**Abstract:** An aerosol-generating system, a cartridge for an aerosol-generating system and a method of detecting user puffs on an aerosol-generating system. The aerosol-generating system comprises a liquid-storage portion (201) for holding a liquid aerosol-forming substrate; a first electrode and a second electrode (304, 305) and a control system. The second electrode is spaced from the first electrode and at least a portion of the liquid storage portion (201) is arranged between the first electrode and the second electrode (304, 305). The control system is configured to measure an electrical quantity between the first electrode and the second electrode (304, 305), and detect a user puff on the aerosol-generating system based on the measured electrical quantity information.

**Figure 2**
AEROSOL-GENERATING SYSTEM WITH PUFF DETECTOR

The present invention relates to aerosol-generating systems and cartridges for aerosol-generating systems. The aerosol-generating systems may be electrically operated smoking systems.

One type of aerosol-generating system is an electrically operated smoking system. Electrically operated smoking systems typically comprise a liquid aerosol-forming substrate, which is atomised to form an aerosol. Electrically operated smoking systems often comprise a power supply, a liquid-storage portion for holding a supply of liquid aerosol-forming substrate and an atomiser. A common type of atomiser used in electrically operated smoking systems comprises a coil of heater wire wound around an elongate wick soaked in liquid aerosol-forming substrate.

Electrically operated smoking systems may have puff detectors, such as microphones. Puff detectors are typically arranged in an airflow path of the electrically operated smoking system and are arranged to sense air passing over the detector when a user takes a puff.

It would be desirable to provide an improved puff detector for an aerosol-generating system. It would be desirable to reduce the number of components of an aerosol-generating system. It would be desirable to reduce manufacturing complexity and cost of aerosol-generating systems.

In a first aspect of the present invention, there is provided an aerosol-generating system comprising: a liquid-storage portion for holding a liquid aerosol-forming substrate; a first electrode and a second electrode spaced from the first electrode and a control system. The first electrode and the second electrode are arranged such that at least a portion of the liquid storage portion is arranged between the first electrode and the second electrode. The control system is configured to measure an electrical quantity between the first electrode and the second electrode, and detect a user puff on the aerosol-generating system based on the measured electrical quantity information. This may provide the aerosol-generating system with a reliable puff detector. This may enable aerosol-generating systems to dispense with other puff detectors, such as puff detectors arranged in the airflow path of the aerosol generating system. This may enable aerosol-generating systems to dispense with additional airflow paths for puff detectors.

A user may puff on an aerosol-generating system, drawing air through the aerosol-generating system for inhalation of an aerosol generated by the aerosol-generating system. A user puff may cause changes or fluctuations in electrical properties of the liquid storage portion. The changes or fluctuations in the electrical properties may be caused by fluctuations in pressure in the liquid storage portion during a puff. The aerosol-generating
system of the present invention is configured to monitor an electrical property of the liquid storage portion. This is achieved by arranging at least a portion of the liquid storage portion between the first electrode and the second electrode and configuring the control system to measure an electrical quantity between the first electrode and the second electrode. As such, the control system is configured to measure an electrical quantity across at least a portion of the liquid storage portion. The control system is further configured to use the measurements of the electrical quantity to detect a user puff on the aerosol-generating system.

As used herein with reference to the present invention, the term 'electrical quantity' is used to describe any electrical property, parameter or attribute of a system that can be quantified by measurement. For example, suitable 'electrical quantities' include impedance, capacitance and resistance. The control system may be configured to measure at least one of impedance, capacitance and resistance.

The control system may be configured to detect a puff on detection of a change in magnitude of the electrical quantity that exceeds a predetermined threshold. The magnitude of the fluctuations in the measured electrical quantity may be small in comparison to the total magnitude of the measured electrical quantity, but may be measurable by the control system. The control system may be configured to detect a puff when the rate of change of the measured electrical quantity exceeds a predetermined threshold. The rate of change of the electrical quantity due to a puff may be substantially different to the average rate of change of the electrical quantity. The predetermined thresholds may be set in the factory, before first use, or by a user.

The control system may be configured to determine the profile of a user puff based on the measured electrical quantity. A user puff may cause a predictable change or fluctuation in the measured electrical quantity over time.

The control system may be configured to detect two or more successive user puffs. The control system may be configured to determine an average time between successive user puffs.

The control system may be configured to supply an oscillating measurement signal to the first electrode and the second electrode. In other words, the control system may be configured to supply an alternating voltage to the first and second electrodes. The control system may be configured to supply an oscillating measurement signal to the first electrode and the second electrode at a predetermined frequency. The predetermined frequency may be any suitable frequency for the control system to measure the electrical quantity between the first electrode and the second electrode. The predetermined frequency may be equal to or less than about 20 MHz, or equal to or less than about 10 MHz.
predetermined frequency may be between about 10 kHz and about 10 MHz, or between about 10 kHz and about 1 MHz, or between about 100 kHz and about 1 MHz.

Surprisingly, it has been found that the fluctuations in measured electrical quantities due to user puffs are greatest at low frequencies, such as frequencies of less than 1 MHz. This may enable reliable and accurate detection of puffs.

The liquid storage portion may hold liquid aerosol-forming substrate. The liquid storage portion may also comprise one or more of: air held in the liquid storage portion, a carrier material for holding the liquid aerosol-forming substrate and a housing for holding the liquid aerosol-forming substrate. The liquid aerosol-forming substrate, air, carrier material and housing may have different electrical properties.

The liquid storage portion may comprise an electrical load. The liquid storage portion may comprise at least one of a resistive load and a capacitive load. Advantageously, electrical quantities of resistive and capacitive loads may be measured without requiring complex electronics.

The first and second electrodes may be arranged such that liquid aerosol-forming substrate held in the liquid storage portion is arranged between the first and second electrodes. The first and second electrodes may also be arranged such that one or more of the air held in the liquid storage portion, the carrier material and the housing are arranged between the first and second electrodes. The first and second electrodes may be arranged in contact with liquid aerosol-forming substrate held in the liquid storage portion. The first and second electrodes may be arranged in contact with the carrier material. The first and second electrodes may be arranged in contact with the housing.

The control system may be configured to detect a user puff on the aerosol-generating system by comparison. The control system may be configured to compare the measured electrical quantity information to reference electrical quantity information stored in the control system.

Reference electrical quantity information may be stored in a memory of the control system. The reference electrical quantity information may be electrical quantity information measured by the control system and stored in a memory of the control system. The reference electrical quantity information may be associated with puff information. This may enable detection of a puff to be reliable. The reference electrical quantity information may comprise the one or more predetermined thresholds.

The reference electrical quantity information may comprise a plurality of ranges of reference electrical quantity information. Each range of the reference electrical quantity information may be associated with a puff. The control system may be configured to compare and match measured electrical quantity information to a stored range of reference electrical quantity information.
The reference electrical quantity information may be stored in a lookup table. The lookup table may comprise stored reference electrical quantity information and stored puff information. The stored reference electrical quantity information may be associated with the stored liquid aerosol-forming substrate puff information. The stored puff information may include one or more of: the occurrence of a puff, the magnitude of the puff, the occurrence of the start of a puff, the occurrence of the end of a puff and the volume of a puff.

The control system may be configured to indicate to a user that a puff is occurring. The control system may be configured to indicate to a user that a puff has occurred. The control system may be configured to count the number of detected puffs. The control system may be configured to indicate to a user the counted number of detected puffs.

The aerosol-generating system may further comprise aerosol-generating means arranged to receive liquid aerosol-forming substrate from the liquid storage portion. The control system may be further configured to supply power to the aerosol-generating means on detection of a puff.

A puff may have a duration. The control system may be configured to detect the start of a puff. The start of a puff may affect the electrical properties of the liquid storage portion substantially to enable a puff to be detected by the control system. On detection of the start of a puff, the control system may be configured to supply power to the aerosol-generating means. Supplying power to the aerosol-generating means enables the aerosol-generating means to atomise the liquid aerosol-forming substrate received at the aerosol-generating means and generate an aerosol for inhalation by the user. The control system may be configured to supply power to the aerosol-generating means during the remainder of the puff. The control system may be configured to detect the end of a puff. The control system may be configured to substantially prevent or inhibit power from being supplied to the aerosol-generating means on detection of the end of a puff. This may reduce the power requirements of an aerosol-generating system. This may prolong the life of a power supply of the aerosol-generating system.

The control system may be configured to measure the electrical quantity between the first electrode and the second electrode and detect a puff of a user on the aerosol-generating means independently of operation the aerosol-generating means. This may enable the control system to operate the aerosol-generating means once a puff has been detected. This may reduce the power drawn from a power supply of the aerosol-generating system. This may reduce the operation time of the aerosol-generating means per puff and prolong the life of the aerosol-generating means.

The first electrode and the second electrode may be arranged at any suitable location relative to the liquid storage portion. The first electrode and the second electrode
may be arranged at or in the liquid storage portion. The first electrode and the second electrode may be arranged at or on the housing. Where the housing of the liquid storage portion forms a cavity for holding the liquid aerosol-forming substrate, the first electrode and the second electrode may be arranged at or in the cavity.

The aerosol-generating system may comprise one or more pairs of first and second electrodes. The aerosol-generating system may comprise two or more pairs of electrodes arranged such that different portions of the liquid storage portion are arranged between the first and second electrodes. Providing multiple pairs of electrodes may improve the reliability of the measurements. The one or more pairs of first and second electrodes may comprise part of a sensor.

The electrodes may be any suitable type of electrode. For example, suitable types of electrodes include point electrodes, ring electrodes, plate electrodes or track electrodes. The first electrode and the second electrode may be the same type of electrode. The first electrode and the second electrode may be different types of electrode.

The electrodes may by any suitable shape. For example, the electrodes may be: square, rectangular, curved, arcuate, annular, spiral or helical. The electrodes may be substantially cylindrical. The electrodes may comprise one or more sections that are substantially linear, non-linear, planar or non-planar. The electrodes may be rigid. This may enable the electrodes to maintain their shape. The electrodes may be flexible. This may enable the electrodes to conform to the shape of the liquid storage portion. The electrodes may be configured to conform to the shape of a housing of the liquid storage portion.

The electrodes may have a length, a width and a thickness. The length of the electrodes may be substantially greater than the width of the electrodes. In other words, the electrodes may be elongate. The thickness of the electrodes may be substantially less than the length and the width of the electrodes. In other words, the electrodes may be thin. Thin electrodes and elongate electrodes may have a larger surface area to volume ratio. This may improve the sensitivity of measurements.

The electrodes may comprise any suitable material. The electrodes may comprise any suitable electrically conductive material. Suitable electrically conductive materials include metals, alloys, electrically conductive ceramics and electrically conductive polymers. As used herein with respect to the present invention, an electrically conductive material refers to a material having a volume resistivity at 20°C of less than about 1 x 10⁻⁵ Qm, typically between about 1 x 10⁻⁵ Qm and about 1 x 10⁻⁹ Qm. The materials may include gold and platinum. The electrodes may be coated with a passivation layer. The electrodes may comprise or be coated in material that is sufficiently non-reactive so as not to react with or contaminate the liquid aerosol-forming substrate. The electrodes may
comprised transparent or translucent material. For example, a suitable transparent material may be Indium Tin Oxide (ITO).

The electrodes may be arranged in any suitable arrangement relative to the liquid storage portion. The electrodes may be arranged in the liquid storage portion. The first electrode and the second electrode may be arranged at opposite sides of the liquid storage portion. The first electrode and the second electrode may be arranged at opposite ends of the liquid storage portion. Where the liquid-storage portion comprises a carrier material, the electrodes may be arranged in contact with the carrier material. Where the liquid storage portion comprises a housing, at least one of the first and second electrodes may be arranged at or in contact with the housing. The first and second electrodes may be substantially cylindrical. The first electrode may be arranged to substantially surround the second electrode. The first and second electrodes may be arranged concentrically about a common axis.

At least one of the first electrode and the second electrode may be arranged on a platform. The platform may comprise electrically insulating material. Where the liquid storage portion comprises a housing, the platform may be separate from the housing. The platform may be arranged on the housing. The platform may form a portion of the housing. The platform may comprise the same material as the housing. The platform may comprise a different material to the housing.

The platform may comprise any suitable electrically insulating material. For example, suitable electrically insulating materials include glasses, plastics and ceramic materials. As used herein with respect to the present invention, an electrically insulating material refers to a material having a volume resistivity at 20°C of greater than about 1 x 10⁶ Ωm, typically between about 1 x 10⁹ Ωm and about 1 x 10²¹ Ωm.

The electrodes may be secured on the platform. The electrodes may be secured on the platform by any suitable means. For example, the electrodes may be secured on the platform by a bonding material, such as an adhesive. The electrodes may be deposited on the platform by any suitable method of deposition. The electrodes may be etched in the platform.

The second electrode may be spaced apart from the first electrode. This may substantially prevent direct contact between the first electrode and the second electrode. The spacing between the first electrode and the second electrode may be consistent along the length of the first electrode and the second electrode. Where the first electrode and the second electrode are arranged at opposite sides of the liquid storage portion, the spacing may be about the width of the liquid storage portion. The spacing between the first electrode and the second electrode may be between about 1 µm and about 1 mm, or between about 1 µm and about 500 µm, or between about 10 µm and about 100 µm.
The second electrode may substantially follow the path of the first electrode. This may enable the spacing between the first and second electrodes to remain consistent along the length of the first and second electrodes. The second electrode may be arranged substantially parallel to the first electrode.

The first electrode and the second electrode may be interdigitated. The first electrode may comprise a plurality of protrusions and interspaces and the second electrode may comprise a plurality of protrusions and interspaces. The protrusions of the first electrode may extend into the interspaces of the second electrode and the protrusions of the second electrode may extend into the interspaces of the first electrode. Interdigitating the electrodes may minimise the spacing between the electrodes. This may improve the sensitivity of the measurements.

The protrusions of the first and second electrodes may be substantially linear. The protrusions of the first electrode may extend substantially in a first direction and the protrusions of the second electrode may extend substantially in a second direction. The first and second electrodes may be arranged with the first direction substantially parallel to the second direction. The protrusions may be substantially non-linear. The protrusions may be curved or arcuate. For example, a suitable sensor comprising interdigitated electrodes may be of the type DRP-G-IDEPT10 from DropSens™.

The aerosol-generating system may comprise aerosol-generating means comprising one or more aerosol-generating elements. The one or more aerosol-generating elements may comprise one or more heating elements. The one or more aerosol-generating elements may comprise one or more vibratable elements. Where the aerosol-generating means comprises one or more aerosol-generating elements, at least one of the aerosol-generating elements may comprise one of the electrodes. Forming one of the electrodes as part of the aerosol-generating means may reduce the number of components required to manufacture the aerosol-generating system.

The control system may comprise electric circuitry. The electric circuitry may comprise a microprocessor, which may be a programmable microprocessor. The electric circuitry may comprise further electronic components. The electric circuitry may be configured to regulate a supply of power to the first electrode and the second electrode.

The control system may be configured to control or regulate a supply of power to the first electrode and the second electrode. The control system may be configured to control or regulate a supply of power to the aerosol-generating means. A first control system may be configured to control or regulate the supply of power to the first electrode and the second electrode and a second control system may be configured to control or regulate the supply of power to the aerosol-generating means.
Power may be supplied continuously to the first electrode and the second electrode. Power may be supplied to the first electrode and the second electrode following activation of the system. Power may be supplied to the first electrode and the second electrode in the form of pulses of electrical current.

The control system may be configured to detect a puff on the aerosol-generating system following activation of a system. The control system may be configured to detect a puff on the aerosol-generating system continuously. The control system may be configured to detect a puff on the aerosol-generating system periodically at predetermined intervals.

The aerosol-generating system may comprise a power supply. The aerosol-generating system may comprise a power supply arranged to supply power to the control system, the first electrode and the second electrode and the aerosol-generating means. The aerosol-generating means may comprise a single power supply. The aerosol-generating means may comprise a first power supply arranged to supply power to the first electrode and the second electrode and a second power supply configured to supply power to the aerosol-generating means.

During use, liquid aerosol-forming substrate held in the liquid storage portion is consumed and replaced with air. Liquid aerosol-forming substrates typically have substantially different electrical properties to air. Therefore, the amount of liquid aerosol-forming substrate held in the liquid storage portion may affect the electrical properties of the liquid storage portion. This may affect the measurement of the electrical quantity between the first electrode and the second electrode and the detection of a puff on the aerosol-generating system. The control system may be configured to determine the amount of liquid aerosol-forming substrate held in the liquid storage portion. The control system may be configured to adjust the puff detection based on the amount of liquid aerosol-forming substrate held in the liquid storage portion. In other words, the control system may be configured to compensate for the amount of liquid aerosol-forming substrate held in the liquid storage portion.

The composition of the liquid aerosol-forming substrate held in the liquid storage portion may affect the measurement of the electrical quantity and the detection of a puff on the aerosol-generating system. The control system may be configured to determine the identity of the liquid aerosol-forming substrate held in the liquid storage portion. The control system may be configured to adjust the puff detection based on the amount of liquid aerosol-forming substrate held in the liquid storage portion. In other words, the control system may be configured to compensate for the composition of liquid aerosol-forming substrate held in the liquid storage portion.

The control system may comprise any suitable means for measuring the electrical quantity between the first electrode and the second electrode. For example, the control
system may comprise a bridge circuit configured to measure the electrical quantity between the first electrode and the second electrode. The bridge circuit may be any suitable bridge circuit known in the art, such as a Wheatstone bridge or a Wien bridge. The control system may comprise an LCR meter.

The electrical quantity to be measured by the control system may be impedance. The impedance between the first electrode and the second electrode may depend on the composition of the liquid aerosol-forming substrate held in the liquid storage portion.

The impedance may be measured directly by the control system. The impedance may be calculated. For example, the impedance may be calculated from measurements of the magnitude of the voltage and the current between the electrodes, and measurements of the phase difference between the current and voltage. A puff on the aerosol-generating system may be determined from the measured or calculated impedance.

The electrical quantity to be measured by the control system may be resistance. The resistance between the first electrode and the second electrode may depend on the composition of the liquid aerosol-forming substrate held in the liquid storage portion. The resistivity between the first electrode and the second electrode may depend on the liquid aerosol-forming substrate held in the liquid storage portion. The portion of the liquid storage portion arranged between the first electrode and the second electrodes may comprise a resistive load.

The resistance between the first electrode and the second electrode may be measured. This may be advantageous where the liquid aerosol-forming substrate comprises conductive materials.

The resistance may be calculated. For example, the resistance may be calculated from measurements of the magnitude of the voltage and the current and the phase difference between the voltage and the current. The resistance may be determined from measurements of the impedance between the first electrode and the second electrode. A puff on the aerosol-generating system may be calculated from the measured or calculated resistance.

The electrical quantity to be measured by the control system may be capacitance.

This may be advantageous where the aerosol-forming substrate comprises dielectric materials.

The capacitance between the first electrode and the second electrode may depend on the composition of the liquid aerosol-forming substrate held in the liquid storage portion. The permittivity between the first electrode and the second electrode may depend on the composition of the liquid aerosol-forming substrate held in the liquid storage portion. The portion of the liquid storage portion between the first electrode and the second electrode may comprise a capacitive load. The first electrode and the second electrode may form a
capacitor. The first electrode may form a first capacitor plate and the second electrode may form a second capacitor plate. Liquid aerosol-forming substrate held in the liquid storage portion may form part of the dielectric of the capacitor. The capacitive load between the first electrode and the second electrode may have a capacitance in the picofarad (pF) range. This may enable fast charging and discharging times of the capacitor, and enable fast measurements of the capacitance.

The capacitance may be measured. For example, the control system may comprise means for measuring charge and discharge times of the capacitor comprising the first and second electrodes. The control system may comprise a timer circuit, such as a 555 timer circuit, and may be configured to determine capacitance based on the frequency of the timer circuit output.

The capacitance may be calculated. For example, the capacitance may be calculated from measurements of the magnitude of the voltage and the current between the first and second capacitor plates and the phase difference between the voltage and the current. The capacitance may be calculated from measurements of the impedance. A puff on the aerosol-generating system may be calculated from the measured or calculated capacitance.

The electrical quantity to be measured by the control system may depend on the size of the first and second electrodes and on the separation between the first and second electrodes. For example, capacitance is a function of the separation between the first and second capacitor plates and the shape and size of the first and second capacitor plates. To ensure that a change in the electrical quantity being measured is not the result of a change in the shape or separation of the first and second electrodes, the first and second electrodes may be rigid and secured to a rigid platform or housing. The capacitor plates may comprise solid metal plates or thin walled metal sheets attached to a supporting substrate. The supporting substrate may be arranged between the capacitor plates to form part of the dielectric between the capacitor plates. The substrate may be arranged on the outside of the capacitor plates.

The liquid storage portion may be any suitable shape and size. For example, the liquid storage portion may be substantially cylindrical. The cross-section of the liquid storage portion may, for example, be substantially circular, elliptical, square or rectangular.

The liquid storage portion may comprise a housing. The housing may comprise a base and one or more sidewalls extending from the base. The base and the one or more sidewalls may be integrally formed. The base and one or more sidewalls may be distinct elements that are attached or secured to each other. The housing may be a rigid housing. As used herein, the term 'rigid housing' is used to mean a housing that is self-supporting. The rigid housing of the liquid storage portion may provide mechanical support to the
aerosol-generating means. The liquid storage portion may comprise one or more flexible walls. The flexible walls may be configured to adapt to the volume of the liquid aerosol-forming substrate held in the liquid storage portion. The housing of the liquid storage portion may comprise any suitable material. The liquid storage portion may comprise substantially fluid impermeable material. The housing of the liquid storage portion may comprise a transparent or a translucent portion, such that liquid aerosol-forming substrate held in the liquid storage portion may be visible to a user through the housing.

The liquid storage portion may be configured such that aerosol-forming substrate held in the liquid storage portion is protected from ambient air. The liquid storage portion may be configured such that aerosol-forming substrate stored in the liquid storage portion is protected from light. This may reduce the risk of degradation of the substrate and may maintain a high level of hygiene.

The liquid storage portion may be substantially sealed. The liquid storage portion may comprise one or more outlets for liquid aerosol-forming substrate held in the liquid storage portion to flow from the liquid storage portion to the aerosol-generating means. The liquid storage portion may comprise one or more semi-open inlets. This may enable ambient air to enter the liquid storage portion. The one or more semi-open inlets may be semi-permeable membranes or one way valves, permeable to allow ambient air into the liquid storage portion and impermeable to substantially prevent air and liquid inside the liquid storage portion from leaving the liquid storage portion. The one or more semi-open inlets may enable air to pass into the liquid storage portion under specific conditions.

The liquid storage portion may comprise at least one channel for holding liquid aerosol-forming substrate. The at least one channel may be configured such that capillary forces act on the liquid aerosol-forming substrate. The capillary force acting on the liquid aerosol-forming substrate may hold the level of the liquid aerosol-forming substrate substantially perpendicular to at least one of the sidewalls of the liquid storage portion and the first and second electrodes. One dimension of the channel may be less than a predetermined value, such that capillary forces act on liquid aerosol-forming substrate held in the channel. The dimension of the one or more channels may be the width of the one or more channel. The predetermined value may be below about 3 mm, below about 2 mm, below about 0.5 mm or below about 0.25 mm.

The liquid storage portion may comprise aerosol-forming substrate held in the liquid storage portion. As used herein with reference to the present invention, an aerosol-forming substrate is a substrate capable of releasing volatile compounds that can form an aerosol. Volatile compounds may be released by heating the aerosol-forming substrate. Volatile compounds may be released by moving the aerosol-forming substrate through passages of a vibratable element.
The aerosol-forming substrate may be liquid. The aerosol-forming substrate may be liquid at room temperature. The liquid aerosol-forming substrate may comprise both liquid and solid components. The aerosol-forming substrate may comprise nicotine. The nicotine containing liquid aerosol-forming substrate may be a nicotine salt matrix. The aerosol-forming substrate may comprise plant-based material. The aerosol-forming substrate may comprise tobacco. The aerosol-forming substrate may comprise a tobacco-containing material containing volatile tobacco flavour compounds, which are released from the aerosol-forming substrate upon heating. The aerosol-forming substrate may comprise homogenised tobacco material. The aerosol-forming substrate may comprise a non-tobacco-containing material. The aerosol-forming substrate may comprise homogenised plant-based material.

The liquid aerosol-forming substrate may comprise at least one aerosol-former. An aerosol-former is any suitable known compound or mixture of compounds that, in use, facilitates formation of a dense and stable aerosol and that is substantially resistant to thermal degradation at the temperature of operation of the system. Suitable aerosol-formers are well known in the art and include, but are not limited to: polyhydric alcohols, such as triethylene glycol, 1,3-butandiol and glycerine; esters of polyhydric alcohols, such as glycerol mono-, di- or triacetate; and aliphatic esters of mono-, di- or polycarboxylic acids, such as dimethyl dodecanedioate and dimethyl tetradecanedioate. Aerosol formers may be polyhydric alcohols or mixtures thereof, such as triethylene glycol, 1,3-butandiol and glycerine. The liquid aerosol-forming substrate may comprise other additives and ingredients, such as flavourants.

The liquid aerosol-forming substrate may comprise water, solvents, ethanol, plant extracts and natural or artificial flavours. The liquid aerosol-forming substrate may comprise one or more aerosol formers. Examples of suitable aerosol formers include glycerine and propylene glycol.

The liquid aerosol-forming substrate may comprise nicotine and at least one aerosol former. The aerosol former may be glycerine. The aerosol-former may be propylene glycol. The aerosol former may comprise both glycerine and propylene glycol. The liquid aerosol-forming substrate may have a nicotine concentration of between about 0.5% and about 10%, for example about 2%.

The liquid aerosol-forming substrate may contain a mixture of dielectric materials, each with a separate dielectric constant (k). The main constituents of a liquid aerosol-forming substrate at room temperature, about 20°C, may include: glycerine (k \sim 42), propylene glycol (k \sim 32), water (k \sim 80), air (k \sim 1), nicotine and flavourants. Where the liquid aerosol-forming substrate forms a dielectric material, the electrical quantity to be measured by the control system may be capacitance.
The liquid aerosol-forming substrate may comprise a mixture of electrically conductive materials. Where the liquid aerosol-forming substrate forms an electrically conductive material, the electrical quantity to be measured by the control system may be resistance.

The liquid storage portion may comprise a carrier material within the housing for holding the liquid aerosol-forming substrate. The liquid aerosol-forming substrate may be adsorbed or otherwise loaded onto the carrier material. Liquid aerosol-forming substrate absorbed in the material may spread or permeate through the carrier material, and changes in the saturation of the carrier material affect the entire body of carrier material.

This may enable first and second electrodes arranged in contact with a portion of the carrier material to sense changes in the electrical quantity of the entire body of carrier material. This may enable the control system to measure the electrical quantity of the entire liquid storage portion.

The carrier material may be made from any suitable absorbent body of material, for example, a foamed metal or plastics material, polypropylene, terylene, nylon fibres or ceramic. The aerosol-forming substrate may be retained in the carrier material prior to use of the aerosol-generating system. The aerosol-forming substrate may be released into the carrier material during use. The aerosol-forming substrate may be released into the carrier material immediately prior to use. For example, the liquid aerosol-forming substrate may be provided in a capsule. The shell of the capsule may melt upon heating by the heating means and releases the liquid aerosol-forming substrate into the carrier material. The capsule may contain a solid in combination with the liquid.

The liquid aerosol-forming substrate may be held in a capillary material. A capillary material is a material that actively conveys liquid from one end of the material to another. This may be advantageous, as the capillary material may draw liquid aerosol-forming substrate to a specific location in the liquid storage portion, regardless of the orientation of the liquid storage portion. This may facilitate arrangement of the first and second electrodes for accurate and reliable detection of a puff on the aerosol-generating system.

The capillary material may be configured to convey the aerosol-forming substrate to the aerosol-generating means. The capillary material may have a fibrous structure. The capillary material may have a spongy structure. The capillary material may comprise a bundle of capillaries. The capillary material may comprise a plurality of fibres. The capillary material may comprise a plurality of threads. The capillary material may comprise fine bore tubes. The fibres, threads or fine-bore tubes may be generally aligned to convey liquid to an atomiser. The capillary material may comprise a combination of fibres, threads and fine-bore tubes. The capillary material may comprise sponge-like material. The capillary material may comprise foam-like material. The structure of the capillary material
may form a plurality of small bores or tubes, through which the liquid can be transported by capillary action.

The capillary material may comprise any suitable material or combination of materials. Examples of suitable materials are a sponge or foam material, ceramic- or graphite-based materials in the form of fibres or sintered powders, foamed metal or plastics materials, a fibrous material, for example made of spun or extruded fibres, such as cellulose acetate, polyester, or bonded polyolefin, polyethylene, terylene or polypropylene fibres, nylon fibres or ceramic. The capillary material may have any suitable capillarity and porosity so as to be used with different liquid physical properties. The liquid aerosol-forming substrate has physical properties, including but not limited to viscosity, surface tension, density, thermal conductivity, boiling point and vapour pressure, which allow the liquid to be transported through the capillary material by capillary action.

The aerosol-generating means may be arranged to receive aerosol-forming substrate from the liquid storage portion. The aerosol-generating means may be an atomiser. The aerosol-generating means may comprise one or more aerosol-generating elements. The aerosol-generating means may be configured to atomise received aerosol-forming substrate using heat. The aerosol-generating means may comprise heating means for atomising received liquid aerosol-forming substrate. The one or more aerosol-generating elements may be heating elements. The aerosol-generating means may be configured to atomise received aerosol-forming substrate using ultrasonic vibrations. The aerosol-generating means may comprise an ultrasonic transducer. The one or more aerosol-generating elements may comprise one or more vibratable elements.

The aerosol-generating means may comprise heating means configured to heat the aerosol-forming substrate. The heating means may comprise one or more heating elements. The one or more heating elements may be arranged appropriately so as to most effectively heat received aerosol-forming substrate. The one or more heating elements may be arranged to heat the aerosol-forming substrate primarily by means of conduction. The one or more heating elements may be arranged substantially in direct contact with the aerosol-forming substrate. The one or more heating elements may be arranged to transfer heat to the aerosol-forming substrate via one or more heat conductive elements. The one or more heating elements may be arranged to transfer heat to ambient air drawn through the aerosol-generating system during use, which may heat the aerosol-forming substrate by convection. The one or more heating elements may be arranged to heat the ambient air before it is drawn through the aerosol-forming substrate. The one or more heating elements may be arranged to heat the ambient air after it is drawn through the aerosol-forming substrate.
The heating means may be electric heating means or an electric heater. The
electric heater may comprise one or more electric heating elements. The one or more
electric heating elements may comprise an electrically resistive material. Suitable
electrically resistive materials may include: semiconductors such as doped ceramics,
electrically "conductive" ceramics (such as, for example, molybdenum disilicide), carbon,
graphite, metals, metal alloys and composite materials made of a ceramic material and a
metallic material.

The one or more electric heating elements may take any suitable form. For
example, the one or more electric heating elements may take the form of one or more
heating blades. The one or more electric heating elements may take the form of a casing
or substrate having different electro-conductive portions, or one or more electrically
resistive metallic tube.

The liquid storage portion may incorporate one or more disposable heating
elements. The one or more electric heating elements may comprise one or more heating
needles or rods that run through the aerosol-forming substrate. The one or more electric
heating elements may comprise one or more flexible sheets of material. The electric
heating means may comprise one or more heating wires or filaments, for example Ni-Cr,
platinum, tungsten or alloy wires, or heating plates. The one or more heating elements
may be deposited in or on a rigid carrier material.

The one or more heating elements may comprise one or more heat sinks or heat
reservoirs. The one or more heat sinks or heat reservoirs may comprise a material capable
of absorbing and storing heat and subsequently releasing the heat over time to heat the
aerosol-forming substrate.

The heating means may be substantially flat to allow for straightforward
manufacture. As used herein, the term 'substantially flat' means formed in a single plane
and not wrapped around or otherwise confirmed to fit a curved or other non-planar shape.
A flat heating means may be easily handled during manufacture and provide for a robust
construction.

The heating means may be of the type described in EP-B1-2493342. For example,
the heating means may comprise one or more electrically conductive tracks on an
electrically insulating substrate. The electrically insulating substrate may comprise any
suitable material, and may be a material that is able to tolerate high temperatures (in
excess of 300°C) and rapid temperature changes. An example of a suitable material is a
polyimide film, such as Kapton®.

The heating means may comprise means for heating a small amount of liquid
aerosol-forming substrate at a time. The means for heating a small amount of liquid
aerosol-forming substrate at a time may include, for example, a liquid passageway in
communication with the liquid aerosol-forming substrate. The liquid aerosol-forming substrate may be forced into the liquid passageway by capillary force. The at least one heater may be arranged such that during use, only the small amount of liquid aerosol-forming substrate within the liquid passageway, and not the liquid within the housing, is heated. The heating means may comprise a coil substantially surrounding at least a portion of a liquid passageway.

The heating means may comprise inductive heating means. Inductive heating means are described in more detail below, in relation to the cartridge.

The aerosol-generating means may comprise one or more vibratable elements and one or more actuators arranged to excite vibrations in the one or more vibratable elements. The one or more vibratable elements may comprise a plurality of passages through which aerosol-forming substrate may pass and become atomised. The one or more actuators may comprise one or more piezoelectric transducers.

The aerosol-generating means may comprise one or more capillary wicks for conveying liquid aerosol-forming substrate held in the liquid storage portion to the one or more elements of the aerosol-generating means. The liquid aerosol-forming substrate may have physical properties, including viscosity, which allow the liquid to be transported through the one or more capillary wicks by capillary action. The one or more capillary wicks may have any of the properties of structures described above relating to the capillary material.

The one or more capillary wicks may be arranged to contact liquid held in the liquid storage portion. The one or more capillary wicks may extend into the liquid storage portion. In this case, in use, liquid may be transferred from the liquid storage portion to the one or more elements of the aerosol-generating means by capillary action in the one or more capillary wicks. The one or more capillary wicks may have a first end and a second end. The first end may extend into the liquid storage portion to draw liquid aerosol-forming substrate held in the liquid storage portion into the aerosol generating means. The second end may extend into an air passage of the aerosol-generating system. The second end may comprise one or more aerosol-generating elements. The first end and the second end may extend into the liquid storage portion. One or more aerosol-generating elements may be arranged at a central portion of the wick between the first and second ends. In use, when the one or more aerosol-generating elements are activated, the liquid aerosol-forming substrate in the one or more capillary wicks is atomised at and around the one or more aerosol-generating elements.

The aerosol-generating means may comprise one or more heating wires or filaments encircling a portion of one or more capillary wicks. The heating wire or filament may support the encircled portion of the one or more capillary wicks.
In use of the aerosol-generating means, atomised aerosol-forming substrate may be mixed with and carried in air flow through an air passage of the aerosol-generating system. The capillary properties of the one or more capillary wicks, combined with the properties of the liquid substrate, may ensure that, during normal use when there is sufficient aerosol-forming substrate, the wick is always wet with liquid aerosol-forming substrate in the area of the aerosol-generating means.

The aerosol-generating system may comprise one or more power supplies. The power supply may be a battery. The battery may be a Lithium based battery, for example a Lithium-Cobalt, a Lithium-Iron-Phosphate, a Lithium Titanate or a Lithium-Polymer battery. The battery may be a Nickel-metal hydride battery or a Nickel cadmium battery. The power supply may be another form of charge storage device such as a capacitor. The power supply may require recharging and be configured for many cycles of charge and discharge. The power supply may have a capacity that allows for the storage of enough energy for one or more smoking experiences; for example, the power supply may have sufficient capacity to allow for the continuous generation of aerosol for a period of around six minutes, corresponding to the typical time taken to smoke a conventional cigarette, or for a period that is a multiple of six minutes. In another example, the power supply may have sufficient capacity to allow for a predetermined number of puffs or discrete activations of the heating means and actuator.

The aerosol-generating system may comprise a control system configured to operate the aerosol-generating means. The control system configured to operate the aerosol-generating means may be the control system configured to detect a user puff on the aerosol-generating system. The control system configured to operate the aerosol-generating means may be distinct of the control system configured to detect a user puff on the aerosol-generating system. The control system configured to operate the aerosol-generating means may comprise similar components to the control system configured to detect a user puff on the aerosol-generating system.

The aerosol-generating system may comprise a temperature sensor in communication with the control system. The temperature sensor may be adjacent to the liquid storage portion. The temperature sensor may be a thermocouple. At least one element of the aerosol-generating means may be used by the control system to provide information relating to the temperature. The temperature dependent resistive properties of the at least one element may be known and used to determine the temperature of the at least one element in a manner known to the skilled person. The control system may be configured to account or compensate for the effect of temperature on the electrical load between the first electrode and the second electrode using measurements of temperature from the temperature sensor. For example, where the portion of the liquid storage portion between
the first and second electrodes comprises a capacitive load, the control system may be configured to account for variations in the dielectric properties of the liquid storage portion due to changes in temperature.

The control system may comprise a tilt sensor. The tilt sensor may be configured to sense the orientation of the liquid storage portion. The aerosol-generating system may comprise a control system configured to receive sensed orientation information from the tilt sensor and to determine the orientation of the liquid storage portion. By determining the orientation of the liquid storage portion, the control system may be configured to determine whether the liquid aerosol-forming substrate held in the liquid storage portion is substantially perpendicular to the first electrode and the second electrode. The control system may be configured to detect a user puff on the aerosol-generating system when the liquid aerosol-forming substrate held in the liquid storage portion is substantially perpendicular to the first and second electrodes, such as when the liquid storage portion is determined to be upright.

The liquid aerosol-forming substrate may be subject to gravitational and acceleration forces that move the liquid aerosol-forming substrate to different sections of the liquid storage portion. Provided that the entire liquid storage portion is arranged between the first and second electrodes, the measurement of the electrical quantity should not be affected.

The aerosol-generating system may comprise a user input, such as a switch or button. This enables the user to turn the system on. The switch or button may activate the aerosol-generating means. The switch or button may initiate aerosol generation. The switch or button may prepare the control electronics to await input from the puff detector.

The aerosol-generating system may comprise indication means, for indicating the occurrence of a puff to a user. The indication means may comprise one or more of lights, such as light emitting diodes (LEDs), a display, such as an LCD display, and a loudspeaker or buzzer. The control system may be configured to indicate that a puff has occurred to a user with the indication means. The control system may be configured to light one or more of the lights depending on the determined strength of liquid aerosol-forming substrate, display a type or strength of liquid aerosol-forming substrate on the display or emit sounds via the loudspeaker or buzzer to indicate determination of an authorised or unauthorised liquid aerosol-forming substrate.

The aerosol-generating system may comprise a housing. The housing may be elongate. The housing may comprise any suitable material or combination of materials. Examples of suitable materials include metals, alloys, plastics or composite materials containing one or more of those materials, or thermoplastics that are suitable for food or pharmaceutical applications, for example polypropylene, polyetheretherketone (PEEK) and
polyethylene. The material may be light and non-brittle.

The housing may comprise a cavity for receiving the power supply. The housing may comprise a mouthpiece. The mouthpiece may comprise at least one air inlet and at least one air outlet. The mouthpiece may comprise more than one air inlet. One or more of the air inlets may reduce the temperature of the aerosol before it is delivered to a user and may reduce the concentration of the aerosol before it is delivered to a user.

The aerosol-generating system may be portable. The aerosol-generating system may have a size comparable to a conventional cigar or cigarette. The aerosol-generating system may have a total length between about 30 mm and about 150 mm. The aerosol-generating system may have an external diameter between about 5 mm and about 30 mm.

The aerosol generating system may be an electrically operated smoking system. The aerosol-generating system may be an electronic cigarette or cigar.

The aerosol-generating system may comprise a main unit and a cartridge. The main unit comprises the control system. The cartridge comprises the liquid storage portion for holding the liquid aerosol-forming substrate. The main unit may be configured to removably receive the cartridge. The first electrode and the second electrode may be arranged such that a portion of the liquid storage portion of the cartridge is arranged between the first electrode and the second electrode when the cartridge is received by the main unit.

The main unit may comprise one or more power supplies. The main unit may comprise the aerosol-generating means.

The cartridge may comprise the aerosol-generating means. Where the cartridge comprises the aerosol-generating means, the cartridge may be referred to as a 'cartomiser'.

The aerosol-generating system may comprise an aerosol-generating component comprising the aerosol-generating means. The aerosol-generating component may be separate of the main unit and the cartridge. The aerosol-generating component may be removably receivable by at least one of the main unit and the cartridge.

The main unit may comprise the first electrode and the second electrode. The cartridge may comprise the first electrode and the second electrode. The main unit may comprise one of the first electrode and the second electrode. The cartridge may comprise one of the first electrode and the second electrode. Arranging one of the first electrode and the second electrode on the main unit and arranging the other of the first electrode and the second electrode on the cartridge may enable identification of the cartridge. In other words, the presence or absence of an electrode on the cartridge may be used to verify whether the cartridge received by the main unit is a genuine or authentic cartridge from the manufacturer of the main unit. The type of electrode or measurements between the electrode of the main unit and the electrode of the cartridge may also be used to identify the type of cartridge received by the main unit or the type of liquid aerosol-forming substrate held in the liquid
storage portion of the cartridge. The control system may be configured to determine the presence or absence of an electrode in the cartridge. The control system may be configured to determine the identity the cartridge based on the presence or absence of an electrode in the cartridge. The control system may also be configured to determine whether the cartridge has been correctly received by the main unit based on the presence or absence of an electrode in the cartridge.

The aerosol-generating means may comprise heating means substantially as described above in relation to the first aspect of the present invention. The heating means may be inductive heating means, such that no electrical contacts are formed between the cartridge and the main unit. The main unit may comprise an inductor coil and a power supply configured to provide high frequency oscillating current to the inductor coil. The cartridge may comprise a susceptor element positioned to heat the aerosol-forming substrate. As used herein, a high frequency oscillating current means an oscillating current having a frequency of between 10 kHz and 20 MHz.

The cartridge may be removably coupled to the main unit. The cartridge may be removed from the main unit when the aerosol-forming substrate has been consumed. The cartridge is preferably disposable. However, the cartridge may be reusable and the cartridge may be refillable with liquid aerosol-forming substrate. The cartridge may be replaceable in the main unit. The main unit may be reusable.

The cartridge may be manufactured at low cost, in a reliable and repeatable fashion. As used herein, the term 'removably coupled' is used to mean that the cartridge and main unit can be coupled and uncoupled from one another without significantly damaging either the main unit or cartridge.

The cartridge may have a simple design. The cartridge may have a housing within which a liquid aerosol-forming substrate is held. The cartridge housing may be a rigid housing. The housing may comprise a material that is impermeable to liquid.

The cartridge may comprise a lid. The lid may be peelable before coupling the cartridge to the main unit. The lid may be piercable.

The main unit may comprise a cavity for receiving the cartridge. The main unit may comprise a cavity for receiving the power supply.

The main unit may comprise the aerosol-generating means. The main unit may comprise one or more control systems of the aerosol-generating system. The main unit may comprise the power supply. The power supply may be removably coupled to the main unit.

The main unit may comprise the mouthpiece. The mouthpiece may comprise at least one air inlet and at least one air outlet. The mouthpiece may comprise more than one air inlet.

The main unit may comprise a piercing element for piercing the lid of the cartridge.
The mouthpiece may comprise the piercing element. The mouthpiece may comprise at least one first conduit extending between the at least one air inlet and a distal end of the piercing element. The mouthpiece may comprise at least one second conduit extending between a distal end of the piercing element and the at least one air outlet. The mouthpiece may be arranged such that in use, when a user draws on the mouthpiece, air flows along an air passage extending from the at least one air inlet, through the at least one first conduit, through a portion of the cartridge, through the at least one second conduit and exits the at least one outlet. This may improve airflow through the main unit and enable the aerosol to be delivered to the user more easily.

In use, a user may insert a cartridge as described herein into the cavity of a main unit as described herein. The user may attach the mouthpiece to the body of the main unit, which may pierce the cartridge with the piercing portion. The user may activate the main unit by pressing the switch or the button. The user may draw on the mouthpiece to draw air into the main unit through the one or more air inlets. The air may pass over a portion of the aerosol-generating means, entraining atomised aerosol-forming substrate, and exit the main unit through the air outlet in the mouthpiece to be inhaled by the user.

A kit of parts may be provided, comprising a cartridge and a main unit, substantially as described above. An aerosol-generating system according to the first aspect of the present invention may be provided by assembling the cartridge, the aerosol-generating means and the main unit. The components of the kit of parts may be removably connected. The components of the kit of parts may be interchangeable. Components of the kit of parts may be disposable. Components of the kit of parts may be reusable.

According to a second aspect of the present invention, there is provided a main unit for an aerosol-generating system according to the first aspect of the present invention. The main unit comprises the control system and at least one of the first electrode and the second electrode.

There may be provided a cartridge for an aerosol-generating system according to the first aspect of the present invention. The cartridge may comprise: the liquid storage portion; and at least one of the first electrode and the second electrode. The cartridge may comprise a housing for holding a liquid aerosol-forming substrate in the liquid storage portion.

According to a third aspect of the present invention, there is provided a method of detecting user puffs on an aerosol-generating system, the method comprising: holding a liquid aerosol-forming substrate in a liquid storage portion of an aerosol-generating system; arranging at least a portion of the liquid storage portion between a first electrode and a second electrode; measuring an electrical quantity between the first electrode and the second electrode; and detecting a user puff on the aerosol-generating system based on the measured electrical quantity information.
The method has all of the advantages described in relation to the first and second aspects of the present invention. Features such as the liquid storage portion and the first electrode and the second electrode may be the same as those described in relation to the first and second aspects of the present invention.

The step of detecting a user puff on the aerosol-generating system may comprise the step of comparing the measured electrical quantity information to reference electrical quantity information. The reference electrical quantity information may be electrical quantity information previously measured by the control system. The reference electrical quantity information may be stored in a memory of the aerosol-generating system. The reference electrical quantity information may be stored in a lookup table.

The reference electrical quantity information may be measured by the control system in a calibration procedure. The calibration procedure may be performed to populate the lookup table. In the calibration procedure, the liquid storage portion may be loaded with a liquid aerosol-forming substrate and puffs having a regular profile and duration may be made on the aerosol-generating system. The electrical quantity between the first electrode and the second electrode may be measured and fluctuations corresponding to puffs may be measured. The absolute or relative magnitude of the fluctuations of the electrical quantity due to puffs may be stored in a lookup table in a memory of the control system and associated in the lookup table with the detection of a puff.

The calibration procedure may be performed in the factory before the aerosol-generating system is distributed. The calibration procedure may be performed by a user before first use of the aerosol-generating system.

A method of operating an aerosol-generating system may comprise: holding a liquid aerosol-forming substrate in a liquid storage portion of an aerosol-generating system; arranging at least a portion of the liquid storage portion between a first electrode and a second electrode; measuring an electrical quantity between the first electrode and the second electrode; detecting a user puff on the aerosol-generating system based on the measured electrical quantity information; and supplying power to an aerosol-generating means of the aerosol-generating system on detection of a user puff.

Features described in relation to one aspect of the present invention may also be applicable to other aspects of the present invention. Features described in relation to the method may be applicable to the aerosol-generating system and features corresponding to the aerosol-generating system may be applicable to the method.

The invention will be further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a schematic illustration of an exemplary aerosol-generating system;
Figure 2 shows a liquid storage portion for an aerosol-generating system according to a first embodiment of the present invention;

Figure 3 shows a liquid storage portion for an aerosol-generating system according to a second embodiment of the present invention;

Figure 4 shows a liquid storage portion for an aerosol-generating system according to a third embodiment of the present invention;

Figure 5 shows a liquid storage portion for an aerosol-generating system according to a fourth embodiment of the present invention;

Figure 6 shows a liquid storage portion for an aerosol-generating system according to a fifth embodiment of the present invention;

Figure 7 shows a sensor comprising interdigitated first and second electrodes according to the present invention;

Figure 8 shows a sensor comprising interdigitated first and second electrodes according to the present invention;

Figure 9 shows a liquid storage portion for an aerosol-generating system according to a sixth embodiment of the present invention;

Figure 10 shows a liquid storage portion for an aerosol-generating system according to a seventh embodiment of the present invention;

Figure 11 shows a liquid storage portion for an aerosol-generating system according to an eighth embodiment of the present invention;

Figure 12 shows a schematic circuit diagram for an aerosol-generating system according to the present invention;

Figure 13 shows a schematic circuit diagram for an aerosol-generating system according to the present invention; and

Figure 14 shows a schematic circuit diagram for an aerosol-generating system according to the present invention.

Figure 1 is a schematic illustration of an aerosol-generating system. Figure 1 is schematic in nature, and the components shown are not necessarily to scale either individually or relative to one another. The aerosol-generating system comprises a main unit 100, which is preferably reusable, in cooperation with a cartridge 200, which is preferably disposable. The aerosol-generating system shown in Figure 1 is an electrically operated smoking system.

The main unit 100 comprises a main housing 101. The housing is substantially circularly cylindrical and has a longitudinal length of about 100 mm and an external diameter of about 20 mm, comparable to a conventional cigar. The main unit 100 comprises an electric power supply in the form of a lithium ion phosphate battery 102 and a
control system in the form of control electronics 104. The main housing 101 also defines a cavity 112 into which the cartridge 200 is received.

The main unit 100 also includes a mouthpiece portion 120 including an outlet 124. The mouthpiece portion is connected to the main housing 101 by a hinged connection in this example but any kind of connection may be used, such as a snap fitting or a screw fitting. One or more air inlets 122 are provided between the mouthpiece portion 120 and the main body 101 when the mouthpiece portion is in a closed position, as shown in Figure 1.

Within the mouthpiece portion is a flat spiral inductor coil 110. The coil 110 is formed by stamping or cutting a spiral coil from a sheet of copper. The coil 110 is positioned between the air inlets 122 and the air outlet 124 so that air drawn through the inlets 122 to the outlet 124 passes through the coil.

The cartridge 200 (shown in schematic form in Figure 1) comprises a rigid housing 204 defining a liquid storage portion 201. The liquid storage portion 201 contains a liquid aerosol-forming substrate (not shown). The housing 204 of the cartridge 200 is fluid impermeable but has an open end covered by a permeable susceptor element 210. The permeable susceptor element 210 comprises a ferrite mesh, comprising a ferrite steel. The aerosol-forming substrate can form a meniscus in the interstices of the mesh. When the cartridge 200 is engaged with the main unit and is received in the cavity 112, the susceptor element 210 is positioned adjacent the flat spiral coil 110. The cartridge 200 may include keying features to ensure that it cannot be inserted into the main unit upside-down.

In use, a user puffs on the mouthpiece portion 120 to draw air through the air inlets 122 into the mouthpiece portion 120 and out of the outlet 124 into the user’s mouth. The main unit includes a puff sensor 106 in the form of a microphone, as part of the control electronics 104. A small air flow is drawn through sensor inlet 121 past the microphone 106 and up into the mouthpiece portion 120 when a user puffs on the mouthpiece portion. When a puff is detected, the control electronics provide a high frequency oscillating current to the coil 110. This generates an oscillating magnetic field as shown in dotted lines in Figure 1. An LED 108 is also activated to indicate that the main unit is activated. The oscillating magnetic field passes through the susceptor element, inducing eddy currents in the susceptor element. The susceptor element heats up as a result of Joule heating and as a result of hysteresis losses, reaching a temperature sufficient to vapourise the aerosol-forming substrate close to the susceptor element. The vapourised aerosol-forming substrate is entrained in the air flowing from the air inlets to the air outlet and cools to form an aerosol within the mouthpiece portion before entering the user’s mouth. The control electronics supplies the oscillating current to the coil for a predetermined duration, in this example five seconds, after detection of a puff and then switches the current off until a new puff is detected.
The cartridge 200 has a circularly cylindrical shape and the susceptor element spans a circular open end of the cartridge housing. It will be appreciated that other configurations are possible. For example, the susceptor element may be a strip of steel mesh 220 that spans a rectangular opening in the cartridge housing 204.

The example aerosol-generating system shown in Figure 1 relies on inductive heating. Further examples of suitable inductive heating elements and explanation of the operation of inductive heating systems are described in WO 2015/177046 A1.

It will be appreciated that the aerosol-generating system may comprise other types of aerosol-generating means. For example, the aerosol-generating means may comprise other aerosol-generating means configured to atomise the liquid aerosol-forming substrate by heat. The aerosol-generating means may comprise one or more resistive heating elements. The aerosol-generating means may also comprise aerosol-generating means configured to atomise the liquid aerosol-forming substrate by vibration. The aerosol-generating means may comprise one or more vibratable elements and actuators.

Aerosol-generating systems according to the present invention comprise first electrodes and second electrodes spaced from the first electrodes, wherein portions of the liquid storage portions are arranged between the first electrodes and the second electrodes. The control systems are configured to measure an electrical quantity between the first electrodes and second electrodes, and detect a user puff on the aerosol-generating system based on measured electrical quantity information. As such, aerosol-generating systems according to the present invention do not require additional puff detectors, such as the puff detector 106 of the aerosol-generating system 100 shown in Figure 1.

Several examples of cartridges suitable for main units of aerosol-generating systems, such as the main unit shown in Figure 1, are shown in Figures 2 to 12. The cartridges shown in Figures 2 to 12 comprise liquid storage portions and electrode arrangements according to the present invention.

The cartridge 300 shown in Figure 2 comprises a substantially circularly cylindrical housing 301, having a closed end and a substantially open end. The housing is rigid and substantially fluid impermeable, and defines a liquid storage portion that is configured to hold liquid aerosol-forming substrate (not shown) either freely or held in a carrier material. Aerosol-generating elements 302 are provided over the open end of the housing 301. In this embodiment, the aerosol-generating elements comprise a ferrite mesh susceptor. A sensor 303 is arranged on an inner surface of the housing 301, within the liquid storage portion. The sensor comprises a first electrode 304 and a second electrode 305. The first and second electrodes 304, 305 are substantially identical and comprise arcuate metal plates arranged at opposite sides of housing 301. Each electrode 304, 305 circumscribes about half the circumference of the inner surface of the housing 301 and extends
substantially the length of the housing 301, from the open end to the closed end. The electrodes 304, 305 are arranged on the housing with a gap between the sides of the plates, to ensure that the plates 304, 305 are not in an electrically conductive relationship. This arrangement enables the sensor 303 to sense electrical quantities of the entire liquid storage portion.

Electrical contacts (not shown) extend through the housing, from the outer surface to the inner surface of each of the plates. When the cartridge 300 is received in a cavity of a main unit, the contacts of the cartridge 300 abut complimentary contacts arranged in the cavity of the main unit to electrically connect the sensor 303 to a power supply and a control system of the main unit.

The cartridge 310 shown in Figure 3 has a substantially similar construction to the cartridge 300 shown in Figure 2. The cartridge 310 comprises a substantially circularly cylindrical housing 311 defining a liquid storage portion, and an aerosol-generating element 312 arranged over an open end. The cartridge 300 comprises a sensor 313 arranged around at an outer surface of the liquid storage portion. The sensor 313 comprises a first electrode 314 and a second electrode 315. The first and second electrodes 314, 315 are substantially identical and comprise copper rings circumscribing the outer surface of the housing 311. The first electrode 314, 315 is arranged towards the open end of the housing 311 and the second electrode 315 is arranged towards the closed end so that the sensor 313 is configured to sense electrical quantities of the entire liquid storage portion.

The cartridge 320 shown in Figure 4 has a substantially similar construction to the cartridge 310 shown in Figure 3. The cartridge 320 comprises a substantially circularly cylindrical housing 321, having an open end and a closed end, and an aerosol-generating element 322 arranged over the open end. The cartridge 320 comprises a sensor 323 comprising a first electrode 324 comprising a ring electrode arranged at an inner surface of the housing 321, and a second electrode comprising the aerosol-generating element 322.

The cartridge 330 shown in Figure 5 has a substantially similar construction to the cartridges 300, 310 and 320 shown in Figures 2, 3 and 4. The cartridge 330 comprises a substantially circularly cylindrical housing 331, having an open end and a closed end, and an aerosol-generating element 332 arranged over the open end. The cartridge 330 comprises a sensor 333 arranged at an inner surface of the housing 321. The sensor 333 comprises a first electrode 334 and a second electrode 335. The first and second electrodes 334, 335 are point electrodes extending through opposing sides of the housing 331 at the same position along the length of the housing 331. This minimises the distance between the electrodes and may increase the sensitivity of the sensor 333. Where carrier material is provided in the liquid storage portion, the point electrodes 334, 335 may be arranged in contact with the carrier material. Liquid aerosol-forming substrate held in the
liquid storage portion permeates through the carrier material. A change in the amount of liquid aerosol-forming substrate held in the liquid storage portion affects the saturation of the carrier material, and changes the electrical quantities of the carrier material. This enables the point electrodes 334, 335 to sense electrical quantities of the entire liquid storage portion.

The cartridge 340 shown in Figure 5 has a substantially similar construction to the cartridges 300, 310, 320 and 330 shown in Figures 2, 3, 4 and 5. The cartridge 340 comprises a substantially circularly cylindrical housing 341, having an open end and a closed end, and an aerosol-generating element 342 arranged over the open end. The cartridge 340 comprises a sensor 343 arranged at an inner surface of the housing 341. The sensor 343 comprises first and second electrodes (not shown) arranged on a platform. The platform comprises an electrically insulating polymer sheet, having a similar size and shape to one of the electrodes 304, 305 of the cartridge 300 shown in Figure 2. The platform is adhered to the inner surface of the housing 343 and is sufficiently flexible to conform to the shape of the housing 343.

An example arrangement of first and second electrodes on a platform, such as the platform of the sensor 343, is shown in Figure 7. The sensor 343' comprises a first electrode 344' and a second electrode 345' that are interdigitated. Each electrode 344', 345' is substantially identical and comprises a linear main track and a plurality of linear protrusions extending away from the main track, in a direction substantially perpendicular to the main track. Each electrode 344', 345' comprises 125 protrusions, each protrusion having a length \( l_p \), of about 6760 \( \mu \text{m} \), and a width \( w_p \), of about 10 \( \mu \text{m} \). Neighbouring protrusions are spaced apart by interspaces having a width \( w_i \), of about 30 \( \mu \text{m} \).

The main track of the first electrode 344' and the main track of the second electrode 345' are arranged in parallel on the platform, at a separation of about 6780 \( \mu \text{m} \). The first electrode 344' is arranged with its protrusions 346' facing the second electrode 345' and within the interspaces of the second electrode 345'. The second electrode 345' is arranged with its protrusions 347' facing the first electrode 344' and within the interspaces of the first electrode 344'. In this arrangement, a consistent spacing of about 10 \( \mu \text{m} \) is provided between the first electrode 344' and the second electrode 345' along the entire length of the electrodes 344', 345'.

Another example arrangement of first and second electrodes on a platform, such as the platform of the sensor 343, is shown in Figure 8. The sensor 343'' comprises a first electrode 344'' and a second electrode 345'' that are interdigitated. Each electrode 344'', 345'' comprises a linear main track and a plurality of pairs of arcuate protrusions, extending in opposite directions away from the main track. Each electrode 344'', 345'' comprises 50 pairs of arcuate protrusions. Each protrusion has a width of about 10 \( \mu \text{m} \). Each pair of
protrusions forms an incomplete circle that is not joined at the distalmost end from the main track. Neighbouring pairs of protrusions are spaced apart by interspaces having a width of about 30 μm. The distalmost protrusion of the second electrode 345" comprises a complete circle.

The main track of the first electrode 344" and the main track of the second electrode 345" are arranged in coaxial alignment on the platform parallel on the platform, with the protrusions 346" of the first electrode 344" within the interspaces of the second electrode 345" and the protrusions 347" of the second electrode 345" within the interspaces of the first electrode 344". The distalmost protrusion of the first electrode 344" substantially surrounds the distalmost protrusion of the second electrode 345". In this arrangement, a consistent spacing of about 10 μm is provided between the first electrode 344" and the second electrode 345" along the entire length of the electrodes 344", 345".

The cartridge 350 shown in Figure 9 comprises a rigid housing 351 defining a liquid storage portion. The housing 351 comprises substantially planar sides. The internal volume of the housing 301 is sufficiently narrow that capillary forces act on a liquid aerosol-forming substrate held in the liquid storage portion. A sensor 353 comprises a first plate electrode 354 and a second plate electrode 355 arranged at opposite sides of the liquid storage portion. The electrodes 354, 355 form substantially parallel electrode plates having a length of between about 25 mm to 30 mm and a width of between about 5 mm to 7 mm. This corresponds to a surface area of between about 25 mm x 5 mm to about 30 mm x 7 mm. The separation between the first and second electrodes 344, 345 is between about 2 mm and about 3 mm.

The cartridge 350 further comprises aerosol-generating means in the form of a wick 352 extending from an end of the liquid storage portion and a heating coil 358 wound around the wick 352 at the distal end. In use, the coil 358 heats the wick 352 and atomises liquid aerosol-forming substrate in the wick 352. This draws liquid aerosol-forming substrate held in the liquid storage portion to the wick end of the liquid storage portion. The capillary forces caused by the narrow separation between the first and second electrodes 354, 355 do not enable the liquid aerosol-forming substrate held in the liquid storage portion to move freely. As a result, liquid aerosol-forming substrate collects at the wick end of the liquid storage portion and the liquid storage portion may be notionally divided into two sections, a first section 38A towards the wick end that is filled with liquid aerosol-forming substrate and a second section 38B opposite the wick end that is filled with air. As the liquid aerosol-forming substrate is consumed in use, the second section 38B filled with air increases in size and the first section 38A filled with liquid aerosol-forming substrate decreases in size.
The cartridge 360 shown in Figure 10 comprises a substantially circularly cylindrical housing 361 comprising a central airflow passage extending there through. A liquid storage portion is defined between the housing 361 and the central airflow passage, and comprises an annular body of carrier material. The cartridge 360 comprises aerosol-generating means in the form of a wick 362 extending across the airflow passage and a heating coil 368 arranged in the air passage and wound around the wick 362. The cartridge 360 comprises a sensor 363 comprising a first electrode 364 and a second electrode 365 arranged at opposite sides of the wick. In use, the coil 368 heats the wick 362 and atomises liquid aerosol-forming substrate in the wick 362. This draws liquid aerosol-forming substrate held in the carrier material to the wick and changes the saturation of both the wick 362 and the carrier material. As the saturation of the wick changes, the electrical load between the electrodes, 364, 365 changes.

The cartridge 370 shown in Figure 11 has a similar construction and arrangement to the cartridge 360 shown in Figure 10. The cartridge 370 comprises a sensor 373 comprising a first, circularly cylindrical plate electrode 374 arranged around the inner surface of the annular body of carrier material and a second, circularly cylindrical plate electrode 375 arranged around the outer surface of the body of carrier material. The first and second electrodes 375, 374 form concentric circularly cylindrical plates bounding the inner and outer surfaces of the annular body of carrier material. In use, the coil heats the wick and atomises liquid aerosol-forming substrate in the wick, which draws liquid aerosol-forming substrate held in the carrier material to the wick. This changes the saturation of the carrier material, which changes the electrical load between the electrodes 374, 375.

Figure 12 shows a schematic circuit diagram of a sensor circuit 401 and control system circuit 402 for an aerosol-generating system according to the present invention. The sensor circuit 401 comprises a sensor 403, in series with a resistor R and a dedicated sensor power supply to supply an alternating voltage to the sensor 403 at a predetermined frequency. The control system circuit 402 comprises control electronics comprising a controller 404 and memory 405. The control electronics are connected to a power supply 406.

In other embodiments (not shown) the sensor 403 may be connected to the power supply 406, which may be configured to supply power to the sensor circuit 401 and the control system circuit 402. The power supply 406 may also be configured to supply power to the aerosol-generating means of the aerosol-generating system and the control system circuit 402 may be configured to control operation of the aerosol-generating means.

In one embodiment of the present invention, an aerosol-generating system comprises one of the cartridges shown in Figures 2 to 12. In use, the aerosol-generating system is turned on by the user activating a switch, and a control system of the aerosol-
generating system supplies an oscillating measurement signal to the first and second
electrodes at a frequency of about 100 kHz. The control system receives impedance
information from the first and second electrodes and determines the rate of change of the
impedance information from two or more successive measurements of the impedance.

The control system compares the determined rate of change to a first predetermined
threshold rate of change stored in a memory of the control system. When the determined
rate of change of the impedance exceeds the first predetermined threshold, the control
system identifies the start of a user puff, and supplies power to aerosol-generating means
of the aerosol-generating system. An LED is also activated to indicate to the user that the
aerosol-generating means are activated.

When the control system is supplying power to the aerosol-generating means, the
control system continues to measure the impedance and determine the rate of change of
the impedance. However, when the control system is supplying power to the aerosol-
generating means, the control system compares the determined rate of change to a second
predetermined threshold. When the determined rate of change exceeds the second
predetermined threshold, the control system detects the end of a user puff, and stops
supplying power to the aerosol-generating means and the LED.

Figure 13 shows exemplary experimental data of measured resistance 501 and
measured capacitance 502 over time for an exemplary aerosol-generating system
according to the present invention.

The experimental data shown in Figure 13 was obtained using a cartridge
comprising a liquid storage portion and electrode arrangement as shown in Figure 5. The
cartridge comprised a substantially circularly cylindrical liquid storage portion holding a
carrier material comprising long polypropylene polyethylene (PP-PE) foam that was
saturated with a liquid aerosol-forming substrate. An aerosol-generating means comprising
a ferrite mesh, having a wire diameter of about 25 μm and an aperture width of about 39
μm, was arranged at one end of the cartridge, to receive liquid aerosol-forming substrate
from the liquid storage portion. A sensor comprising opposing first and second point
electrodes, in the form of copper wires, was arranged at a central position along the length
of the liquid storage portion. The first and second point electrodes were in direct contact
with the carrier material. A mouthpiece was also attached to the cartridge at the aerosol-
generating means end.

A 2 V alternating voltage was supplied to the sensor at a frequency of 100 kHz, and
the resistance 501 and capacitance 502 of the sensor were measured using an LCR meter.
Power was supplied to heat the aerosol-generating means to atomised liquid aerosol-
forming substrate received at the mesh and a regular series of puffs were taken on the
mouthpiece using an analytical machine at a frequency of 2 puffs per minute. Each puff had a rectangular puff profile, a puff volume of 55 ml and a duration of 3 s.

Figure 13 shows regular fluctuations in both the measured resistance 501 and capacitance 502 across the first and second electrodes. The fluctuations occur at a frequency of about 2 fluctuations per minute. In other words, the fluctuations correspond to a puff on the aerosol-generating system. The resistance 501 increased sharply from a starting resistance, and gradually decreases to about the starting resistance over a period 503 of about 30 seconds. The size and profile of the fluctuations is regular and may be used to determine the start and end of a puff. The capacitance 502 shows a short increase in capacitance, in a sharp peak, at the beginning of the period 503, which may be used to detect a puff.

Figure 14 shows exemplary experimental data of measured resistance 601 and measured capacitance 602 over time for an exemplary aerosol-generating system according to the present invention.

The experimental data shown in Figure 14 was obtained using cartridge comprising a cartridge comprising a substantially circularly cylindrical liquid storage portion holding a carrier material comprising long polypropylene polyethylene (PP-PE) foam that was saturated with a liquid aerosol-forming substrate. An aerosol-generating means comprising a ferrite mesh, having a wire diameter of about 25 µm and an aperture width of about 39 µm, was arranged at one end of the cartridge, to receive liquid aerosol-forming substrate from the liquid storage portion. A sensor comprising interdigitated first and second electrodes, as shown in Figure 7, was arranged at the opposite end of the cartridge to the aerosol-generating means. The first and second electrodes were in direct contact with the carrier material. A mouthpiece was also attached to the cartridge at the aerosol-generating means end.

A 1 V alternating voltage was supplied to the sensor at a frequency of 100 kHz, and the resistance 601 and the capacitance 602 of the sensor were measured using an LCR meter. Power was supplied to heat the aerosol-generating means to atomised liquid aerosol-forming substrate received at the mesh and a regular series of puffs were taken on the mouthpiece using an analytical machine at a frequency of 2 puffs per minute. Each puff had a rectangular puff profile, a puff volume of 55 ml and a duration of 3 s.

Figure 14 shows regular fluctuations in both the measured resistance 601 and capacitance 602 across the first and second electrodes. The fluctuations occur at a frequency of approximately 2 fluctuations per minute. In other words, the fluctuations correspond to a puff on the aerosol-generating system. The resistance 601 increased sharply from a starting resistance, and gradually decreases to the starting resistance over a period 603 of about 30 seconds. The size and profile of the fluctuations is regular and may
be used to determine the start and end of a puff. The capacitance 602 shows a short decrease in capacitance at the beginning of the period 503 that returns to the starting capacitance which may be used to detect a puff.

Similar procedures may be performed during calibration of an aerosol-generating system, wherein a predetermined series of puffs may be taken on the aerosol-generating system, and a change in at least one of the inductance, resistance or capacitance may be measured and associated with detection of a puff. The results of such a calibration procedure may be stored in the memory of a control system of the aerosol-forming substrate.

It will be appreciated that the relationship between the impedance, resistance and capacitance between the first and second electrodes and the fluctuations caused by the occurrence of a puff will depend on the type and relative positions of the electrodes relative to the liquid storage portion.

It will be appreciated that in other embodiments (not shown) that the cartridges described in relation to Figures 2 to 12 may not be cartridges, but rather may be integral parts of aerosol-generating systems, such as the aerosol-generating system shown in Figure 1. It will also be appreciated that main units may be provided with sensors, such as the pairs of first and second electrodes shown in Figures 2 to 12, arranged to sense electrical quantities of liquid storage portions of cartridges received by main units.

It will be appreciated that features described for one embodiment may be provided in other embodiments. In particular, it will be appreciated that cartridges and aerosol-generating systems according to the present invention may comprise more than one means of detecting a user puff on the aerosol-generating system, such as more than one pair of first and second electrodes.
CLAIMS

1. An aerosol-generating system comprising:
   a liquid-storage portion for holding a liquid aerosol-forming substrate;
   a first electrode and a second electrode spaced from the first electrode,
   wherein at least a portion of the liquid storage portion is arranged between
   the first electrode and the second electrode; and
   a control system configured to:
       measure an electrical quantity between the first electrode and the
       second electrode, and
       detect a user puff on the aerosol-generating system based on the
       measured electrical quantity information.

2. An aerosol-generating system according to claim 1, wherein the control system is
   configured to apply an oscillating measurement signal to the first electrode and the
   second electrode, the oscillating measurement signal having a frequency of less
   than 10 MHz.

3. An aerosol-generating system according to claim 1 or claim 2, wherein the control
   system is configured to detect a user puff when a change in the measured electrical
   quantity exceeds a threshold.

4. An aerosol-generating system according to any preceding claim, wherein the
   aerosol-generating system further comprises aerosol-generating means arranged to
   receive aerosol-forming substrate from the liquid storage portion, and wherein the
   control system is further configured to supply power to the aerosol-generating
   means on detection of a puff.

5. An aerosol-generating system according to any preceding claim, wherein the first
   electrode and the second electrode are arranged on a platform of electrically
   insulating material.

6. An aerosol-generating system according to any preceding claim, wherein the first
   electrode and the second electrode are interdigitated.

7. An aerosol-generating system according to any preceding claim, wherein the
   aerosol-generating system comprises aerosol-generating means comprising one or
more aerosol-generating elements, and wherein at least one of the aerosol-generating elements comprises one of the first electrode and the second electrode.

8. An aerosol-generating system according to any preceding claim, wherein the electrical quantity to be measured by the control system is the impedance between the first electrode and the second electrode.

9. An aerosol-generating system according to any one of claims 1 to 7, wherein the electrical quantity to be measured by the control system is the resistance between the first electrode and the second electrode.

10. An aerosol-generating system according to any one of claims 1 to 7, wherein the electrical quantity to be measured by the control system is the capacitance between the first electrode and the second electrode.

11. An aerosol-generating system as claimed in any preceding claim, wherein the system comprises:
   a cartridge comprising the liquid storage portion; and
   a main unit comprising the control system,
   wherein the main unit is configured to removably receive the cartridge and the first electrode and the second electrode are arranged such that a portion of the liquid storage portion of the cartridge is arranged between the first electrode and the second electrode when the cartridge is received by the main unit.

12. An aerosol-generating system as claimed in claim 11, wherein:
   the cartridge comprises the first electrode and the second electrode or
   the main unit comprises the first electrode and the second electrode or
   the cartridge comprises one of the first electrode and the second electrode and the main unit comprises the other of the first electrode and the second electrode.

13. A main unit for an aerosol-generating system as claimed in claim 11 or claim 12, wherein the main unit comprises:
   the control system; and
   at least one of the first electrode and the second electrode.

14. A method of detecting user puffs on an aerosol-generating system, the method comprising:
holding a liquid aerosol-forming substrate in a liquid storage portion of an aerosol-generating system;
arranging at least a portion of the liquid storage portion between a first electrode and a second electrode;
measuring an electrical quantity between the first electrode and the second electrode; and
detecting a user puff on the aerosol-generating system based on the measured electrical quantity information.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. A24F47/00 A61M15/06 G01F1/56

ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A24F A61M G01F

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.

See patent family annex.

Date of the actual completion of the international search: 11 April 2017

Date of mailing of the international search report: 17/05/2017

Name and mailing address of the ISA:

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV RIJSWIJK
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer: Koob, Michael
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