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(71) Applicant: JT INTERNATIONAL SA [CH/CH]; 8 rue Kazem Radjavi, 1202 Geneva (CH).

(72) Inventor: MCEVOY, Jaakko; Enenkelstrasse 15/16, 1160 Vienna (AT).

(74) Agent: GILL JENNINGS & EVERY LLP; The Broadgate Tower, 20 Primrose Street, London EC2A 2ES (GB).

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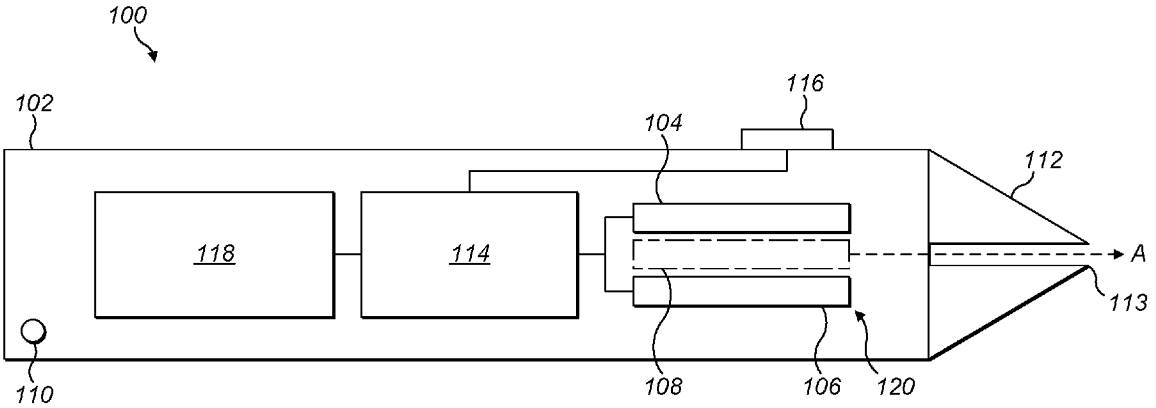

FIG. 1

(57) Abstract: An aerosol generating device (100) configured to generate an aerosol for inhalation by a user is disclosed, comprising: a first heater (104) and a second heater (106) controllable independently from the first heater, each configured to heat an aerosol forming substance to generate an aerosol; a cavity (108) provided between the first heater and the second heater, configured to receive the aerosol forming substance; and a controller (114) configured to operate the first heater and the second heater by setting target heating temperatures for the first heater and the second heater using a first temperature profile (200) and a second temperature profile (210), respectively; wherein the first temperature profile comprises an initial target heating temperature (202) and a final target heating temperature (208) that are substantially equal.

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AEROSOL GENERATING DEVICE

FIELD OF INVENTION

The invention relates to aerosol generating devices. In particular, the invention relates to aerosol generating devices with independently heatable heaters.

BACKGROUND TO THE INVENTION

Aerosol generating devices can generate an aerosol by heating a consumable including an aerosol generating substance above an aerosol generating temperature, using one or more heaters. The choice of temperature profile for the heater or heaters during an aerosol generation session strongly affects the quality of the aerosol and the efficiency of the aerosol generating device. For example, a high vapour volume can be achieved using high temperatures at the start of the session, which is enjoyable for the user, but this increases the energy consumption of the device. In another example, using a flat temperature profile for heaters in the session can provide a poor sensory experience for the user and fails to account for changes in the properties of the aerosol generating substance over the course of a session. There is therefore a demand to balance the competing requirements of vapour quality and device efficiency. Additionally, different types of consumables and heaters require different temperature profiles for maximising aerosol quality and device efficiency.

It can also take several seconds for the heater or heaters to reach an initial temperature for initiating aerosol generation. There is therefore a demand for aerosol generating devices that are more convenient to use.

SUMMARY OF INVENTION

According to an aspect of the invention there is provided an aerosol generating device configured to generate an aerosol for inhalation by a user, comprising: a first heater and a second heater controllable independently from the first heater, each configured to heat an aerosol forming substance to generate an aerosol; a cavity provided between the first heater and the second heater, configured to receive the aerosol forming substance; and a controller configured to operate the first heater and the second heater by setting target heating temperatures for the first heater and the second heater using a first temperature profile and a second temperature profile, respectively; wherein the first temperature profile comprises an initial target heating temperature and a final target heating temperature that are substantially equal.

In this way, once an aerosol generation session, or “vaping session” has been completed (after which the aerosol forming substance is depleted), the first heater is immediately ready for use in a further aerosol generation session that can be initiated shortly after a previous session. The user does not need to wait for the first heater to ramp up (or down) to the initial temperature in the subsequent vaping session because the first heater is already at or very close to the initial target temperature required for starting vaping. This can avoid several seconds of waiting compared to a temperature profile using a final target heating temperature that is lower or higher than the initial target heating temperature. In one example embodiment, the initial and final target heating temperatures of the first temperature profile are about 230ºC. The first temperature profile may use any suitable target heating temperatures in any suitable arrangement, wherein the initial and final target heating temperatures are substantially equal.

The first temperature profile and the second temperature profile each comprise a plurality of target heating temperatures. It should be understood that the term “target heating temperature” refers to an aerosol generation temperature and can therefore be distinguished from a non-heating target temperature. For example, an ambient temperature would be a non-heating target temperature applied when the first and second heater are not in use or the aerosol generating device is turned off. Furthermore, the skilled person would understand that “target heating temperature” refers to a desired temperature that may not reflect the actual temperature of the first or second heater at a given moment. In general, the actual temperature of the first or second heater lags behind the target heating temperature. The amount of lag is influenced by the change in electrical power provided to the heaters when switching between different target heating temperatures as well as other factors such as the material used in the heaters, the ambient temperature, and the depletion level of an aerosol forming substance in the cavity.

The first heater and the second heater are controllable independently. In one example, the first and second heaters may be wired separately to the controller so that the controller can control the delivery of electrical power to each heater independently. In other examples, any control electronics that enable the first and second heater to operate at different temperatures at the same point in time may be implemented.

Planar heaters are known to be able to heat a planar consumable more quickly compared to other arrangements of heaters and consumables, such as cylindrical heaters and consumables. It is therefore desirable to use such a heating assembly in aerosol generating devices. The first and second temperature profiles of the invention have been found to be particularly suitable for planar heaters. The first heater may be a first planar heater and the second heater may be a second planar heater. The first planar heater and the second planar heater can be arranged to heat different sides of a consumable. The cavity is preferably provided in a layer between the first planar heater and the second planar heater, wherein each heater provides a layer adjacent to the cavity. The cavity may be configured to receive a planar consumable through a door or other suitable opening in a housing of the aerosol generating device. The first and second planar heaters may have a rectangular shape. Other suitable shapes, such as circular or square, may also be implemented. In a further example, each of the first and second planar heater could comprise a plurality of adjacent separated sections arranged in a common plane.

The first and second planar heaters may each comprise a single planar surface. Alternatively, the first and second planar heater may comprise a respective plurality of adjacent separated sections arranged in a common plane.

The first and second heaters, which may be planar heaters, may be configured to generate heat using electrical resistive heating.

In other examples, the first and second heaters may have other, non-planar shapes, such as a rod shape configured to penetrate a consumable, or a curved film shape lining the walls of the cavity for receiving the aerosol generating substance.

The first heater and the second heater may be arranged to face different areas of an aerosol generating consumable. The cavity may also be at least partially formed by the first heater and the second heater. The first heater and the second heater may be planar or non-planar, in these examples.

The first temperature profile preferably comprises a maximum target heating temperature and a minimum target heating temperature. The second temperature profile preferably comprises an initial target heating temperature, a final target heating temperature, a maximum target heating temperature and a target minimum heating temperature.

Preferably, the initial and final target heating temperatures of the second temperature profile are substantially equal. In this way, the user does not need to wait for either of the first or second heater to ramp up (or down) to an initial temperature in a subsequent vaping session initiated shortly after a previous session.

Preferably, the first temperature profile comprises at least three target heating temperatures and a direct transition from the maximum target heating temperature to the minimum target heating temperature of the first temperature profile. In this way, the efficiency of the device can be increased. This is achieved because the actual operating temperature of each heater lags behind their corresponding target heating temperature. By transitioning directly from the highest to the lowest target heating temperature the energy consumption of the first heater is reduced in the period following the transition due to the lower power required to maintain the heater at lower temperatures. Meanwhile, the actual temperature of the first heater decreases more gradually. This allows the first heater to have a higher temperature while expending less energy. Conserving energy by dropping the target heating temperature without allowing a significant drop in actual heater temperature can also be described as “temperature coasting”.

Put differently, the area under a temperature profile of target heating temperatures is proportional to, or at least correlates with, the energy consumption of the corresponding heater. Thus, including large drops in a temperature profile can significantly reduce the energy consumption of the profile without necessarily causing undesirable sudden drops in the actual temperature of the heater, due to the lagging effect.

Providing at least three target heating temperatures and a drop from the maximum to the minimum can enable a greater energy saving. In some examples, the transition from the maximum to the minimum target heating temperature of the first heater can involve a change in target heating temperature of at least 50ºC, 100ºC, 150ºC, 180ºC, greater, or other values in between. The maximum and minimum target heating temperatures of the first temperature profile may be about 270ºC and about 170ºC, respectively, in one example.

Preferably, the second temperature profile comprises at least three target heating temperatures and a direct transition from the minimum target heating temperature to the maximum target heating temperature of the second temperature profile. In this way, the second temperature profile can store thermal energy in the second heater to allow a subsequent drop in target heating temperature to be used after the transition to the maximum target heating temperature. A transition from minimum to maximum in this way can be beneficial for aerosol quality while also facilitating temperature coasting in the period following the transition.

The transition from the minimum to maximum target heating temperature of the second heater can involve a change in target heating temperature of at least 50ºC, 100ºC, 150ºC, 180ºC, greater, or other values in between. The maximum and minimum target heating temperatures of the second temperature profile may be about 280ºC and about 100ºC, respectively.

Preferably, the initial target heating temperature of the first temperature profile is substantially equal to the initial and/or final target heating temperature of the second temperature profile. In one example embodiment, the initial and final target heating temperatures of the first temperature profile are about 230ºC, and the initial or the final, or both of the initial and final target heating temperature of the second temperature profile are about 230ºC. This can provide even heating of the aerosol forming substance from both sides.

Preferably, the first temperature profile and the second temperature profile are set to their respective initial and/or final target heating temperatures for different durations. This has been found to provide a particularly effective balance between efficiency and vapour quality for the arrangement of two heaters with the cavity positioned between them.

Preferably, the initial target heating temperature of the first temperature profile is between the minimum target heating temperature and the maximum target heating temperature of the first temperature profile. This has been found to provide a particularly effective balance between efficiency and vapour quality for the arrangement of two heaters with the cavity positioned between them. The maximum target heating temperature for the first heating profile may correspond to a maximum rate of aerosol generation that is acceptable to avoid an overly rapid depletion of the aerosol generating substance. Similarly, the minimum target heating temperature may correspond to a minimum rate of aerosol generation that is acceptable for providing a good quality aerosol. Having the initial target heating temperature between the maximum and minimum target heating temperatures in this way ensures the aerosol generation rate is well within acceptable levels.

The maximum and minimum target heating temperatures may be selected based on the boiling point of ingredients in the aerosol generating substance. In one example, the maximum, initial, and minimum target heating temperatures can be 260 ºC, 230 ºC, and 180 ºC, respectively. In this case, the aerosol generating substance may include ingredients with boiling points between 180 ºC and 260 ºC.

Preferably, the initial and/or final target heating temperature of the second temperature profile is between the minimum target heating temperature and the maximum target heating temperature of the second temperature profile. This has been found to provide a particularly effective balance between efficiency and vapour quality for the arrangement of two heaters with the cavity positioned between them. This also allows for the depletion of the consumable at different rates at different times during a vaping session and at different locations in the consumable. Varying the depletion of the consumable in this way has been found to generate more vapour and deplete the consumable more evenly, leading to a higher quality aerosol.

Preferably, the first temperature profile and the second temperature profile have a first period in which the target heating temperature of the first temperature profile exceeds the target heating temperature of the second temperature profile, and a second period in which the target heating temperature of the second temperature profile exceeds the target heating temperature of the first temperature profile. This has been found to provide a particularly effective balance between efficiency and vapour quality for the arrangement of two heaters with the cavity positioned between them. During the first period, the first target temperature profile may always have a higher target heating temperature than the second temperature profile. During the second period the second target temperature profile may always have a higher target heating temperature than the first temperature profile.

Having only one heater in operation during a vaping session has been found to provide a cooler vapour that is less enjoyable for the user. By having one heater at a higher temperature for aerosol generation and the remaining heater at a lower, moderately high temperature, the lower temperature heater can heat the aerosol received by the user to provide a more enjoyable aerosol. Additionally, setting one heater to a lower temperature reduces the heat flux onto the substrate from one side, meaning that the other heater has a preferrable thermal gradient and can theoretically push more energy into the substrate from its corresponding side.

Preferably, the first temperature profile and the second temperature profile have different respective maximum and/or minimum target heating temperatures. This has been found to provide a particularly effective balance between efficiency and vapour quality for the arrangement of two heaters with the cavity positioned between them. In one example, the first and second temperature profiles may have maximum target heating temperatures of about 270ºC and about 280ºC, respectively. Alternatively or in addition, the first and second temperature profiles may have minimum target heating temperatures of about 170ºC and about 100ºC, respectively.

Preferably, the second temperature profile may be set to its maximum target heating temperature at the end of the second temperature profile, for example in the final half, third, or fifth of the second temperature profile's total duration. As the aerosol generating substance depletes, higher temperatures are generally required to maintain the same level of aerosol generation. Placing the maximum target heating temperature at the end of the profile ensures as much of the aerosol generating substance is vaporised as possible and maintains a good quality of aerosol through until the end of a vaping session. It may only be necessary to increase the temperature of one of the first and second heaters to maintain a good aerosol quality throughout the vaping session. Thus, increasing the temperature of only the second heater at the end of the vaping session may be more efficient.

Preferably, the first heater and/or the second heater comprise ceramic. This has been found to provide a particularly effective balance between efficiency and vapour quality for the arrangement of two heaters with the cavity positioned in-between, in conjunction with the features of the first and second temperature profiles described above. In particular, ceramic heaters generally have a higher specific heat capacity compared to metal heaters and therefore require specifically tailored temperature profiles. The higher specific heat capacity of ceramic heaters means the actual temperatures of the first and second heaters can drop more slowly compared to some metal heaters. This is due to their higher specific heat capacity causing the actual temperature of the heaters to lag behind their target heating temperature to a greater extent and allows ceramic heaters to derive a greater benefit from temperature coasting.

Additionally, a planar arrangement of heaters benefits from the use of two different temperature heating profiles, various features of which are described above. Depletion of the consumable at different rates at different times during a vaping session, and at different locations in the consumable, means that high-quality vapour can be generated throughout a vaping session. Varying the depletion of the consumable in this way has been found to generate more vapour and deplete the consumable more evenly, leading to a higher quality aerosol. These benefits are thus particularly accentuated when the planar heaters are arranged to heat different sides of a consumable. When combined with the use of ceramic planar heaters, first and second temperature profiles are provided that maximise the competing requirements of device efficiency and vapour quality.

Preferably, the first temperature profile and the second temperature profile are configured for heating an aerosol forming substance comprising tobacco. The temperature profiles of the present invention have been found to provide a particularly effective balance between efficiency and vapour quality for the arrangement of two heaters with the cavity positioned in-between, in conjunction with the use of tobacco as an aerosol generating substance. This is particularly the case when the first and second heaters comprise ceramic and are planar. For example, the maximum and minimum target heating temperatures of the first and second temperature profiles may be selected based on known properties of tobacco to generate a high vapour volume without burning the tobacco.

Preferably, the first heater is substantially planar and the second heater is substantially planar. In this way, the first and second temperature profiles provide a particularly effective balance between vapour quality and device efficiency because the first and second temperature profiles have been found to be particularly effective for such an arrangement of heaters.

According to a further aspect of the invention there is provided a method for operating an aerosol generating device comprising a first heater and a second heater controllable independently from the first heater, comprising: operating the first heater and the second heater by setting target heating temperatures for the first heater and the second heater using a first temperature profile and a second temperature profile, respectively; wherein the first temperature profile comprises an initial target heating temperature and a final target heating temperature that are substantially equal.

According to a further aspect of the invention there is provided a non-transitory computer readable medium comprising executable instructions that, when executed by a processor on an aerosol generating device comprising a first heater and a second heater controllable independently from the first heater, cause the aerosol generating device to perform steps comprising: operating the first heater and the second heater by setting target heating temperatures for the first heater and the second heater using a first temperature profile and a second temperature profile, respectively; wherein the first temperature profile comprises an initial target heating temperature and a final target heating temperature that are substantially equal.

According to a further aspect of the invention, there is provided an aerosol generating device configured to generate an aerosol for inhalation by a user, comprising: a first heater and a second heater controllable independently from the first heater, arranged to face different areas of an aerosol generating consumable and configured to heat the consumable to generate an aerosol; a cavity at least partially formed by the first heater and the second heater, configured to receive the consumable; and a controller configured to operate the first heater and the second heater by setting target heating temperatures for the first heater and the second heater using a first temperature profile and a second temperature profile, respectively; wherein the first temperature profile comprises an initial target heating temperature and a final target heating temperature that are substantially equal.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention are now described, by way of example, with reference to the drawings, in which:

Figure 1 shows a schematic cross-sectional diagram of an aerosol generating device according to an embodiment of the invention;

Figure 2 shows a schematic control diagram according to an embodiment of the invention;

Figure 3 shows a schematic perspective view of a heating apparatus in use according to an embodiment of the invention;

Figure 4 shows a schematic perspective view of a consumable suitable for use with an embodiment of the invention;

Figure 5 shows an end view of a consumable suitable for use with an embodiment of the invention;

Figure 6 shows a schematic perspective view of an aerosol generating device according to an embodiment of the invention; and

Figure 7 shows a schematic cross-sectional diagram of an aerosol generating device according to an embodiment of the invention;

Figure 8 shows a graph plotting a first temperature profile and a second temperature profile according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Figure 1 shows a schematic diagram of an aerosol generating device 100 according to an embodiment of the invention.

The aerosol generating device 100 comprises a tubular housing 102 for containing and protecting the internal components of the aerosol generating device 100. A first planar heater 104 and a second planar heater 106 are provided in a substantially parallel orientation, spaced apart to create a cavity 108 in a layer between them. Each of the first planar heater 104 and the second planar heater 106 are configured to heat an aerosol generating substance received in the cavity 108. The housing 102 may comprise a mechanism (not shown), such as a door or a removable part that enables insertion of the aerosol generating substance into the cavity 108. An air inlet 110 is provided on the housing 102 and is fluidically connected to the cavity 108. An airflow channel (A) connects the cavity 108 to an air outlet 113 provided on a mouthpiece 112 to enable a user to draw air from the air inlet 110 through the cavity 108.

A controller 114 is provided and is configured to control target heating temperatures of the first planar heater 104 and the second planar heater 106 using a first temperature profile and a second temperature profile, respectively. A button 116 is provided on the housing 102 in electrical connection with the controller 114 for enabling a user to initiate aerosol generation. A battery 118 is provided for providing power to the first planar heater 104, the second planar heater 106, the controller 114, and any other electric components of the aerosol generating device 100.

Figure 2 shows a schematic control diagram of the aerosol generating device 100. The controller 114 comprises at least one processor 114a and a memory 114b for executing and storing executable instructions 114c, respectively. The instructions 114c include instructions for implementing the first and second temperature profiles. The controller 114 is configured to receive or send signals from the components shown in Figure 2 to control the various operations of the aerosol generating device 100.

Temperature sensors 107 are provided on or near the first and second planar heaters 104, 106 for monitoring the temperature of each of the first and second planar heaters 104, 106. The temperature sensors 107 are connected to the controller 114 for relaying temperature measurements, or, alternatively, relaying data from which a temperature measurement can be determined by the controller 114. Temperature can be measured directly using sensors such as a thermocouple or indirectly by measuring a property such as electrical resistance.

The housing 102 may comprise any suitable material known in the art, such as plastic or metal. In other embodiments, the button 116 can be replaced with or used alongside any other suitable input mechanism, such as a fingerprint sensor, a gesture sensor, or an air flow sensor. The battery 118 may be permanently fixed within the housing 102 and rechargeable. Alternatively, the battery 118 may be removable. In other embodiments, the aerosol generating device may be provided without a battery 118 and the user may supply a separate battery pack or disposable power source.

The first planar heater 104 and the second planar heater 106 form a heating assembly 120, as shown in Figure 3 with a consumable 10 including tobacco as an aerosol generating substance placed in the cavity 108.

Figures 1 and 3 show a simplified depiction of the aerosol generating device 100 and the heating assembly 120. Figures 6 and 7 show the aerosol generating device 100 and the heating assembly 120 in greater detail.

Each heater of the heating assembly 120 comprises a rectangular ceramic plate with an electrical heating element (not shown) embedded inside the ceramic plate. The electrical heating elements have a high electrical resistance and generate heat in response to an electric current flow. The ceramic plates, which are in contact with the consumable 10 during use, conduct heat from the heating elements and transfer the heat to the consumable 10 by conduction. The air in the cavity 108 is also heated. In this way, the heating assembly 120 and the cavity 108 form a heating oven for the tobacco in the consumable 10.

The heating element embedded in each ceramic plate is electrically connected to the controller 114, which controls the amount of electrical power flowing to each heater of the heating assembly 120 from the battery 118. Each heater of the heating assembly 120 is connected to the controller 114 to enable independent heating. In other words, the heating assembly is electrically connected to the controller 114 to enable the first planar heater 104 to have a different target heating temperature from the second planar heater 106 at any given time. In other embodiments, the heating elements can be provided on the ceramic plates.

Alternatively, the first and second planar heaters 104, 106 may be other types of heater, such as non-ceramic metal heating plates.

The first and second planar heaters 104, 106 may, in other embodiments, be replaced with non-planar heaters, such as rod-shaped or curved film heaters.

Temperature sensors 107 are provided for each of the first planar heater 104 and the second planar heater 106 in the heating assembly 120. This can allow the controller 114 to ensure the temperature of each heater does not exceed a desired target heating temperature. The temperature sensors 107 can be embodied as a thermistor or thermocouple, for example. Alternatively, the controller 114 may be able to infer the temperature of each heater of the heating assembly 120 by tracking the amount of electrical power provided to each heater or the electrical resistance of each heater, in which case temperature sensors 107 may not be necessary.

The controller 114 controls the target heating temperature of the first planar heater 104 using a first temperature profile. The second planar heater 106 is controlled by the controller 114 using a second temperature profile, which in general is different from the first temperature profile. The first and second temperature profiles and the heating assembly 120 are configured specifically to heat but not burn the consumable 10 comprising tobacco. However, in other embodiments, other forms of aerosol forming substances may be used.

The heating assembly 120 may be provided with a hinge or other mechanism (not shown) that enables the first planar heater 104 and the second planar heater 106 to be moved apart so that the consumable 10 can be inserted more easily. The mechanism may be incorporated into a door of the housing 102, in one example. Alternatively, as described further below, the consumable 10 may be insertable through an opening in the mouthpiece 112.

Figure 4 shows a more detailed view of the consumable 10 according to an example embodiment.

The consumable 10 is a flat-shaped tobacco article having, for example, a flat cuboid shape extending along an article axis X and having external dimensions LxWxD. In a typical example, the length L of the consumable 10 according to the article axis X equals substantially to 33 mm while its width W and depth D are substantially equal respectively to 12 mm and 1,2 mm. According to different examples, the values L, W and D can be selected within a range of +/- 40%, for example. The depth D of the consumable 10 is formed by a pair of parallel walls 13A, 13B, called hereinafter narrow walls 13A, 13B, and the width W of the consumable 10 is formed by a pair of parallel walls 14A, 14B, called hereinafter wide walls 14A, 14B. In some embodiments, the edges between the wide and narrow walls 13A, 13B, 14A, 14B can be rounded. According to other embodiments of the invention, the consumable 10 can have any other suitable flat shape and/or external dimensions. According to still other embodiments, the consumable 10 can present any other suitable shape, as for example a stick shape.

The consumable 10 comprises a substrate portion 15 and a mouthpiece portion 16 arranged along the article axis X. The substrate portion 15 may for example be slightly longer than the mouthpiece portion 16. For example, the length L2 of the substrate portion 15 according to the article axis X may be substantially equal to 18 mm and the length L1 of the mouthpiece portion 16 according to the article axis X may be substantially equal to 15 mm. The substrate portion 15 defines an abutting end 18 of the consumable 10 and the mouthpiece portion 16 defines a mouth end 20 of the consumable 10. The substrate portion 15 and the mouthpiece portion 16 may be fixed one to the other by a wrapper 21 extending around the substrate axis X. The wrapper 21 forms the narrow and wide walls 13A, 13B, 14A, 14B of the consumable 10. In some embodiments, the wrapper 21 is formed from a same wrapping sheet. In some other embodiments, the wrapper 21 is formed by separate wrapping sheets wrapping separately the portions 15, 16 and fixed one to the other by any other suitable means. The wrapper 21 may, for example, comprise paper and/or non-woven fabric and/or aluminium foil. The wrapper 21 may be porous or air impermeable and forms a plurality of airflow channels extending inside the consumable 10 between the abutting end 18 and the mouth end 20.

The mouthpiece portion 16 comprises a core 27 intended to act for example as a cooler to cool slightly the vapour before it is inhaled by the user. The core 27 may comprise for this purpose corrugated paper, for example, as shown in Figure 4. The core 27 may be formed through an extrusion and/or rolling process into a stable shape. Advantageously, the core 27 is arranged inside the mouthpiece portion 16 to be entirely in contact with the internal surface of the wrapper 21 delimiting this mouthpiece portion 16.

In some example embodiments, the consumable 10 can have a total volume of 2118 or 554 mm^3. The aerosol generating substance in the consumable 10 can comprise, by percentage of weight, 50% tobacco, 11.5% Propylene Glycol (PG), 20% Glycerin, 11.0% binder, 4.5% gum, and 3% water. The aerosol generating substance in the consumable 10 can have a weight of 200 mg. The aerosol generating substance can contain 3.07 mg of Nicotine.

Alternatively, the aerosol generating substance can have a weight of 275mg, contain 4.76 mg of Nicotine, 0.9 mg of PG, 44.5 mg of Glycerin, and can be in an elongated stick form.

The wrapper 21 can include a base paper of 0.13 mm thickness and a basis weight of 100 g/m^2. The wrapper 21 can include an aluminium foil of 0.006 mm thickness. The core 27 can comprise paper having 0.13 mm thickness and basis weight of 100 g/m^2.

Figure 5 shows an end view of the substrate portion 15. The substrate portion 15 comprises a vaporizable material for heating in the heating assembly 120. In this example, the vaporizable material comprises tobacco 30. The tobacco 30 is arranged within the wrapper 21 and has a corrugated shape so that a plurality of air channels 32 aligned with the substrate axis X are formed within the substrate portion 15. The air channels 32 allow air to be drawn through the consumable 10 during use so that generated aerosol can be drawn from the cavity 108 more easily.

A more detailed depiction of the aerosol generating device 100 is shown in Figures 6 and 7.

The aerosol generating device 100 comprises a housing 102 extending along a device axis Y and a mouthpiece 112. According to the example described below, the mouthpiece 112 and the housing 102 form two different pieces. Particularly, according to this example, the mouthpiece 112 is designed to be fixed on a fixing end of the housing 102.

As shown in Figure 7, the mouthpiece 112 comprises a central part 43 and a peripheral part 44 extending around the central part 43. The peripheral part 44 defines for example a collar covering partially an external surface of the housing 102 when the mouthpiece 112 is fixed on a fixing end of the housing 102. For example, the peripheral part 44 can be designed to cooperate with a gasket 45 arranged on the fixing end of the housing 102 in order to seal the space formed between the peripheral part 44 and the external surface of the housing 102. The peripheral part 44 also has an intermediate portion extending for example transversally to the device axis Y and forming a transition between the central part 43 of the mouthpiece 112 and the collar defined by the peripheral part 44. The central part 43 of the mouthpiece 112 defines a through hole 46 adapted to receive at least partially the consumable 10. Particularly, the through hole 46 can be adapted to receive at least a part of the mouthpiece portion 16 of the consumable 10, as shown in Figure 7. Advantageously, the through hole 46 can be adapted to fit tightly the mouthpiece portion 16 of the consumable 10 so as to avoid or minimise flow leakage between a wall delimiting the through hole 46 and an external surface of the consumable 10. In some embodiments, the consumable 10 can be retained for example by friction in the through hole 46. In this case, it is possible for example to insert first the mouthpiece portion 16 of the consumable 10 inside the through hole 46.

As shown in Figure 7, an inner volume 47 is formed between an inner surface 48 of the mouthpiece 112 and the fixing end of the housing 102. This inner volume 47 is crossed by the consumable 10 when it is inserted inside the housing 102. For example, the consumable 10 can divide the inner volume 47 in two symmetric parts.

The housing 102 delimits an internal space of the aerosol generating device 100 receiving various elements designed to carry out different functionalities of the aerosol generating device 100. This internal space can, for example, receive the battery 118 and controller 114. The internal space also comprises a heating chamber 50 containing the heating assembly 120 for heating the substrate portion 15 of the consumable 10.

As shown in this Figure 7, the heating chamber 50 can form a cup shape adapted to receive at least the substrate portion 15 of the consumable 10 and, in some cases, at least a part of the mouthpiece portion 16. The heating chamber 50 may form a cuboid shape, similar to the consumable 10, extending along the device axis Y and comprising a pair of parallel narrow walls extending along the device axis Y, a pair of parallel wide walls 54A, 54B extending also along the device axis Y and a bottom wall 58 adjacent to each of said walls and extending perpendicularly to the device axis Y. The bottom wall 58 forms a closed end of the chamber 50. Opposite to the bottom wall 58, the heating chamber 50 defines an opening 60 configured to receive the consumable 10 so that the corresponding wide walls 14A, 14B of the consumable 10 face the corresponding wide walls 54A, 54B of the heating chamber 50 and the corresponding narrow walls 13A, 13B of the consumable 10 face the corresponding narrow walls of the heating chamber 50 and the abutting end 18 of the consumable 10 abuts against the bottom wall 58 or at least a rib extending from this bottom wall 58. Alternatively, the abutting end 18 faces the bottom wall 58 without being in contact with it.

The heating chamber 50 is thus configured to receive the consumable 10 so that the narrow walls 13A, 13B of the consumable 10 face the narrow walls of the heating chamber 50, and the wide wall 14A (respectfully 14B) of the consumable 10 faces the wide wall 54B (respectfully 54A) of the heating chamber 50. The facing wide walls 14A, 14B, 54A, 54B and the facing narrow walls can be in contact one with the other or spaced one from the other. In this way, the heating chamber 50 provides the cavity 108 for receiving the consumable 10, as discussed previously.

The heating chamber 50 further comprises the first planar heater 104 and the second planar heater 106, which are arranged in the heating chamber 50 to heat the substrate portion 15 of the consumable 10. In the example embodiment of Figure 7, the first planar heater 104 and the second planar heater 106 are arranged on the inner faces of the wide walls 54A, 54B, with the intervening space between the first and second planar heaters 104, 106 forming the cavity 108. The first and second planar heaters 104, 106 can have other arrangements within the heating chamber 50 in other example embodiments.

An airflow channel extending from an air inlet 110 until the closed end of the heating chamber 50 is formed inside the aerosol generating device 100. Thus, air can enter the heating chamber 50 through the airflow channel and pass first to the substrate portion 15 and then through the mouthpiece portion 16 of the consumable 10 before being delivered to the user. The air inlet 110 is shown positioned on the housing 102 in Figure 1; however, in other embodiments the air inlet 110 can also be arranged in or on the mouthpiece 112. Specifically, the air inlet can be arranged in the intermediate portion of the peripheral part 44 of the mouthpiece 112. The air inlet 110 can be formed by a through hole.

An example use of the aerosol generating device 100 will now be described.

In use, a user inserts the consumable 10 into the cavity 108 and presses the button 116 to initiate aerosol generation, or, in other words, initiate a vaping session. The controller 114 then sets a sequence of target heating temperatures for the first planar heater 104 using the first temperature profile over the course of the session. It may take several seconds for the actual temperature of the first planar heater 104 and the cavity 108 to reach temperatures close to the initial target heating temperature of the first planar heater 104, which can be inconvenient for the user.

In this example embodiment, the controller 114 implements each target heating temperature in the first temperature profile by varying the duty cycle of the first planar heater 104 to a corresponding value, so that more or less power is delivered to the first planar heater 104. In general, the controller 114 is able to change the target heating temperature near-instantaneously, whereas the first planar heater 104 changes temperature more gradually. The controller 114 may receive feedback from one of the temperature sensors 107 to ensure the first planar heater 104 does not exceed the current target heating temperature. The controller 114 may turn off the first planar heater 104 completely if the current target heating temperature is exceeded, until the temperature drops within a threshold value based on the target heating temperature. Alternatively, the duty cycle of the first planar heater 104 may be lowered. Similarly, the controller 114 may increase the amount of power to the first planar heater 104 if the first planar heater 104 drops below a threshold temperature based on the current target heating temperature.

At the same time, the controller 114 instructs the second planar heater 106 to operate in the same manner using the second temperature profile, which also comprises a plurality of target heating temperatures. A vaping session may have a pre-defined duration, such as about 5 minutes, and the first heating and second temperature profiles each have a total duration equal to the duration of the vaping session. In this example, the first and second temperature profiles are initiated simultaneously by the controller 114 and have the same total duration. However, in other embodiments, the first and second temperature profiles may have different durations and the controller 114 may initiate the first and second temperature profiles at different times.

The consumable 10 in the cavity 108 then generates an aerosol in response to the heat delivered by the heating assembly 120 during the vaping session. The user inhales through the air outlet 113 on the mouthpiece 112, causing air to flow through the air inlet 110 and the cavity 108 towards the mouthpiece 112. This carries the generated aerosol to the user to enjoy. Once the session is finished, the consumable 10 is expended and can be removed from the aerosol generating device 100 by the user.

Advantageously, the first temperature profile has an initial target heating temperature and a final target heating temperature that are substantially equal. Thus, if the user decides to begin a subsequent vaping session shortly afterwards, then the first planar heater 104 is already at or very close to the initial target heating temperature of the first temperature profile. This means the heating assembly 120 can be ready to generate aerosol more quickly, and the user does not have to wait in the subsequent vaping session for aerosol generation to begin.

More aerosol (or “vapour”) is, in general, generated at a given point in time depending on the actual temperatures of the first and second planar heaters 104, 106. More or less energy is consumed by the heating apparatus 120 depending on the target heating temperatures used at a given point during the session. Advantageously, in this example the first temperature profile includes at least three target heating temperatures and a direct transition from the maximum to the minimum target heating temperature. Following the transition, the actual temperature of the first planar heater 104 drops gradually towards the minimum target heating temperature. This gradual drop means that a higher level of vapour generation can be prolonged while at the same time enacting a lower target heating temperature for the first planar heater 104, thereby reducing energy usage. The first planar heater 104 comprises ceramic and, consequently, is able to retain its temperature for longer following a drop in target heating temperature, compared to some other materials often used for heaters, such as metal. This provides a particularly effective profile for planar ceramic planar heaters heating tobacco.

Similarly, the second temperature profile can include at least three target heating temperatures and a direct transition from the minimum to the maximum transition. This transition can generate a larger vapour volume, which is pleasant for the user, and also prepares the second planar heater 106 for temperature coasting for the remainder of the vaping session and in any immediate subsequent vaping session.

Figure 8 shows a graph plotting an example first temperature profile 200 and an example second temperature profile 210 according to an embodiment of the invention.

The first temperature profile 200 comprises a plurality of target heating temperatures including a first, second, third, and fourth target heating temperature 202, 204, 206, 208, referred to hereafter as “temperatures” for brevity. The second temperature profile 210 comprises a plurality of target heating temperatures including a first, second, third, and fourth target heating temperature 212, 214, 216, 218, referred to hereafter as “temperatures” for brevity. Times t0-t7 shown in Figure 8 denote transitions between target heating temperatures.

The first temperature profile 200 begins at the first (and initial) temperature 202 and rises to the second temperature 204 at time t1. In this example, the second temperature 204 is the maximum temperature of the first temperature profile 200. At time t3, the first temperature profile 200 drops directly to the third temperature 206, which is the minimum temperature of the first temperature profile 200, before rising to the fourth and final temperature 208 at time t5. The first (and initial) temperature 202 and the fourth (and final) temperature 208 are substantially equal. The first temperature 202 is between the maximum temperature 204 and the minimum temperature 206 of the first temperature profile 200, such that at least three distinct target heating temperatures are provided. The first temperature profile 200 ends at time t7.

The second temperature profile 210 begins at the first (and initial) temperature 212 and drops to the second temperature 214 at time t2. In this example, the second temperature 214 is the minimum temperature of the second temperature profile 210. At time t4, the second temperature profile 210 rises to the third temperature 216, which is the maximum temperature for the second temperature profile 210, and then drops to the fourth and final temperature 218 at time t6. The first (and initial) temperature 212 and the fourth (and final) temperature 218 are substantially equal. The first temperature 212 is between the minimum temperature 214 and the maximum temperature 216, such that the second temperature profile comprises at least three target heating temperatures. The transition at t4 is a direct transition from the minimum to the maximum temperature. The second temperature profile 210 ends at time t7.

Table 1 shows the temperature values for each target heating temperature in the specific example of the first temperature profile 200 and the second temperature profile 210.

First temperature profile 200 (ºC)		**Second temperature profile 210 (ºC)**	
Temperature 202	230 ± 20	Temperature 212	230 ± 20
Temperature 204	270	Temperature 214	100
Temperature 206	170	Temperature 216	280
Temperature 208	230 ± 20	Temperature 218	230 ± 20

Table 1: example target heating temperatures for the first temperature profile 200 and the second temperature profile 210.

Table 2 (left two columns) shows the values of times t0-t7 in the specific example of Figure 8. Table 2 (right two columns) shows example durations that can be used in the first and second temperature profiles, some of which have been used in the specific example of Figure 8.

Time	Value (s)	Period	Duration (s)
t0	0	t0-t1	15 10 ± 10
t1	15	t0-t2	50
t2	50	t1-t3	85 70 ≤ t1-t3 < 120
t3	100	t2-t4	100 100 ± 20
t4	150	t3-t5	80
t5	180	t4-t6	60 40 < t4-t6 < 90
t6	210	t5-t7	100
t7	280	t6-t7	70

Table 2: The two leftmost columns show the specific values of times t0-t7 used in the example profiles of Figure 8. The two rightmost columns show example periods suitable for use in the first temperature profile and the second temperature profile, some of which have been used in the first temperature profile 200 and the second temperature profile 210.

The first temperature 202 and the first temperature 212 are equal in the example of Figure 8. The fourth temperature 208 and the fourth temperature 218 are also equal. Thus, all four temperatures are 230 ºC in this example. However, as shown in Figure 8 and Table 2, the first temperature profile 200 and the second temperature profile 210 spend different amounts of time at their corresponding initial and final temperatures. From t1-t4 the first temperature profile 200 always exceeds the temperature of the second temperature profile 210. From t4-t6 the second temperature profile 210 always exceeds the first temperature profile 200. The second temperature profile 210 has a higher maximum temperature 216 and a lower minimum temperature 214 compared to the first temperature profile 100.

Over a vaping session, the consumable 10 loses mass, may expand and contract in line with the associated heating and mass loss, and, consequently, undergoes changes in material properties (e.g., specific heat, density, thermal conductivity). It has been found that the above described features of the first and second temperature profiles 200, 210 are particularly effective for accounting for these issues in the heating apparatus of Figure 3.

The features of the first and second temperature profiles 200, 210 described above may be implemented using values other than those shown in Figure 8 and Tables 1 and 2. In particular, the timing and target heating temperature values used may be selected to optimise use of the aerosol generating device 100 with tobacco as the aerosol generating substance. For example, the maximum temperatures 206, 216 may be selected for being below the combustion temperature of tobacco and at or above temperatures known to generate a large quantity of vapour from tobacco to maximise the user experience.

As described previously, the first temperature profile 200 comprises a direct transition from the maximum temperature 204 to the minimum temperature 210. The durations t1-t3 and t3-t5 and temperatures 204, 206 are such that the total area under the first temperature profile 200 is less compared to a flat profile of 230 ºC. This reduces the energy consumption of operating the first planar heater 104 because the target heating temperature is proportional to, or at least correlates with, power consumption. Due to the lag in actual temperature of the first planar heater 104, a prolonged period of higher vapour volume is maintained in the period t3-t5, despite the lower energy expenditure.

Similarly, the transition from minimum temperature 214 to maximum temperature 216 provides the second temperature profile 210 with a total area under the second temperature profile 210 that is less than a flat temperature profile of 230 ºC. The second temperature profile 210 can temperature coast in the period t6-t7 (and in t0-t4 in a subsequent vaping session) for improved efficiency and higher vapour volume.

CLAIMS

1. An aerosol generating device configured to generate an aerosol for inhalation by a user, comprising:

a first heater and a second heater controllable independently from the first heater, each configured to heat an aerosol forming substance to generate an aerosol;

a cavity provided between the first heater and the second heater, configured to receive the aerosol forming substance; and

a controller configured to operate the first heater and the second heater by setting target heating temperatures for the first heater and the second heater using a first temperature profile and a second temperature profile, respectively;

wherein the first temperature profile comprises an initial target heating temperature and a final target heating temperature that are substantially equal.

2. The aerosol generating device of claim 1, wherein the first temperature profile comprises a maximum target heating temperature and a minimum target heating temperature; and wherein the second temperature profile comprises an initial target heating temperature, a final target heating temperature, a maximum target heating temperature and a minimum target heating temperature.

3. The aerosol generating device of claims 2, wherein the initial and final target heating temperatures of the second temperature profile are substantially equal.

4. The aerosol generating device of claim 2 or claim 3, wherein the first temperature profile comprises at least three target heating temperatures and a direct transition from the maximum target heating temperature to the minimum target heating temperature of the first temperature profile.

5. The aerosol generating device of claims 2 to 4, wherein the second temperature profile comprises at least three target heating temperatures and a direct transition from the minimum target heating temperature to the maximum target heating temperature of the second temperature profile.

6. The aerosol generating device of claims 2 to 5, wherein the initial target heating temperature of the first temperature profile is substantially equal to the initial and/or final target heating temperature of the second temperature profile.

7. The aerosol generating device of claims 2 to 6, wherein the first temperature profile and the second temperature profile are set to their respective initial and/or final target heating temperatures for different durations.

8. The aerosol generating device of claims 2 to 7, wherein the initial target heating temperature of the first temperature profile is between the minimum target heating temperature and the maximum target heating temperature of the first temperature profile.

9. The aerosol generating device of claims 2 to 8, wherein the initial and/or final target heating temperature of the second temperature profile is between the minimum target heating temperature and the maximum target heating temperature of the second temperature profile.

10. The aerosol generating device of claims 2 to 9, wherein the first temperature profile and the second temperature profile have a first period in which the target heating temperature of the first temperature profile exceeds the target heating temperature of the second temperature profile, and a second period in which the target heating temperature of the second temperature profile exceeds the target heating temperature of the first temperature profile.

11. The aerosol generating device of claims 2 to 10, wherein the first temperature profile and the second temperature profile have different respective maximum and/or minimum target heating temperatures.

12. The aerosol generating device of any of the preceding claims, wherein the first heater and/or the second heater comprise ceramic.

13. The aerosol generating device of any of the preceding claims, wherein the first heater is substantially planar and the second heater is substantially planar.

14. A method of operating an aerosol generating device comprising a first heater and a second heater controllable independently from the first heater, comprising:

operating the first heater and the second heater by setting target heating temperatures for the first heater and the second heater using a first temperature profile and a second temperature profile, respectively;

wherein the first temperature profile comprises an initial target heating temperature and a final target heating temperature that are substantially equal.

15. A non-transitory computer readable medium comprising executable instructions that, when executed by a processor on an aerosol generating device comprising a first heater and a second heater controllable independently from the first heater, cause the aerosol generating device to perform steps comprising:

operating the first heater and the second heater by setting target heating temperatures for the first heater and the second heater using a first temperature profile and a second temperature profile, respectively;

wherein the first temperature profile comprises an initial target heating temperature and a final target heating temperature that are substantially equal.

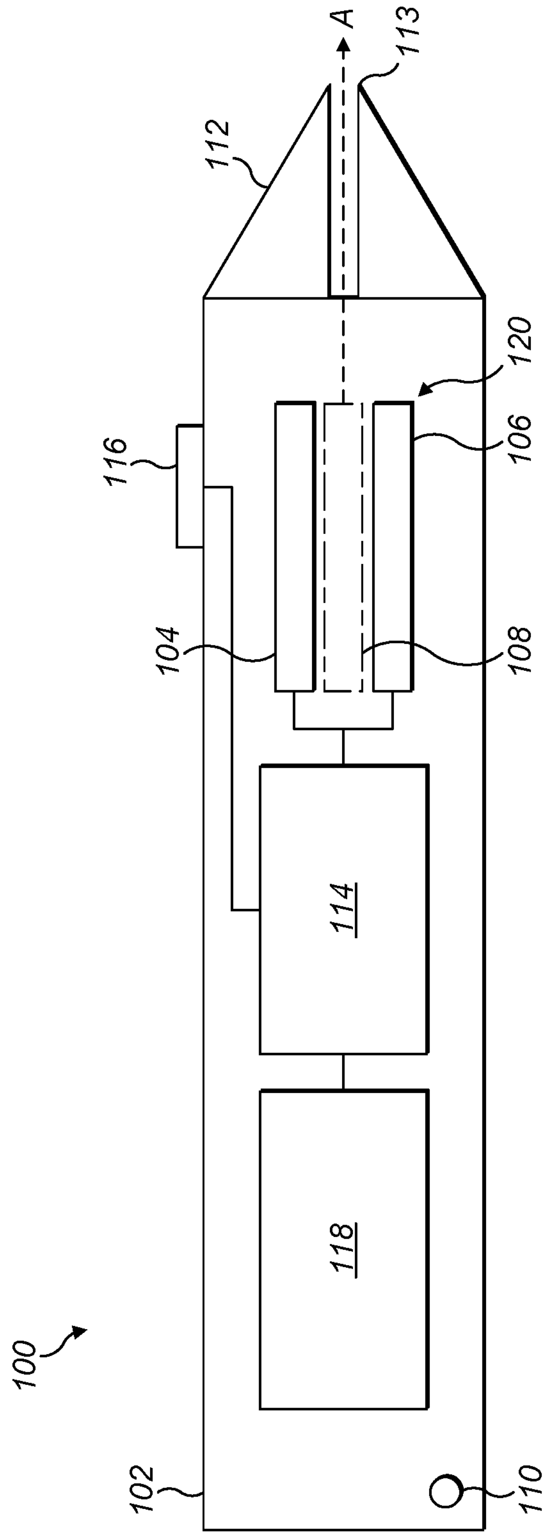

FIG. 1

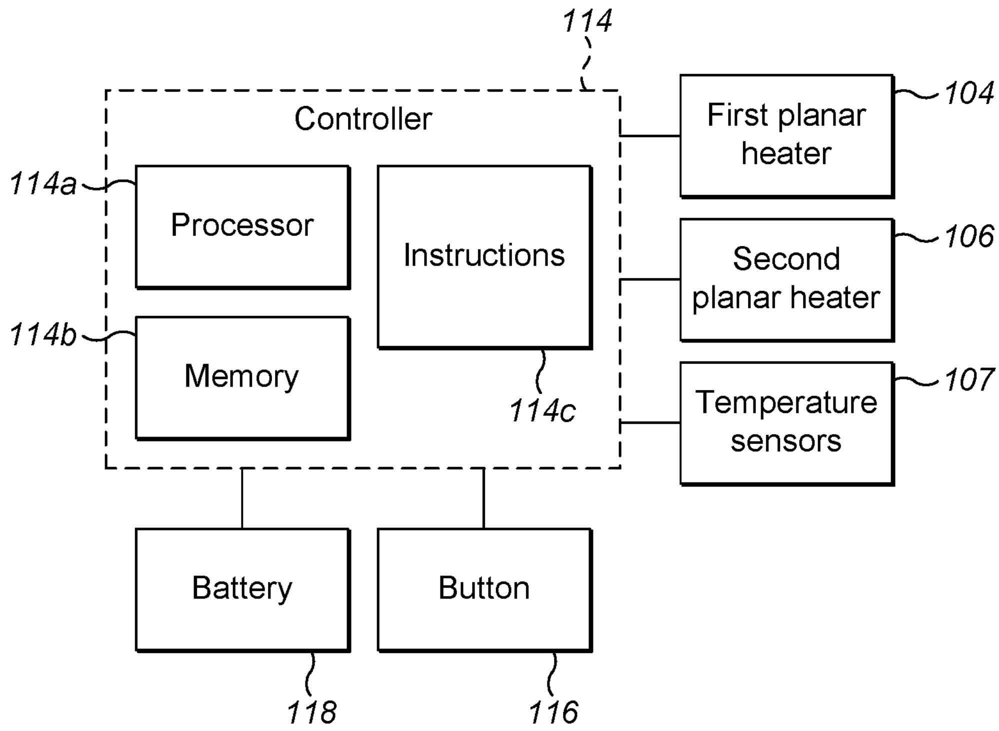
114
Controller
114a
Processor
Instructions
114b
Memory
114c
First planar heater
104
Second planar heater
106
Temperature sensors
107
Battery
Button
118
116

FIG. 2

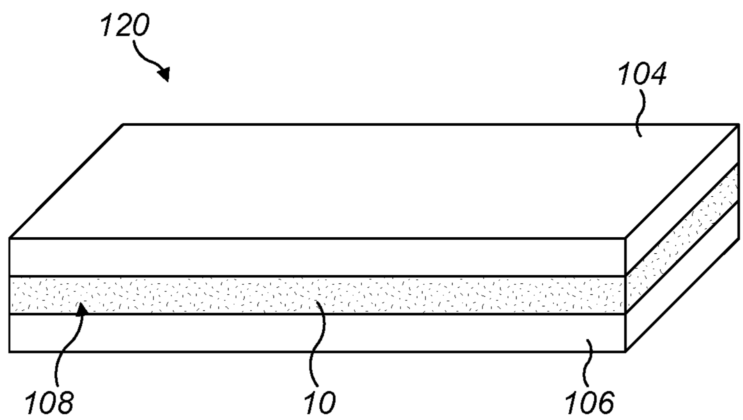
120
104
108
10
106

FIG. 3

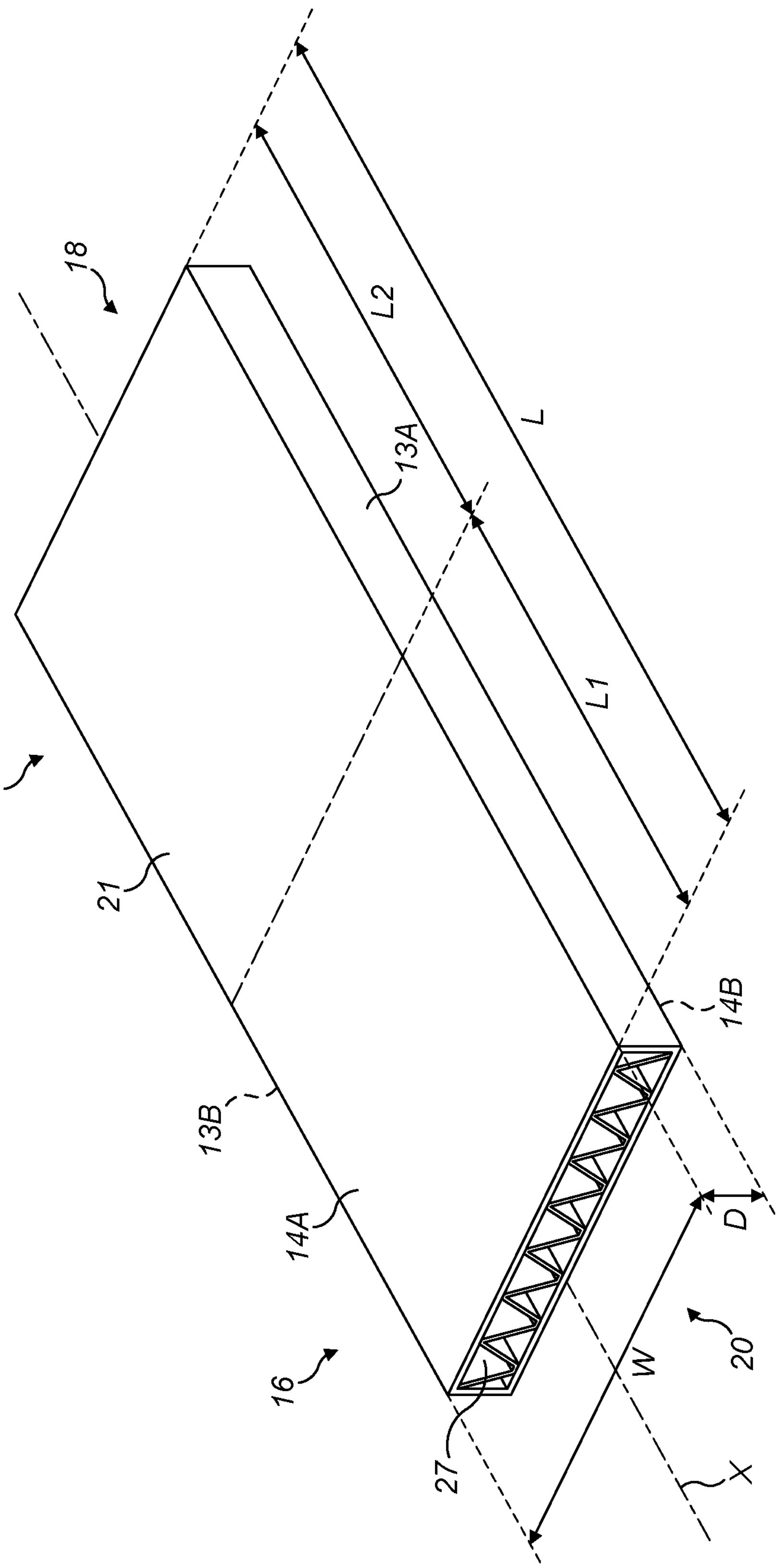

FIG. 4

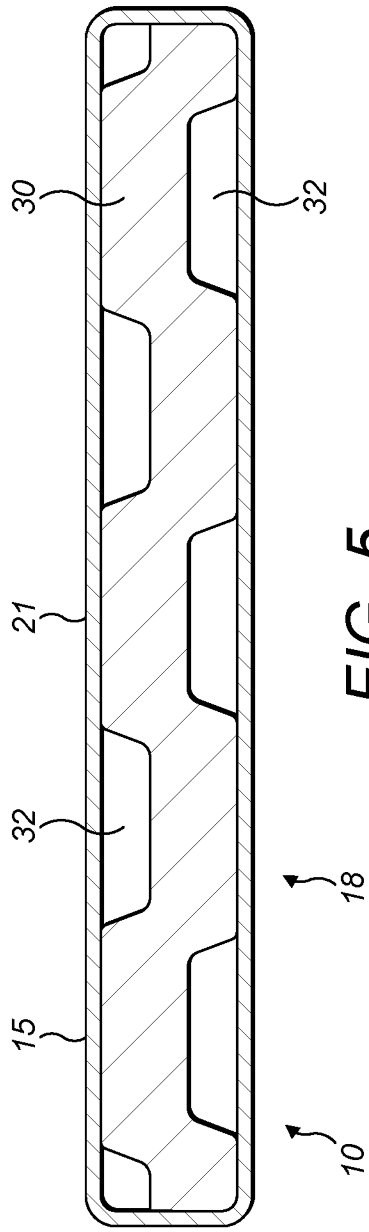

FIG. 5

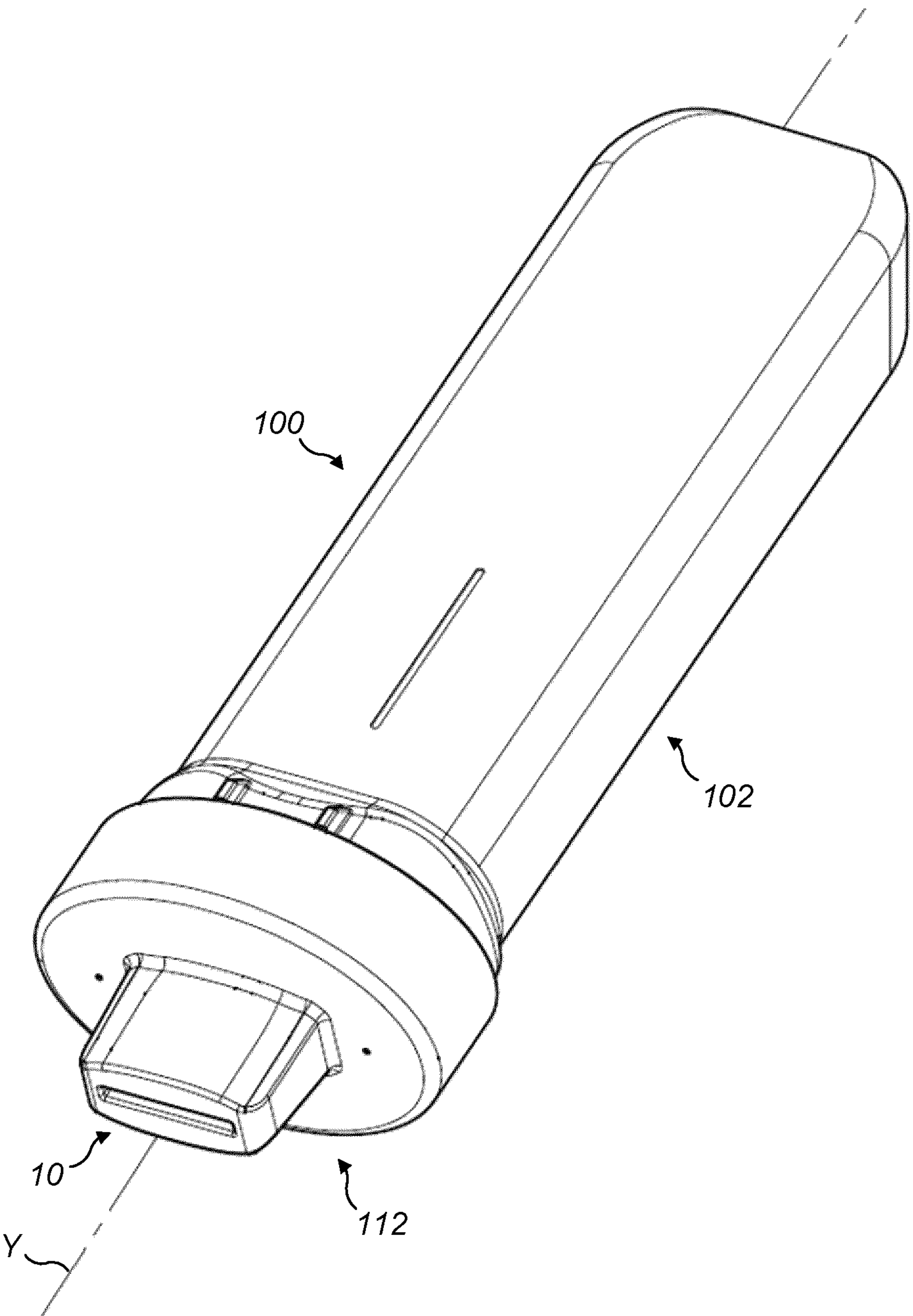

FIG. 6

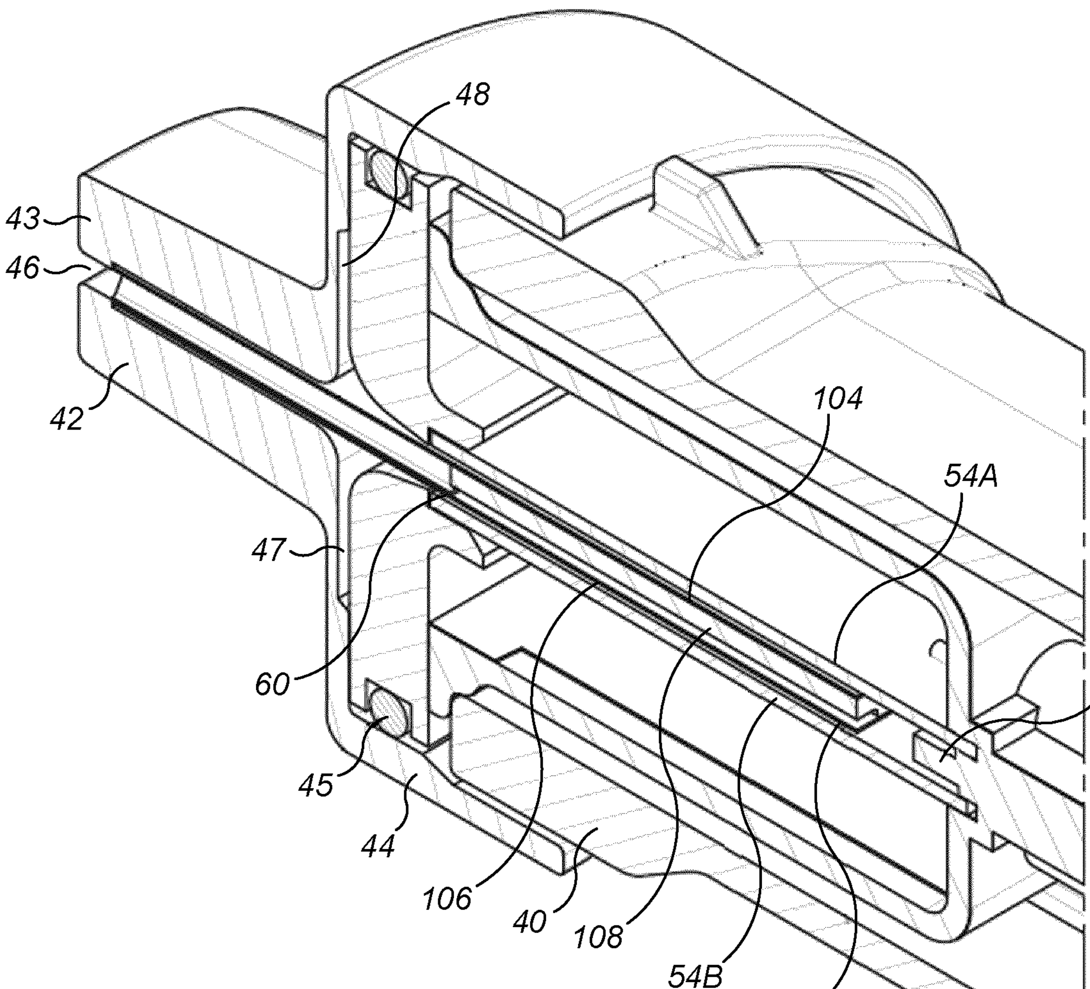

FIG. 7

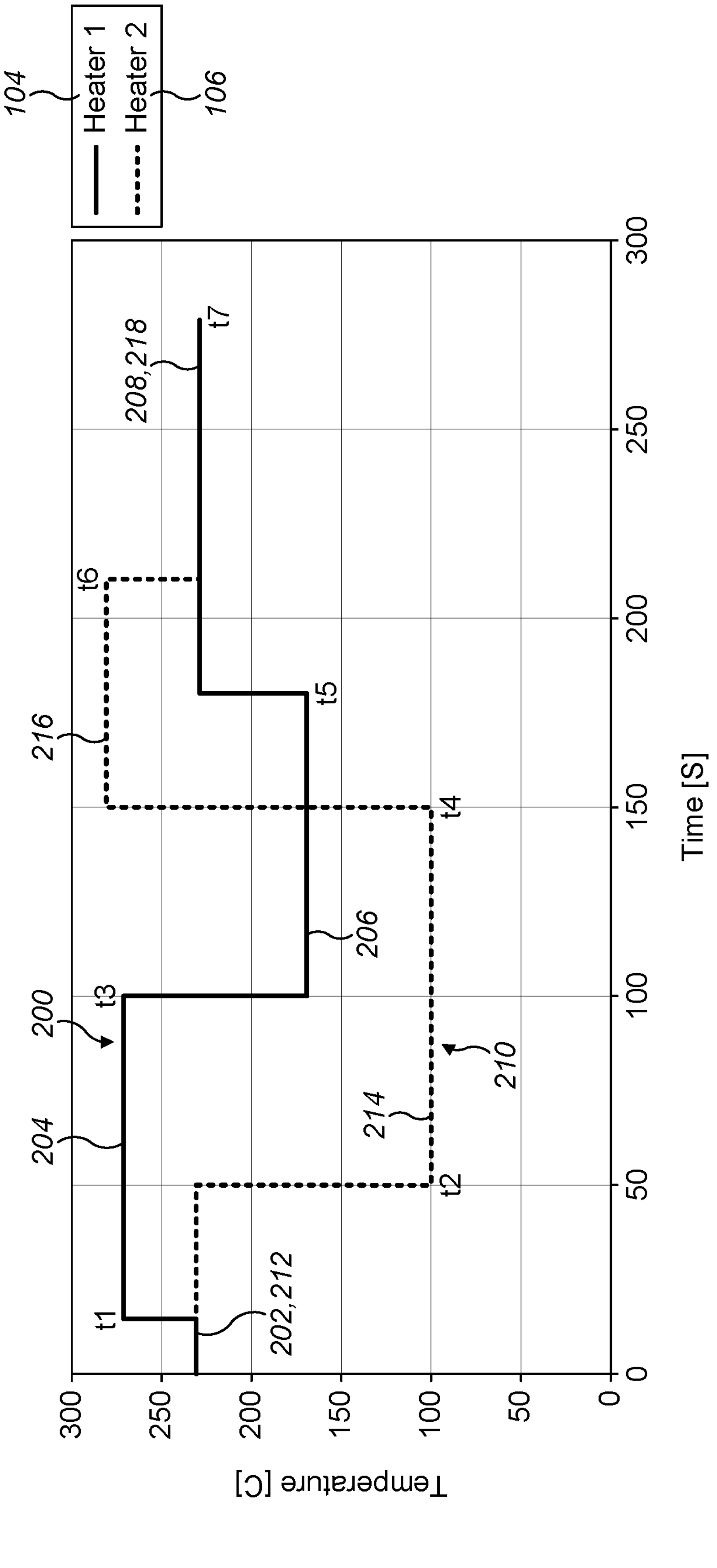
Heater 1
Heater 2
104
106
Temperature [C]
Time [S]
0
50
100
150
200
250
300
t1
t2
t3
t4
t5
t6
t7
200
202,212
204
206
208,218
210
214
216

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/083942

A. CLASSIFICATION OF SUBJECT MATTER
INV. A24F40/46 A24F40/50
ADD. A24F40/20

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A24F

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 February 2024	29/02/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Anticoli, Claud

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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