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(54) **VAPOUR GENERATING DEVICE**

(57) A vapour generating device (10) comprises: a wall (12) comprising an interior surface (12a) that defines a bore (14); a wick (18) located at a first end region of the bore (14) and arranged to receive a liquid (L); a first heater (22) arranged to vaporise the liquid (L) in the wick (18) to produce a vapour (V) in the bore (14); a mouthpiece (16) located at a second end region of the bore (14) and configured for a user to apply a suction force to draw the vapour (V) along the bore (14) from the wick (18) to the mouthpiece (16); a second heater (24) controllable to heat the interior surface (12a) in order to limit heat transfer from the vapour (V) in the bore (14) to the interior surface (12a); and a controller (26) configured to control the second heater (24) to heat the interior surface (12a) to maintain the temperature of the interior surface (12a) above a dew point of the vapour (V), thereby to prevent the vapour (V) from cooling to the dew point and condensing on the interior surface (12a).

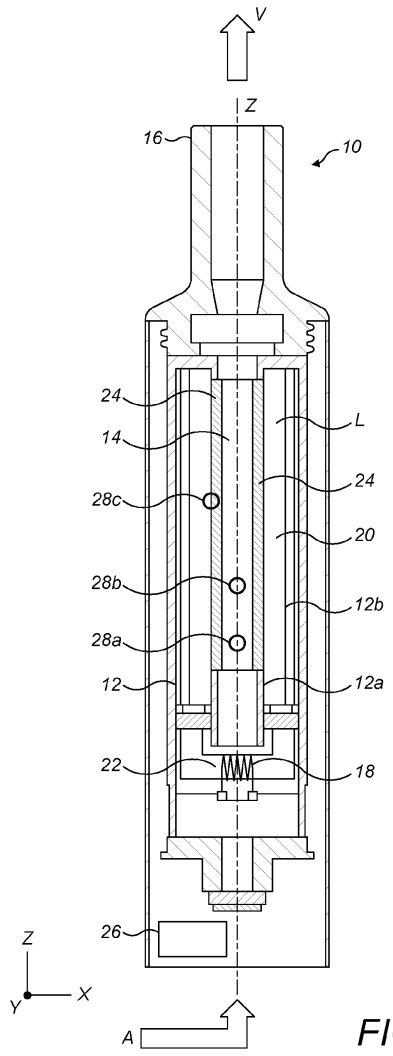

FIG. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to vapour generating devices, and more particularly to the prevention of condensation within vapour generating devices.

BACKGROUND

[0002] Vapour generating devices, such as electronic cigarettes and other electronic nicotine delivery systems (ENDS), have become popular as substitutes for traditional means of tobacco consumption such as cigarettes and cigars.

[0003] Devices for vaporisation or aerosolisation typically include a heating wall arranged to heat a vaporisable product from an inlet surface to an outlet surface. In operation, the vaporisable product is heated and the constituents of the product are vaporised for the consumer to inhale. In some examples, the product may comprise tobacco in a capsule or may be similar to a traditional cigarette, in other examples the product may be a liquid, or liquid contents in a capsule.

[0004] Some vapour generating devices generate a vapour or aerosol from a vaporisable liquid, for example using a heater coil which applies heat to a liquid held in a wick in order to vaporise the liquid. A common problem is the generation of condensation within the device. Excess condensation can lead to droplets of liquid reaching the consumer's mouth, causing an unpleasant experience for the consumer. Condensation build-up is also undesirable because it can make it appear to the consumer that the device is leaking liquid.

[0005] Some devices comprise spiral tube arrangements or other convoluted vapour flow paths, aimed at minimising the risk of condensation reaching the consumer's mouth. However, these may not be very effective and they may complicate the manufacture of the device.

[0006] The present invention aims to alleviate at least to some extent these problems of conventional vapour generating devices.

SUMMARY OF INVENTION

[0007] According to an aspect of the invention, there is provided a vapour generating device comprising: a wall comprising an interior surface that defines a bore; a wick located at a first end region of the bore and arranged to receive a liquid; a first heater arranged to vaporise the liquid in the wick to produce a vapour in the bore; a mouthpiece located at a second end region of the bore and configured for a user to apply a suction force to draw the vapour along the bore from the wick to the mouthpiece; a second heater controllable to heat the interior surface in order to limit heat transfer from the vapour in the bore to the interior surface; and a controller configured to control the second heater to heat the interior surface to maintain the temperature of the interior surface above a dew point of the vapour, thereby to prevent the vapour from cooling to the dew point and condensing on the interior surface.

[0008] The invention provides a heater for heating the material of the interior surface along the flow path of the vapour. Controlling the temperature of the interior surface, to remain above the dew point of the vapour, ensures that the vapour will not cool down to its dew point and thus will not condense on the interior surface.

[0009] Furthermore, heating the interior surface in this manner tends not to increase significantly the temperature of the vapour itself. This is highly advantageous, since the applicant's own sensory tests have shown that excessively high vapour temperatures are detrimental to the vaping experience for the user.

[0010] The invention therefore solves the problem of condensation in the device, without detriment to the user experience in respect of vapour temperature.

[0011] As used herein, a "vapour generating device" is a device arranged to heat a vapour generating product to produce a vapour for inhalation by a consumer. A vapour generating device can also be referred to as an aerosol generating device or an electronic cigarette. In the context of the present disclosure, the terms vapour and aerosol can be used interchangeably. The vapour generating product, or aerosol generating product, can be a liquid or a combination of a liquid and a solid such as a fibrous material. The vapour generating product may also be referred to as an e-liquid. The liquid or e-liquid may comprise colourants, flavourings, tobacco, nicotine, propylene glycol, glycerine and/or other chemical components.

[0012] It will be understood by the skilled person that, in general, dew point is the temperature at which a sample of moist air (or other liquid vapour) at constant pressure reaches saturation. At this saturation temperature, further cooling results in condensation of liquid. As used herein, "dew point" means the temperature at which the vapour in the bore of the device would condense into liquid. The dew point is a function of temperature and relative humidity. It may be determined by calculation according to a variety of established conventional methods, for example the Magnus formula, or it may be determined by reference to values of temperature and relative humidity obtained by experiment, contained for example in look-up tables or psychrometric charts.

[0013] The vapour generating device may comprise: a vapour temperature sensor located in the bore and configured to detect a temperature of the vapour; a humidity sensor located in the bore and configured to detect a relative humidity of the vapour; and a surface temperature sensor located at the interior surface and configured to detect a temperature of the interior surface, wherein the controller is configured to: determine the dew point of the vapour based on the detected values of vapour temperature and relative humidity; and compare the value of the dew point to the detected value of the temper-

ature of the interior surface, thereby to control the second heater to heat the interior surface to maintain the temperature of the interior surface above the dew point.

[0014] The controller may be configured to calculate the dew point based on the detected values of vapour temperature and relative humidity.

[0015] The controller may be configured to infer the dew point from the detected values of vapour temperature and relative humidity, based on a range of values of vapour temperature and relative humidity that are stored in memory and are accessible by the controller.

[0016] Each of a pre-determined value of the dew point and a pre-determined target value of interior surface temperature may be stored in memory and is accessible by the controller, the pre-determined target value of interior surface temperature being greater than the pre-determined value of dew point; and the controller may be configured to control the second heater to heat the interior surface to maintain the temperature of the interior surface at the pre-determined target value of interior surface temperature.

[0017] The second heater may be located between the wick and the mouthpiece.

[0018] The second heater may be located between the interior surface of the wall and an exterior surface of the wall.

[0019] The second heater may form part of the wall, such that the second heater comprises the interior surface of the wall.

[0020] The second heater may comprise an element which extends continuously around a longitudinal axis of the bore so as to fully surround the bore.

[0021] The second heater may comprise spaced-apart elements, each of the elements extending partially around a longitudinal axis of the bore so as to partially surround the bore.

[0022] The controller may be configured to activate the first and second heaters at the same time.

[0023] The controller may be configured to activate at least one of the first and second heaters in response to application of said suction force by the user.

[0024] The controller may be configured to deactivate the first and second heaters at the same time.

[0025] The controller may be configured to deactivate at least one of the first and second heaters in response to cessation of said suction force by the user.

[0026] The liquid may comprise propylene glycol, glycerine, flavourants, or nicotine.

BRIEF DESCRIPTION OF DRAWINGS

[0027] An example will now be described with reference to the accompanying Figure 1, which is a simplified cross-sectional view of a vapour generating device comprising a heater for preventing condensation, in accordance with the invention.

DETAILED DESCRIPTION

[0028] Referring to Figure 1, a vapour generating device 10 comprises a body containing a tubular wall 12 having an interior surface 12a and an exterior surface 12b. The interior surface 12a of the tubular wall 12 defines a bore 14 that extends along a central longitudinal (or vertical) axis Z of the device 10. Ambient air A is able to enter the device 10 and to reach the bore 14 via a flow passage.

[0029] In this example, the tubular wall 12 and the bore 14 are circular in cross-section. In this example, the bore has a length (or height) of about 29 mm and a diameter of about 3 mm and a cross-sectional area of about 7 mm^2. In this example, the tubular wall 12 is constructed from plastics.

[0030] A first (or upper) part or end of the tubular wall 12 comprises a mouthpiece 16 configured for engagement with the mouth of a consumer or user of the device 10. A wick 18 is located at a second (or lower) part of the tubular wall 12 and extends across the bore 14 in a transverse (or horizontal orX-Y) direction, i.e. in a plane substantially normal to the longitudinal axis Z. A storage reservoir or tank 20 containing an e-liquid L is formed within the tubular wall 12 and is arranged to be in fluid communication with the wick 18 so that the wick 18 can receive and absorb the e-liquid L by means of capillary action.

[0031] A first heater 22, which in this example is a metallic heater coil, extends around the wick 18 and is operable to vaporise the e-liquid L held by the wick 18. The bore 14 defines a flow channel for flow of the vapour V from the heater coil (and the wick 18) to the mouthpiece 16 for inhalation by the user.

[0032] A second heater 24, which in this example is an electrical resistance heater, is located between the wick 18 and the mouthpiece 16. More particularly, in this example the second heater 24 is generally tubular in shape and is located between the interior surface 12a and the exterior surface 12b of the tubular wall 12 (i.e. within the thickness of the material of the tubular wall 12), such as to surround the longitudinal axis Z and to extend in the axial direction along about 80% of the length of the bore 14.

[0033] A controller 26 (e.g. a microprocessor) is located within the device 10 at a lower part thereof. The controller 26 is configured to control the first and second heaters 22, 24, as will be described later herein.

[0034] In this example, the device 10 includes a sensor system for providing temperature and humidity data for the determination of dew point and thermal management of the device 10. The sensor system comprises: a vapour temperature sensor 28a located in the bore 14 and configured to detect a temperature of the vapour V therein; a humidity sensor 28b located in the bore 14 and configured to detect a relative humidity of the vapour V therein; and a surface temperature sensor 28c located at the interior surface 12a of the tubular wall 12 and configured to detect a temperature of the interior surface 12a. Each

of the sensors 28a-c is connected to the controller 10 in order to provide data thereto. The temperature sensors 28a, 28c may be of any suitable type, e.g. thermocouple, thermistor, or the like. The humidity sensor 28b may be of any suitable type, e.g. resistive sensor, capacitive sensor, hygrometer, or the like.

[0035] The operation of the vapour generating device 10 will now be described.

[0036] In use, a suction force is applied by the user via the mouthpiece 16. In response to the application of the suction force, the controller 26 activates the first heater 24 to cause e-liquid L held in the wick 18 to be heated and vaporised. The vapour V (or aerosol) so produced has a high level of moisture containing droplets of the constituents of the e-liquid L.

[0037] The vapour V is drawn along the bore 14 under the suction force so as to reach the mouthpiece 16 and thereby the user's mouth. The vapour V will come into contact with the interior surface 12a of the tubular wall 12 as the vapour V migrates along the bore 14 toward the user's mouth. If the temperature of the interior surface 12a is lower than the temperature of the vapour V then heat will be transferred (lost) from the vapour V to the interior surface 12a. In this case, there is a risk that the temperature of the interior surface 12a might be sufficiently low, and the heat transfer from the vapour V to the interior surface 12a sufficiently high, that the vapour V will be cooled to its dew point so that condensation will form on the interior surface 12a.

[0038] As has been discussed herein above, the formation of condensation in the device 10 is undesirable. Thus the device 10 is operable to prevent the formation of condensation on the interior surface 12a, as follows.

[0039] The controller 26 monitors: the temperature of the vapour V in the bore 14, based on measurement data received from the vapour temperature sensor 28a; the relative humidity of the vapour V in the bore 14, based on measurement data received from the humidity sensor 28b; and the temperature of the interior surface 12a, based on measurement data received from the surface temperature sensor 28c. The controller 26 determines the dew point of the vapour V, based on the temperature and relative humidity of the vapour V in the bore 14. In this example, the dew point is determined by calculation. The calculation of the dew point may be according to any suitable conventional method, e.g. the Magnus formula.

[0040] The controller 26 compares the temperature of the interior surface 12a to the dew point of the vapour V. If the controller 26 determines that the temperature of the interior surface 12a is less than the dew point of the vapour V, there is a risk that heat could be lost from the vapour V to the interior surface 12a, so that the vapour V could cool to the dew point and condense on the interior surface 12a. In this case, the controller 26 activates the second heater 24 to apply heat to the interior surface 12a, in order to increase the temperature of the interior surface 12a to a value that is greater than the dew point of the vapour V. The controller 26 monitors the temperature of the interior surface 12a and controls the second heater 24 to apply heat to the interior surface 12a as needed, in order to maintain the temperature of the interior surface 12a above the dew point of the vapour V, at least while the suction force is present.

[0041] Thus a temperature differential (or a potential temperature differential), between the interior surface 12a and the dew point of the vapour V, is controlled (reduced) so as to limit heat loss from the vapour V to the interior surface 12a. Maintaining the temperature of the interior surface 12a above the dew point of the vapour limits the heat transfer such as to prevent the vapour V from cooling to the dew point, thereby preventing the formation of condensation on the interior surface 12a.

[0042] In an example, the temperature of the vapour V in the bore 14 may be about 60-70 °C and the relative humidity may be about 90 %. The dew point may be about 55 °C. The unheated interior surface 12a (i.e. unheated by the second heater 24) may have a temperature of about 30 °C. Thus the temperature differential between the vapour V and the unheated interior surface 12a may be up to about 40 °C. This temperature differential and a high relative humidity could result in formation of condensation on the interior surface 12a. The risk of condensation may be mitigated by heating the interior surface 12a (i.e. by activating the second heater 24) to some maintenance temperature above 55 °C, for example any temperature between about 56 and 70 °C. The interior surface 12a may be set and maintained at this temperature for a period of time while the suction force is applied, i.e. while the user "puffs" on the device 10. The period of time may be, for example, about 3 seconds. The surface maintenance temperature is high enough to prevent the formation of condensation, but low enough (and over a short enough duration) to avoid increasing the temperature of the vapour V to an undesirable extent. Thus condensation may be avoided without detriment to the user experience.

[0043] Some variants of the inventive device will now be discussed.

[0044] In the above-described example, the controller calculates the dew point of the vapour, based on measured vapour temperature and relative humidity. In another example, the controller takes the measured vapour temperature and relative humidity values and infers the dew point from them, based on data stored in memory. The stored data may be experimental data containing values of vapour temperature, relative humidity and dew point, for example in look-up tables or psychrometric charts.

[0045] While the above-described example comprises a particular arrangement of sensors for measuring or determining temperature and humidity, it will be understood that different types and/or numbers of sensors could be provided and these could be arranged in different ways to achieve the same result. All such arrangements are within the scope of the claimed invention.

[0046] In examples, the vapour temperature and hu-

midity sensors are omitted. In some of these examples, a pre-determined value of dew point of the vapour is stored in memory and is compared with the measured temperature of the interior surface of the tubular wall, as has been described herein above. The pre-determined representative value of dew point may be derived and selected by experiment as part of the design process of the device. In others of these examples, the interior surface temperature sensor is also omitted from the device. In these examples, a pre-determined value of interior surface temperature is stored in memory, and the controller is operable to control the second heater to maintain the interior surface temperature at (or above) the pre-determined temperature value. Of course, the pre-determined temperature value is selected to be greater than the pre-determined value of dew point, to ensure that the vapour does not cool to the dew point. Thus, in a basic form of the device, the controller is simply programmed to control the second heater to maintain the heated interior surface at some pre-determined temperature value, which is greater than a pre-determined representative value of vapour dew point, so as to prevent the vapour from cooling to the dew point and condensing on the interior surface.

[0047] In each example described herein, the controller preferably controls the second heater to heat the interior surface each time the suction force is applied by the user, i.e. the second heater is activated by the controller in response to the application of the suction force. Preferably, the controller is arranged to control the first heater as well as the second heater, and to activate the first heater in response to the application of the suction force. The first and second heaters may be configured to be deactivated at the same time. One or both of the first and second heaters may be configured to be deactivated in response to cessation of the suction force. The first and second heaters may each comprise a part of a heater system that is controlled by the controller.

[0048] While in the above-described example the vapour generating device (first heater) comprises a heater coil wound around a wick, in other examples different means of liquid delivery and/or heating/vaporisation are provided. All such arrangements are within the scope of the claimed invention.

[0049] While the above-described example comprises a particular arrangement of the second heater, it will be understood that the second heater could take a wide variety of different forms. For example, the second heater may form part of the tubular wall such that the second heater comprises the interior surface of the wall. The second heater may comprise a plurality of discrete elements, which may be arranged in a variety of ways. For example, the elements may be spaced-apart, each of the elements extending partially around the longitudinal axis of the bore so as to partially surround the bore. The second heater may even be located in the device at some distance from the bore. In this case, a heat conductor element is provided to transmit heat from the second heater to the interior surface. All such arrangements are within the scope of the claimed invention, provided that the second heater is controllable to heat the interior surface so as to maintain the temperature of the interior surface above the dew point of the vapour.

[0050] It should be understood that the invention has been described in relation to its preferred embodiments and may be modified in many different ways without departing from the scope of the invention as defined by the accompanying claims.

Claims

1. A vapour generating device (10) comprising:

a wall (12) comprising an interior surface (12a) that defines a bore (14);
a wick (18) located at a first end region of the bore (14) and arranged to receive a liquid (L);
a first heater (22) arranged to vaporise the liquid (L) in the wick (18) to produce a vapour (V) in the bore (14);
a mouthpiece (16) located at a second end region of the bore (14) and configured for a user to apply a suction force to draw the vapour (V) along the bore (14) from the wick (18) to the mouthpiece (16);
a second heater (24) controllable to heat the interior surface (12a) in order to limit heat transfer from the vapour (V) in the bore (14) to the interior surface (12a); and
a controller (26) configured to control the second heater (24) to heat the interior surface (12a) to maintain the temperature of the interior surface (12a) above a dew point of the vapour (V), thereby to prevent the vapour (V) from cooling to the dew point and condensing on the interior surface (12a).

2. A vapour generating device (10) according to claim 1, comprising:

a vapour temperature sensor (28a) located in the bore (14) and configured to detect a temperature of the vapour (V);
a humidity sensor (28b) located in the bore (14) and configured to detect a relative humidity of the vapour (V); and
a surface temperature sensor (28c) located at the interior surface (12a) and configured to detect a temperature of the interior surface (12a), wherein the controller (26) is configured to:

determine the dew point of the vapour (V) based on the detected values of vapour temperature and relative humidity; and
compare the value of the dew point to the

detected value of the temperature of the interior surface (12a), thereby to control the second heater (24) to heat the interior surface (12a) to maintain the temperature of the interior surface (12a) above the dew point.

3. A vapour generating device (10) according to claim 2, wherein the controller (26) is configured to calculate the dew point based on the detected values of vapour temperature and relative humidity.

4. A vapour generating device (10) according to claim 2, wherein the controller (26) is configured to infer the dew point from the detected values of vapour temperature and relative humidity, based on a range of values of vapour temperature and relative humidity that are stored in memory and are accessible by the controller (26).

5. A vapour generating device (10) according to claim 1, wherein:

each of a pre-determined value of the dew point and a pre-determined target value of interior surface temperature is stored in memory and is accessible by the controller (26), the pre-determined target value of interior surface temperature being greater than the pre-determined value of dew point; and
the controller (26) is configured to control the second heater (24) to heat the interior surface (12a) to maintain the temperature of the interior surface (12a) at or above the pre-determined target value of interior surface temperature.

6. A vapour generating device (10) according to any preceding claim, wherein the second heater (24) is located between the wick (18) and the mouthpiece (16).

7. A vapour generating device (10) according to claim 6, wherein the second heater (24) is located between the interior surface (12a) of the wall (12) and an exterior surface (12b) of the wall (12).

8. A vapour generating device (10) according to claim 6, wherein the second heater (24) forms part of the wall (12), such that the second heater (24) comprises the interior surface (12a) of the wall (12).

9. A vapour generating device (10) according to any one of claims 6 to 8, wherein the second heater (24) comprises an element which extends continuously around a longitudinal axis of the bore (14) so as to fully surround the bore (14).

10. A vapour generating device (10) according to any one of claims 6 to 8, wherein the second heater (24) comprises spaced-apart elements, each of the elements extending partially around a longitudinal axis of the bore (14) so as to partially surround the bore (14).

11. A vapour generating device (10) according to any preceding claim, wherein the controller (26) is configured to activate the first and second heaters (22, 24) at the same time.

12. A vapour generating device (10) according to any preceding claim, wherein the controller (26) is configured to activate at least one of the first and second heaters (22, 24) in response to application of said suction force by the user.

13. A vapour generating device (10) according to any preceding claim, wherein the controller (26) is configured to deactivate the first and second heaters (22, 24) at the same time.

14. A vapour generating device (10) according to any preceding claim, wherein the controller (26) is configured to deactivate at least one of the first and second heaters (22, 24) in response to cessation of said suction force by the user.

15. A vapour generating device (10) according to any preceding claim, wherein the liquid (L) comprises propylene glycol, glycerine, flavourants, or nicotine.

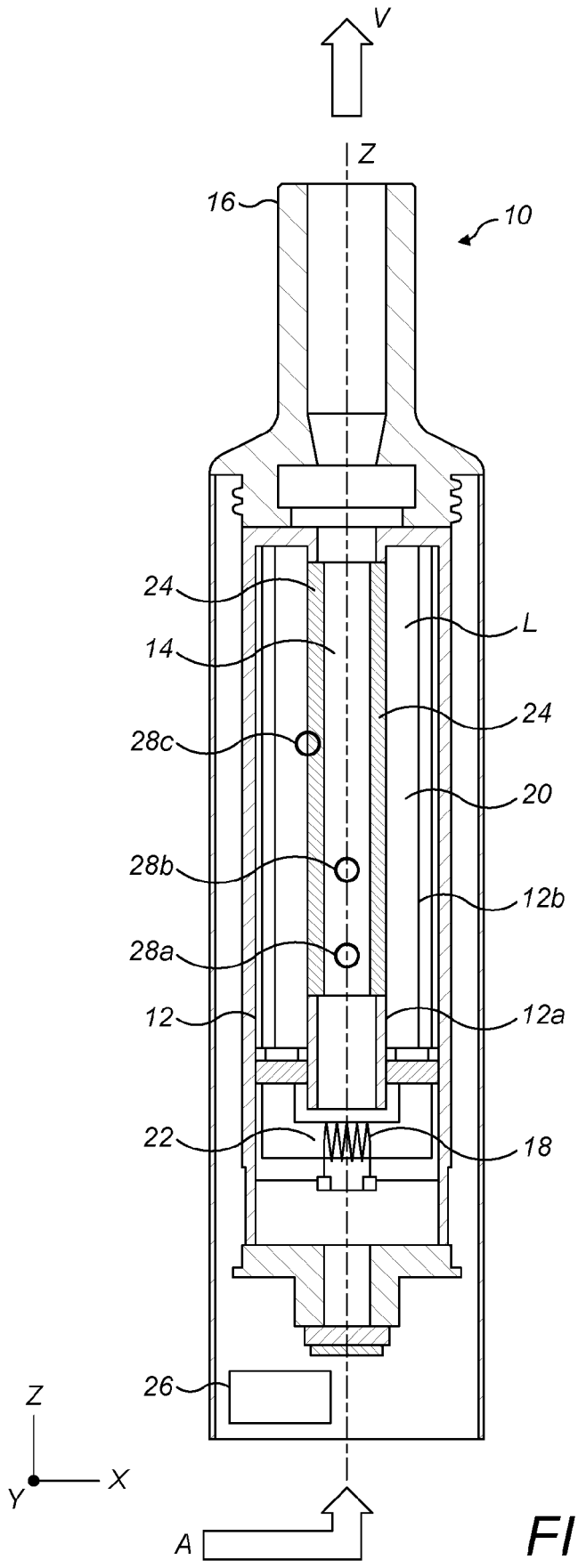

FIG. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 6533

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 September 2022	Dobbs, Harvey

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 16 6533

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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19-09-2022

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82