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(54) HEATING METHOD FOR A FLAT-SHAPED HEATING CHAMBER OF AN AEROSOL GENERATING DEVICE AND ASSOCIATED AEROSOL GENERATING DEVICE

(57) A heating method (100) for a flat-shaped heating chamber of an aerosol generating device configured to operate with a flat-shaped tobacco article comprising a substrate part, the substrate part defining two opposite heating surfaces, the heating chamber comprising two heating elements arranged to face each other, each heating element being designed to extend along substantially the whole area of the respective heating surface;
the method comprising the following steps:
- carry out a pre-heating phase (110) comprising powering only one heating element until achieving a target temperature;
- carry out a vaping phase (120) by powering each heating element according to different heating profiles, at least one heating profile comprising powering of the corresponding heating element within predetermined heating intervals (122) according to a predefined powering value.

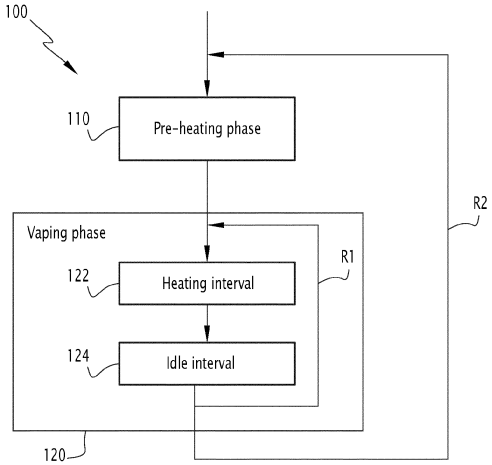

FIG.5

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Description

FIELD OF THE INVENTION

[0001] The present invention concerns a heating method for a flat-shaped heating chamber of an aerosol generating device.

[0002] Particularly, the aerosol generating device implementing the heating method according to the invention is configured to operate with a flat-shaped tobacco article, which comprises for example a solid substrate able to form aerosol when being heated. Thus, such type of aerosol generating devices, also known as heat-not-burn devices, is adapted to heat, rather than burn, the substrate by conduction, convection and/or radiation, to generate aerosol for inhalation.

[0003] The present invention also concerns an aerosol generating device configured to implement the heating method.

BACKGROUND OF THE INVENTION

[0004] The popularity and use of reduced-risk or modified-risk devices (also known as vaporisers) has grown rapidly in the past few years as an aid to assist habitual smokers wishing to quit smoking traditional tobacco products such as cigarettes, cigars, cigarillos, and rolling tobacco. Various devices and systems are available that heat or warm vaporizable substances as opposed to burning tobacco in conventional tobacco products.

[0005] A commonly available reduced-risk or modified-risk device is the heated substrate aerosol generation device or heat-not-burn device. Devices of this type generate aerosol or vapour by heating an aerosol substrate that typically comprises moist leaf tobacco or other suitable vaporizable material to a temperature typically in the range 150°C to 350°C. Heating an aerosol substrate, but not combusting or burning it, releases aerosol that comprises the components sought by the user but not the toxic and carcinogenic byproducts of combustion and burning. Furthermore, the aerosol produced by heating the tobacco or other vaporizable material does not typically comprise the burnt or bitter taste resulting from combustion and burning that can be unpleasant for the user and so the substrate does not therefore require the sugars and other additives that are typically added to such materials to make the smoke and/or vapour more palatable for the user.

[0006] In order to provide high user comfort, it is desirable to obtain fast heating of the aerosol substrate. However, some known aerosol generating devices operating with tobacco articles comprise heater which consumes a lot of energy to bring the heater up to a predefined temperature and thus to heat the tobacco article to the target temperature.

[0007] The high energy consumption may lead to constraints on design of aerosol generating devices, for example the need of large batteries. Also, the high energy consumption may not provide optimal user comfort, because frequent recharge of the battery of the aerosol generating device may be required.

SUMMARY OF THE INVENTION

[0008] One of the aims of the invention is to provide a heating method for a flat-shaped heating chamber of an aerosol generating device requiring less electrical energy.

[0009] For this purpose, the invention relates to a heating method for a flat-shaped heating chamber of an aerosol generating device configured to operate with a flat-shaped tobacco article comprising a substrate part, the substrate part defining two opposite heating surfaces, the heating chamber comprising two heating elements arranged to face each other, each heating element being designed to extend along substantially the whole area of the respective heating surface;
the method comprising the following steps:

- carry out a pre-heating phase comprising powering only one heating element until achieving a target temperature;
- carry out a vaping phase by powering each heating element according to different heating profiles, at least one heating profile comprising powering of the corresponding heating element within predetermined heating intervals according to a predefined powering value.

[0010] Thanks to these features, heating carried out by the aerosol generating device according to the heating method of the invention requires less electrical energy than in known methods. In particular, the heating method according to the invention allows reducing the consumed electrical energy both during the pre-heating phase and the vaping phase.

[0011] During the pre-heating phase, as only one heating element is powered until achieving the target temperature, less energy is required for implementing the pre-heating phase compared for example with methods comprising powering both heating elements during the pre-heating phase. In addition, a maximum current required from a battery of the device is for example lower than if two heating elements are simultaneously powered.

[0012] The pre-heating phase of the invention allows saving for example around 10% of electrical energy. Furthermore, the pre-heating phase according to the invention allows reducing the duration of the pre-heating phase, because one heating element is heated up very fast. Thus, a first puff during the vaping phase can be taken after a very short time of pre-heating only. This enhances user comfort.

[0013] Thanks to the vaping phase according to the invention, energy consumption is also reduced by powering each heating element according to different heating profiles. For example, the energy consumption is re-

duced by around 7% compared with permanent heating of both heating elements during the vaping phase.

[0014] The combination of the pre-heating phase and the vaping phase allows drastically reducing the energy consumption, in particular compared with methods comprising heating of both heating elements.

[0015] In addition, the heating method allows utilising substantially the whole area of the respective heating surface for heat transfer, because each heating element is designed to extend along substantially the whole area of this respective heating surface. This allows in particular to obtain high efficiency in heat transfer from the heating elements to the respective heating surface.

[0016] According to some embodiments, said heating intervals are defined by temperature of the corresponding heating element.

[0017] Thanks to this feature, the heating method allows obtaining reliable control of the heating elements for example according to a given temperature profile. Also, the control of the aerosol generating device by taking into account the temperature of the corresponding heating element is simple.

[0018] In particular, this feature allows obtaining a control independently from a puff counting for example, leading for example to a control which may be reproduced easily during operation of the aerosol generating device.

[0019] According to some embodiments, each heating interval is carried out until achieving a predetermined temperature, preferably said predetermined temperature is substantially equal to the target temperature.

[0020] Thanks to this feature, the heating method allows controlling each heating element independently from a number of characteristics of the aerosol generating device, for example independently of material characteristics of the heating elements and independently of the current intensity provided to the corresponding heating element.

[0021] According to some embodiments, said heating intervals are defined by time.

[0022] Thanks to this feature, the method is particularly easy to implement, because at a given time, the heating intervals are implemented in a predictable manner. In particular, this feature allows obtaining a predictable behaviour of the heating of the elements, for example independently of external circumstances or measurements of a physical quantity. Also, this feature allows obtaining a control independently from a puff counting for example, leading to a control which may be reproduced easily during operation of the aerosol generating device.

[0023] According to some embodiments, said heating intervals are equispaced by a predetermined time value, said predetermined time value being preferably comprised between 20 and 30 seconds.

[0024] Thanks to this feature, the heating intervals are implemented in a predetermined manner, and on a regular basis. This allows obtaining an energy-efficient operation of the aerosol generating device.

[0025] Furthermore, this feature allows simple control, by providing steady spacing between the heating intervals.

[0026] Also, thanks to the feature according to which the predetermined time value is comprised between 20 and 30 seconds, user comfort is very high, because the heating elements allow providing constant aerosol characteristics for the user also during a heating pause between 20 and 30 seconds of one of the heating elements.

[0027] According to some embodiments, the heating intervals are substantially equal between them, preferably the duration of each heating interval being substantially equal to said predetermined time value.

[0028] Thanks to this feature, the heating is controlled in an easy manner. In particular, this feature allows obtaining heating of the substrate part in constant heating intervals. For example in case of a constant power provided during each heating interval, the same quantity of heat is provided from the corresponding heating element to the substrate part during each heating interval.

[0029] If the duration of each heating interval is substantially equal to the predetermined time value, this allows obtaining an equal time distribution of the heating intervals and pauses between the heating intervals for a given heating element. The control of the heating elements is thus very simple and energy-efficient at the same time.

[0030] According to some embodiments, between the heating intervals, the corresponding heating profile comprises:

- powering of the corresponding heating element according to a minimal powering value strictly smaller than the predefined powering value; or
- cutting off the power.

[0031] If the corresponding heating profile comprises, between the heating intervals, powering of the corresponding heating element according to a minimal powering value strictly smaller than the predefined powering value, this allows reducing energy consumption of the heating element, but still some heat is provided to the substrate part. Thus, for example during the next heating interval, less energy is required in order to reach the target temperature.

[0032] If the corresponding heating profile comprises, between the heating intervals, cutting off the power, this allows reducing energy consumption.

[0033] According to some embodiments, during the pre-heating phase, the corresponding heating element is powered according to the predefined powering value, advantageously the predefined powering value being a maximum powering value.

[0034] Thanks to this feature, the target temperature is reached very fast, and the vaping phase can be implemented after a very short pre-heating phase only. Thus, user comfort is enhanced.

[0035] According to some embodiments, the pre-heating phase furthermore comprises, further to powering on-

ly one of the heating elements until achieving the target temperature, powering the other heating element until achieving the target temperature.

[0036] Thanks to this feature, the consumed energy during the pre-heating phase is reduced, and the method still allows providing heat on both heating surfaces.

[0037] According to some embodiments, each heating profile comprises powering of the corresponding heating element within predetermined heating intervals according to said predefined powering value.

[0038] Thanks to this feature, the control of the powering is very simple, because each heating profile comprises the same power value to be provided. Moreover, thanks to this feature, a maximum amount of heat per time unit is provided by the heating element when the predefined powering value corresponds to a maximum powering value.

[0039] According to some embodiments, the heating profiles of different heating elements are configured to power alternatively according to said predefined powering value the corresponding heating elements.

[0040] Thanks to this feature, the heating elements work together to heat the opposite heating surfaces and thus the substrate part, as the heating elements are powered alternatively. If one of the heating elements is not powered, the other heating element is powered according to the predefined powering value, which allows maintaining constantly a given temperature of the substrate part during the vaping phase.

[0041] According to some embodiments, the heating profiles have substantially the same shape, one of the heating profiles being in offset in respect with the other heating profile to ensure alternative powering of the heating elements.

[0042] Thanks to this feature, the control is very easy. This feature also allows providing the same heat amount at the implementation of each heating profile. Moreover, thanks to the offset of one of the heating profiles with respect to the other, the heating elements work together to heat the opposite heating surfaces and thus the substrate part.

[0043] According to some embodiments, the target temperature is comprised between 260°C and 300°C, and is preferably substantially equal to 280°C.

[0044] Thanks to this feature, the user comfort is very high. In particular, the target temperature of 280°C allows obtaining an optimal heating, not burning, of the substrate part. Moreover, this feature allows obtaining low energy consumption.

[0045] The invention also relates to an aerosol generating device configured to operate with a flat-shaped tobacco article comprising a substrate part, the substrate part defining two opposite heating surfaces, the aerosol generating device comprising:

- a heating chamber configured to receive the flat-shaped tobacco article and comprising two heating elements arranged to face each other, each heating element being designed to extend along substantially the whole area of the respective heating surface;
- a controller configured to operate the heating elements according to the heating method as described above.

[0046] According to some embodiments, each heating element is made from ceramics.

[0047] Thanks to this feature, the heating is very efficient because a high amount of heat is provided to the substrate part, by consuming only a small amount of electrical energy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0048] The invention and its advantages will be better understood upon reading the following description, which is given solely by way of non-limiting example and which is made with reference to the appended drawings, in which:

- Figure 1 is a perspective view of an aerosol generating assembly comprising an aerosol generating device and a tobacco article usable with the aerosol generating device;
- Figure 2 is a perspective view of the tobacco article of Figure 1;
- Figure 3 is a partial cross-sectional view of the aerosol generating assembly of Figure 1 according to a first plane;
- Figure 4 is a partial cross-sectional view of the aerosol generating assembly of Figure 1 according to a second plane perpendicular to the first plane;
- Figure 5 is a flow chart of a heating method for a flat-shaped heating chamber of the aerosol generating device of Figure 1;
- Figure 6 is a schematic diagram illustrating consumed energy in function of time of the aerosol generating device implementing a pre-heating phase according to the heating method of Figure 5, in comparison with the consumed energy when implementing a pre-heating phase comprising heating two heating elements;
- Figure 7 is a schematic diagram illustrating temperature in function of time of one heating element of the an aerosol generating device implementing the heating method of Figure 5, in comparison with the temperature of the heating element when heating both elements during the pre-heating phase;
- Figure 8 is a schematic diagram illustrating consumed energy in function of time of the aerosol gen-

erating device implementing a vaping phase according to the heating method of Figure 5, in comparison with the consumed energy when implementing a vaping phase comprising permanent heating two heating elements.

DETAILED DESCRIPTION OF THE INVENTION

[0049] Before describing the invention, it is to be understood that it is not limited to the details of construction set forth in the following description. It will be apparent to those skilled in the art having the benefit of the present disclosure that the invention is capable of other embodiments and of being practiced or being carried out in various ways.

[0050] As used herein, the term "**aerosol generating device**" or "**device**" may include a vaping device to deliver an aerosol to a user, including an aerosol for vaping, by means of a heater element explained in further detail below. The device may be portable. "Portable" may refer to the device being for use when held by a user. The device may be adapted to generate a variable amount of aerosol, e.g. by activating the heater element for a variable amount of time (as opposed to a metered dose of aerosol), which can be controlled by a trigger. The trigger may be user activated, such as a vaping button and/or inhalation sensor. The inhalation sensor may be sensitive to the strength of inhalation as well as the duration of inhalation to enable a variable amount of vapour to be provided (so as to mimic the effect of smoking a conventional combustible smoking article such as a cigarette, cigar or pipe, etc.). The device may include a temperature regulation control to drive the temperature of the heater and/or the heated aerosol generating substance (aerosol pre-cursor) to a specified target temperature and thereafter to maintain the temperature at the target temperature that enables efficient generation of aerosol.

[0051] As used herein, the term "**aerosol**" may include a suspension of vaporizable material as one or more of: solid particles; liquid droplets; gas. Said suspension may be in a gas including air. Aerosol herein may generally refer to/include a vapour. Aerosol may include one or more components of the vaporizable material.

[0052] As used herein, the term "**vaporizable material**" or "**precursor**" may refer to a smokable material which may for example comprise nicotine or tobacco and an aerosol former. Tobacco may take the form of various materials such as shredded tobacco, granulated tobacco, tobacco leaf and/or reconstituted tobacco. Suitable aerosol formers include: a polyol such as sorbitol, glycerol, and glycols like propylene glycol or triethylene glycol; a non-polyol such as monohydric alcohols, acids such as lactic acid, glycerol derivatives, esters such as triacetin, triethylene glycol diacetate, triethyl citrate, glycerin or vegetable glycerin. In some embodiments, the aerosol generating agent may be glycerol, propylene glycol, or a mixture of glycerol and propylene glycol. The substrate may also comprise at least one of a gelling agent, a binding agent, a stabilizing agent, and a humectant.

[0053] As used herein, "substantially equal to" may refer to a deviation to equality of less than +/- 10%, preferably less than +/- 5%, even more preferably less than +/- 1 %.

[0054] Figure 1 shows an aerosol generating assembly 10 comprising an aerosol generating device 11 and a tobacco article 12. The aerosol generating device 11 is intended to operate with the tobacco article 12 which is shown in more detail in Figure 2.

[0055] In the example of this Figure 2, the tobacco article 12 is a flat-shaped tobacco article presenting for example a flat-shaped cuboid extending along an article axis X and having external dimensions LxWxD. In a typical example, the length L of the article 12 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 tobacco article 12 is formed by a pair of parallel walls 13A, 13B, called hereinafter narrow walls 13A, 13B, and the width W of the tobacco article 12 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 tobacco article 12 can have any other suitable flat shape and/or external dimensions. According to still other embodiments, the tobacco article 12 can present any other suitable shape, as for example a stick shape.

[0056] The tobacco article 12 comprises a substrate part 15 and a mouthpiece part 16 arranged along the article axis X. The substrate part 15 may for example be slightly longer than the mouthpiece part 16. For example, the length L2 of the substrate part 15 according to the article axis X may be substantially equal to 18 mm and the length L1 of the mouthpiece part 16 according to the article axis X may be substantially equal to 15 mm. The substrate part 15 defines an abutting end 18 of the article 12 and the mouthpiece part 16 defines a mouth end 20 of the article 12. The substrate part 15 and the mouthpiece part 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 tobacco article 12. 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 parts 15, 16 and fixed one to the other by any other suitable mean. 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 article 12 between the abutting end 18 and the mouth end 20.

[0057] The substrate part 15 defines two opposite

heating surfaces 17A, 17B. The two opposite heating surfaces 17A, 17B may extend parallel one to another. The two opposite heating surfaces 17A, 17B may be respectively formed by a portion of the wide walls 14A, 14B, in particular by the portion of the wide walls 14A, 14B delimiting the substrate part 15.

[0058] The substrate part 15 comprises a vaporizable material and is intended to be heated by a heating chamber, as it will be explained in further detail below.

[0059] The mouthpiece part 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 for example corrugated paper. 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 part 16 to be entirely in contact with the internal surface of the wrapper 21 delimiting this mouthpiece part 16.

[0060] Referring again to Figure 1, the aerosol generating device 11 comprises a device body 40 extending along a device axis Y and a mouthpiece 42. According to an example, the mouthpiece 42 and the device body 40 may form two different pieces. Particularly, according to this example, the mouthpiece 42 is designed to be fixed on a fixing end of the device body 40.

[0061] As it is shown in Figure 3, the mouthpiece 42 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 device body 40 when the mouthpiece 42 is fixed on the fixing end of the device body 40. For example, the peripheral part 44 can be designed to cooperate with a gasket 45 arranged on the fixing end of the device body 40 in order to seal the space formed between the peripheral part 44 and the external surface of the device body 40. The peripheral part 44 also defines an intermediate portion extending for example transversally to the device axis Y et forming a transition between the central part 43 of the mouthpiece 42 and the collar defined by the peripheral part 44. The central part 43 of the mouthpiece 42 defines a through hole 46 adapted to receive at least partially the tobacco article 12. Particularly, the through hole 46 can be adapted to receive at least a part of the mouthpiece part 16 of the tobacco article 12 as it is shown in Figure 3. Advantageously, the through hole 46 can be adapted to fit tightly the mouthpiece part 16 of the tobacco article 12 so as to avoid or minimise flow leakage between a wall delimiting the through hole 46 and an external surface of the tobacco article 12. In some embodiments, the tobacco article 12 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 part 16 of the tobacco article 12 inside the through hole 46 and when fix both elements on the fixing end of the device body 40.

[0062] As it is also shown in Figure 3, an inner volume 47 is formed between an inner surface 48 of the mouthpiece 42 and the fixing end of the device body 40. This inner volume 47 is crossed by the tobacco article 12 when it is inserted inside the device body 40. For example, the tobacco article 12 can divide the inner volume 47 in two symmetric parts.

[0063] The device body 40 delimits an internal space of the device 11 receiving various elements designed to carry out different functionalities of the device 11. This internal space can for example receive a battery (not-shown) for powering the device 11, one or more temperature sensors (not-shown), a heating chamber 50 for heating the substrate part 15 of the tobacco article 12, a controller 51, illustrated in particular in Figure 1, for controlling the operation of the device 11, etc.

[0064] An example of the heating chamber 50 is described with reference to Figures 3 and 4. The heating chamber 50 can form a cup shape adapted to receive at least the substrate part 15 of the tobacco article 12 and in some cases, at least a part of the mouthpiece part 16. As the tobacco article 12, the heating chamber 50 may also form a cuboid shape extending along the device axis Y and comprising a pair of parallel narrow walls 53A, 53B (shown in Figure 4) 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 thus a closed end of the chamber 50. Opposite to the bottom wall 58, the heating chamber 50 defines an opening 59 configured to receive the tobacco article 12 so as the corresponding wide walls 14A, 14B of the tobacco article 12 face the corresponding wide walls 54A, 54B of the heating chamber 50, the corresponding narrow walls 13A, 13B of the tobacco article 12 face the corresponding narrow walls 53A, 53B of the heating chamber 50 and the abutting end 18 of the tobacco article 12 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 tobacco article 12 so as the narrow wall 13A (respectfully 13B) of the tobacco article 12 faces the narrow wall 53B (respectfully 53A) of the heating chamber 50, and the wide wall 14A (respectfully 14B) of the tobacco article 12 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 13A, 13B, 53A, 53B can be in contact one with the other or spaced one from the other.

[0065] The heating chamber 50 furthermore comprises at least two heating elements 60A, 60B arranged to face each other.

[0066] Each heating element 60A, 60B is arranged to heat the substrate part 15 of the tobacco article 12. According to different embodiments of the invention, each heating element 60A, 60B can present for example a restive element arranged adjacent to at least one of the walls 53A, 53B, 54A, 54B of the heating chamber 50. Advantageously, each heating element 60A, 60B comprises a resistive heater, as for example a heating track

or a polyimide film heater. According to other embodiments of the invention, each heating element 60A, 60B comprises any other suitable means, as for example a heating plate facing the respective heating surface 17A, 17B. According to still another embodiment, each heating element 60A, 60B comprises a magnetic element able to cause heating of a plurality of susceptors comprised in the substrate part 15 by magnetic induction.

[0067] Each heating element 60A, 60B is designed to extend along substantially the whole area of the respective heating surface 17A, 17B of the substrate part 15. By "extend along substantially the whole area of the respective heating surface 17A, 17B", it is understood in particular that each heating element 60A, 60B extends along at least 95%, preferably over 100%, of the respective heating surface 17A, 17B.

[0068] In particular, each heating element 60A, 60B extends at least along the whole length L2 of the substrate part 15 and at least along the whole width W of the substrate part 15. According to a specific example, the length of each heating element 60A, 60B along the device axis Y is greater than the length of the substrate part 15 along the article axis X. Thus, each heating element 60A, 60B protrudes from both ends of the substrate part 15 defined along the device axis Y. According to an example, the width of each heating element 60A, 60B is greater than the width W of the substrate part 15.

[0069] Each heating element 60A, 60B is in particular designed to face one of the heating surfaces 17A, 17B. For example, each heating element 60A, 60B may be in contact with one of the heating surfaces 17A, 17B. According to another example, a gap is defined between each heating element 60A, 60B and the respective heating surface 17A, 17B.

[0070] As illustrated for example in Figure 3, each heating element 60A, 60B may form at least a part of a corresponding wall of the heating chamber 50. For example, the heating elements 60A, 60B may form at least partially opposite walls of the heating chamber 50. According to an embodiment, each heating element 60A, 60B may integrally form the corresponding wall of the heating chamber 50. Such wall is for example one of the wide walls 54A, 54B of the heating chamber 50. As also shown on Figure 3, the substrate part 15 is arranged in sandwich between the two heating elements 60A, 60B.

[0071] Each heating element 60A, 60B may comprise ceramics. For example, each heating element 60A, 60B is made from ceramics.

[0072] With reference to figure 1, the controller 51 is shown with dotted lines illustrating an example of its arrangement inside the internal space of the device body 40.

[0073] The controller 51 may be arranged in any feasible location within the internal space, for example at predetermined distance to the heating chamber 50.

[0074] The controller 51 is configured to control operation of the heating elements 60A, 60B. In particular, the controller 51 comprises a memory for storing software instructions for controlling the operation of the aerosol generating device 11 and a processor configured to execute the software instructions. Alternatively, the controller 49 may be implemented in the form of a programmable logic component, such as an FPGA (Field Programmable Gate Array), or in the form of a dedicated integrated circuit, such as an ASIC (Applications Specific Integrated Circuit).

[0075] According to embodiments, the aerosol generating device 11 may comprise, for each heating element 60A, 60B, a temperature sensor (not-shown), configured to provide a measurement signal of the temperature of the corresponding heating element 60A, 60B. For example, each temperature sensor may be of the type NTC thermistor (from Negative Temperature Coefficient thermistor).

[0076] An example of the operation of the aerosol generating device 11 is now described with reference to Figure 5 showing a flowchart of a heating method 100 for the heating chamber 50 of the aerosol generating device 11.

[0077] The heating method 100 comprises a step of carrying out a pre-heating phase 110 and a step of carrying out a vaping phase 120.

[0078] The pre-heating phase 110 may be initiated by the user when activating the aerosol generating device 11. For example, the pre-heating phase 110 may be initiated when receiving a corresponding command from a switch.

[0079] During the pre-heating phase 110, the controller 51 powers preferably only one of the heating elements 60A, 60B until achieving a target temperature. For example, the controller 51 powers only element 60A during the pre-heating phase 110. According to an alternative, the controller 51 powers only element 60B during the phase 110.

[0080] By "the controller powers", it is understood that the controller commands the battery of the device 11 or a switch connecting the battery and the corresponding heating element 60A, 60B, in order to provide an electric current to the this element 60A, 60B.

[0081] The target temperature is in particular a predefined temperature. The target temperature may be predefined in function of a characteristic of the heating element 60A, 60B and/or in function of the type of vaporizable material comprised in the substrate part 15.

[0082] The target temperature designates in particular a temperature of the corresponding heating element 60A, 60B. For example "powering one of the heating elements 60A, 60B until achieving the target temperature" indicates that the corresponding heating element 60A, 60B is powered until its temperature, for example its surface temperature, achieves the target temperature.

[0083] The target temperature may be comprised between 260°C and 300°C. For example, the target temperature may be substantially equal to 280°C.

[0084] The heating element 60A may be powered according to a predefined powering value during the pre-

heating phase 110.

[0085] The predefined powering value may be predefined in function of a characteristic of the heating element 60A, 60B, of the battery of the aerosol generating device 11, of an electrical connection between the battery and the corresponding heating element 60A, 60B, and/or of a type vaporizable material. The predefined powering value is in general a power value strictly larger than zero, and preferably lower than 35 W for each heating element 60A, 60B.

[0086] According to embodiments, the predefined powering value may be a maximum powering value. By "maximum powering value", it is in particular understood a maximum power that the battery of the aerosol generating device 11 is able to provide to the corresponding heating element 60A, 60B.

[0087] Figure 6 illustrates examples of consumed energy E in joule J in function of time t in seconds s of the aerosol generating device 11. In this Figure, the pre-heating phase 110 is highlighted by the ellipse P. A first curve S illustrates an example of the consumed energy E when implementing a pre-heating phase 110 according to the invention, i.e. by powering only one heating element 60A or 60B. A second curve D illustrates an example of the consumed energy E when implementing a pre-heating phase by powering both heating elements 60A and 60B simultaneously. As visible in this example, the pre-heating phase 110 comprising powering only one of the heating elements 60A or 60B allows saving electrical energy compared with a pre-heating phase comprising heating both elements 60A, 60B.

[0088] Figure 7 illustrates examples of temperature T in °C of one of the heating elements 60A, 60B in function of time t in s. A first curve S illustrates an example of the temperature of one of the heating elements 60A, 60B which is powered during the pre-heating phase 110, wherein the other element 60A, 60B is not powered in this example. The curve S corresponds thus to an example of the implementation of the pre-heating phase 110 according to the invention. A second curve D illustrates the temperature T when powering both heating elements 60A and 60B simultaneously. As visible in the example, the target temperature, here substantially equal to 280°C, is reached at about t=20s in the case of the first curve S, whereas this temperature is reached only at about t=25s in the case of the second curve D. Thus, the pre-heating phase 110 according to the invention allows reaching the target temperature very fast, and in particular faster than when heating both heating elements 60A and 60B.

[0089] Preferably, the pre-heating phase 110 comprises, further to powering only one of the heating elements 60A, 60B until achieving the target temperature, powering the other heating element 60A, 60B until achieving the target temperature. For example, during the pre-heating phase 110, only the heating element 60A is powered until achieving the target temperature, and when this target temperature is achieved by the heating element 60A, then the heating element 60B is powered until achieving the target temperature. According to another example, the pre-heating phase 110 may comprise first powering only the heating element 60B until achieving the target temperature, and then powering the heating element 60A until achieving the target temperature.

[0090] According to embodiments, subsequently to powering only one of the heating elements 60A, 60B, for example heating element 60A, until achieving a target temperature during the pre-heating phase 110, the other heating element 60A, 60B, for example heating element 60B, is powered. During this powering of the heating element 60B, the heating element 60A may be powered according to a predetermined powering command. The predetermined powering command may for example correspond to powering the heating element 60A so as to maintain substantially the target temperature, for example by power and/or temperature control. According to another example, the predetermined powering command may correspond to cutting off the power of heating element 60A when the heating element 60B is powered.

[0091] The pre-heating phase 110 may for example comprise a first stage and a second stage. Preferably, the pre-heating phase 110 consists of the first stage and the second stage. During the first stage, only one of the heating elements 60A, 60B is powered, and during the second stage, only the other heating element 60A, 60B is powered, or both heating elements 60A, 60B are powered simultaneously. The second stage may be implemented directly, i.e. without any interruption, when the first stage is completed. For example, only the heating element 60A is powered during the first stage. Achievement of the target temperature of this heating element 60A may correspond to completing the first stage, which triggers powering the heating element 60B until achieving the target temperature.

[0092] According to other embodiments, the pre-heating phase 110 consists of powering only one heating element 60A, 60B until achieving the target temperature, i.e. the other heating element 60A, 60B is not powered during the pre-heating phase 110.

[0093] When the target temperature is reached, at least for one, preferable for both heating elements 60A, 60B, the controller 51 may switch from the pre-heating phase 110 to the vaping phase 120.

[0094] During the vaping phase 120, the controller 51 powers each heating element 60A, 60B according to different heating profiles. At least one heating profile comprises powering of the corresponding heating element 60A, 60B within predetermined heating intervals according to the predefined powering value, for example the maximum powering value.

[0095] According to embodiments, each heating profile, i.e. all of them, comprises powering of the corresponding heating element 60A, 60B within predetermined heating intervals according to the predefined powering value, for example according to the maximum powering value. In particular, each heating profile may comprise at least one predetermined heating interval during

which the corresponding heating element 60A, 60B is powered by applying electrical power according to the predefined powering value, for example according to the maximum powering value, to this element.

[0096] According to embodiments, between the heating intervals, the corresponding heating profile may comprise powering of the corresponding heating element 60A, 60B according to a minimal powering value or cutting off the power. Each period between the heating intervals may also be referred to as idle interval.

[0097] The minimal powering value is preferably strictly smaller than the predefined powering value. The minimal powering value is in particular predefined.

[0098] With reference to Figure 5, the vaping phase 120 may comprise heating interval 122 and idle interval 124 directly following the heating interval 122. The same heating interval 122 may be repeated after implementation of said idle interval 124, as illustrated in particular by arrow R1, and followed again by the same idle interval 124. For example, the vaping phase 120 may comprise a plurality of consecutive implementations of the heating interval 122 and the idle interval 124, depending on a duration of the vaping phase 120. The number of implementations of each interval 122, 124 may be for example at least 5, preferably at least 10.

[0099] Preferably, each heating profile consists only of heating intervals 122 and idle intervals 124 between these heating intervals 122. Each heating interval 122 of each heating profile may for example correspond to powering the corresponding heating element 60A, 60B according to the predefined powering value, for example according to the maximum powering value, and each idle interval 124 of each heating profile may correspond to powering the corresponding element 60A, 60B at the minimal powering value or correspond to cutting off the power.

[0100] According to embodiments, the heating profiles of different heating elements 60A, 60B are configured to power alternatively according to the predefined powering value, for example according to the maximum powering value the corresponding heating elements 60A, 60B. In particular, the heating profiles of the heating elements 60A, 60B are configured so that either element 60A, or element 60B is powered at a given time, and with the predefined, i.e. maximum, powering value. For example, the controller 51 operates as a bang-bang controller, i.e. the controller 51 commands either powering element 60A, or element 60B with the predefined, i.e. maximum, powering value.

[0101] According to embodiments, the heating profiles have substantially the same shape. By "substantially the same shape", it is in particular understood that, for each heating profile, a curve showing power provided the corresponding heating element 60A, 60B over time presents substantially the same geometrical form.

[0102] In the embodiment of the heating profiles having substantially the same shape, preferably one of the heating profiles is in offset in respect with the other heating profile to ensure alternative powering of the heating elements 60A, 60B. By "alternative powering" it is understood in particular that, at a given moment, only one of the heating elements 60A, 60B is powered. According to a specific example of this embodiment, the heating profile of element 60A may be configured to power this element from t=0 s to t=25 s, and again from t=50 s to t=75 s, but not to power it from t=25 s to t=50 s and from t=75 s to t=100 s. The heating profile of element 60B may be configured to power this element from t=25s to t=50s, and again from t=75 s to t=100 s, but not to power the element 60B from t=0 to t=25 s and from t=50 s to t=75 s.

[0103] According to embodiments, the heating intervals 122 are defined by a temperature of the corresponding heating element 60A, 60B. For example, each heating interval 122 is carried out until achieving a predetermined temperature. According to a specific example, the controller 51 may command powering of the element 60A until the predetermined temperature, then stop powering element 60A and start powering element 60B until achieving the predetermined temperature.

[0104] The predetermined temperature is for example substantially equal to the target temperature.

[0105] For example, the controller 51 receives a measurement signal from each temperature sensor of the device 11, and powers the corresponding heating element 60A, 60B until the measurement signal indicates the predetermined temperature of the corresponding element 60A, 60B.

[0106] According to embodiments, the heating intervals 122 are defined by time.

[0107] For example, heating intervals 122 are equispaced by a predetermined time value. In particular, each heating interval 122 of a heating profile presents a same time space (or idle interval) having the predetermined time value between a previous and/or subsequent heating interval 122. For example, the time space having the predetermined time value is defined from the end of a given heating interval 122 to the start of a heating interval 122 which is subsequent to the given heating interval 122.

[0108] For example, the predetermined time value is comprised between 20 and 30 seconds and is for example substantially equal to 25 seconds.

[0109] According to an example, the heating intervals 122 are substantially equal between them. This means in particular that the duration of each heating interval 122 is the same. Preferably, the duration of each heating interval 122 is substantially equal to the predetermined time value.

[0110] An example of a heating profile comprising heating intervals 122 defined by time is described in reference to Figure 8 illustrating the consumed energy E in joule J in function of time t in seconds s of the aerosol generating device 11. In this Figure, the vaping phase 120 starts at about t=25 s and stops at about t=275 s. A first curve S illustrates an example of the consumed energy E when implementing a vaping phase 120 according to an example of the invention. In this example, the heat-

ing element 60A is powered permanently and the heating element 60B is powered only in the following intervals: from t=50 s to t=75 s, from t=100 s to t=125 s, from t=150 s to t=175 s, from t=200 s to t=225 s and from t=250 s to t=275 s. In the intervals between these intervals, the heating element 60B is not powered. A second curve D illustrates an example of the consumed energy E when implementing a vaping phase comprising powering both heating elements 60A and 60B permanently. As visible in this example, the implementation of the vaping phase 120 according to an example of the invention (curve S) allows saving electrical energy compared with a vaping phase comprising heating both elements 60A, 60B. In particular, during each interval in which the heating element 60B is not powered (curve S), the consumed powered is lower than during these intervals for curve D. This leads to a total consumed energy E which is about 200J lower after implementation of the vaping phase 120 (curve S) compared with a permanent powering of both elements 60A, 60B (curve D).

[0111] The method 100 may be repeated as illustrated in Figure 5 by an arrow R2, in particular after a break, requiring another implementation of the pre-heating phase 110 before the implementation of the vaping phase 120.

[0112] It may be understood that the invention is particularly advantageous when combining the pre-heating phase 110 comprising powering only one heating element 60A, 60B until achieving the target temperature, as illustrated for example in Figure 6, with the vaping phase 120 according to the method of the invention. This combination allows reducing battery capacity and/or size, because first, the maximum required current during the pre-heating phase 110 is reduced, and second the total energy consumed during phases 110 and 120 is reduced, in particular thanks to the different heating profiles carried out during the vaping phase 120. The combination of a lower maximum current and a lower total consumed power compared to methods of the state of the art allows thus reducing battery capacity and/or size.

Claims

1. A heating method (100) for a flat-shaped heating chamber (50) of an aerosol generating device (11) configured to operate with a flat-shaped tobacco article (12) comprising a substrate part (15), the substrate part (15) defining two opposite heating surfaces (17A, 17B), the heating chamber (50) comprising two heating elements (60A, 60B) arranged to face each other, each heating element (60A, 60B) being designed to extend along substantially the whole area of the respective heating surface (17A, 17B);
the method comprising the following steps:

   - carry out a pre-heating phase (110) comprising powering only one heating element (60A, 60B) until achieving a target temperature;
   - carry out a vaping phase (120) by powering each heating element (60A, 60B) according to different heating profiles, at least one heating profile comprising powering of the corresponding heating element (60A, 60B) within predetermined heating intervals (122) according to a predefined powering value.

2. The heating method according to claim 1, wherein said heating intervals (122) are defined by temperature of the corresponding heating element (60A, 60B).

3. The heating method according to claim 2, wherein each heating interval (122) is carried out until achieving a predetermined temperature, preferably said predetermined temperature is substantially equal to the target temperature.

4. The heating method according to claim 1, wherein said heating intervals (122) are defined by time.

5. The heating method according to claim 4, wherein said heating intervals (122) are equispaced by a predetermined time value, said predetermined time value being preferably comprised between 20 and 30 seconds.

6. The heating method according to claim 5, wherein the heating intervals (122) are substantially equal between them, preferably the duration of each heating interval (122) being substantially equal to said predetermined time value.

7. The heating method according to any one of the preceding claims, wherein, between the heating intervals (122), the corresponding heating profile comprises:

   - powering of the corresponding heating element (60A, 60B) according to a minimal powering value strictly smaller than the predefined powering value; or
   - cutting off the power.

8. The heating method according to any one of the preceding claims, wherein during the pre-heating phase (110), the corresponding heating element (60A, 60B) is powered according to the predefined powering value, advantageously the predefined powering value being a maximum powering value.

9. The heating method according to any one of the preceding claims, wherein the pre-heating phase (110) furthermore comprises, further to powering only one of the heating elements (60A, 60B) until achieving the target temperature, powering the other heating

element (60A, 60B) until achieving the target temperature.

10. The heating method according to any one of the preceding claims, wherein each heating profile comprises powering of the corresponding heating element (60A, 60B) within predetermined heating intervals (122) according to said predefined powering value.

11. The heating method according to claim 10, wherein the heating profiles of different heating elements (60A, 60B) are configured to power alternatively according to said predefined powering value the corresponding heating elements (60A, 60B).

12. The heating method according to claim 11, wherein the heating profiles have substantially the same shape, one of the heating profiles being in offset in respect with the other heating profile to ensure alternative powering of the heating elements (60A, 60B).

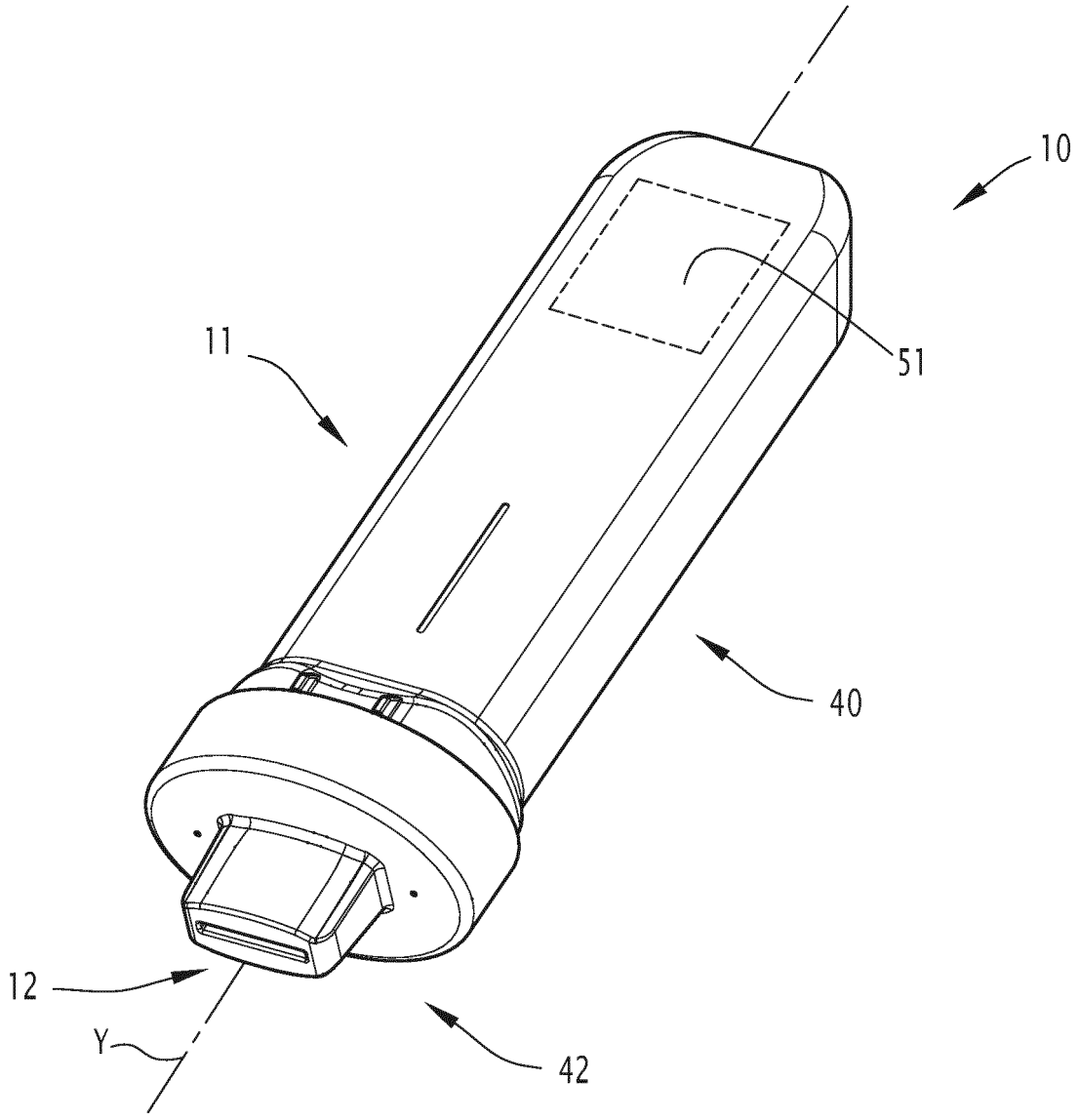
13. The heating method according to any one of the preceding claims, wherein the target temperature is comprised between 260°C and 300°C, and is preferably substantially equal to 280°C.

14. An aerosol generating device (11) configured to operate with a flat-shaped tobacco article (12) comprising a substrate part (15), the substrate part (15) defining two opposite heating surfaces (17A, 17B), the aerosol generating device (11) comprising:

- a heating chamber (50) configured to receive the flat-shaped tobacco article (12) and comprising two heating elements (60A, 60B) arranged to face each other, each heating element (60A, 60B) being designed to extend along substantially the whole area of the respective heating surface (17A, 17B);
- a controller (51) configured to operate the heating elements (60A, 60B) according to the heating method (100) according to any one of the preceding claims.

15. The aerosol generating device (11) according to claim 14, wherein each heating element (60A, 60B) is made from ceramics.

FIG.1



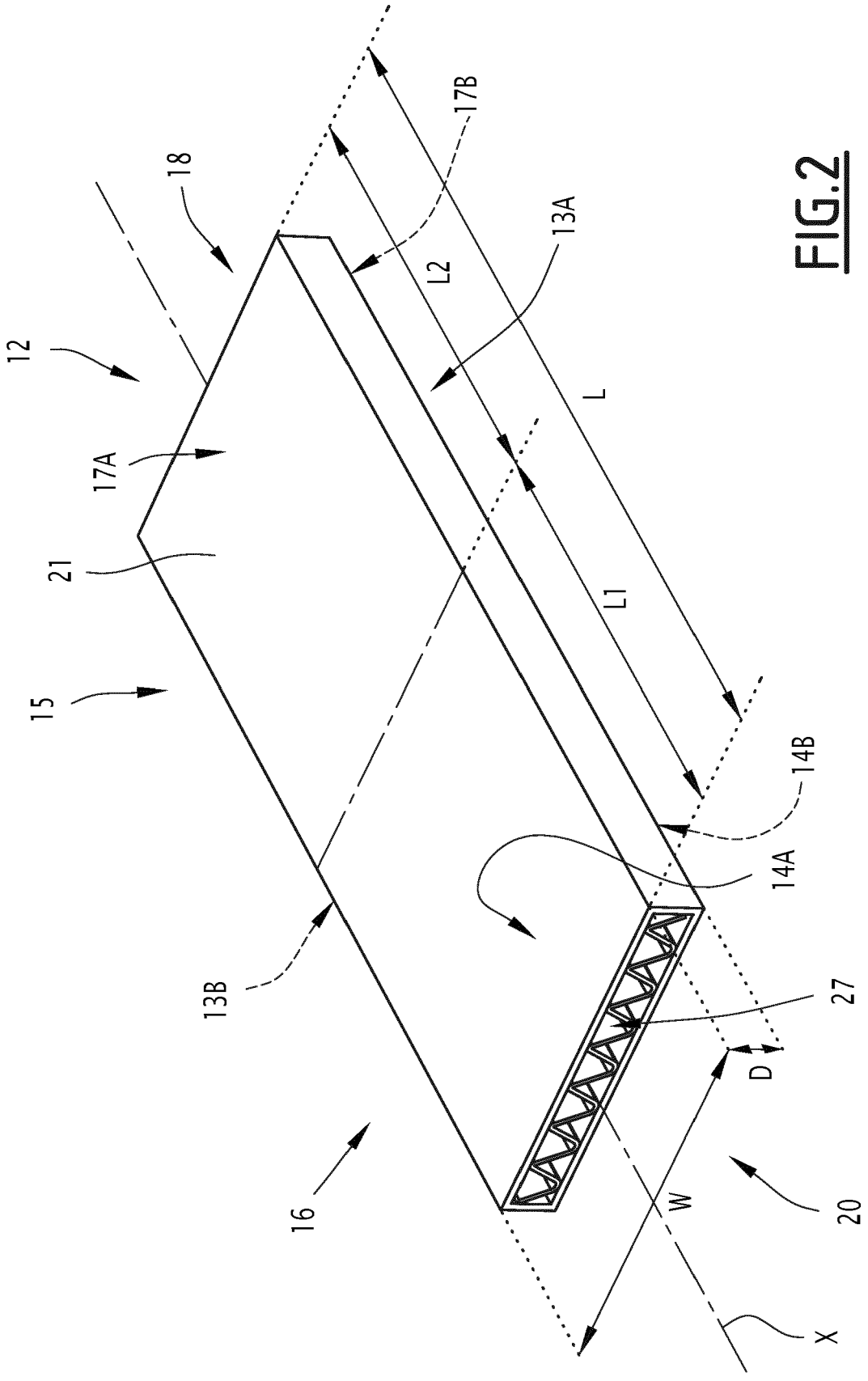


FIG.2

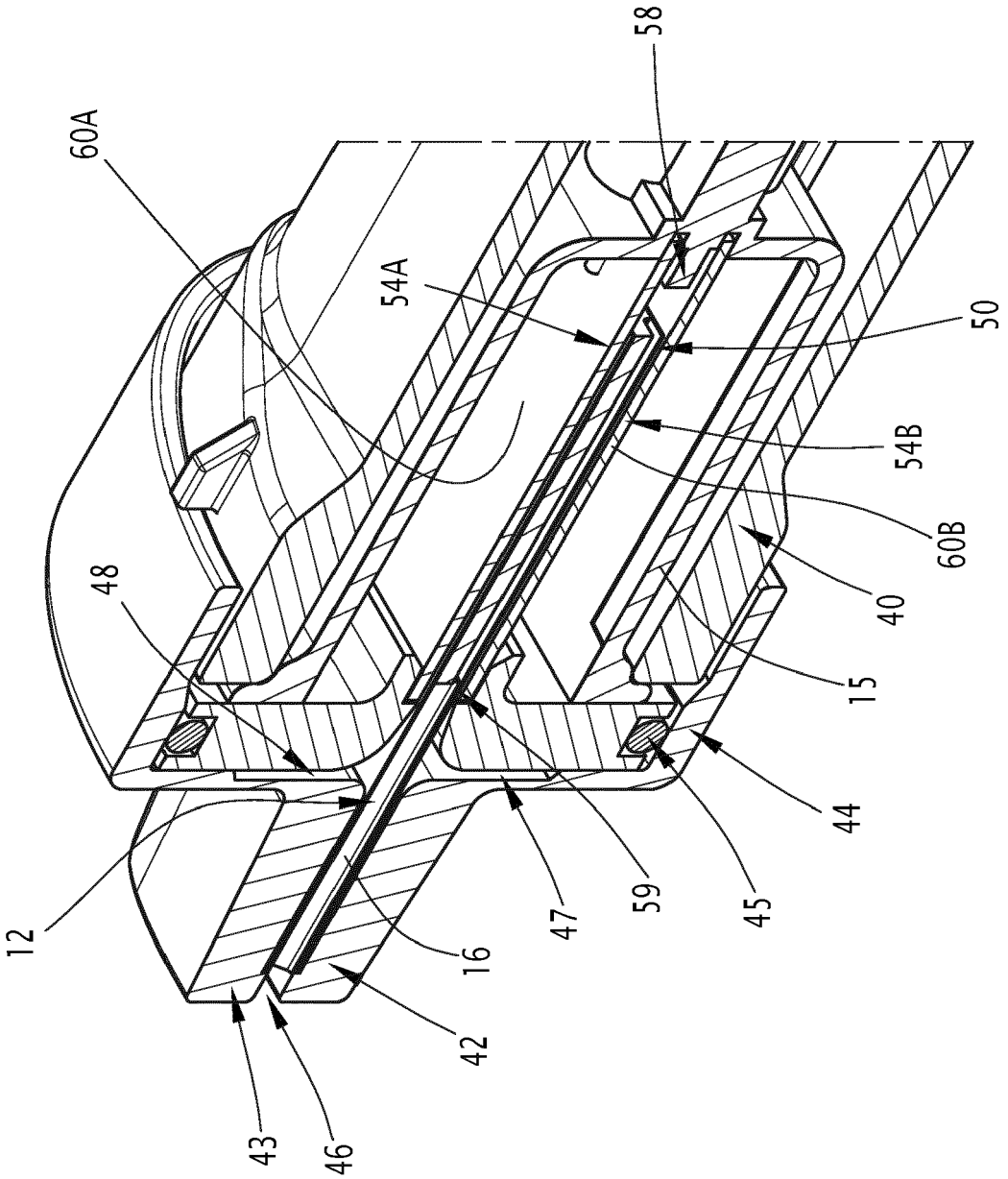


FIG.3

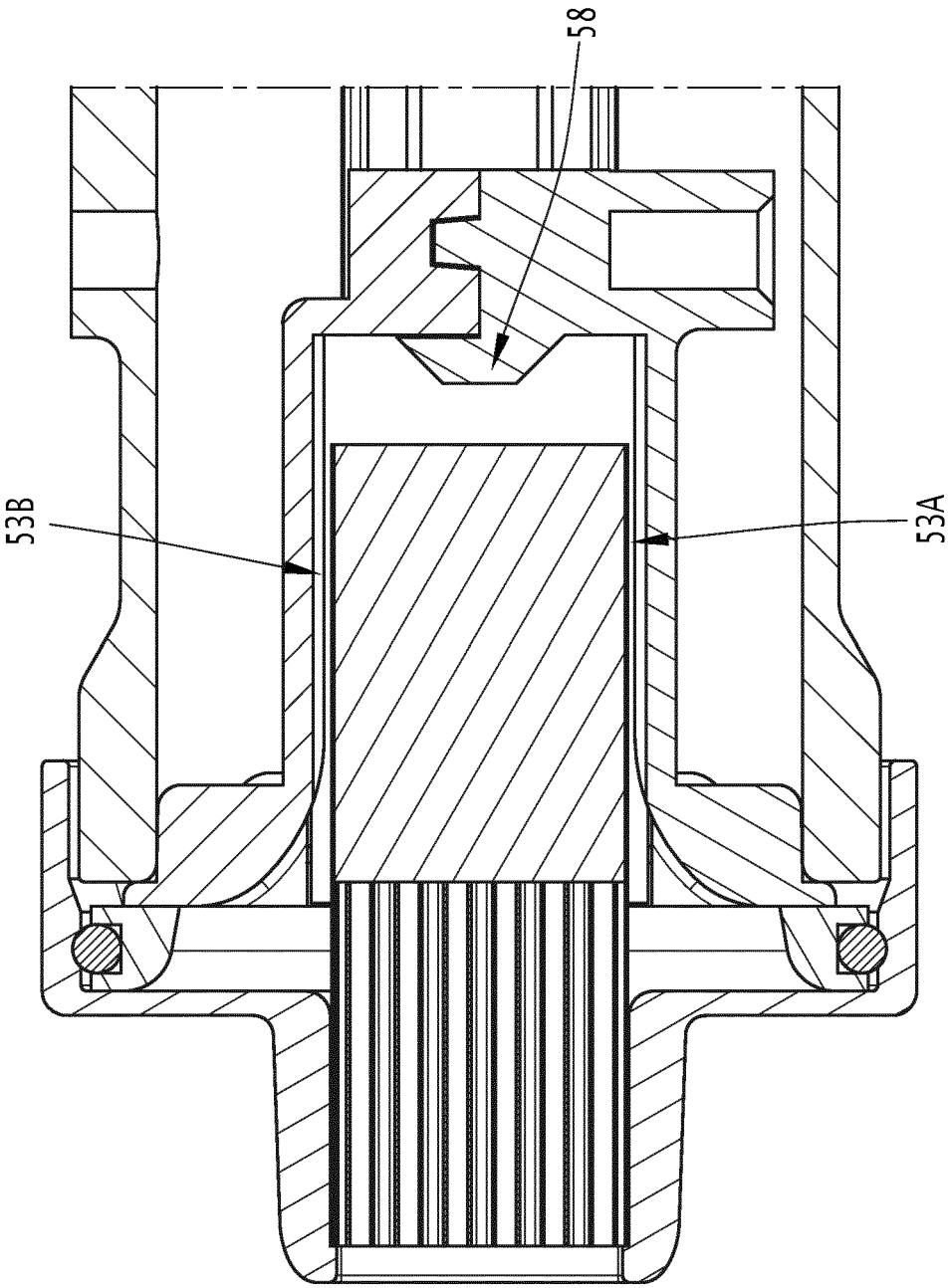


FIG.4

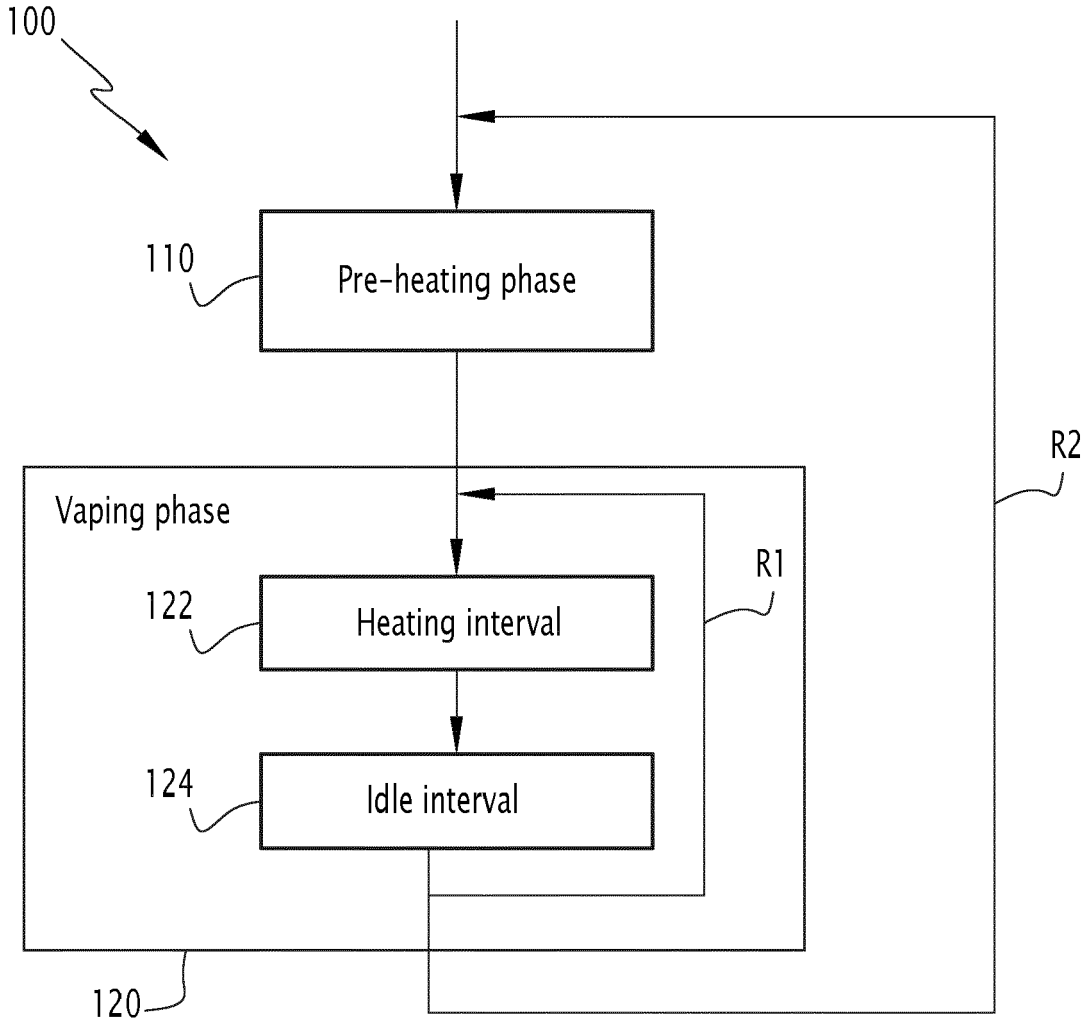
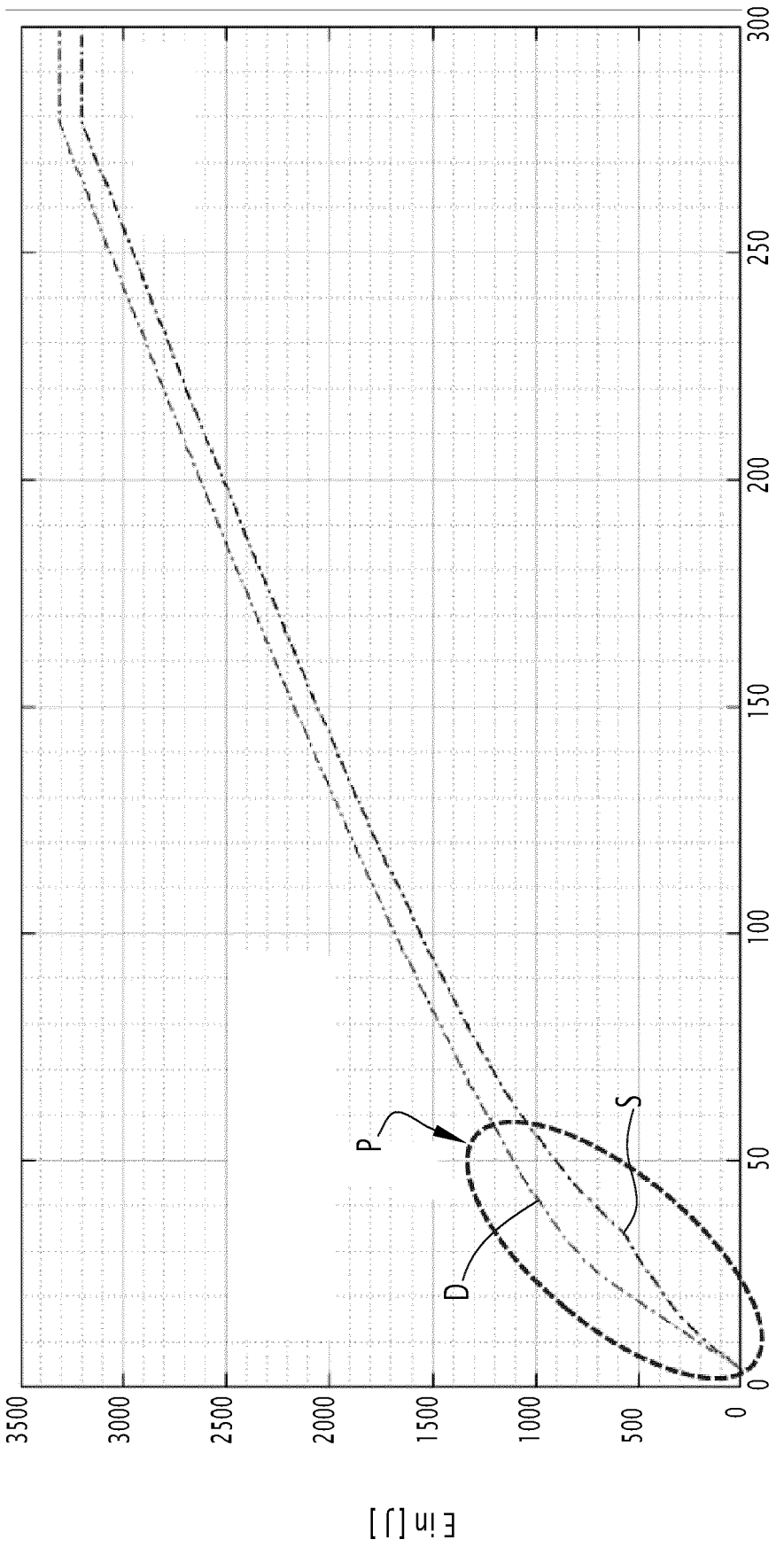

100
110
Pre-heating phase
R2
Vaping phase
R1
122
Heating interval
124
Idle interval
120

FIG.5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D
S

FIG.6

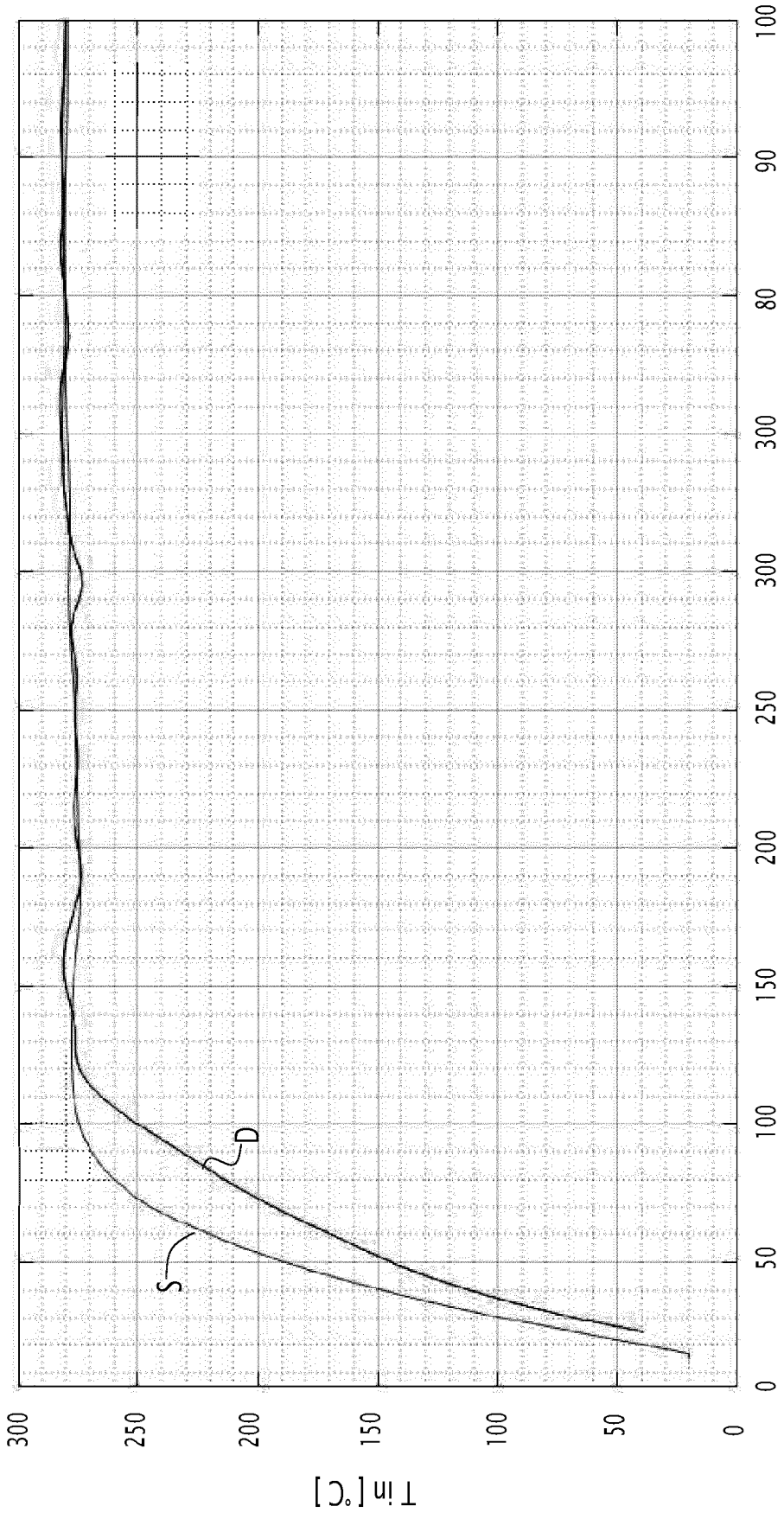
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FIG.7

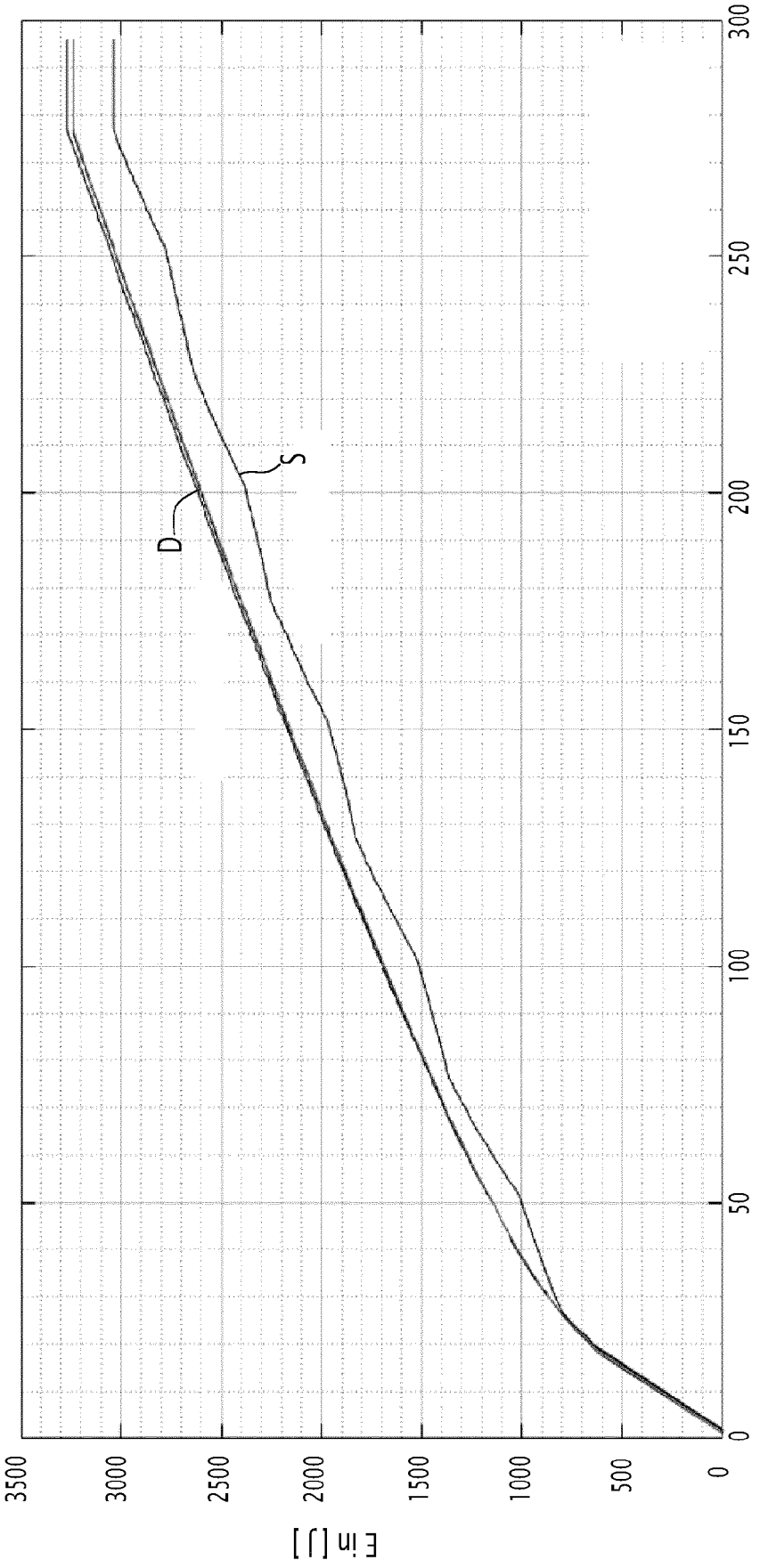
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FIG.8

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EUROPEAN SEARCH REPORT

Application Number
EP 22 17 1626

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2020/239599 A1 (JT INT SA [CH]) 3 December 2020 (2020-12-03) * page 11, line 1 - page 18, line 21; figures 1-15 *	1-15	INV. A24F40/46
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A24F
A61M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	10 October 2022	Klintebäck, Daniel

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10-10-2022

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