number of different categories of smoking substitute devices, each utilising a different smoking substitute approach. A smoking substitute approach corresponds to the manner in which the substitute system operates for a user.

[0010] One approach for a smoking substitute device is the so-called "vaping" approach, in which a vapourisable liquid, typically referred to (and referred to herein) as "e-liquid", is heated by a heating device to produce an aerosol vapour which is inhaled by a user. An e-liquid typically includes a base liquid as well as nicotine and/or flavourings. The resulting vapour therefore typically contains nicotine and/or flavourings. The base liquid may include propylene glycol and/or vegetable glycerin.

[0011] A typical vaping smoking substitute device includes a mouthpiece, a power source (typically a battery), a tank for containing e-liquid, as well as a heating device. In use, electrical energy is supplied from the power source to the heating device, which heats the e-liquid to produce an aerosol (or "vapour") which is inhaled by a user through the mouthpiece.

[0012] Vaping smoking substitute devices can be configured in a variety of ways. For example, there are "closed system" vaping smoking substitute devices which typically have a sealed tank and heating element which is pre-filled with e-liquid and is not intended to be refilled by an end user. One subset of closed system vaping smoking substitute devices include a main body which includes the power source, wherein the main body is configured to be physically and electrically coupled to a consumable including the tank and the heating element. In this way, when the tank of a consumable has been emptied, the main body can be reused by connecting it to a new consumable. Another subset of closed system vaping smoking substitute devices are completely disposable, and intended for one-use only.

[0013] There are also "open system" vaping smoking substitute devices which typically have a tank that is configured to be refilled by a user, so the device can be used multiple times.

[0014] An example vaping smoking substitute device is the myblu™ e-cigarette. The myblu™ e-cigarette is a closed system device which includes a main body and a consumable. The main body and consumable are physically and electrically coupled together by pushing the consumable into the main body. The main body includes

a rechargeable battery. The consumable includes a mouthpiece, a sealed tank which contains e-liquid, as well as a heating device, which for this device is a heating filament coiled around a portion of a wick which is partially immersed in the e-liquid. The device is activated when a microprocessor on board the main body detects a user inhaling through the mouthpiece. When the device is activated, electrical energy is supplied from the power source to the heating device, which heats e-liquid from the tank to produce a vapour which is inhaled by a user through the mouthpiece.

[0015] Another example vaping smoking substitute device is the blu PRO™ e-cigarette. The blu PRO™ e-cigarette is an open system device which includes a main body, a (refillable) tank, and a mouthpiece. The main body and tank are physically and electrically coupled together by screwing one to the other. The mouthpiece and refillable tank are physically coupled together by screwing one of the other, and detaching the mouthpiece from the refillable tank allows the tank to be refilled with e-liquid. The device is activated by a button on the main body. When the device is activated, electrical energy is supplied from the power source to a heating device, which heats e-liquid from the tank to produce a vapour which is inhaled by a user through the mouthpiece.

[0016] Another approach for a smoking substitute system is the so-called Heated Tobacco ("HT") approach in which tobacco (rather than an "e-liquid") is heated or warmed to release vapour. HT is also known as "heat not burn" ("HNB"). The tobacco may be leaf tobacco or reconstituted tobacco. The vapour may contain nicotine and/or flavourings. In the HT approach the intention is that the tobacco is heated but not burned, i.e. the tobacco does not undergo combustion.

[0017] A typical HT smoking substitute system may include a device and a consumable. The consumable may include the tobacco material. The device and consumable may be configured to be physically coupled together. In use, heat may be imparted to the tobacco material by a heating element of the device, wherein airflow through the tobacco material causes components in the tobacco material to be released as vapour. A vapour may also be formed from a carrier in the tobacco material (this carrier may for example include propylene glycol and/or vegetable glycerine) and additionally volatile compounds released from the tobacco. The released vapour may be entrained in the airflow drawn through the tobacco.

[0018] As the vapour passes through the consumable (entrained in the airflow) from the location of vaporisation to an outlet of the consumable (e.g. a mouthpiece), the vapour cools and condenses to form an aerosol for inhalation by the user. The aerosol will normally contain the volatile compounds.

[0019] In HT smoking substitute systems, heating as opposed to burning the tobacco material is believed to cause fewer, or smaller quantities, of the more harmful compounds ordinarily produced during smoking. Consequently, the HT approach may reduce the odour and/or

health risks that can arise through the burning, combustion and pyrolytic degradation of tobacco.

[0020] There may be a need for improved design of smoking substitute systems, in particular HT smoking substitute systems, to enhance the user experience and improve the function of the HT smoking substitute system.

[0021] An example of the HT approach is the IQOS™ smoking substitute device from Philip Morris Ltd. The IQOS™ smoking substitute device uses a consumable, including reconstituted tobacco located in a wrapper. The consumable includes a holder incorporating a mouthpiece. The consumable may be inserted into a main body that includes a heating device. The heating device has a thermally conductive heating knife which penetrates the reconstituted tobacco of the consumable, when the consumable is inserted into the heating device. Activation of the heating device heats the heating element (in this case a heating knife), which, in turn, heats the tobacco in the consumable. The heating of the tobacco causes it to release nicotine vapour and flavourings which may be drawn through the mouthpiece by the user through inhalation.

[0022] A second example of the HT approach is the device known as "Glo"™ from British American Tobacco p.l.c. Glo™ comprises a relatively thin consumable. The consumable includes leaf tobacco which is heated by a heating device located in a main body. When the consumable is placed in the main body, the tobacco is surrounded by a heating element of the heating device. Activation of the heating device heats the heating element, which, in turn, heats the tobacco in the consumable. The heating of the tobacco causes it to release nicotine vapour and flavourings which may be drawn through the consumable by the user through inhalation. The tobacco, when heated by the heating device, is configured to produce vapour when heated rather than when burned (as in a smoking apparatus, e.g. a cigarette). The tobacco may contain high levels of aerosol formers (carrier), such as vegetable glycerine ("VG") or propylene glycol ("PG").

[0023] The present inventor(s) have observed that most smoking substitute devices currently on the market are configured to operate in isolation of other devices, which limits the functions the smoking substitute devices can perform.

[0024] The present inventor(s) have observed that, as smoking substitute devices become more sophisticated, user expectations increase in terms of his or her smoking substitute device monitoring operational parameters for itself. It is helpful for the user to be provided with accurate and timely information regarding operation of his or her smoking substitute device, for example regarding liquid reservoir or consumable pod refill level.

[0025] The present invention has been devised in light of the above considerations.

Summary of the Invention

[0026] At its most general, the invention provides a system, device and method that can accurately detect the fill level (or 'liquid level') of a liquid reservoir within, or connected to, a smoking substitute device. The fill level may comprise the fill level of a reservoir or tank that is integral to the smoking substitute device or it may comprise the fill level of a reservoir or tank that is part of a consumable or pod that connects to the main body of a smoking substitute device. The fill level can be determined accurately regardless of the orientation of the device because the control means that determines the fill level considers a measurement made by an orientation sensor within the smoking substitute device as well as a measurement made by a liquid level sensor.

[0027] The present inventor(s) have recognised that it is highly desirable and useful, from a user perspective, to know the fill level of his or her smoking substitute device, particularly when the fill level is low. This enables the user to purchase or otherwise obtain replacement consumables (or liquid for refilling the tank) before the current tank fill reduces to zero. It can also help the user avoid attempting smoking substitute action when there is little or no liquid in the tank, which can lead to an unsatisfactory user experience and may also risk damage to components of the device, for example if the heating device is heating a wick which is not soaked in e-liquid.

[0028] The control means that determines the fill level may be comprised within the smoking substitute device itself. For example, it may comprise a control unit such as a microprocessor. Alternatively, or additionally, the determination of the fill level may be carried out by a control means within an application that is installed on a mobile device with which the smoking substitute device is in wireless communication. Alternatively, or additionally, the determination of the fill level may be carried out by a control means within a server, for example a cloud-based server, that is in wireless communication with the application and/or with the smoking substitute device.

[0029] The control means may be configured to apply an algorithm to a liquid level measurement provided by the liquid level sensor, based on an orientation measurement provided by the orientation level sensor. For example, the algorithm may apply trigonometric principles to the liquid level sensed by the liquid level sensor, wherein the angle of tilt of the upper surface (or 'meniscus') of the liquid, compared to horizontal, is determined based on the orientation measurement obtained by the orientation sensor (such as an accelerometer), and that angle of tilt is used to calculate a liquid level that would have been sensed, had the device been upright (and the upper surface of the liquid had therefore been horizontal) at the time at which the liquid level measurement was taken. That calculation may take into account the physical location of the liquid level sensor, and its shape, size and so on, within the tank or reservoir.

[0030] The control means may be configured to, in-

stead of changing or correcting a received liquid level sensed by the liquid level sensor, ignoring any liquid level measurements that are taken when, according to the orientation sensor, the device is not in an upright position.

5 The control means may further be configured to request a liquid level measurement from the liquid level sensor when (and, optionally, only when) the smoking substitute device is determined to be in an upright position.

[0031] The control means may used stored look up tables or other reference data, in order to determine a corrected fill level based on a liquid level measurement in combination with an orientation measurement. The liquid level measurements and/or the orientation measurements and/or the determined/corrected liquid level values may be stored in a suitable memory location within the smoking substitute device itself and/or within memory means of an application and/or within memory means of a server.

[0032] The determined fill level values may be output to the user, via an output means of the smoking device itself. Alternatively, they may be output via an application, via an output means of a mobile device on which the application is installed. The output may comprise a warning if the determined fill level value is below a predetermined threshold. The output may comprise a warning if the determined fill level value is above a predetermined threshold - for example, to inform the user that he or she has over-filled the tank of a refillable smoking substitute device.

[0033] According to a first aspect of the invention, there is provided a smoking substitute device comprising: a tank for containing a liquid; a liquid-level sensor for detecting a level of liquid in the tank; an orientation sensor for detecting an orientation of the smoking substitute device; and a control unit. The control unit is configured to determine an amount of liquid in the tank by modifying a liquid level measurement detected by the liquid-level sensor using an orientation measurement detected by the orientation sensor.

[0034] The liquid level measurement may be a measurement that relates directly to liquid level. Alternatively, it could be a measurement of another parameter (for example, capacitance, voltage or current output by a sensor) that can be used as an indicator of liquid level in the tank.

[0035] The control unit may be configured so that the step of modifying a liquid level measurement detected by the liquid-level sensor based on an orientation measurement detected by the orientation sensor comprises applying an algorithm to the liquid level measurement. For example, the control unit may input the liquid level measurement and the orientation measurement to an algorithm whose output is a modified liquid level measurement. The algorithm may modify the liquid level measurement using a modification value or liquid level adjustment that has a predetermined relationship with the orientation measurement.

[0036] For example, the smoking substitute device

may include a memory (e.g. non-volatile memory, such as flash) that stores a look-up table. The control unit may be configured to look up a liquid level adjustment from the look-up table using the orientation measurement, and apply the liquid level adjustment to the liquid level measurement detected by the liquid-level sensor. The look-up table may comprise a list of predetermined liquid level adjustments associated with corresponding orientation values. The control unit may be configured to find an orientation value that corresponds to the orientation measurement, and apply the liquid level adjustment associated with that orientation value to the liquid level measurement. Thus, the memory of the smoking substitute device may be configured to store a list of predetermined modification values and corresponding orientation values. Therefore, when the orientation sensor provides an orientation measurement to the control unit of the smoking substitute device (or to another control means), it can use the closest orientation value from the stored list in order to obtain the modification value that it should use in order to modify the liquid level measurement that it has obtained from the liquid level sensor, in order to determine and output a more accurate liquid level value that takes the orientation of the device into account. This can provide the user with a more accurate indication of the amount of liquid in the tank at that time.

[0037] The step of modifying a liquid level measurement detected by the liquid-level sensor based on an orientation measurement detected by the orientation sensor may be referred to or regarded as being a 'correction' step, since it may comprise correcting, or offsetting, an inherent assumption made by the liquid-level sensor that the entirety of the liquid in the reservoir or tank is at the same level as the particular region of liquid which comes into physical contact with, or is otherwise being monitored by, the liquid-level sensor. In fact the liquid may be tilted, for example if the smoking substitute device is not physically upright, such that liquid that is physically remote from the liquid-level sensor may be at a different level (when viewed along a substantially vertical axis) to the particular region of liquid which comes into physical contact with, or is otherwise being monitored by, the liquid-level sensor.

[0038] The step of modifying a liquid level measurement detected by the liquid-level sensor based on an orientation measurement detected by the orientation sensor may comprise ignoring that liquid level measurement, if it is detected by the orientation sensor that the device was not in a suitable position, when the liquid level measurement was taken. It may further comprise requesting a replacement liquid level measurement, when the device is next determined to be in a suitable position for accurately measuring liquid level in the tank.

[0039] The smoking substitute device may be configured so that the liquid-level sensor and/or the orientation sensor detect and provide liquid level and orientation measurements, respectively, at regular pre-determined intervals. Alternatively, or additionally, they may provide

such measurements in response to demand, either from the user or the application or the mobile device that is in wireless communication with the smoking substitute device. The measurements may be assigned either absolute or relative times. This can help with synchronising liquid-level data and orientation data, for determining a more accurate 'corrected' liquid/fill level for the tank and/or for determining the time(s) at which the received liquid level measurements can be deemed to be sufficiently accurate, taking into account the orientation of the device at that time(s).

[0040] The liquid may comprise any of a vaporisable e-liquid, or an aerosolisable flavouring. The tank may comprise a refillable reservoir or a consumable pod.

[0041] The smoking substitute device may comprise a main body that houses the control unit. The tank and liquid-level sensor may in contrast be in a consumable pod that is detachably mountable to the main body. The main body and the consumable pod may each include an electrical interface, where the electrical interfaces are connected when the consumable pod is mounted to the main body. The liquid-level sensor may be configured to communicate the liquid level measurement to the control unit via the electrical interfaces.

[0042] The smoking substitute device may further comprise a display means configured to display an amount of liquid, as determined by control unit. For example, the display means may comprise an LED or an LCD display. Alternatively, or additionally, the smoking substitute device may further comprise an audible output means configured to inform the user of an amount of liquid, as determined by control unit.

[0043] The smoking substitute device may further comprise a wireless interface configured to wirelessly communicate with an application installed on a mobile device. The wireless interface may comprise any suitable type of wireless communication interface, or terminal, for example a Wi-Fi or Bluetooth™ or Bluetooth™ Low Energy (BLE) interface. The smoking substitute device may thus be configured to wirelessly communicate a message including an amount of liquid, as determined by control unit, to associated application and/or a mobile device. The smoking substitute device may thus be network-enabled, so that it can communicate wirelessly, via its wireless interface, with a mobile device, and/or with an application running on a mobile device, and/or with a remote server such as a cloud-based server. For example, the mobile device may comprise any of a mobile phone, a smart phone, a laptop computer, a tablet computer, a television or a computer-based gaming device.

[0044] The steps for establishing a wireless communication link between the smoking substitute device and a mobile device may follow any suitable protocol. For example, if Bluetooth™ is used, the user can activate the Bluetooth™ functionalities of the smoking substitute device and of his or her selected mobile device, with which a wireless communication link is to be established, and the two devices can identify themselves to one another,

exchange Bluetooth™ messages, and form a wireless communication link. The exchange should preferably involve suitable security steps, to ensure that the correct two devices form the wireless communication link. For example, the two devices may form a paired wireless communication link, which is secure, and which is an exclusive communication link, between those two individual devices. In order to form a paired wireless communication link, the devices should exchange security data such as encryption keys, passwords or codes. The devices may each be configured to store the encryption key received from the respective other, and to re-use that encryption key each time a connection between the two devices is required. This is known as establishing a bonded wireless communication link.

[0045] The steps for establishing a wireless communication link between the smoking substitute device and a mobile device may comprise any suitable combination of user-implemented, computer-implemented and hardware-implemented steps. For example, specific user input should be required in order to identify the mobile device, with which the smoking substitute device is to establish a wireless communication link. However, some or all of the steps involved in actually establishing wireless communication links between the smoking substitute device and the mobile device(s), and the subsequent wireless transmissions between the devices, may happen without any specific user input being required.

[0046] When a mobile device has established a wireless communication link with a smoking substitute device, the devices may share data via that link. For example, if the mobile device comprises a mobile device on which the user has installed an application for management of the smoking substitute device, the smoking substitute device may submit data regarding some of its hardware components, such as its battery, to the mobile device. An application running on the mobile device may access some of that data for storage, or possibly for making determinations - for example, for determining remaining battery power from battery output voltage levels. The application, or the mobile device, may transmit control signals to the smoking substitute device.

[0047] The amount of liquid in the reservoir or tank, as determined by the control unit (or other control means) may comprise a fill level or a volume. It may comprise an indication of the proportion of the full reservoir or tank that is currently filled. It may comprise an indication that a predetermined upper or lower fill threshold has been reached or passed.

[0048] The liquid level sensor may comprise any suitable sensor, for example a capacitance sensor. For example, the liquid level sensor may comprise a capacitive probe, which is configured to be located within the reservoir or tank, and which is configured to detect a different capacitance charge dependent on what proportion (i.e. how much of the top-to-bottom length) of the probe is exposed to either liquid or air. As will be known to the skilled reader, capacitance sensors and probes can be

provided in a light and compact form, that could readily be incorporated into the tank of a smoking substitute device or consumable, without occupying too much space, and therefore without displacing too much liquid or requiring the tank to be unduly large. The capacitance sensor can electrically connect with the control unit of a smoking substitute device, in order to convey sensed capacitance measurements, for the determination of liquid fill level, based on the sensed capacitance measurements.

[0049] The orientation sensor may comprise any suitable sensor. For example, it may comprise any of an accelerometer, a gyroscope or a magnetometer. The orientation sensor may be configured to detect an orientation of the smoking substitute device, relative to a reference position. For example, the orientation sensor may detect an angle of tilt of the device, relative to its upright position, or relative to the position of the device in which the reservoir or tank that holds the liquid, the level of which is being determined, is upright.

[0050] In broad terms, and as will be known to the skilled reader, an accelerometer is configured to sense and measure acceleration, so can be used to detect movement of the smoking substitute device. A gyroscope is configured to measure and/or maintain orientation and angular velocity, so can be used to detect rotational movement of the smoking substitute device. A magnetometer is configured to measure magnetism, i.e. the direction, strength, or relative change of a magnetic field at a particular location. A magnetometer can be used as a compass for a smoking substitute device.

[0051] Some known smoking substitute devices already comprise an orientation sensing component. Such components can be used for management and control of the smoking substitute device. For example, an accelerometer may be comprised within a smoking substitute device and may be used, either in isolation or in combination with other components, to detect motion of the smoking substitute device of the type that is typical during a smoking substitute action. Information regarding such detected motion can be recorded, stored and/or analysed for the smoking substitute device in order to detect smoking substitute actions and, for example, to create a record of the number of smoking substitute actions that a user typically performs within a time period.

[0052] Therefore, the present invention makes use of components that already are comprised within, and/or which can be readily be comprised within, a smoking substitute device. An orientation sensing component and a liquid-level sensing component, of the type required to embody the present invention, can be physically very small and compact. Therefore, their inclusion within a smoking substitute device would not cause significant physical restraint on the device. Nor would the inclusion of a liquid-level sensing component and/or an orientation sensing component, of the type required to embody the present invention, require significant additional processing capability from the smoking substitute device.

[0053] The manner in which the control means uses the orientation measurement to correct or otherwise change the liquid level measurement that the liquid-level sensor has provided may depend on a number of factors. For example, it may depend on the nature of the output that is to be provided by the user - for example, whether an absolute level or a relative level, compared to a threshold, is to be output. It may also depend on predetermined margins of error that the smoking substitute device has been configured to accept, in relation to the liquid level measurements obtained when the reservoir is not in an upright position.

[0054] The functionality described herein for providing a corrected liquid-fill measurement for a smoking substitute device may be pre-programmed into the control means for a smoking substitute device during manufacture and factory setting. Alternatively, an existing smoking substitute device that includes the relevant sensors may be programmed to perform the methods, for example via a software update to an application on a mobile device that is in wireless communication with the smoking substitute device and/or via a firmware update applied to the software running the operation of the smoking substitute device itself.

[0055] According to a second aspect of the invention, there is provided a computer-implemented method for managing a smoking substitute device, the method comprising: detecting, using a liquid-level sensor, a level of liquid in a tank in the smoking substitute device; communicating a liquid level measurement from the liquid-level sensor to a control unit of the smoking substitute device; detecting, using an orientation sensor, an orientation of the smoking substitute device; communicating an orientation measurement from the orientation sensor to the control unit; and determining, by the control unit, an amount of liquid in the tank by modifying the liquid level measurement transmitted by the liquid-level sensor using the orientation measurement transmitted by the orientation sensor. This method may be carried out wholly at the smoking substitute device.

[0056] In other examples, the method may use a mobile device in communication with the smoking substitute device, for example by an application running on a mobile device that is in wireless communication with the smoking substitute device, or by processing means within a server such as, for example, a cloud-based server. Thus, according to a third aspect of the invention, there is provided a computer-implemented method for managing a smoking substitute device, the method comprising: receiving a liquid level measurement obtained by a liquid-level sensor in a tank in the smoking substitute device; receiving an orientation measurement obtained by an orientation sensor of the smoking substitute device; and determining an amount of liquid in the tank by modifying the liquid level measurement using the orientation measurement.

[0057] According to a fourth aspect of the invention, there is provided a computer readable medium containing instructions configured to, when executed by a proc-

essor on a smoking substitute device or by an application installed on a mobile device, perform any of the methods described herein.

[0058] The invention includes the combination of the aspects and preferred features described except where such a combination is clearly impermissible or expressly avoided.

[0059] The skilled person will appreciate that except where mutually exclusive, a feature or parameter described in relation to any one of the above aspects may be applied to any other aspect. Furthermore, except where mutually exclusive, any feature or parameter described herein may be applied to any aspect and/or combined with any other feature or parameter described herein.

Summary of the Figures

[0060] Embodiments and experiments illustrating the principles of the invention will now be discussed with reference to the accompanying figures in which:

Figure 1 shows an example system for managing a smoking substitute device.

Figure 2(a) shows an example smoking substitute device for use as the smoking substitute device in the system of Fig. 1.

Figure 2(b) shows the main body of the smoking substitute device of Fig. 2(a) without the consumable.

Figure 2(c) shows the consumable of the smoking substitute device of Fig. 2(a) without the main body.

Figure 3(a) is a schematic view of the main body of the smoking substitute device of Fig. 2(a), in an embodiment of the invention.

Figure 3(b) is a schematic view of the consumable of the smoking substitute device of Fig. 2(a), in an embodiment of the invention.

Figure 4 is a flow diagram of operations carried out by a smoking substitute device, according to an embodiment of the present invention.

Detailed Description of the Invention

[0061] Aspects and embodiments of the present invention will now be discussed with reference to the accompanying figures. Further aspects and embodiments will be apparent to those skilled in the art. All documents mentioned in this text are incorporated herein by reference.

[0062] Fig. 1 shows an example system 1 for managing a smoking substitute device 10.

[0063] The system 1 as shown in Fig. 1 includes a mobile device 2, an application server 4, an optional charging station 6, as well as the smoking substitute device 10.

[0064] The smoking substitute device 10 is configured to communicate wirelessly, e.g. via Bluetooth™, with an application (or "app") installed on the mobile device 2, e.g. via a suitable wireless interface (not shown) on the mobile device 2. The mobile device 2 may be a mobile phone, for example. The application on the mobile phone is configured to communicate with the application server 4, via a network 8. The application server 4 may utilise cloud storage, for example.

[0065] The network 8 may include a cellular network and/or the internet.

[0066] A skilled person would readily appreciate that the mobile device 2 may be configured to communicate via the network 8 according to various communication channels, preferably a wireless communication channel such as via a cellular network (e.g. according to a standard protocol, such as 3G or 4G) or via a WiFi network.

[0067] The app installed on the mobile device and the application server 4 may be configured to assist a user with their smoking substitute device 10, based on information communicated between the smoking substitute device 10 and the app and/or information communicated between the app and the application server 4.

[0068] The charging station 6 (if present) may be configured to charge (and optionally communicate with) the smoking substitute device 10, via a charging port on the smoking substitute device 10. The charging port on the smoking substitute device 10 may be a USB port, for example, which may allow the smoking substitute device to be charged by any USB-compatible device capable of delivering power to the smoking substitute device 10 via a suitable USB cable (in this case the USB-compatible device would be acting as the charging station 6). Alternatively, the charging station could be a docking station specifically configured to dock with the smoking substitute device 10 and charge the smoking substitute device 10 via the charging port on the smoking substitute device 10.

[0069] Fig. 2(a) shows an example smoking substitute device 110 for use as the smoking substitute device 10 in the system 1 of Fig. 1.

[0070] In this example, the smoking substitute device 110 includes a main body 120 and a consumable 150. The consumable 150 may alternatively be referred to as a "pod".

[0071] In this example, the smoking substitute device 110 is a closed system vaping device, wherein the consumable 150 includes a sealed tank 156 and is intended for one-use only.

[0072] Fig. 2(a) shows the smoking substitute device 110 with the main body 120 physically coupled to the consumable 150.

[0073] Fig. 2(b) shows the main body 120 of the smoking substitute device 110 without the consumable 150.

[0074] Fig. 2(c) shows the consumable 150 of the

smoking substitute device 110 without the main body 120.

[0075] The main body 120 and the consumable 150 are configured to be physically coupled together, in this example by pushing the consumable 150 into an aperture in a top end 122 of the main body 120, e.g. with the consumable 150 being retained in the aperture via an interference fit. In other examples, the main body 120 and the consumable could be physically coupled together by screwing one onto the other, through a bayonet fitting, or through a snap engagement mechanism, for example. An optional light 126, e.g. an LED located behind a small translucent cover, is located a bottom end 124 of the main body 120. The light 126 may be configured to illuminate when the smoking substitute device 110 is activated.

[0076] The consumable 150 includes a mouthpiece (not shown) at a top end 152 of the consumable 150, as well as one or more air inlets (not shown in Fig. 2) so that air can be drawn into the smoking substitute device 110 when a user inhales through the mouthpiece. At a bottom end 154 of the consumable 150, there is located a tank 156 that contains e-liquid. The tank 156 may be a translucent body, for example.

[0077] The tank 156 preferably includes a window 158, so that the amount of e-liquid in the tank 156 can be visually assessed. The main body 120 includes a slot 128 so that the window 158 of the consumable 150 can be seen whilst the rest of the tank 156 is obscured from view when the consumable 150 is inserted into the aperture in the top end 122 of the main body 120. However, as embodiments of the invention also include a liquid level sensor for the tank 156, the window may be omitted such that the tank 156 is not visible in use.

[0078] In this present embodiment, the consumable 150 is a "single-use" consumable. That is, upon exhausting the e-liquid in the tank 156, the intention is that the user disposes of the whole consumable 150. In other embodiments, the e-liquid (i.e. aerosol former) may be the only part of the system that is truly "single-use". In such embodiments, the tank 156 may be refillable with e-liquid or the e-liquid may be stored in a non-consumable component of the system. For example, the e-liquid may be stored in a tank located in the device or stored in another component that is itself not single-use (e.g. a refillable tank).

[0079] The tank 156 may be referred to as a "clearomizer" if it includes a window 158, or a "cartomizer" if it does not.

[0080] Fig. 3(a) is a schematic view of the main body 120 of the smoking substitute device 110.

[0081] Fig. 3(b) is a schematic view of the consumable 150 of the smoking substitute device 110.

[0082] As shown in Fig. 3(a), the main body 120 includes a power source 128, a control unit 130, an airflow sensor 131, a memory 132, a wireless interface 134, an orientation sensor 135, an electrical interface 136, and, optionally, one or more additional components 138.

[0083] The power source 128 is preferably a battery, more preferably a rechargeable battery.

[0084] The control unit 130 may include a microprocessor, for example.

[0085] The memory 132 is preferably includes non-volatile memory.

[0086] The wireless interface 134 is preferably configured to communicate wirelessly with the mobile device 2, e.g. via Bluetooth. To this end, the wireless interface 134 could include a Bluetooth™ antenna. Other wireless communication interfaces, e.g. WiFi, are also possible.

[0087] The electrical interface 136 of the main body 120 may include one or more electrical contacts. The electrical interface 136 may be located in, and preferably at the bottom of, the aperture in the top end 122 of the main body 120. When the main body 120 is physically coupled to the consumable 150, the electrical interface 136 may be configured to pass electrical power from the power source 128 to (e.g. a heating device of) the consumable 150 when the smoking substitute device 110 is activated, e.g. via the electrical interface 160 of the consumable 150 (discussed below). When the main body 120 is not physically coupled to the consumable 150, the electrical interface may be configured to receive power from the charging station 6.

[0088] The additional components 138 of the main body 120 may include the optional light 126 discussed above.

[0089] The additional components 138 of the main body 120 may, if the power source 128 is a rechargeable battery, include a charging port configured to receive power from the charging station 6. This may be located at the bottom end 124 of the main body 120. Alternatively, the electrical interface 136 discussed above is configured to act as a charging port configured to receive power from the charging station 6 such that a separate charging port is not required.

[0090] The additional components 138 of the main body 120 may, if the power source 128 is a rechargeable battery, include a battery charging control circuit, for controlling the charging of the rechargeable battery. However, a battery charging control circuit could equally be located in the charging station 6 (if present).

[0091] The airflow sensor 131 may be configured to detecting airflow in the smoking substitute device 110, e.g. caused by a user inhaling through a mouthpiece 166 (discussed below) of the smoking substitute device 110. The smoking substitute device 110 may be configured to be activated when airflow is detected by the airflow sensor 131. This optional sensor could alternatively be included in the consumable 150 (though this is less preferred where the consumable 150 is intended to be disposed of after use, as in this example).

[0092] The additional components 138 of the main body 120 may include an actuator, e.g. a button. The smoking substitute device 110 may be configured to be activated when the actuator is actuated. This provides an alternative to the airflow sensor noted, as a mecha-

nism for activating the smoking substitute device 110.

[0093] The additional components 138 of the main body 120 may include a reader configured to read information associated with the consumable from a machine readable data source included in (e.g. contained in the body of, or attached to) the consumable 150.

[0094] The reader may be configured to read information from the machine readable data source wirelessly, e.g. via electromagnetic waves or optically. Thus, for example, the machine readable data source included in the consumable 150 could be an RFID tag (in which case the reader included in the main body 120 may be an RFID reader) or a visual data source such as a barcode (in which case the reader included in the main body may be an optical reader, e.g. a barcode scanner). Various wireless technologies and protocols may be employed to allow the reader to wirelessly read information from a machine readable data source included in or attached to the consumable 150, e.g. NFC, Bluetooth, Wi-Fi, as would be appreciated by a skilled person.

[0095] For avoidance of any doubt, the reader (if present) may be configured to read information from the machine readable data source non-wirelessly, e.g. using a direct electrical connection between the main body 120 and consumable 150.

[0096] The orientation sensor 135 is configured to detect a current orientation of the device. The orientation may be relative to a reference direction, which may be the direction gravity or some other predetermined or settable reference orientation. The orientation sensor may comprise an accelerometer, gyroscope and/or a magnetometer.

[0097] The orientation sensor 135 may comprise an electromechanical device that measures acceleration forces, and provides a measure of "proper acceleration", which is the acceleration of a body or object, relative to free fall. Some accelerometers are configured to measure static acceleration forces, like the continuous force of gravity. In one example, the orientation sensor 135 may be an accelerometer configured to measure dynamic acceleration forces, and so can sense movement or vibrations. The accelerometer may be configured to measure acceleration and its outputs may be used to determine orientation factors such as tilt, tilt angle, and incline. It may also be configured to determine actions or events such as rotation, vibration and collision. The accelerometer may be a piezoelectric accelerometer. However other types of accelerometer may be used in a smoking substitute device, such as a capacitance accelerometer. In brief, a piezoelectric accelerometer uses microscopic crystal structures that become stressed due to accelerative forces. These crystals create a voltage from the stress, and the accelerometer outputs a voltage, which can be used to determine velocity and orientation. The accelerometer comprises a three-axis model, to enable it to sense rotational tilt, as well as movement in a two-dimensional plane.

[0098] In this invention, the orientation sensor 135 is

used to determine an amount of tilt or incline of the smoking substitute device, and therefore of the tank 156 which is housed therein, away from a substantially upright position. In this embodiment, the smoking substitute device is physically configured so that, when the consumable 150 is inserted correctly into the main body 120 of the smoking substitute device 110, the tank 156 within the consumable 150 is substantially upright - and so the top level of the liquid in the tank 156 is substantially flat or horizontal - when the main body 120 of the device 110 is upright. Of course, in other embodiments there could be a different physical configuration, in which the tank is at an incline to the vertical (or upright) axis of the main body of the smoking substitute device. In such an embodiment, the control means would account for this relative positioning, when using the orientation and liquid-level measurements to determine an accurate fill level for the tank.

[0099] In this embodiment, the orientation sensor 135 is configured to detect movement and relative positioning of the smoking substitute device 110, for example relative to a reference position such as its upright position, and to provide one or more voltage outputs to the control unit 130, within the smoking substitute device 110, as a result of what it has detected. For example, when the orientation sensor 135 detects that the smoking substitute device 110 has moved such as to be inclined relative to its upright position, the orientation sensor 135 transmits a corresponding voltage signal to the control unit 130. The control unit 130 can then control the memory 132 of the smoking substitute device 110 to store (at least temporarily) a measure of the voltage signal, along with an indicator of the time at which it was received.

[0100] As shown in Fig. 3(b), the consumable 150 includes the tank 156, an electrical interface 160, a heating device 162, one or more air inlets 164, a mouthpiece 166, and, optionally, one or more additional components 168.

[0101] The electrical interface 160 of the consumable 150 may include one or more electrical contacts. The electrical interface 136 of the main body 120 and an electrical interface 160 of the consumable 150 are preferably configured to contact each other and therefore electrically couple the main body 120 to the consumable 150 when the main body 120 is physically coupled to the consumable 150. In this way, electrical energy (e.g. in the form of an electrical current) is able to be supplied from the power source 128 in the main body 120 to the heating device 162 in the consumable 150.

[0102] The heating device 162 is preferably configured to heat e-liquid contained in the tank 156, e.g. using electrical energy supplied from the power source 128. In one example, the heating device 162 may include a heating filament and a wick 159, wherein a first portion of the wick extends into the tank 156 in order to draw e-liquid out from the tank 156, and wherein the heating filament coils around a second portion of the wick located outside the tank 156. In this example, the heating filament is configured to heat up e-liquid drawn out of the tank 156 by

the wick to produce an aerosol vapour.

[0103] The one or more air inlets 164 are preferably configured to allow air to be drawn into the smoking substitute device 110, when a user inhales through the mouthpiece 166.

[0104] The additional components 168 of the consumable 150 may include a machine readable data source, which may e.g. be contained in the body of, or attached to the consumable 150. The machine readable data source may store information associated with the consumable. The information associated with the consumable may include information concerning the content of the consumable (e.g. e-liquid type, batch number) and/or a unique identifier, for example.

[0105] The machine readable data source may be rewritable, e.g. a rewritable RFID chip, or read only, e.g. a visual data source such as a barcode. As indicated above, the additional components 138 of the main body 120 may include a reader configured to read information associated with the consumable from the machine readable data source.

[0106] In use, a user activates the smoking substitute device 110, e.g. through actuating an actuator included in the main body 120 or by inhaling through the mouthpiece 166 as described above. Upon activation, the control unit 130 may supply electrical energy from the power source 128 to the heating device 162 (via electrical interfaces 136, 166), which may cause the heating device 162 to heat e-liquid drawn from the tank 156 to produce a vapour which is inhaled by a user through the mouthpiece 166.

[0107] In the present example, the consumable 150 includes a liquid level sensor 157, which may be disposed in or adjacent the tank 156 and operably engaged with an internal volume of the tank to detect a fill level thereof. Knowledge of the fill level can enable a user to know how much longer he or she can continue to use the smoking substitute device for smoking substitute action (i.e. how many more inhalations he or she can make using the device) before the consumable 150 will have to be replaced or before the fill level of the tank 156 in the consumable 150 will reach such a low level that smoking substitute action may be difficult, inadequate or even unpleasant. For example, an unpleasant taste can be created when the user takes a so-called 'dry hit' from a smoking substitute device, in which the heating filament heats the wick 159 without any liquid.

[0108] The liquid level sensor 157 may be used instead of or in addition to a window that permits visual inspection of liquid in the tank. For example, at least in so-called 'clearomizer' embodiments, the user may be able to see the remaining liquid level in the consumable of his or her smoking substitute device. However, it can be appreciated that such an approach may be quite approximate. It also relies on the window giving the user visual access to the entire tank, top-to-bottom, which is potentially difficult to provide in practice in a physically quite compact consumable. Furthermore, since the user inherently

does not look at his or her smoking substitute device during smoking substitute action, because the device will be located at and below the user's mouth level, a user is likely to find it inconvenient to rely solely on visual inspection (or trial and error) in order to determine whether and when a consumable must be replaced for his or her smoking substitute device.

[0109] The liquid level sensor 157 may comprise a capacitive probe, which is located within the tank 156 of the consumable 150. For example, the tank 156 may be configured such that at least a portion of one inner wall thereof comprises a metal. The capacitive probe may include a metal shaft inserted along the length of the tank. The shaft and the inner wall are electrically connected in a manner that causes them to resemble or behave as a capacitor, i.e. as spaced parallel conductive structures, similar to capacitor plates. In this arrangement, a dielectric medium between the plates is formed by a combination of air and e-liquid in the tank 156. As the skilled reader will recognise, the e-liquid and the air will have different respective inherent dielectric permittivity values (or dielectric constants (ϵ)). Therefore, as the fill level of e-liquid within the tank 156 changes, so too will the overall dielectric permittivity of the medium within the capacitor and so the output capacitance will change.

[0110] The capacitive probe is configured to electrically connect to the control unit 130, via the electrical interfaces 136, 160 of the consumable 150 and the smoking substitute device 110. Therefore, the control unit 130 can receive a signal indicative of the capacitance values of the probe to determine a corresponding fill levels for the tank 156. The control unit 130 may assign time values to the received signals, so that they can be stored in the memory 132 in connection with their time values, and/or used in conjunction with other operating data for the same time - which may be an instantaneous time or may be a time period.

[0111] When the smoking substitute device is network-enabled and configured to communicate with an application installed on a mobile device, the application may also make use of information from the liquid level sensor 157 (i.e. information indicative of a fill level of the consumable 150) received from the smoking substitute device. The control unit 130 in the main body 120 may be arranged to receive data from the liquid level sensor via a communication link that runs through the electrical interfaces 136, 160, for example. The application may be configured to automatically link to an online facility for purchasing replacement consumables when the fill level of the tank 156 within the current consumable 150 (or the fill level of the tank within a pre-determined one of a previously purchased batch of consumables) falls below a pre-determined level.

[0112] Of course, a skilled reader would readily appreciate that the smoking substitute device 110 shown in Figs. 2 and 3 shows just one example implementation of a smoking substitute device, and that other forms of smoking substitute device could be used as the smoking

substitute device 10 of Fig. 1.

[0113] By way of example, a HNB smoking substitute device including a main body and a consumable could be used as the smoking substitute device 10 of Fig. 1, instead of the smoking substitute device 110. One such HNB smoking substitute device is the IQOS™ smoking substitute device discussed above.

[0114] As another example, an open system vaping device which includes a main body, a refillable tank, and a mouthpiece could be used as the smoking substitute device 10 of Fig. 1, instead of the smoking substitute device 110. One such open system vaping device is the blu PRO™ e-cigarette discussed above.

[0115] As another example, an entirely disposable (one use) smoking substitute device could be used as the smoking substitute device 10 of Fig. 1, instead of the smoking substitute device 110.

[0116] Embodiments of the present invention relate to the accurate determination of the tank fill level. Although the description above relates to a "closed system" type smoking substitute device, in which the smoking substitute device is arranged to mechanically and electrically interface with a consumable or "pod", it will be appreciated that the present invention is not limited to that particular type of smoking substitute device and corresponding consumable but could be applied to other types as well.

[0117] The present invention provides an accurate means for determining a fill level for a smoking substitute device through the inclusion of both an orientation sensor and a liquid level sensor in the smoking substitute device and/or in the consumable which inserts into a smoking substitute device.

[0118] According to the present embodiment, the control unit 130 is configured to obtain a signal from the liquid level sensor 157 on a periodic or ad hoc basis. The control unit 130 is configured to obtain a orientation signal from the orientation sensor 135 when a signal from the liquid level sensor 157 is obtained. In this way, the sensed liquid level may always be associated with a detected orientation. In other examples, the control unit 130 may operate to derive or estimate an orientation based on the most recent available measurement.

[0119] In one example, when the control unit 130 receive a signal from the liquid level sensor 157, it judges, based on the corresponding orientation signal, whether or not the smoking substitute device 110 is upright at that time. If the orientation signal from the orientation sensor 135 indicates that the smoking substitute device 110 was upright at the time, or could have been deemed to have been upright within a pre-determined acceptable margin of error, then it can use the signal from the liquid level sensor 157 directly in order to determine a fill level for the tank 156 at that time. The control unit 130 may include or have access to calibration data or some other look up data structure that transforms the signal from the liquid level sensor 157 to a fill level. The fill level may be displayed on the device using a suitable indicator (e.g. LED

or LCD) or may be communicated, e.g. using the wireless interface 134, for display on the application running on the mobile device.

[0120] If the orientation signal from the orientation sensor 135 indicates that the smoking substitute device 110 was not upright or not sufficiently upright at the time at which the signal from the liquid level sensor 157 was measured, the control unit 130 may be configured to determine a corrected fill level based on the signal from the liquid level sensor 157 and received orientation signal. For example, if the orientation signal indicates that the smoking substitute device was tilted, so that the height, in a substantially vertical plane, of the upper surface of the e-liquid in the tank 156 was not uniform, when viewed along a left-to-right horizontal plane, the control unit 130 may apply an algorithm or look up function to correct the fill level to what it would be if the device was held upright and therefore the height of the e-liquid in the tank 156 had been uniform across its upper surface.

[0121] The algorithm may operate in any suitable manner. For example, it may correct the signal output by the liquid level sensor 157 before a fill level is obtained from that signal. Alternatively, it may correct the fill level itself. The algorithm may be established based on measurements obtained in advance, which are indicative of the effect of orientation on output of the sensor. Alternatively, the algorithm may be configured to construct a virtual model of the tank using pre-stored information about tank dimensions together with information from the orientation sensor. In conjunction with pre-stored knowledge about the location of a probe of the liquid level sensor 157 in the tank, the algorithm may be able to determine a volume of liquid in the tank using a signal from the liquid level sensor 157 and a signal from the orientation sensor 135, wherein the determined volume of liquid is used to obtain the fill level that is communicated or displayed to the user. In examples where the probe of the liquid level sensor is not symmetrically mounted in the tank, the algorithm may make use of an orientation signal that includes not only the angle or extent of tilt of the device but also the direction of the tilt.

[0122] In one example, instead of correcting the signal output by the liquid level sensor at times at which the smoking substitute device is determined to have been tilted, the control unit may instead be configured to ignore such signals and wait until it next receives a signal output by the liquid level sensor at a time at which the smoking substitute device is not tilted. The smoking substitute device may include means for indicating to a user that the device is not upright.

[0123] Referring back to Fig. 3(a), the additional components 138 of the smoking substitute device 110 may also comprises a visual display, e.g. comprises an LCD or LED display. The smoking substitute device 110 may be configured so that the tank fill level can be displayed on the visual display. The tank fill level need not be permanently displayed on the visual display but can be displayed in response to a user command, for example by

actuating a switch on the smoking substitute device. In addition, the control unit 130 is configured to store or access a predetermined threshold value that indicates that the fill level of the tank is low, such that the present consumable will soon have to be replaced. When it is determined that the fill level of the tank has reached or gone below this predetermined threshold value, a warning will be issued to the user via the visual display.

[0124] As mentioned above, the smoking substitute device 110 may have an establish bonded wireless communication link to a mobile device and can provide data to an application running on that mobile device. The data provided to the application can include fill level data as determined by the control unit 130. In a variation of the present embodiment, the raw capacitance and orientation measurements obtained by the liquid level sensor 157 and orientation sensor 135 respectively can be sent to the application, so that processing capability on the mobile device on which the application runs is used to determine tank fill level. The application may be configured to provide fill level data to the user either automatically and/or in response to a user request. The application may also be configured to output a warning to the user via an output of the mobile device to warn the user that the tank fill level is low, for example below a predetermined low threshold value.

[0125] Fig. 4 is a flow diagram depicting steps in a method 400 carried out by the components of the smoking substitute device and its consumable according to the above described embodiment of the present invention.

[0126] At step 402, the liquid-level sensor detects a level of liquid in the tank. This is done by a capacitive probe in this embodiment, but other types of liquid level sensors could be used to perform this task, e.g. optical sensors, ultrasonic sensors, etc.

[0127] At step 404, a liquid level measurement is transmitted from the liquid-level sensor to the control unit. The control unit may comprise a microprocessor located within the smoking substitute device. Alternatively or additionally, the liquid level measurement may be transmitted to an application or to a server for use in a subsequent determination. As the skilled reader will appreciate, any suitable electrical components and software may be used in the smoking substitute device in order to provide a connection between the liquid level sensor and control unit.

[0128] At step 406, the orientation sensor detects an orientation of the smoking substitute device. For example, it may obtain one or more orientation measurements regarding absolute or relative position of the device and/or measurements of movement of the device away from a reference position. In this embodiment the orientation sensor is an accelerometer, but other types of orientation sensor could be used to perform this task.

[0129] At step 408, an orientation measurement is transmitted from the orientation sensor to the control unit. As the skilled reader will appreciate, any suitable electri-

cal components and software maybe used in the smoking substitute device in order to provide a connection between the orientation sensor and control unit.

[0130] At step 410, the control unit modifies the liquid level measurement transmitted by the liquid-level sensor, based on the orientation measurement transmitted by the orientation sensor, to determine a tank fill level. This modification may comprise applying an algorithm to the liquid level measurement or changing it in accordance with values in a pre-stored database. Or the modification may include discarding or ignoring the liquid level measurement, based on an assessment that the tilt of the device at the time was too great for it to be reliable.

[0131] Step 412 is an optional step, in which a tank fill level is output to the user, via a visual display. As mentioned above, the smoking substitute device in this particular embodiment may have a screen via which to display tank fill level but it will not do so at all times. it will only do so in response to a user request to see the tank fill level and when the tank fill level has reached or passed a predetermined low threshold, at which point a suitable warning will be issued to the user via the screen. As also mentioned already above, the output to the user of tank fill level data could instead be done by the mobile device which is in wireless communication with the smoking substitute device.

[0132] Thus a reliable and efficient means is provided for accurately monitoring the tank fill level for a smoking substitute device and for providing tank fill level data to the user. This is achieved using components that are physically small and compact enough to be readily incorporated into a smoking substitute device and or a consumable for a smoking substitute device consumable, without requiring significant additional physical space or without adding significantly to the size, weight or cost of the device or the consumable. The method employed to provide accurate tank fill level data is computationally streamlined and does not present an undue processing burden on the control unit of a smoking substitute device.

[0133] Whilst a particular embodiment has been shown and described in detail herein, it will be appreciated that variations can be made to the physical details without departing from the described invention. For example, an alternative type of capacitive probe may be used which has a substantially cylindrical inner rod and an outer shell, concentric with one another, with a gap between the inner rod and the outer shell, wherein a capacitor is formed between the inner rod and the outer shell. In use, when such a capacitive probe is inserted into the tank of a smoking substitute consumable, e-liquid from the tank will flow up into the gap between the inner rod and the outer shell, therefore enabling the e-liquid to displace air as part of the dielectric medium between the inner rod and the outer shell. In such an embodiment, there is no need for part of the tank inner wall to be metal.

[0134] The terms 'liquid level sensor', 'orientation sensor', 'tank fill level;' and so on are intended to be illustrative of the functions on the relevant component and need

not to be limited to specific types of device.

[0135] The smoking substitute device does not have to form a bonded wireless communication link with the mobile device on which the application ins installed. But there should preferably be some security or identification steps followed, before the smoking substitute device accepts firmware update messages from the application, via the wireless interface of a mobile device.

[0136] The features disclosed in the foregoing description, or in the following claims, or in the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for obtaining the disclosed results, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

[0137] While the invention has been described in conjunction with the exemplary embodiments described above, many equivalent modifications and variations will be apparent to those skilled in the art when given this disclosure. Accordingly, the exemplary embodiments of the invention set forth above are considered to be illustrative and not limiting. Various changes to the described embodiments may be made without departing from the spirit and scope of the invention.

[0138] For the avoidance of any doubt, any theoretical explanations provided herein are provided for the purposes of improving the understanding of a reader. The inventors do not wish to be bound by any of these theoretical explanations.

[0139] Any section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described.

[0140] Throughout this specification, including the claims which follow, unless the context requires otherwise, the word "comprise" and "include", and variations such as "comprises", "comprising", and "including" will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

[0141] It must be noted that, as used in the specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise. Ranges may be expressed herein as from "about" one particular value, and/or to "about" another particular value. When such a range is expressed, another embodiment includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by the use of the antecedent "about," it will be understood that the particular value forms another embodiment. The term "about" in relation to a numerical value is optional and means for example +/- 10%.

Claims

1. A smoking substitute device comprising:

- a tank for containing a liquid;
 a liquid-level sensor for detecting a level of liquid in the tank;
 an orientation sensor for detecting an orientation of the smoking substitute device; and
 a control unit, wherein the control unit is configured to determine an amount of liquid in the tank by modifying a liquid level measurement detected by the liquid-level sensor using an orientation measurement detected by the orientation sensor.
2. The smoking substitute device of claim 1, wherein the control unit inputs the liquid level measurement and the orientation measurement to an algorithm whose output is a modified liquid level measurement.
 3. The smoking substitute device of claim 1 or 2 further comprising a memory storing a look-up table, wherein the control unit is configured to look up a liquid level adjustment from the look-up table using the orientation measurement, and apply the liquid level adjustment to the liquid level measurement detected by the liquid-level sensor.
 4. The smoking substitute device of claim 3, wherein the look-up table comprises a list of predetermined liquid level adjustments associated with corresponding orientation values.
 5. The smoking substitute device of claim 4, wherein the control unit is configured to find an orientation value that corresponds to the orientation measurement, and apply the liquid level adjustment associated with that orientation value to the liquid level measurement.
 6. The smoking substitute device of any preceding claim, wherein the liquid comprises any of: a vaporisable e-liquid, or an aerosolisable flavouring.
 7. The smoking substitute device of any preceding claim, wherein the tank comprises a refillable reservoir or a consumable pod.
 8. The smoking substitute device of any preceding claim comprising a main body that houses the control unit, wherein the tank and liquid-level sensor are in a consumable pod that is detachably mountable to the main body, wherein the main body and the consumable pod each include an electrical interface, where the electrical interfaces are connected when the consumable pod is mounted to the main body, and wherein the liquid-level sensor is configured to communicate the liquid level measurement to the control unit via the electrical interfaces.
 9. The smoking substitute device of any preceding claim, further comprising a display means configured to display an amount of liquid, as determined by control unit.
10. The smoking substitute device of any preceding claim further comprising a wireless interface configured to wirelessly communicate with an application installed on a mobile device.
 11. The smoking substitute device of any preceding claim wherein the liquid level sensor comprises a capacitance sensor.
 12. The smoking substitute device of any preceding claim wherein the orientation sensor comprises any of: an accelerometer, a gyroscope or a magnetometer.
 13. A computer-implemented method for managing a smoking substitute device, the method comprising:
 - detecting, using a liquid-level sensor, a level of liquid in a tank in the smoking substitute device;
 - communicating a liquid level measurement from the liquid-level sensor to a control unit of the smoking substitute device;
 - detecting, using an orientation sensor, an orientation of the smoking substitute device;
 - communicating an orientation measurement from the orientation sensor to the control unit; and
 - determining, by the control unit, an amount of liquid in the tank by modifying the liquid level measurement transmitted by the liquid-level sensor using the orientation measurement transmitted by the orientation sensor.
 14. A computer-implemented method for managing a smoking substitute device, the method comprising:
 - receiving a liquid level measurement obtained by a liquid-level sensor in a tank in the smoking substitute device;
 - receiving an orientation measurement obtained by an orientation sensor of the smoking substitute device; and
 - determining an amount of liquid in the tank by modifying the liquid level measurement using the orientation measurement.
 15. A computer readable medium containing instructions configured to, when executed by processor, perform the method of claim 13 or claim 14.

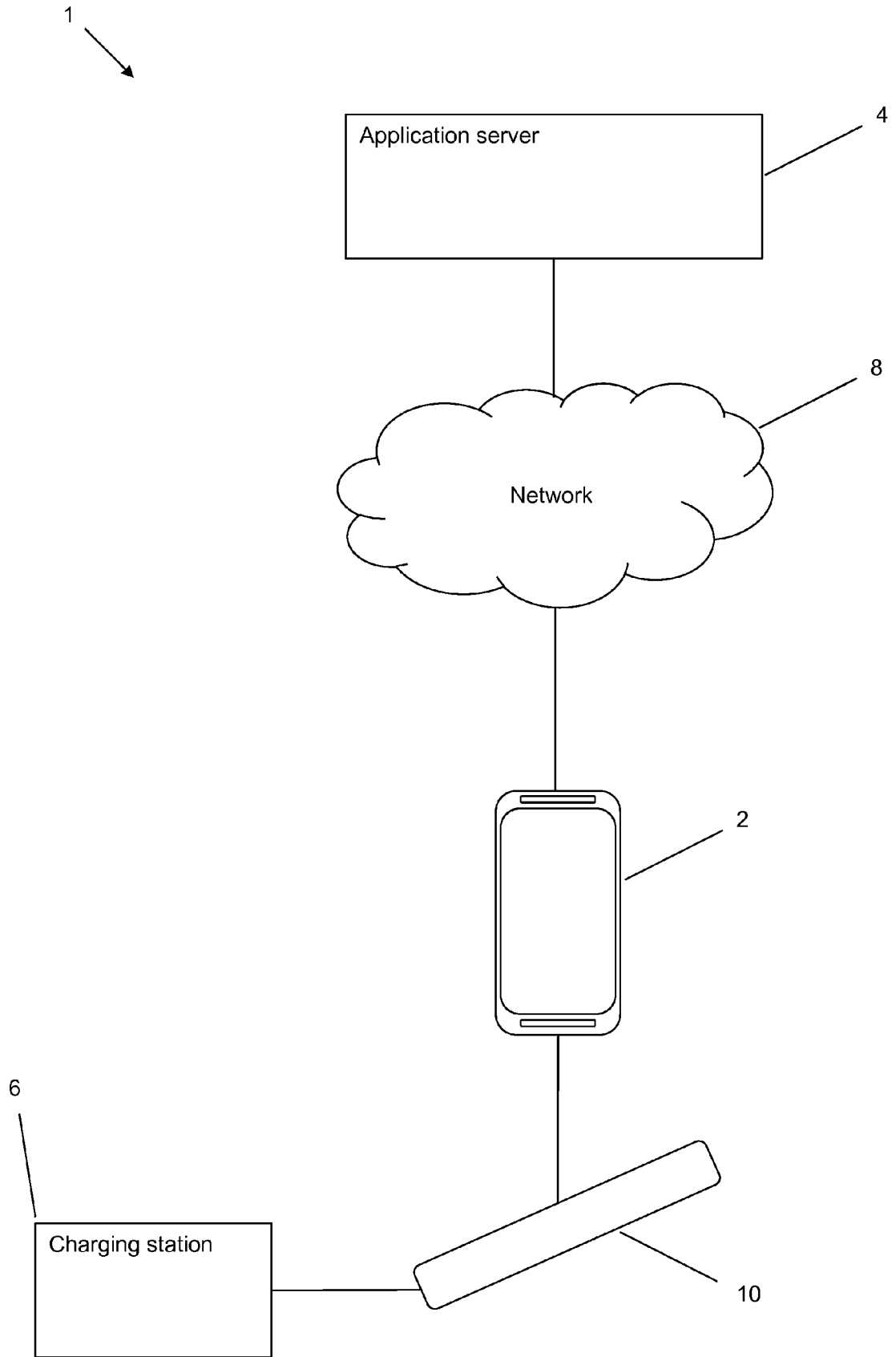


Fig. 1

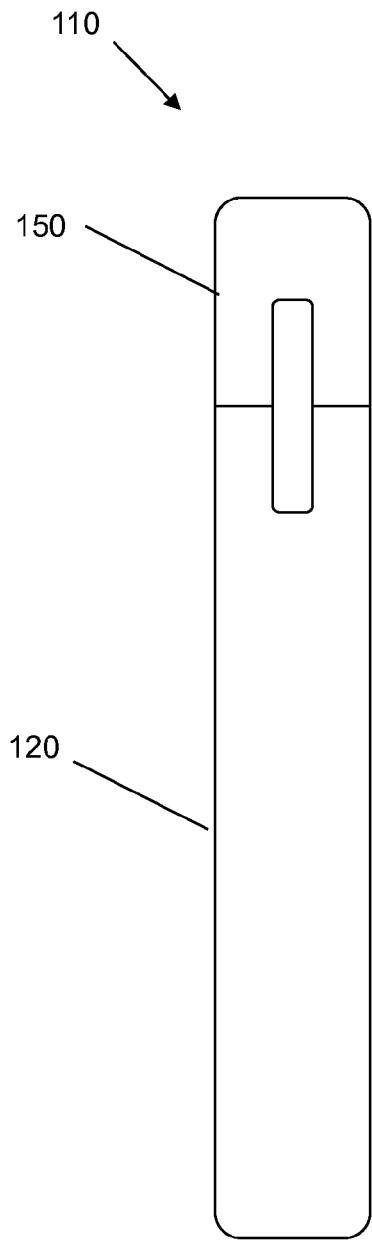


Fig. 2(a)

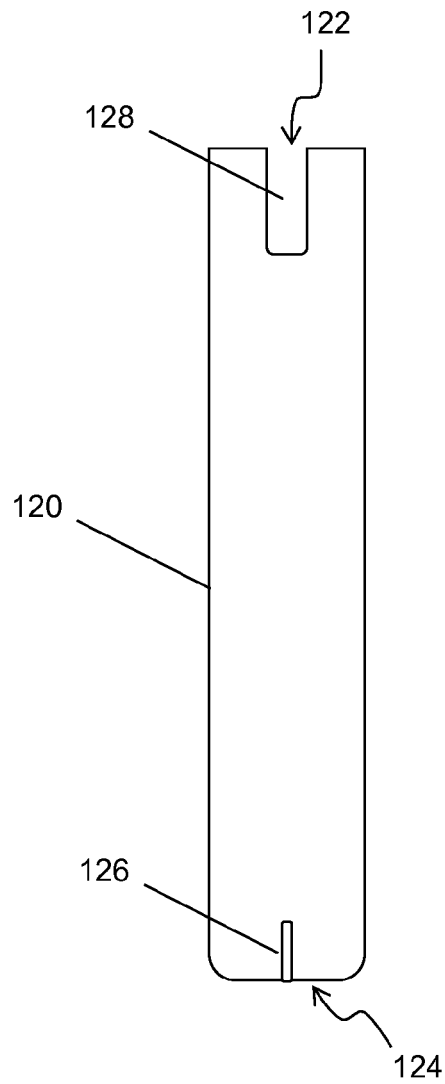


Fig. 2(b)

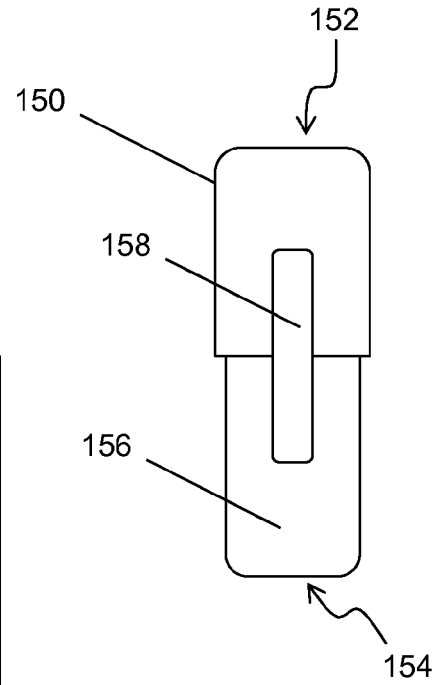


Fig. 2(c)

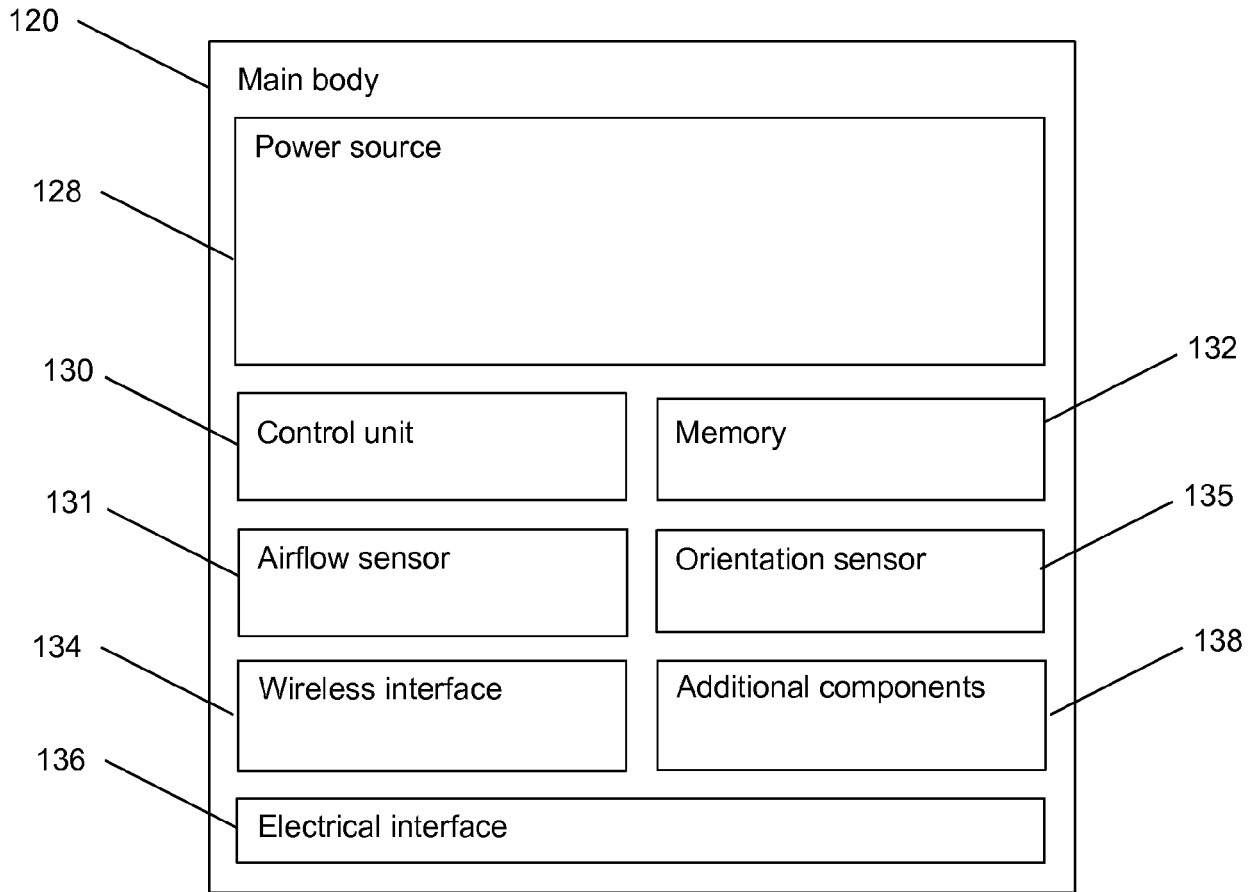


Fig. 3(a)

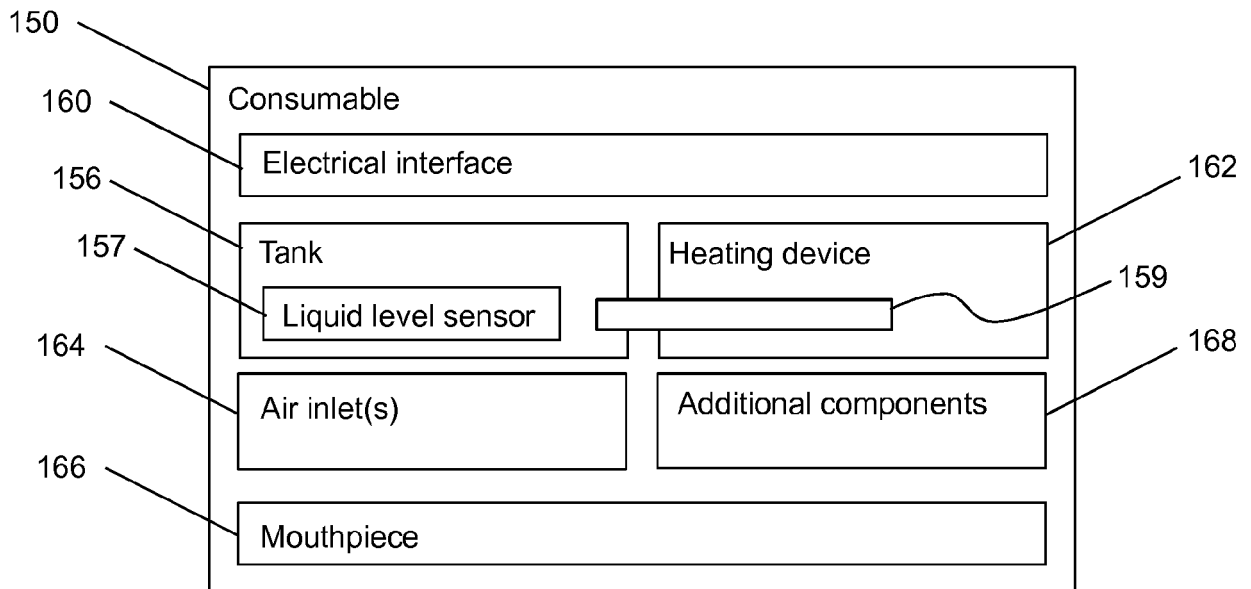


Fig. 3(b)

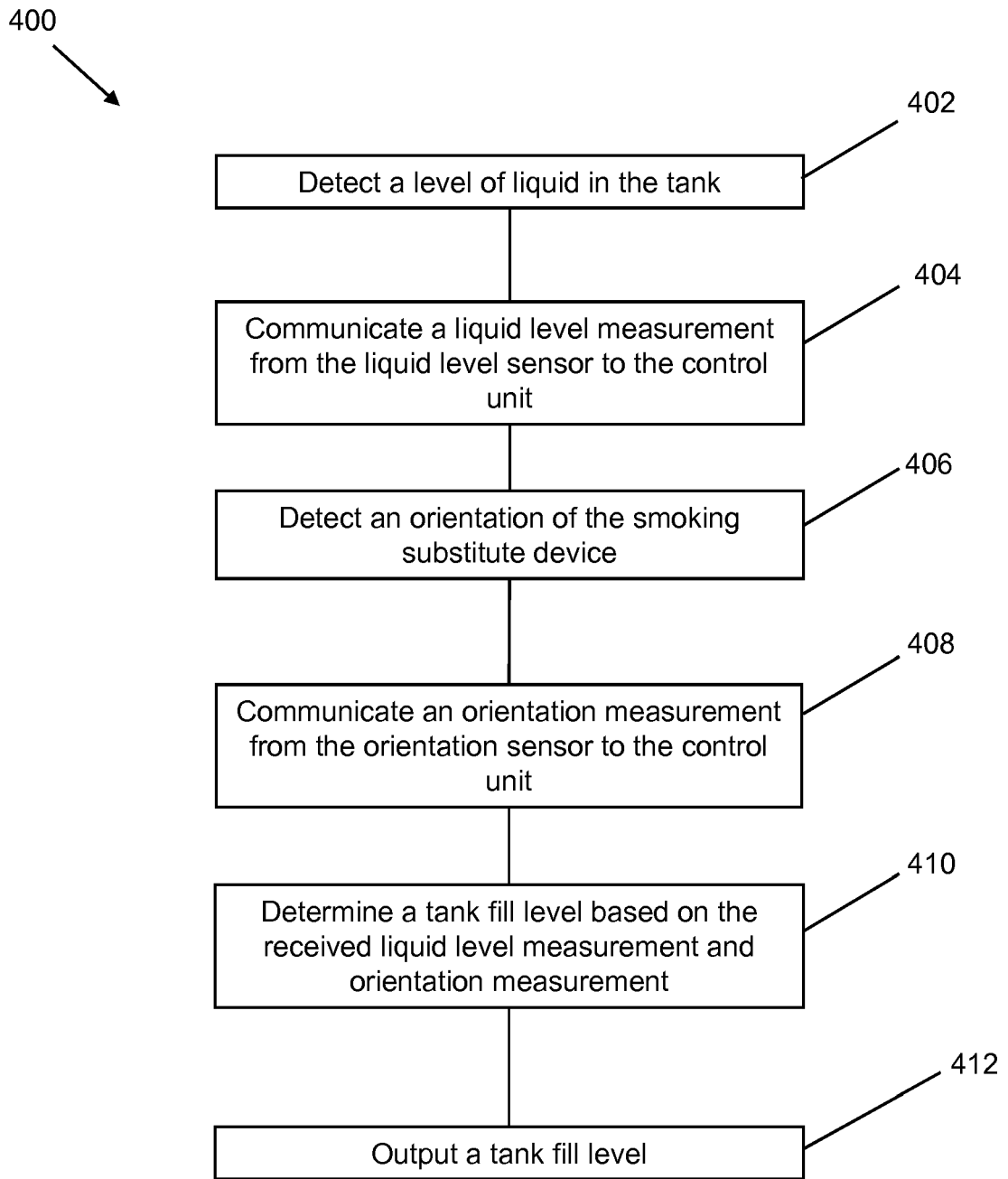


Fig. 4



EUROPEAN SEARCH REPORT

Application Number
EP 19 17 9906

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