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(54) AEROSOL DELIVERY DEVICE

(57) The present disclosure relates to an aerosol delivery device and system e.g. a smoking substitute device and system. In particular, the present disclosure relates to an aerosol delivery device for forming an aerosol delivery system comprising the aerosol delivery system, a tank for containing an aerosol precursor, and a heater for heating the aerosol precursor. The aerosol delivery device comprises a controller configured to determine a plurality of resistance values of the heater, wherein each of the plurality of resistance values is determined based on a reference resistance of a sense resistor, a measured voltage at a first point between the sense resistor and the heater, and a constant voltage at a second point located at an opposite side of the sense resistor to the first point. The controller is further configured to determine a rate of change of resistance of the heater based on the plurality of resistance values of the heater, and to detect a low liquid level of the aerosol precursor in the tank based on the rate of change of resistance of the heater. An aerosol delivery system comprising the aerosol delivery device as well as a method for detecting a low liquid level of aerosol precursor in an aerosol delivery system are also described. A computer program configured to cause an aerosol delivery system to perform the method for detecting a low liquid level of aerosol precursor is also provided.

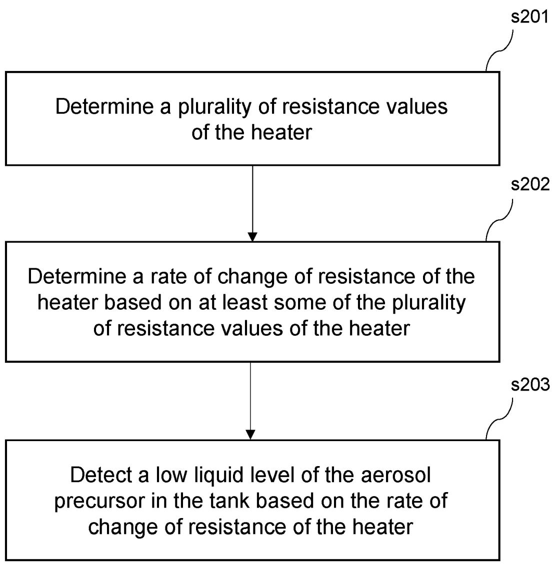

FIG. 3

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Description

Technical field

[0001] The present disclosure relates to an aerosol delivery device and an aerosol delivery system such as a smoking substitute device/system.

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] Combustion of organic material such as tobacco is known to produce tar and other potentially harmful by-products. There have been proposed various smoking substitute systems in order to avoid the smoking of tobacco.

[0004] Such smoking substitute systems can form part of nicotine replacement therapies aimed at people who wish to stop smoking and overcome a dependence on nicotine.

[0005] Smoking substitute systems, which may also be known as electronic nicotine delivery systems, may comprise electronic systems that permit a user to simulate the act of smoking by producing an aerosol, also referred to as a "vapour", which 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.

[0006] In general, smoking substitute systems 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.

[0007] The popularity and use of smoking substitute systems has grown rapidly in the past few years. Some smoking substitute systems are designed to resemble a traditional cigarette and are cylindrical in form with a mouthpiece at one end. Other smoking substitute systems do not generally resemble a cigarette (for example, the smoking substitute device may have a generally box-like form).

[0008] There are a number of different categories of smoking substitute systems, each utilising a different smoking substitute approach. A smoking substitute approach corresponds to the manner in which the substitute system operates for a user.

[0009] One approach for a smoking substitute system is the so-called "vaping" approach, in which a vaporisable liquid, typically referred to (and referred to herein) as "e-liquid", is heated by a heater 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 glycerine.

[0010] A typical vaping smoking substitute system includes a mouthpiece, a power source (typically a battery), a tank or liquid reservoir for containing e-liquid, as well as a heater. In use, electrical energy is supplied from the power source to the heater, which heats the e-liquid to produce an aerosol (or "vapour") which is inhaled by a user through the mouthpiece.

[0011] Vaping smoking substitute systems can be configured in a variety of ways. For example, there are "closed system" vaping smoking substitute systems which typically have a heater and a sealed tank 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 systems include a device which includes the power source, wherein the device is configured to be physically and electrically coupled to a component including the tank and the heater. In this way, when the tank of a component has been emptied, the device can be reused by connecting it to a new component. Another subset of closed system vaping smoking substitute systems are completely disposable and intended for one-use only.

[0012] There are also "open system" vaping smoking substitute systems which typically have a tank that is configured to be refilled by a user, so the system can be used multiple times.

[0013] An example vaping smoking substitute system is the myblu™ e-cigarette. The myblu™ e cigarette is a closed system which includes a device and a consumable component. The device and consumable component are physically and electrically coupled together by pushing the consumable component into the device. The device includes a rechargeable battery. The consumable component includes a mouthpiece, a sealed tank which contains e-liquid, as well as a vaporiser, which for this system is a heating filament coiled around a portion of a wick which is partially immersed in the e-liquid. The system is activated when a microprocessor on board the device detects a user inhaling through the mouthpiece. When the system is activated, electrical energy is supplied from the power source to the vaporiser, which heats e-liquid from the tank to produce a vapour which is inhaled by a user through the mouthpiece.

[0014] Another example vaping smoking substitute system is the blu PRO™ e-cigarette. The blu PRO™ e cigarette is an open system which includes a device, a (refillable) tank, and a mouthpiece. The device 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 into the other, and detaching the mouthpiece from the refillable tank allows the tank to be refilled with e-liquid. The system is activated by a button on the device. When the system is activated, electrical energy is supplied from the power source to a vaporiser, which heats e-liquid from the tank to produce a vapour which is inhaled by a user through the mouthpiece.

[0015] An alternative to the "vaping" approach 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. In the HT approach the intention is that the tobacco is heated but not burned, i.e. the tobacco does not undergo combustion.

[0016] The heating, as opposed to burning, of 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.

[0017] A typical HT smoking substitute system may include a device and a consumable component. The consumable component may include the tobacco material. The device and consumable component 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 component (entrained in the airflow) from the location of vaporization to an outlet of the component (e.g. a mouthpiece), the vapour cools and condenses to form an aerosol for inhalation by the user. The aerosol may contain nicotine and/or flavour compounds.

[0019] As e-liquid in the tank is depleted during operation, the quantity of e-liquid remaining in the tank can become insufficient for normal operation of the aerosol delivery system. For example, insufficient amount of e-liquid in the tank can reduce the amount of aerosol generated by the aerosol delivery system and/or result in an undesired change in properties (e.g. flavour) of the generated aerosol.

[0020] Accordingly, there is a need for an improved aerosol delivery device/system which addresses at least some of the problems of the known devices and systems.

Summary

[0021] According to a first aspect, there is provided an aerosol delivery device for forming an aerosol delivery system, the aerosol delivery system comprising the aerosol delivery device, a tank for containing an aerosol precursor, and a heater for heating the aerosol precursor, wherein the aerosol delivery device is for controlling operation of the heater and the aerosol delivery device comprises:

a controller configured to:

> determine a plurality of resistance values of the heater, wherein each of the plurality of resistance values is determined based on a reference resistance of a sense resistor, a measured voltage at a first point between the sense resistor and the heater, and a constant voltage at a second point located at an opposite side of the sense resistor to the first point;
> determine a rate of change of resistance of the heater based on the plurality of resistance values of the heater; and
> detect a low liquid level of the aerosol precursor in the tank based on the rate of change of resistance of the heater.

[0022] The aerosol delivery device of this aspect ensures that device operation under conditions of insufficient aerosol precursor (e-liquid) in the tank can be avoided by detecting the low liquid level of the aerosol precursor in the tank. The controller can advantageously detect the low liquid level of the aerosol precursor in the tank with high accuracy. This is at least partially due to the use of a constant voltage (as opposed to e.g. a voltage of a power source of the aerosol delivery system) in the determination of the plurality of resistance values of the heater. The constant voltage may be a voltage which does not exceed a predetermined voltage value, irrespective of fluctuations in the value of the battery voltage. Advantageously, using the constant voltage to determine the plurality of resistance values of the heater can improve the accuracy of low liquid level detection performed by the controller. Furthermore, detecting the low liquid level of the aerosol precursor in the tank based on the rate of change of resistance of the heater can also ensure high detection accuracy. This is because by using the rate of change of resistance of the heater, the detection is based on a plurality of resistance values of the heater, as opposed to a single resistance value which may not on its own sufficiently accurately represent the state (i.e. liquid level) of the system.

[0023] Optional features will now be set out. These are applicable singly or in any combination with any aspect.

[0024] Throughout the present specification resistance refers to electrical resistance. The aerosol precursor is a liquid precursor. The aerosol precursor may comprise an e-liquid, for example, comprising a base liquid and e.g. nicotine. The base liquid may include propylene glycol and/or vegetable glycerine. The rate of change of resistance of the heater may be a rate of change of electrical resistance over time, e.g. over a predefined period of time.

[0025] The low liquid detection executed by the controller may be performed during a heating phase of operation of the aerosol delivery device, i.e. a phase during which power is supplied to the heater, e.g. periodically, to increase or maintain an operating temperature of the heater. That is, the plurality of resistance values of the heater may be determined during the heating phase of operation. Alternatively, the low liquid detection may be performed during a cooling phase of operation of the aerosol delivery device, i.e. a phase during which power supply to the heater is terminated in order to decrease an operating temperature of the heater. That is, the plurality of resistance values of the heater may be determined during the cooling phase.

[0026] The controller may be configured to determine the plurality of resistance values of the heater over time, e.g., sequentially. The plurality of resistance values may be determined at predefined intervals, for example. They may be determined at a constant rate.

[0027] Optionally, detecting a low liquid level of the aerosol precursor in the tank includes comparing the rate of change of resistance of the heater to a reference rate of change of resistance. The reference rate of change of resistance may be based on a plurality of reference resistance values. For example, the reference rate of change of resistance may be based on resistance values of the heater previously determined by the controller. In this way, the reference rate of change of resistance is representative of the performance of the specific heater whose resistance is monitored to detect the low liquid level in the aerosol delivery system. This is in contrast for example to a configuration in which the reference rate of change of resistance is based on resistance values from a standardised look-up table representative of typical performance of heaters of this kind. Thus, using a reference rate of change of resistance based on resistance values of the heater can improve the accuracy of low liquid detection.

[0028] Alternatively, the reference rate of change of resistance may be based on resistance values from a standardised look-up table representative of a typical heater.

[0029] The reference rate of change of resistance may be stored at the aerosol delivery device, e.g., in a memory operatively connected to the controller.

[0030] The reference rate of change of resistance may be indicative of a sufficient liquid level of the aerosol precursor in the tank, i.e. a liquid level in the tank which is sufficient for normal operation of the aerosol delivery device.

[0031] Optionally, the controller is configured to detect a low liquid level of the aerosol precursor in the tank when the rate of change of resistance of the heater is greater than the reference rate of change of resistance. When the controller performs the low liquid detection during the heating phase of operation as described above, the controller may be configured to detect the low liquid level of the aerosol precursor in the tank when the rate of change of resistance of the heater, which is a positive rate of change, is greater than the reference rate of change of resistance. This is indicative of the resistance of the heater rising more quickly compared to under normal operating conditions associated with a normal liquid level in the tank. Alternatively, when the controller performs the low liquid detection during the cooling phase of operation, the controller may be configured to detect the low liquid level of the aerosol precursor in the tank when the rate of change of resistance of the heater, which is a negative rate of change, is greater than the reference rate of change of resistance. This corresponds to a situation in which the heater cools down more slowly compared to under normal operating conditions associated with a normal liquid level in the tank.

[0032] Optionally, the controller is configured to detect a low liquid level of the aerosol precursor in the tank when the rate of change of resistance of the heater is greater than the reference rate of change of resistance for longer than a predefined time period. In particular, the controller may be configured to determine a plurality of values for the rate of change of resistance over time, and detect a low liquid level of the aerosol precursor in the tank when more than a predefined number of the plurality of values for the rate of change of resistance meets a predefined criterion (e.g., is greater than a predefined threshold). Advantageously, this can reduce a risk of falsely detecting a low liquid level of the aerosol precursor (e.g., detecting false positives), thereby improving detection accuracy.

[0033] Optionally, the reference rate of change of resistance is updated periodically. For example, the reference rate of change of resistance may be dynamically updated as resistance values of the heater are determined by the controller over time. The reference rate of change of resistance may be updated at least once during the lifetime of a consumable component coupled to the aerosol delivery device. This is because different consumable components may have different heaters with different characteristics. Therefore, it is advantageous to update the reference rate of change of resistance so that it is specific to the heater of the consumable component currently coupled to the aerosol delivery device.

[0034] Optionally, the aerosol delivery device further comprises a power source for supplying power to the heater, wherein the constant voltage is independent of a voltage of the power source. The power source may be a battery. The power source may be a capacitor. The power source may be a rechargeable power source. The device may comprise a charging connection for connection to an external power supply for recharging of the power source within the device.

[0035] Optionally, the aerosol delivery device comprises a constant voltage source for providing the constant voltage.

[0036] Optionally, the constant voltage source is powered by the power source. In other words, the power source may supply electric power to the constant voltage source to drive it.

[0037] Optionally, the constant voltage source comprises a Zener diode. The Zener diode may have a breakdown voltage less than the output voltage of the power source (e.g., battery). In these examples, as the breakdown voltage of the Zener diode is less than the output voltage of the power source, the output voltage of the Zener diode is constant. The Zener diode may have a breakdown voltage of less than or equal to 3.3V. The breakdown voltage of the Zener diode may be between 2.4 and 3V, for example. The power source (e.g., battery) may have an output voltage of greater than 3.5V. The output voltage of the power source may be between 3.5 and 4.3V (which may depend on charge level), for example.

[0038] Optionally, the aerosol delivery device further comprises electrical circuitry, the electrical circuitry comprising a resistance-monitoring path for determining the resistance of the heater, and a main power supply path for supplying power to the heater for aerosol generation. The resistance-monitoring path may be arranged electrically in parallel to the main power supply path. The resistance-monitoring path may comprise the sense resistor. The sense resistor may be a resistor having a known, fixed resistance value under predetermined operating conditions of the aerosol delivery device, e.g. in the normal operating temperature range of the device. For example, the sense resistor may have a resistance value of approximately 1.6Ω.

[0039] Optionally, the controller is configured to switch the supply of power from the power source to the heater between the main power supply path and the resistance-monitoring path. This may be performed during the heating phase of operation of the aerosol delivery device. The electrical circuitry may comprise a switch for switching the supply of power from the power source to the heater between the main power supply path and the resistance-monitoring path. The switch may be a plurality of switches. The/each switch may be for example a field-effect transistor (FET). Alternatively, during the cooling phase of operation, no power is supplied via the main power supply path in order to decrease the temperature of the heater. During the cooling phase, power may still be supplied via the resistance-monitoring path in order to enable low liquid detection.

[0040] Optionally, the controller is configured to periodically switch between the main path and the resistance-monitoring path at a predetermined switching frequency. For example, the predetermined switching frequency may be a frequency, f, between 10 Hz and 1kHz (corresponding to a switching period, T, of between 1 ms and 100 ms inclusive). The predetermined frequency may be between 100 Hz and 1kHz, more preferably between 500 Hz and 1kHz, for example.

[0041] The device may comprise a device body for housing the controller and the power source and/or other electrical components. The device body may be an elongate body i.e. with a greater length than depth/width. It may have a greater width than depth.

[0042] The device body may have a length of between 5 and 30 cm e.g. between 5 and 10 cm such as between 7 and 9 cm. The maximum depth of the device body may be between 5 and 15 mm e.g. between 9 and 12 mm.

[0043] The device body may have a longitudinal axis.

[0044] The device body may have a front surface that is curved in the transverse dimension, wherein the transverse dimension is in a direction perpendicular to the longitudinal axis of the device body. The device body may have a rear surface that is curved in the transverse dimension. The curvatures of the front surface and rear surface may be of the opposite sense to one another. Both front and rear surfaces may be convex in the transverse dimension.

[0045] The device body may have a substantially oval transverse cross-sectional shape.

[0046] The device body may be formed of a metal e.g. of aluminium.

[0047] The front and/or rear surface of the device body may include at least one visual user feedback element, for example one or more lights e.g. one or more LEDs.

[0048] The device may comprise a movement detection unit (e.g. an accelerometer) for detecting a movement of the device.

[0049] The device may comprise a haptic feedback generation unit (e.g. an electric motor and a weight mounted eccentrically on a shaft of the electric motor).

[0050] The controller may be further configured to identify an operation of the device; and control the one or more lights contained within the device body, (e.g. to illuminate the LED(s)) based on the operation of the device identified.

[0051] The controller may be configured to control the haptic feedback generation unit to generate the haptic feedback in response to the detection of movement of the device by the movement detection unit.

[0052] The controller may be configured to control one or more components of the aerosol delivery device in response to a low liquid level detection. The controller may be configured to control the one or more lights, haptic feedback generation unit and/or the power supplied to the heater based on a detection of a low liquid level. In this way, feedback can be provided to the user that the liquid level is too low. In some examples, the controller may prevent the supply of power to the heater for aerosol generation when a low liquid level of the aerosol precursor is detected. Accordingly, unwanted properties (e.g., unpleasant taste, reduced aerosol production) can be avoided, and the user is also aware of when to replace the aerosol precursor in the tank.

[0053] As mentioned above, a memory may be provided and may be operatively connected to the controller. The memory may include non-volatile memory. The memory may include instructions which, when implemented, cause the controller to perform certain tasks or steps of a method. As discussed above, when detecting a low liquid level of the aerosol precursor in the tank includes comparing the rate of change of resistance of the heater to a reference rate of change of resistance, the memory may store the reference rate of change of resistance.

[0054] The device may comprise a wireless interface, which may be configured to communicate wirelessly with another device, for example a mobile device, e.g. via Bluetooth™. To this end, the wireless interface could include a Bluetooth™ antenna. Other wireless communication interfaces, e.g. WiFi™, are also possible. The wireless interface may also be configured to communicate wirelessly with a remote server.

[0055] The device may comprise an airflow (i.e. puff) sensor that is configured to detect a puff (i.e. inhalation from a user). The airflow sensor may be operatively connected to the controller so as to be able to provide a signal to the controller that is indicative of a puff state (i.e. puffing or not puffing). The airflow sensor may, for example, be in the form of a pressure sensor or an acoustic sensor.

[0056] The controller may control power supply to a vaporiser in response to airflow detection by the sensor. The control may be in the form of activation of the vaporiser in response to a detected airflow.

[0057] The device may comprise an electrical connection (e.g. one or more contact pins) for connection of the power source to the vaporiser.

[0058] The device may comprise a chassis within the device body and one or more of the electrical components of the device (e.g. one or more of the power source, charging connection, visual feedback element, movement detection unit, haptic feedback generation unit, controller, memory, wireless interface, puff sensor and/or electrical connection) may be mounted on or affixed to the chassis.

[0059] According to a second aspect, there is provided an aerosol delivery system comprising:

the aerosol delivery device of the first aspect; and
a consumable component configured to be coupled to the aerosol delivery device;
wherein the consumable component comprises the tank for containing the aerosol precursor and the heater for heating the aerosol precursor.

[0060] In particular, there is provided an aerosol delivery system comprising:

an aerosol delivery device comprising a controller; and
a consumable component configured to be coupled to the aerosol delivery device, wherein the consumable component comprises a tank for containing aerosol precursor and a heater for heating the aerosol precursor, wherein the controller is configured to:

determine a plurality of resistance values of the heater, wherein each of the plurality of resistance values is determined based on a reference resistance of a sense resistor, a measured voltage at a first point between the sense resistor and the heater, and a constant voltage at a second point located at an opposite side of the sense resistor to the first point;
determine a rate of change of resistance of the heater based on the plurality of resistance values of the heater; and detect a low liquid level of the aerosol precursor in the tank based on the rate of change of resistance of the heater.

[0061] As discussed above, the aerosol delivery device may further comprise electrical circuitry comprising a resistance-monitoring path for determining the resistance of the heater, and a main power supply path for supplying power to the heater for aerosol generation. However, another option is for at least a part of electrical circuitry comprising a resistance-monitoring path for determining the resistance of the heater, and a main power supply path for supplying power to the heater for aerosol generation to be provided in the consumable component and any remaining part to be provided in the device. That is, the electrical circuitry may be closed/completed upon coupling the consumable component to the aerosol delivery device. For example, the resistance-monitoring path may be at least partially provided inside the consumable component. Similarly, the main power supply path may be provided at least partially inside the consumable component. In some examples, the heater may be provided in the consumable component and the remaining components of the electrical circuitry may be provided in the aerosol delivery device.

[0062] The consumable component may be an aerosol-delivery (e.g. a smoking substitute) consumable i.e. in some embodiments the consumable component may be a consumable component for engagement with the aerosol-delivery (e.g. a smoking substitute) device to form the aerosol-delivery (e.g. smoking substitute) system.

[0063] The device may be configured to receive the consumable component. The device and the consumable component may be configured to be physically coupled together. For example, the consumable component may be at least partially received in a recess of the device (e.g. in a recess defined by the body). There may be a snap engagement between the device and the consumable component. Alternatively, the device and the consumable component may be physically coupled together by screwing one onto the other, or through a bayonet fitting.

[0064] Thus, the consumable component may comprise one or more engagement portions for engaging with the device.

[0065] The device and consumable component may be coupled together by magnetic attraction. For example, the device may comprise at least one magnet whilst the component may comprise a magnet or ferrous plate.

[0066] The consumable component may comprise a vaporiser. The vaporiser may comprise the heater. Alternatively, the vaporiser may comprise an ultrasonic or flow expansion unit, or an induction heating system.

[0067] The consumable component may comprise an electrical interface for interfacing with a corresponding electrical interface of the device. One or both of the electrical interfaces may include one or more electrical contacts. Thus, when the device is engaged with the consumable component, the electrical interface may be configured to transfer electrical power from the power source to the vaporiser (e.g. heater) of the consumable component. The electrical interface may also be used to identify the consumable component from a list of known types. The electrical interface may additionally or alternatively be used to identify when the consumable component is connected to the device.

[0068] The device may alternatively or additionally be able to detect information about the consumable component via an RFID reader, a barcode or QR code reader. This interface may be able to identify a characteristic (e.g. a type) of the consumable. In this respect, the consumable component may include any one or more of an RFID chip, a barcode or QR code, or memory within which is an identifier and which can be interrogated via the interface.

[0069] In other embodiments, the component may be integrally formed with the aerosol-delivery (e.g. a smoking substitute) device to form the aerosol-delivery (e.g. s smoking substitute) system.

[0070] In such embodiments, the aerosol former (e.g. e-liquid) may be replenished by re-filling a tank that is integral with the device (rather than replacing the consumable). Access to the tank (for re-filling of the e-liquid) may be provided via e.g. an opening to the tank that is sealable with a closure (e.g. a cap).

[0071] The smoking substitute system may comprise an airflow path therethrough, the airflow path extending from an air inlet to an outlet. The air inlet may be provided in the device body. The outlet may be at a mouthpiece portion of the component. In this respect, a user may draw fluid (e.g. air) into and along the airflow path by inhaling at the outlet (i.e. using the mouthpiece portion).

[0072] The airflow path passes the vaporiser between the air inlet and the outlet. The vaporiser may be provided in the component.

[0073] The airflow path may comprise a first portion extending from the air inlet towards the vaporiser. A second portion of the airflow path passes the vaporiser (e.g. over or around the vaporiser) to a conduit that extends to the outlet. The conduit may extend along the axial centre of the component.

[0074] References to "downstream" in relation to the airflow path are intended to refer to the direction towards the outlet/mouthpiece portion. Thus the second portion of the airflow path is downstream of the first portion of the airflow path. Conversely, references to "upstream" are intended to refer to the direction towards the air inlet. Thus the first portion of the airflow path (and the air inlet) is upstream of the second portion of the airflow path (and the outlet/mouthpiece portion).

[0075] References to "upper", "lower", "above" or "below" are intended to refer to the component when in an upright/vertical orientation i.e. with elongate (longitudinal/length) axis of the component vertically aligned and with the mouthpiece vertically uppermost.

[0076] As already discussed, the consumable component comprises the tank for housing the aerosol precursor. As discussed above, the aerosol precursor may comprise an e-liquid, for example, comprising a base liquid and e.g. nicotine. The base liquid may include propylene glycol and/or vegetable glycerine.

[0077] The conduit may extend through the tank with the conduit walls defining an inner region of the tank. In this respect, the tank may surround the conduit e.g. the tank may be annular.

[0078] The tank may be transparent or translucent.

[0079] As discussed above, the air flow path passes (e.g. passes over or around) the vaporiser between the air inlet and the outlet. The vaporiser may be within a vaporiser chamber.

[0080] The vaporiser may comprise a wick. The wick may form the base of the tank so that the aerosol precursor may be in contact with the wick. The wick may comprise one or more channels on its upper surface (facing the tank), the channels being in fluid communication with the tank.

[0081] The wick may have a length and width defining its upper surface with a depth aligned with the longitudinal axis of the component. Thus the upper surface and opposing lower surface of the wick may lie in respective planes that are perpendicular to the longitudinal axis of component and longitudinal to the first and third portions of the airflow path.

[0082] The wick may comprise a porous material e.g. a ceramic material. A portion of the wick e.g. at least a portion of the lower surface and/or at least a portion of at least one side wall extending between the upper and lower surface (in a depth direction) may be exposed to airflow in the second portion of the airflow path.

[0083] The heater may be in the form of a heater track on the wick e.g. on the lower surface of the wick. The heater is electrically connected (or connectable) to the power source. Thus, in operation, the power source may supply electricity to (i.e. apply a voltage across) the heater so as to heat the heater. This may cause liquid stored in the wick (i.e. drawn from the tank) to be heated so as to form a vapour and become entrained in airflow along the airflow path. This vapour may subsequently cool to form an aerosol e.g. in the conduit.

[0084] According to a third aspect there is provided a method of using the aerosol-delivery (e.g. smoking substitute) system according to the second aspect, the method comprising engaging the consumable component with an aerosol-delivery (e.g. smoking substitute) device (as described above) having a power source so as to electrically connect the power source to the consumable component (i.e. to the vaporiser of the consumable component).

[0085] According to a fourth aspect, there is provided a method for detecting a low liquid level of aerosol precursor in an aerosol delivery system, the aerosol delivery system comprising a tank for containing the aerosol precursor, and a heater for heating the aerosol precursor, the method comprising:

determining a plurality of resistance values of the heater, wherein each of the plurality of resistance values is determined based on a reference resistance of a sense resistor, a measured voltage at a first point between the sense resistor and the heater, and a constant voltage at a second point located at an opposite side of the sense resistor to the first point;
determining a rate of change of resistance of the heater based on the plurality of resistance values of the heater; and
detecting a low liquid level of the aerosol precursor in the tank based on the rate of change of resistance of the heater.

[0086] According to a fifth aspect there is provided a computer program configured to cause an aerosol delivery system to perform the method of the fourth aspect upon execution of the computer program.

[0087] A computer readable medium comprising the computer program of the fifth aspect is also disclosed.

[0088] The invention includes the combination of the aspects and preferred features described except where such a combination is clearly impermissible or expressly avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0089] So that further aspects and features thereof may be appreciated, embodiments will now be discussed in further detail with reference to the accompanying figures, in which:

- Fig. 1A is a front schematic view of a smoking substitute system;
- Fig. 1B is a front schematic view of a device of the system;
- Fig. 1C is a front schematic view of a component of the system;
- Fig. 2A is a schematic view of the electrical components of the device;
- Fig. 2B is a schematic view of the parts of the component;
- Fig. 3 is a flow diagram of method steps performed to detect a low liquid level of aerosol precursor in the system; and
- Fig. 4 is a schematic view of an electrical circuitry of the system.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0090] Aspects and embodiments will now be discussed with reference to the accompanying figures. Further aspects and embodiments will be apparent to those skilled in the art.

[0091] Fig. 1A shows a first embodiment of a smoking substitute system 100. In this example, the smoking substitute system 100 includes a device 102 and a component 104. The component 104 may alternatively be referred to as a "pod", "cartridge" or "cartomizer". It should be appreciated that in other examples (i.e. open systems), the device may be integral with the component. In such systems, a tank of the aerosol delivery system may be accessible for refilling the device.

[0092] In this example, the smoking substitute system 100 is a closed system vaping system, wherein the component 104 includes a sealed tank 106 and is intended for single-use only. The component 104 is removably engageable with the device 102 (i.e. for removal and replacement). Fig. 1A shows the smoking substitute system 100 with the device 102 physically coupled to the component 104, Fig. 1B shows the device 102 of the smoking substitute system 100 without the component 104, and Fig. 1C shows the component 104 of the smoking substitute system 100 without the device 102.

[0093] The device 102 and the component 104 are configured to be physically coupled together by pushing the component 104 into a cavity at an upper end 108 of the device 102, such that there is an interference fit between the device 102 and the component 104. In other examples, the device 102 and the component may be coupled by screwing one onto the other, or through a bayonet fitting. In yet further examples, the cavity in the device houses a magnet and the component 104 comprises a metal portion (e.g. a metal base) and the component 104 is coupled to the device by magnetic attraction between the magnet and the metal portion of the component 104.

[0094] The component 104 includes a mouthpiece portion at an upper end 109 of the component 104, and one or more air inlets (not shown) in fluid communication with the mouthpiece portion such that air can be drawn into and through the component 104 when a user inhales through the mouthpiece portion. The tank 106 containing e-liquid is located at the lower end 111 of the component 104.

[0095] The lower end 110 of the device 102 also includes a light 116 (e.g. an LED) located behind a small translucent cover. The light 116 may be configured to illuminate when the smoking substitute system 100 is activated and/or when charging. Whilst not shown, the component 104 may identify itself to the device 102, via an electrical interface, RFID chip, or barcode.

[0096] The lower end 110 of the device 102 also includes a charging connection 115, which is usable to charge a battery within the device 102. The charging connection 115 can also be used to transfer data to and from the device, for example to update firmware thereon.

[0097] Figs. 2A and 2B are schematic drawings of the device 102 and component 104. As is apparent from Fig. 2A, the device 102 includes a power source 118, a controller 120, a memory 122, a wireless interface 124, an electrical interface 126, and, optionally, one or more additional components 128.

[0098] The power source 118 is preferably a battery, more preferably a rechargeable battery. The controller 120 may include a microprocessor, for example. The memory 122 preferably includes non-volatile memory. The memory may include instructions which, when implemented, cause the controller 120 to perform certain tasks or steps of a method.

[0099] The wireless interface 124 is preferably configured to communicate wirelessly with another device, for example a mobile device, e.g. via Bluetooth™. To this end, the wireless interface 124 could include a Bluetooth™ antenna. Other wireless communication interfaces, e.g. WiFi™, are also possible. The wireless interface 124 may also be configured to communicate wirelessly with a remote server.

[0100] The electrical interface 126 of the device 102 may include one or more electrical contacts. The electrical interface 126 may be located in a base of the aperture in the upper end 108 of the device 102. When the device 102 is physically coupled to the component 104, the electrical interface 126 is configured to transfer electrical power from the power source 118 to the component 104 (i.e. upon activation of the smoking substitute system 100).

[0101] The electrical interface 126 may also be used to identify the component 104 from a list of known components. For example, the component 104 may be a particular flavour and/or have a certain concentration of nicotine (which may be identified by the electrical interface 126). This can be indicated to the controller 120 of the device 102 when the component 104 is connected to the device 102. Additionally, or alternatively, there may be a separate communication interface provided in the device 102 and a corresponding communication interface in the component 104 such that, when connected, the component 104 can identify itself to the device 102.

[0102] The additional components 128 of the device 102 may comprise the light 116 discussed above.

[0103] The additional components 128 of the device 102 also comprises the charging connection 115 configured to receive power from the charging station (i.e. when the power source 118 is a rechargeable battery). This may be located at the lower end 110 of the device 102.

[0104] The additional components 128 of the device 102 may, if the power source 118 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 a charging station (if present).

[0105] The additional components 128 of the device 102 may include a sensor, such as an airflow (i.e. puff) sensor for detecting airflow in the smoking substitute system 100, e.g. caused by a user inhaling through a mouthpiece portion 136 of the component 104. The smoking substitute system 100 may be configured to be activated when airflow is detected by the airflow sensor. This sensor could alternatively be included in the component 104. The airflow sensor can be used to determine, for example, how heavily a user draws on the mouthpiece or how many times a user draws on the mouthpiece in a particular time period.

[0106] The additional components 128 of the device 102 may include a user input, e.g. a button. The smoking substitute system 100 may be configured to be activated when a user interacts with the user input (e.g. presses the button). This provides an alternative to the airflow sensor as a mechanism for activating the smoking substitute system 100.

[0107] As shown in Fig. 2B, the component 104 includes the tank 106, an electrical interface 130, a vaporiser 132, one or more air inlets 134, a mouthpiece portion 136, and one or more additional components 138.

[0108] The electrical interface 130 of the component 104 may include one or more electrical contacts. The electrical interface 126 of the device 102 and an electrical interface 130 of the component 104 are configured to contact each other and thereby electrically couple the device 102 to the component 104 when the lower end 111 of the component 104 is inserted into the upper end 108 of the device 102 (as shown in Fig. 1A). In this way, electrical energy (e.g. in the form of an electrical current) is able to be supplied from the power source 118 in the device 102 to the vaporiser 132 in the component 104.

[0109] The vaporiser 132 is configured to heat and vaporise e-liquid contained in the tank 106 using electrical energy supplied from the power source 118. As will be described further below, the vaporiser 132 includes a heater (provided as a heating filament) and a wick. The wick draws e-liquid from the tank 106 and the heating filament heats the e-liquid to vaporise the e-liquid.

[0110] The one or more air inlets 134 are preferably configured to allow air to be drawn into the smoking substitute system 100, when a user inhales through the mouthpiece portion 136. When the component 104 is physically coupled to the device 102, the air inlets 134 receive air, which flows to the air inlets 134 along a gap between the device 102 and the lower end 111 of the component 104.

[0111] In operation, a user activates the smoking substitute system 100, e.g. through interaction with a user input forming part of the device 102 or by inhaling through the mouthpiece portion 136 as described above. Upon activation, the controller 120 may supply electrical energy from the power source 118 to the vaporiser 132 (via electrical interfaces 126, 130), which may cause the vaporiser 132 to heat e-liquid drawn from the tank 106 to produce a vapour which is inhaled by a user through the mouthpiece portion 136.

[0112] An example of one of the one or more additional components 138 of the component 104 is an interface for obtaining an identifier of the component 104. As discussed above, this interface may be, for example, an RFID reader, a barcode, a QR code reader, or an electronic interface which is able to identify the component. The component 104 may, therefore include any one or more of an RFID chip, a barcode or QR code, or memory within which is an identifier and which can be interrogated via the electronic interface in the device 102.

[0113] According to the present invention, it is possible to detect a low liquid level of the aerosol precursor in the tank 106 of the system 100. The method steps involved in the low liquid level detection are discussed with reference to the flow diagram shown in Fig. 3. The method may be performed using the circuitry 1 shown in Fig. 4. As shown in s201 of Fig. 3, a plurality of resistance values of the heater 20 (which is part of the vaporiser 132) are determined based on a reference resistance of a sense resistor 16, a measured voltage V_1 at a point between the sense resistor 16 and the heater 20 and a constant voltage V_2 (see Fig. 4). A rate of change of resistance of the heater 20 is then determined based on at least some of the plurality of resistance values of the heater (see e.g., s202 of Fig. 3). A low liquid level of the aerosol precursor in the tank 106 can then be detected based on the rate of change of resistance of the heater 20 determined at step s202 (see e.g., s203).

[0114] In some examples, the method steps s201-s203 for detecting the low liquid level of the aerosol precursor in the tank 106 are performed by the controller 120.

[0115] In some examples, the method includes comparing the rate of change of resistance of the heater 20 to a reference rate of change of resistance. The reference rate of change of resistance may be based on resistance values of the heater previously determined by the controller 120. That is, in some examples, the method shown in Fig. 3 includes an additional, penultimate step (not shown) between steps s202 and s203 which includes comparing the rate of change of resistance of the heater 20 to the reference rate of change of resistance. The reference rate of change of resistance is indicative of a sufficient liquid level of the aerosol precursor in the tank. In some examples, the controller 120 is configured to detect a low liquid level of the aerosol precursor in the tank 106 when the rate of change of resistance of the heater is greater than the reference rate of change of resistance, e.g. for longer than a predefined time period. If the rate of change of resistance of the heater is less than the reference rate of change of resistance, then a low liquid level is not detected. The reference rate of change of resistance is stored in the memory 122.

[0116] In some examples, the reference rate of change of resistance is updated periodically. For example, the reference rate of change of resistance is dynamically updated as resistance values of the heater 20 are determined by the controller over time.

[0117] An example of a physical implementation of the method of Fig. 3 is discussed with reference to Fig. 4 which shows an electrical circuitry 1 of the smoking substitute system 100. The electrical circuitry 1 comprises a resistance-monitoring path for determining the resistance of the heater 20, and a main power supply path for supplying power to the heater 20 for aerosol generation. In the example schematic shown in Fig. 4, the "REFERENCE BRANCH" and the "SAMPLE" together form the resistance-monitoring path. The main power supply path is labelled "HEATING BRANCH". The resistance-monitoring path comprises the sense resistor 16. The sense resistor is a resistor having a known, fixed resistance value, R_{SENSE}. The resistance-monitoring path also comprises a resistance-monitoring path switch 12 such as a FET, which, when switched on (i.e. closed), allows current to flow from the power supply (not shown in Fig. 3) through the sense resistor 16 and the heater 20 (e.g., to switch in the sense resistor to sample the resistance of the heater). Finally, the electrical circuitry 1 comprises a constant voltage source 22 for providing a constant voltage to the resistance-monitoring path. In this example, the constant voltage source 22 is a Zener diode. The constant voltage source 22 is powered by the power source such that the power source supplies electric power to the constant voltage source to drive it. However, the constant voltage produced by the constant voltage source 22 is independent of the voltage V_{BAT} of the power source.

[0118] In particular, in examples where the constant voltage source 22 is a Zener diode, the Zener diode may have a breakdown voltage less than the output voltage of the power source. In these examples, as the breakdown voltage of the Zener diode is less than the output voltage of the power source, the output voltage of the Zener diode is constant. The Zener diode may have a breakdown voltage of less than or equal to 3.3V. The breakdown voltage of the Zener diode may be between 2.4 and 3V, for example. The power source may have an output voltage of greater than 3.5V. The output voltage of the power source may be between 3.5 and 4.3V (which may depend on charge level), for example.

[0119] The main power supply path comprises a pair of main path switches 14, 24 either side of the heater 20 which, when switched on (i.e. closed), allows current to flow from the power supply through to the heater 20 so as to drive the heater 20. The main path switches 14, 24 may be FETs, for example. Switch 24 may be present for safety reasons, for example, and has a negligible resistance such that its presence does not affect the Ohm's law calculations (see below). The controller 120 is configured to switch the supply of power from the power source to the heater 20 between the main power supply path and the resistance-monitoring path by operating the resistance-monitoring path switch 12 and the main path switches 14, 24 accordingly. In other words, power is either supplied via the resistance-monitoring path or via the main power supply path. In this example, the switching is performed periodically at a predetermined switching frequency, f, between 1kHz and 10Hz inclusive (corresponding to a period, T, between 10ms and 100ms inclusive).

[0120] The electrical circuitry 1 of this example also comprises a resistor 18 in parallel to the sense resistor 16. The resistor 18 limits the amount of current to the constant voltage source 22.

[0121] At least a part of the electrical circuitry 1 is provided in the consumable component 104. That is, the electrical circuitry 1 is closed/completed upon coupling the consumable component 104 to the aerosol delivery device 102. In particular, at least the heater 20 may be provided in the consumable component 104.

[0122] During operation of the system 100, to detect a low liquid level of the aerosol precursor in the tank 106, the main path switches 14, 24 of the main power supply path are opened and the resistance-monitoring path switch 12 is closed. This causes current to flow from the power supply through the sense resistor 16 and on to the heater 20. The current, I, flowing through the sense resistor can be determined based on the constant voltage V_2 produced by the constant voltage source 22, a voltage value V_1 measured at a point on the electrical circuitry 1 between the sense resistor 16 and the heater 20, and the known resistance value R_{SENSE} of the sense resistor. In some examples, to improve the accuracy of the measurement, the voltage V_2 may be measured at a point on the electrical circuitry between the constant voltage source 22 and the sense resistor 16 (rather than assuming that the voltage V_2 is equal to the breakdown voltage of the constant voltage source 22). This may be particularly important when the output voltage of the power source is similar to (and in particular when it is less than) the breakdown voltage of the constant voltage source 22.

[0123] The current, I, through the sense resistor 16 can be calculated using Ohm's law as a change in the voltage difference between V_1 and V_2 over the known resistance of the sense resistor, as follows:

$$\mathrm{I} = \frac{\mathrm{V_2} - \mathrm{V_1}}{\mathrm{R_{SENSE}}} \,. \qquad \text{(Eqn. 1)}$$

[0124] A resistance value (i.e. an instantaneous resistance value) R_H of the heater 20 can be determined using Ohm's law from the voltage value V_1 measured between the sense resistor 16 and the heater 20 relative to ground GND, and the determined current value through the sense resistor 16. This is shown in Eqn. 2 below:

$$\mathrm{R_H} = \frac{\mathrm{V_1}}{\mathrm{I}} \,. \qquad \text{(Eqn. 2)}$$

[0125] Substituting the expression for the current I through the sense resistor 16 from Eqn. 1 into Eqn. 2, the following expression for the resistance value R_H of the heater 20 is obtained:

$$\mathrm{R_H} = \frac{\mathrm{V_1 R_{SENSE}}}{\mathrm{V_2} - \mathrm{V_1}} \,. \qquad \text{(Eqn. 3)}$$

[0126] Thus, each resistance value R_H is determined based on the reference resistance R_{SENSE} of the sense resistor 16, the voltage V_1 measured at a point between the sense resistor 16 and the heater 20, and the constant voltage V_2.

[0127] A plurality of resistance values R_H each determined in this way is used to determine a rate of change of resistance of the heater ΔR_H. The low liquid level of the aerosol precursor in the tank 106 is detected based on the rate of change of resistance ΔR_H of the heater 20 e.g. by comparing it to the reference rate of change of resistance as described above.

[0128] The controller may control one or more components of the aerosol delivery device/system in response to a low liquid level detection. For example, the controller may be configured to control one or more LEDs and/or a haptic feedback component to provide user feedback. The controller may be configured to control (e.g., prevent or reduce) power supply to the heater for aerosol generated in response to a low liquid level detection.

[0129] It should be appreciated that the smoking substitute system 100 shown in figures 1A to 2B is just one exemplary implementation of a smoking substitute system. For example, the system could otherwise be in the form of an entirely disposable (single-use) system or an open system in which the tank is refillable (rather than replaceable).

[0130] While exemplary embodiments have been described above, many equivalent modifications and variations will be apparent to those skilled in the art when given this disclosure. Accordingly, the exemplary embodiments set forth above are considered to be illustrative and not limiting.

[0131] Throughout this specification, including the claims which follow, unless the context requires otherwise, the words "have", "comprise", and "include", and variations such as "having", "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.

[0132] 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%.

[0133] The words "preferred" and "preferably" are used herein refer to embodiments of the invention that may provide certain benefits under some circumstances. It is to be appreciated, however, that other embodiments may also be preferred under the same or different circumstances. The recitation of one or more preferred embodiments therefore does not mean or imply that other embodiments are not useful, and is not intended to exclude other embodiments from the scope of the disclosure, or from the scope of the claims.

Claims

1. An aerosol delivery device (102) for forming an aerosol delivery system (100), the aerosol delivery system comprising the aerosol delivery device (102), a tank (106) for containing an aerosol precursor, and a heater (20) for heating the aerosol precursor, wherein the aerosol delivery device (102) is for controlling operation of the heater (20) and the aerosol delivery device comprises:
a controller (120) configured to:

    determine a plurality of resistance values of the heater (20), wherein each of the plurality of resistance values is determined based on a reference resistance of a sense resistor (16), a measured voltage (V1) at a first point between the sense resistor (16) and the heater (20), and a constant voltage (V2) at a second point located at an opposite side of the sense resistor (16) to the first point;
    determine a rate of change of resistance of the heater (20) based on the plurality of resistance values of the heater; and
    detect a low liquid level of the aerosol precursor in the tank (106) based on the rate of change of resistance of the heater (20).

2. The aerosol delivery device (102) of claim 1, wherein detecting a low liquid level of the aerosol precursor in the tank (106) includes comparing the rate of change of resistance of the heater (20) to a reference rate of change of resistance.

3. The aerosol delivery device (102) of claim 2, wherein the controller (120) is configured to detect a low liquid level of the aerosol precursor in the tank (106) when the rate of change of resistance of the heater (20) is greater than the reference rate of change of resistance.

4. The aerosol delivery device (102) of claim 3, wherein the controller (120) is configured to detect a low liquid level of the aerosol precursor in the tank (106) when the rate of change of resistance of the heater is greater than the reference rate of change of resistance for longer than a predefined time period.

5. The aerosol delivery device (102) of any one of claims 2-4, wherein the reference rate of change of resistance is based on resistance values of the heater (20) previously determined by the controller (120).

6. The aerosol delivery device (102) of any one of claims 2-5, wherein the reference rate of change of resistance is updated periodically.

7. The aerosol delivery device (102) of any preceding claim further comprising a power source (118) for supplying power to the heater (20), wherein the constant voltage (V2) is independent of a voltage of the power source (118).

8. The aerosol delivery device (102) of any preceding claim, wherein the aerosol delivery device comprises a constant voltage source (22) for providing the constant voltage (V2).

9. The aerosol delivery device (102) of claim 8 as dependent on claim 7, wherein the constant voltage source (22) is powered by the power source (118).

10. The aerosol delivery device (102) of claim 8 or claim 9, wherein the constant voltage source (22) comprises a Zener diode.

11. The aerosol delivery device (102) of any preceding claim, further comprising electrical circuitry (1), the electrical

circuitry comprising a resistance-monitoring path for determining the resistance of the heater (20), and a main power supply path for supplying power to the heater (20) for aerosol generation.

12. The aerosol generating device (102) of claim 11, wherein the controller (120) is configured to switch the supply of power from the power source (118) to the heater (20) between the main power supply path and the resistance-monitoring path.

13. An aerosol delivery system (100) comprising:

the aerosol delivery device (102) of any preceding claim; and
a consumable component (104) configured to be coupled to the aerosol delivery device (102);
wherein the consumable component (104) comprises the tank (106) for containing the aerosol precursor and the heater (20) for heating the aerosol precursor.

14. A method for detecting a low liquid level of aerosol precursor in an aerosol delivery system (100), the aerosol delivery system comprising a tank (106) for containing the aerosol precursor, and a heater (20) for heating the aerosol precursor, the method comprising:

determining a plurality of resistance values of the heater (20), wherein each of the plurality of resistance values is determined based on a reference resistance of a sense resistor (16), a measured voltage (V1) at a first point between the sense resistor (16) and the heater (20), and a constant voltage (V2) at a second point located at an opposite side of the sense resistor (16) to the first point;
determining a rate of change of resistance of the heater (20) based on the plurality of resistance values of the heater; and
detecting a low liquid level of the aerosol precursor in the tank (106) based on the rate of change of resistance of the heater (20).

15. A computer program configured to cause an aerosol delivery system to perform the method of claim 14 upon execution of the computer program.

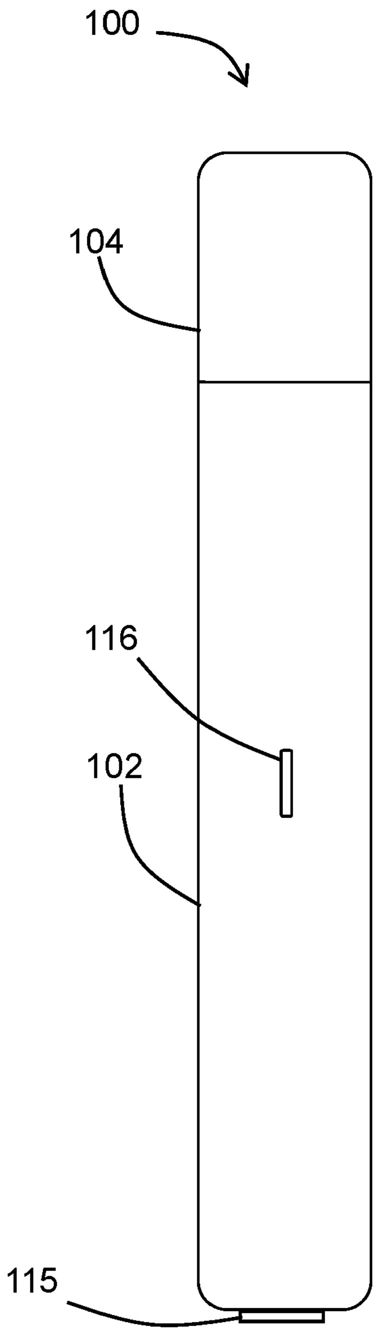

FIG. 1A

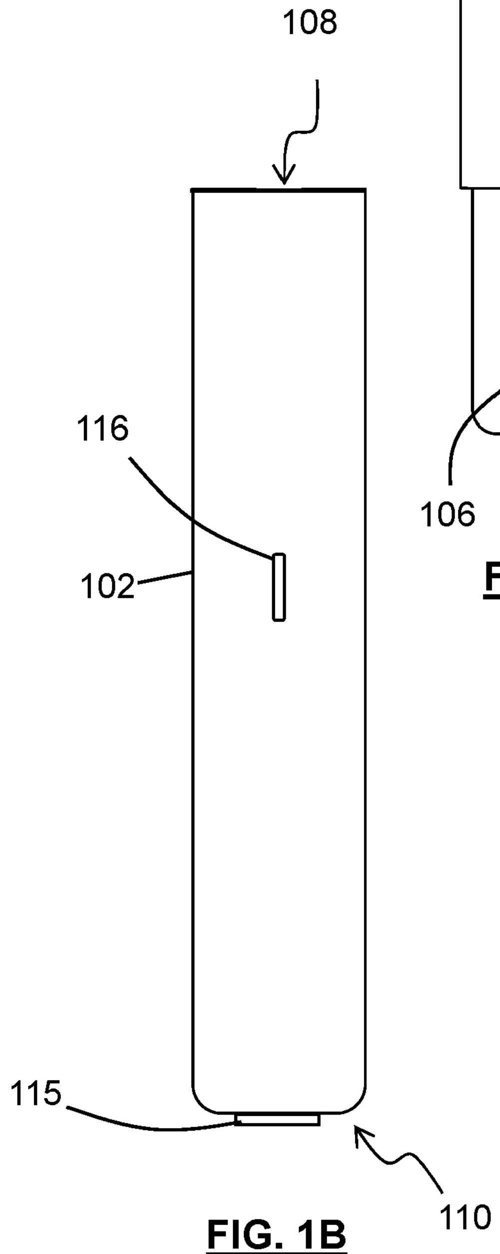

FIG. 1B

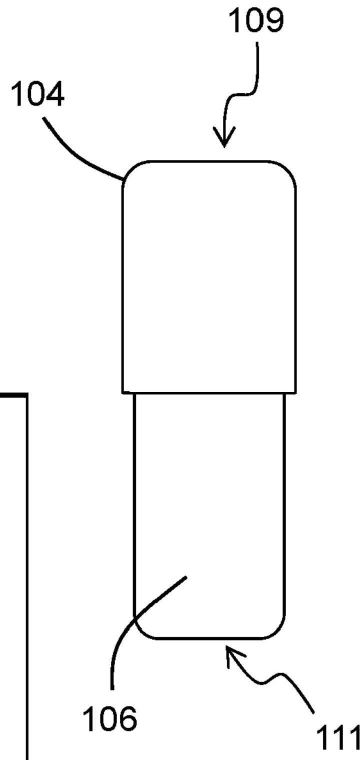

FIG. 1C

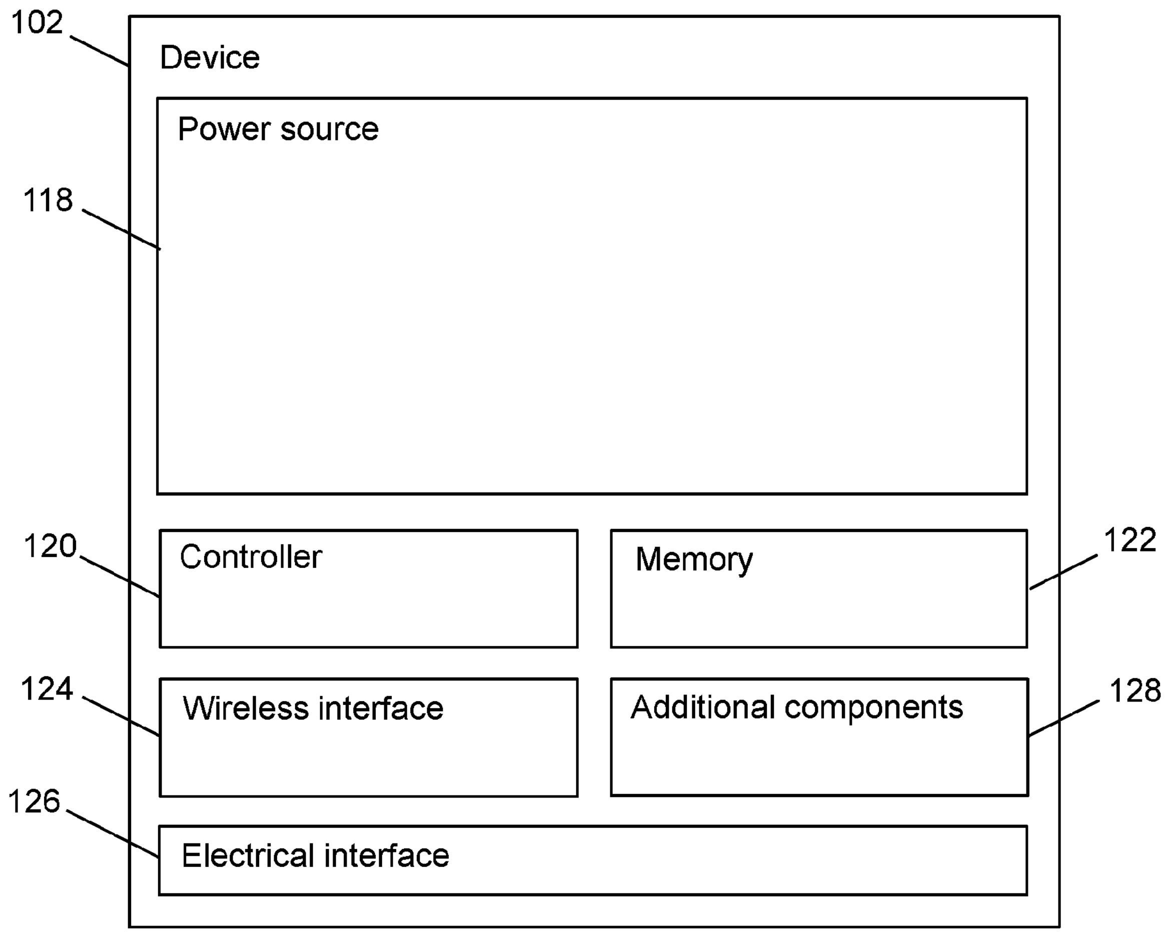
102
Device
Power source
118
120
Controller
Memory
122
124
Wireless interface
Additional components
128
126
Electrical interface

FIG. 2A

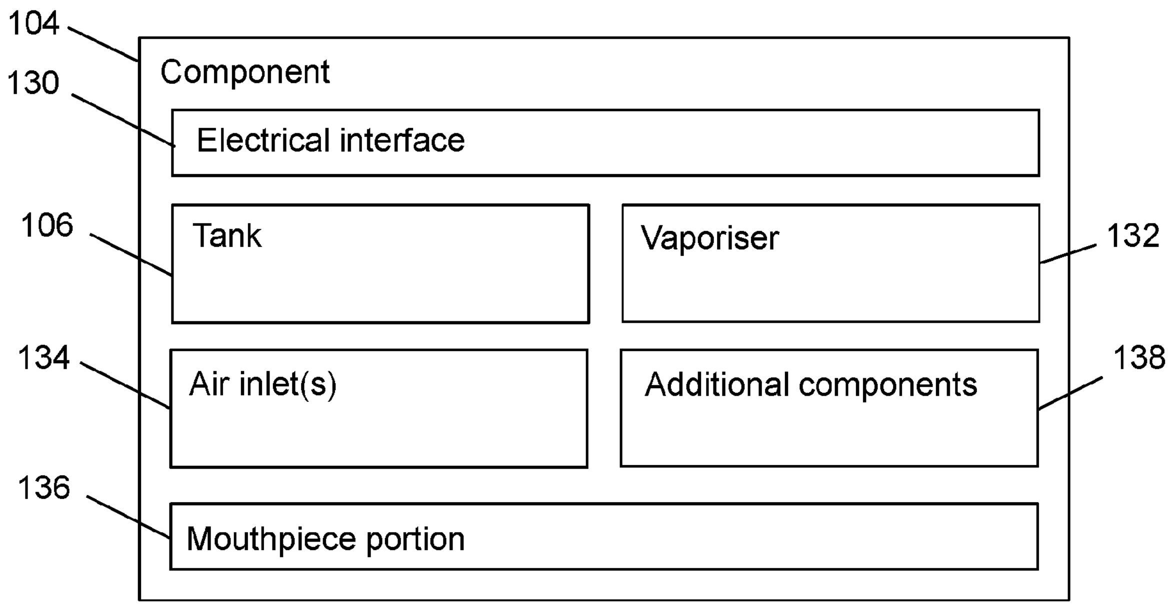
104
Component
130
Electrical interface
106
Tank
Vaporiser
132
134
Air inlet(s)
Additional components
138
136
Mouthpiece portion

FIG. 2B

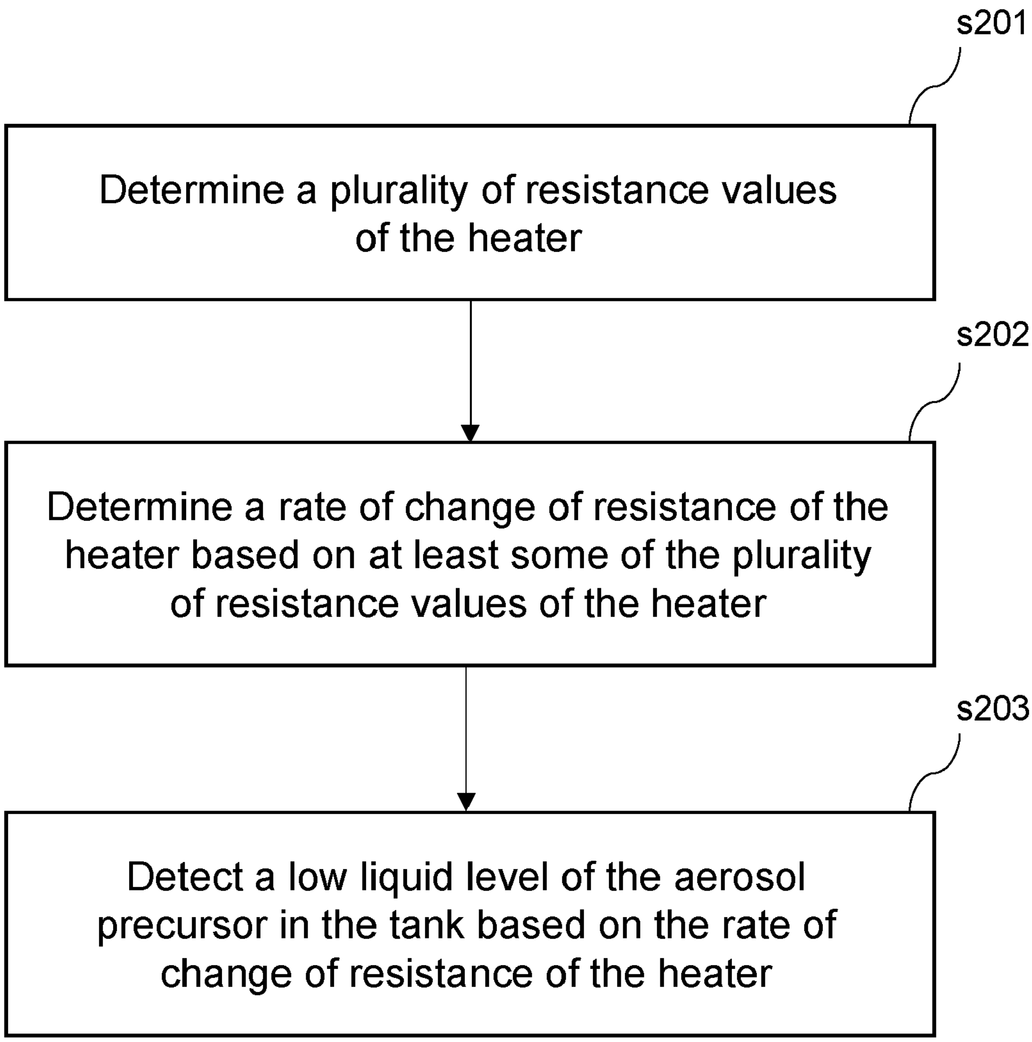
s201
Determine a plurality of resistance values of the heater
s202
Determine a rate of change of resistance of the heater based on at least some of the plurality of resistance values of the heater
s203
Detect a low liquid level of the aerosol precursor in the tank based on the rate of change of resistance of the heater

FIG. 3

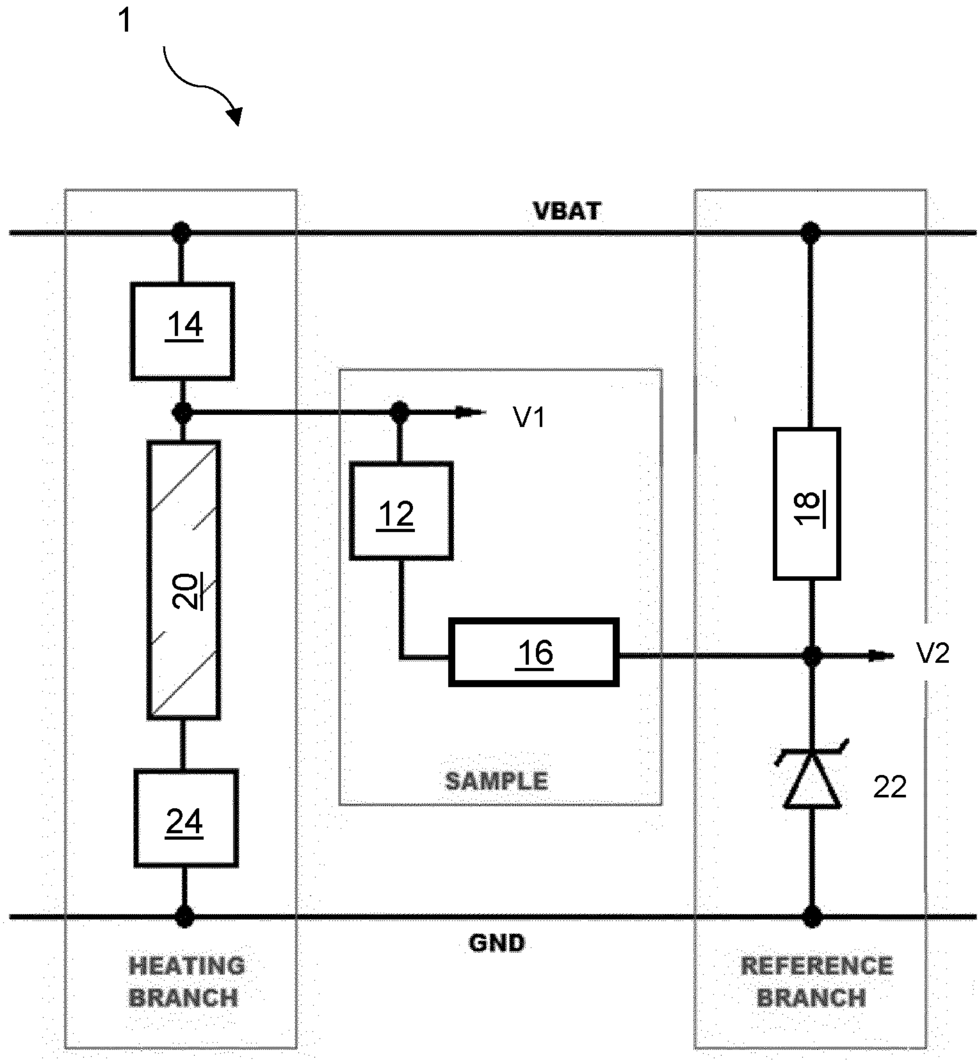
1
VBAT
14
V1
12
20
18
16
V2
22
SAMPLE
24
GND
HEATING
BRANCH
REFERENCE
BRANCH

FIG. 4

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 24 15 0613

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 10 912 333 B2 (JUUL LABS INC [US]) 9 February 2021 (2021-02-09) * column 23, line 14 - column 49, line 25; figures 1-23 * -----	1-15	INV. A24F40/51 A24F40/53 A24F40/57
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TECHNICAL FIELDS SEARCHED (IPC)

A24F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	19 June 2024	Klintebäck, Daniel

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 24 15 0613

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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19-06-2024

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