



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
24.03.2021 Bulletin 2021/12

(51) Int Cl.:
A24F 40/40 (2020.01)

(21) Application number: **19198574.6**

(22) Date of filing: **20.09.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **NERUDIA LIMITED**
Liverpool Merseyside L24 9HP (GB)

(72) Inventor: **The designation of the inventor has not yet been filed**

(74) Representative: **Mewburn Ellis LLP**
Aurora Building
Counterslip
Bristol BS1 6BX (GB)

(54) **SMOKING SUBSTITUTE APPARATUS**

(57) A smoking substitute apparatus (150) comprises: a housing; an air inlet (176) and an air outlet (174) provided at the housing, the air inlet being arranged to be in fluid communication with the air outlet through an air flow channel (170). A heater (164) is provided for generating an aerosol from an aerosol precursor such as an e-liquid. The heater is arranged to be in fluid communication with a downstream portion of the air flow channel so as to allow the generated aerosol to flow towards the air outlet via said downstream portion. The downstream portion of the air flow channel is configured to induce a swirling annular flow path to a portion of the air flow in the air flow channel.

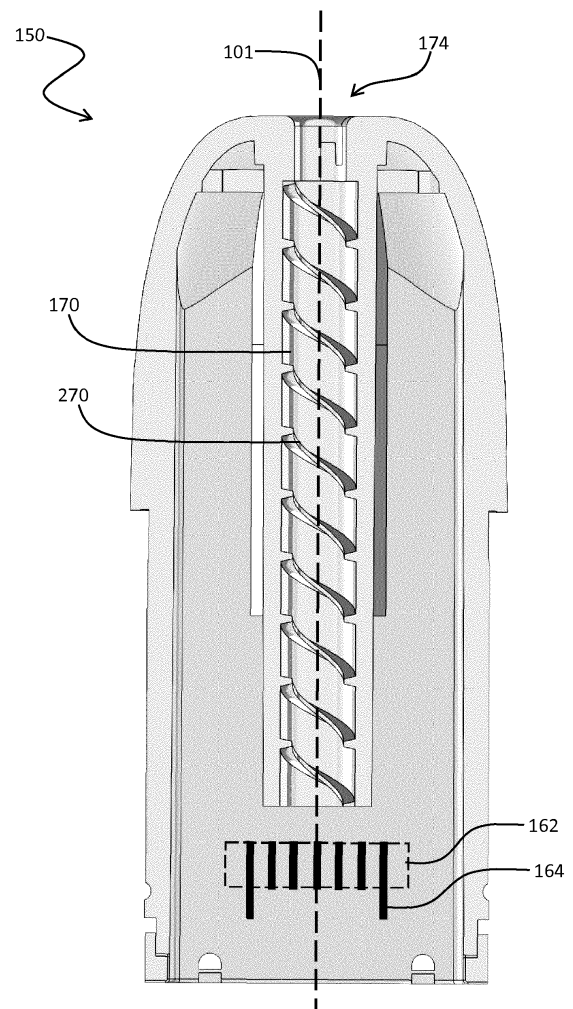


FIG. 5

Description

Field of the Invention

[0001] The present invention relates to a smoking substitute apparatus and, in particular, a smoking substitute apparatus that is able to deliver nicotine to a user in an effective manner.

Background

[0002] The smoking of tobacco is generally considered to expose a smoker to potentially harmful substances. It is thought that a significant amount of the potentially harmful substances are generated through the burning and/or combustion of the tobacco and the constituents of the burnt tobacco in the tobacco smoke itself.

[0003] Low temperature combustion of organic material such as tobacco is known to produce tar and other potentially harmful by-products. There have been proposed various smoking substitute systems in which the conventional smoking of tobacco is avoided.

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

[0005] Known smoking substitute systems include electronic systems that permit a user to simulate the act of smoking by producing an aerosol (also referred to as a "vapour") that is drawn into the lungs through the mouth (inhaled) and then exhaled. The inhaled aerosol typically bears nicotine and/or a flavourant without, or with fewer of, the health risks associated with conventional smoking.

[0006] In general, smoking substitute systems are intended to provide a substitute for the rituals of smoking, whilst providing the user with a similar, or improved, experience and satisfaction to those experienced with conventional smoking and with combustible tobacco products.

[0007] The popularity and use of smoking substitute systems has grown rapidly in the past few years. Although originally marketed as an aid to assist habitual smokers wishing to quit tobacco smoking, consumers are increasingly viewing smoking substitute systems as desirable lifestyle accessories. There are a number of different categories of smoking substitute systems, each utilising a different smoking substitute approach. Some smoking substitute systems are designed to resemble a conventional cigarette and are cylindrical in form with a mouthpiece at one end. Other smoking substitute devices do not generally resemble a cigarette (for example, the smoking substitute device may have a generally box-like form, in whole or in part).

[0008] One approach is the so-called "vaping" approach, in which a vaporisable liquid, or an aerosol former, sometimes typically referred to herein as "e-liquid", is heated by a heating device (sometimes referred to herein as an electronic cigarette or "e-cigarette" de-

vice) to produce an aerosol vapour which is inhaled by a user. The e-liquid typically includes a base liquid, nicotine and may include a flavourant. The resulting vapour therefore also typically contains nicotine and/or a flavourant. The base liquid may include propylene glycol and/or vegetable glycerine.

[0009] A typical e-cigarette device includes a mouthpiece, a power source (typically a battery), a tank for containing e-liquid and a heating device. In use, electrical energy is supplied from the power source to the heating device, which heats the e-liquid to produce an aerosol (or "vapour") which is inhaled by a user through the mouthpiece.

[0010] E-cigarettes can be configured in a variety of ways. For example, there are "closed system" vaping smoking substitute systems, which typically have a sealed tank and heating element. The tank is prefilled with e-liquid and is not intended to be refilled by an end user. One subset of closed system vaping smoking substitute systems include a main body which includes the power source, wherein the main body is configured to be physically and electrically couplable to a consumable including the tank and the heating element. In this way, when the tank of a consumable has been emptied of e-liquid, that consumable is removed from the main body and disposed of. The main body can then be reused by connecting it to a new, replacement, consumable. Another subset of closed system vaping smoking substitute systems are completely disposable, and intended for one-use only.

[0011] There are also "open system" vaping smoking substitute systems which typically have a tank that is configured to be refilled by a user. In this way the entire device can be used multiple times.

[0012] An example vaping smoking substitute system is the myblu™ e-cigarette. The myblu™ e-cigarette is a closed system which includes a main body and a consumable. The main body and consumable are physically and electrically coupled together by pushing the consumable into the main body. The main body includes a rechargeable battery. The consumable includes a mouthpiece and a sealed tank which contains e-liquid. The consumable further includes a heater, which for this device is a heating filament coiled around a portion of a wick. The wick is partially immersed in the e-liquid, and conveys e-liquid from the tank to the heating filament. The system is controlled by a microprocessor on board the main body. The system includes a sensor for detecting when a user is inhaling through the mouthpiece, the microprocessor then activating the device in response. When the system is activated, electrical energy is supplied from the power source to the heating device, which heats e-liquid from the tank to produce a vapour which is inhaled by a user through the mouthpiece.

Summary of the Invention

[0013] For a smoking substitute system it is desirable

to deliver nicotine into the user's lungs, where it can be absorbed into the bloodstream. However, the present disclosure is based in part on a realisation that some prior art smoking substitute systems, such delivery of nicotine is not efficient. In some prior art systems, the aerosol droplets have a size distribution that is not suitable for delivering nicotine to the lungs. Aerosol droplets of a large particle size tend to be deposited in the mouth and/or upper respiratory tract. Aerosol particles of a small (e.g. sub-micron) particle size can be inhaled into the lungs but may be exhaled without delivering nicotine to the lungs. As a result the user would require drawing a longer puff, more puffs, or vaporising e-liquid with a higher nicotine concentration in order to achieve the desired experience.

[0014] Accordingly, there is a need for improvement in the delivery of nicotine to a user in the context of a smoking substitute system.

[0015] The present disclosure has been devised in the light of the above considerations.

[0016] In a general aspect, the present invention relates to inducing a swirling annular flow path to at least a portion of the generated aerosol.

[0017] According to a first preferred aspect there is provided a smoking substitute apparatus comprising: a housing; an air inlet and an air outlet provided at the housing, the air inlet is arranged to be in fluid communication with the air outlet through an air flow channel; an aerosol generator for generating an aerosol, wherein the aerosol generator is arranged to be in fluid communication with a downstream portion of the air flow channel so as to allow the generated aerosol to flow towards the air outlet via said downstream portion; wherein the downstream portion of the air flow channel is configured to induce a swirling annular flow path to a portion of the air flow in the air flow channel.

[0018] In a second aspect, there is provided a method of operating a smoking substitute apparatus according to the first aspect, in which an air flow is drawn through the apparatus from the air inlet to the air outlet by user inhalation, and the heater operated to generate an aerosol from an aerosol precursor.

[0019] An advantage of the swirling annular flow is a decreased level of liquid reaching the mouth of the user. For example, this may be due to the spiral or helical air flow being relatively laminar in nature. This can reduce the number of droplets that impact the wall, and therefore reduce deposition on the wall.

[0020] Optionally, the downstream portion of the air flow channel is configured to induce a swirling annular flow path to a portion of the generated aerosol alongside a wall of the air flow channel. This allows a central part of the airflow channel to remain free of obstruction and allows a substantially straight central air flow path to be surrounded by the swirling annular flow.

[0021] Optionally, the downstream portion of the air flow channel comprises a helical guide which protrudes from a wall of the air flow channel.

[0022] Optionally, the helical guide protrudes radially inwardly from a wall of the air flow channel.

[0023] Optionally, the downstream portion of the air flow channel has a width, orthogonal to a longitudinal axis of the air flow channel, and the helical guide protrudes radially inwardly from a wall of the air flow channel by at least 5% of the width of the air flow channel.

[0024] Optionally, the downstream portion of the air flow channel has a width, orthogonal to a longitudinal axis of the air flow channel, and the helical guide protrudes radially inwardly from a wall of the air flow channel by up to 40% of the width of the air flow channel.

[0025] The helical guide may protrude radially inwardly from a wall of the air flow channel by 10%, or 15%, or 20%, or 25%, or 35% of the width of the air flow channel.

[0026] Optionally, a width of the helical guide, in a direction parallel to the longitudinal axis of the air flow channel, reduces from a first width closest to a wall of the air flow channel to a second width at a radially innermost extent of the helical guide.

[0027] Optionally, the helical guide has at least two rotations about the longitudinal axis of the air flow channel.

[0028] Optionally, the helical guide extends continuously along the downstream portion of the air flow channel.

[0029] In some embodiments, the downstream portion of the air flow channel is configured to induce the swirling annular flow path surrounding a substantially axial flow path. This substantially axial flow path corresponds to the central part of the flow channel mentioned above. In this case, the average magnitude of velocity of the flow in the substantially axial flow path may be greater than average magnitude of velocity of the flow in the swirling annular flow path.

[0030] Another aspect provides a smoking substitute system comprising: a main body; and a smoking substitute apparatus according to the first aspect.

[0031] The smoking substitute apparatus may be in the form of a consumable. The consumable may be configured for engagement with a main body. When the consumable is engaged with the main body, the combination of the consumable and the main body may form a smoking substitute system such as a closed smoking substitute system. For example, the consumable may comprise components of the system that are disposable, and the main body may comprise non-disposable or non-consumable components (e.g. power supply, controller, sensor, etc.) that facilitate the generation and/or delivery of aerosol by the consumable. In such an embodiment, the aerosol precursor (e.g. e-liquid) may be replenished by replacing a used consumable with an unused consumable.

[0032] Alternatively, the smoking substitute apparatus may be a non-consumable apparatus (e.g. that is in the form of an open smoking substitute system). In such embodiments an aerosol former (e.g. e-liquid) of the system may be replenished by re-filling, e.g. a reservoir of the smoking substitute apparatus, with the aerosol precursor

(rather than replacing a consumable component of the apparatus).

[0033] In light of this, it should be appreciated that some of the features described herein as being part of the smoking substitute apparatus may alternatively form part of a main body for engagement with the smoking substitute apparatus. This may be the case in particular when the smoking substitute apparatus is in the form of a consumable.

[0034] Where the smoking substitute apparatus is in the form of a consumable, the main body and the consumable may be configured to be physically coupled together. For example, the consumable may be at least partially received in a recess of the main body, such that there is an interference fit between the main body and the consumable. Alternatively, the main body and the consumable may be physically coupled together by screwing one onto the other, or through a bayonet fitting, or the like.

[0035] Thus, the smoking substitute apparatus may comprise one or more engagement portions for engaging with a main body. In this way, one end of the smoking substitute apparatus may be coupled with the main body, whilst an opposing end of the smoking substitute apparatus may define a mouthpiece of the smoking substitute system.

[0036] The smoking substitute apparatus may comprise a reservoir configured to store an aerosol precursor, such as an e-liquid. The e-liquid may, for example, comprise a base liquid. The e-liquid may further comprise nicotine. The base liquid may include propylene glycol and/or vegetable glycerine. The e-liquid may be substantially flavourless. That is, the e-liquid may not contain any deliberately added additional flavourant and may consist solely of a base liquid of propylene glycol and/or vegetable glycerine and nicotine.

[0037] The reservoir may be in the form of a tank. At least a portion of the tank may be light-transmissive. For example, the tank may comprise a window to allow a user to visually assess the quantity of e-liquid in the tank. A housing of the smoking substitute apparatus may comprise a corresponding aperture (or slot) or window that may be aligned with a light-transmissive portion (e.g. window) of the tank. The reservoir may be referred to as a "clearomizer" if it includes a window, or a "cartomizer" if it does not.

[0038] The smoking substitute apparatus may comprise a passage for fluid flow therethrough. The passage may extend through (at least a portion of) the smoking substitute apparatus, between openings that may define an inlet and an outlet of the passage. The outlet may be at a mouthpiece of the smoking substitute apparatus. In this respect, a user may draw fluid (e.g. air) into and through the passage by inhaling at the outlet (i.e. using the mouthpiece). The passage may be at least partially defined by the tank. The tank may substantially (or fully) define the passage, for at least a part of the length of the passage. In this respect, the tank may surround the pas-

sage, e.g. in an annular arrangement around the passage.

[0039] The aerosol generator may comprise a wick. The aerosol generator may further comprise a heater.

5 The wick may comprise a porous material, capable of wicking the aerosol precursor. A portion of the wick may be exposed to air flow in the passage. The wick may also comprise one or more portions in contact with liquid stored in the reservoir. For example, opposing ends of the wick may protrude into the reservoir and an intermediate portion (between the ends) may extend across the passage so as to be exposed to air flow in the passage. Thus, liquid may be drawn (e.g. by capillary action) along the wick, from the reservoir to the portion of the wick exposed to air flow.

10 **[0040]** The heater may comprise a heating element, which may be in the form of a filament wound about the wick (e.g. the filament may extend helically about the wick in a coil configuration). The heating element may be wound about the intermediate portion of the wick that is exposed to air flow in the passage. The heating element may be electrically connected (or connectable) to a power source. Thus, in operation, the power source may apply a voltage across the heating element so as to heat the heating element by resistive heating. This may cause liquid stored in the wick (i.e. drawn from the tank) to be heated so as to form a vapour and become entrained in air flowing through the passage. This vapour may subsequently cool to form an aerosol in the passage, typically downstream from the heating element.

15 **[0041]** The smoking substitute apparatus may comprise a vaporisation chamber. The vaporisation chamber may form part of the passage in which the heater is located. The vaporisation chamber may be arranged to be in fluid communication with the inlet and outlet of the passage. The vaporisation chamber may be an enlarged portion of the passage. In this respect, the air as drawn in by the user may entrain the generated vapour in a flow away from heater. The entrained vapour may form an aerosol in the vaporisation chamber, or it may form the aerosol further downstream along the passage. The vaporisation chamber may be at least partially defined by the tank. The tank may substantially (or fully) define the vaporisation chamber. In this respect, the tank may surround the vaporisation chamber, e.g. in an annular arrangement around the vaporisation chamber.

20 **[0042]** In use, the user may puff on a mouthpiece of the smoking substitute apparatus, i.e. draw on the smoking substitute apparatus by inhaling, to draw in an air stream therethrough. A portion, or all, of the air stream (also referred to as a "main air flow") may pass through the vaporisation chamber so as to entrain the vapour generated at the heater. That is, such a main air flow may be heated by the heater (although typically only to a limited extent) as it passes through the vaporisation chamber. Alternatively or in addition, a portion of the air stream (also referred to as a "dilution air flow" or "bypass air flow") may bypass the vaporisation chamber and be di-

rected to mix with the generated aerosol downstream from the vaporisation chamber. That is, the dilution air flow may be an air stream at an ambient temperature and may not be directly heated at all by the heater. The dilution air flow may combine with the main air flow for diluting the aerosol contained therein. The dilution air flow may merge with the main air flow along the passage downstream from the vaporisation chamber. Alternatively, the dilution air flow may be directly inhaled by the user without passing through the passage of the smoking substitute apparatus.

[0043] As a user puffs on the mouthpiece, vaporised e-liquid entrained in the passing air flow may be drawn towards the outlet of the passage. The vapour may cool, and thereby nucleate and/or condense along the passage to form a plurality of aerosol droplets, e.g. nicotine-containing aerosol droplets. A portion of these aerosol droplets may be delivered to and be absorbed at a target delivery site, e.g. a user's lung, whilst a portion of the aerosol droplets may instead adhere onto other parts of the user's respiratory tract, e.g. the user's oral cavity and/or throat. Typically, in some known smoking substitute apparatuses, the aerosol droplets as measured at the outlet of the passage, e.g. at the mouthpiece, may have a droplet size, d_{50} , of less than $1\mu\text{m}$.

[0044] The particle droplet sizes, d_{50} , of an aerosol may be measured by a laser diffraction technique. For example, the stream of aerosol output from the outlet of the passage may be drawn through a Malvern Spraytec laser diffraction system, where the intensity and pattern of scattered laser light are analysed to calculate the size and size distribution of aerosol droplets. As will be readily understood, the particle size distribution may be expressed in terms of d_{10} , d_{50} and d_{90} , for example. Considering a cumulative plot of the volume of the particles measured by the laser diffraction technique, the dio particle size is the particle size below which 10% by volume of the sample lies. The d_{50} particle size is the particle size below which 50% by volume of the sample lies. The d_{90} particle size is the particle size below which 90% by volume of the sample lies. Unless otherwise indicated herein, the particle size measurements are volume-based particle size measurements, rather than number-based or mass-based particle size measurements.

[0045] The d_{50} particle size of the aerosol particles is preferably at least 1 micron, more preferably at least 2 microns. Typically, the d_{50} particle size is not more than 10 microns, preferably not more than 9 microns, not more than 8 microns, not more than 7 microns, not more than 6 microns, not more than 5 microns, not more than 4 microns or not more than 3 microns. It is considered that providing aerosol particle sizes in such ranges permits improved interaction between the aerosol particles and the user's lungs.

[0046] The smoking substitute apparatus (or main body engaged with the smoking substitute apparatus) may comprise a power source. The power source may be electrically connected (or connectable) to a heater of

the smoking substitute apparatus (e.g. when the smoking substitute apparatus is engaged with the main body). The power source may be a battery (e.g. a rechargeable battery). A connector in the form of e.g. a USB port may be provided for recharging this battery.

[0047] When the smoking substitute apparatus is in the form of a consumable, the smoking substitute apparatus may comprise an electrical interface for interfacing with a corresponding electrical interface of the main body. One or both of the electrical interfaces may include one or more electrical contacts. Thus, when the main body is engaged with the consumable, the electrical interface of the main body may be configured to transfer electrical power from the power source to a heater of the consumable via the electrical interface of the consumable.

[0048] The electrical interface of the smoking substitute apparatus may also be used to identify the smoking substitute apparatus (in the form of a consumable) from a list of known types. For example, the consumable may have a certain concentration of nicotine and the electrical interface may be used to identify this. The electrical interface may additionally or alternatively be used to identify when a consumable is connected to the main body.

[0049] Again, where the smoking substitute apparatus is in the form of a consumable, the main body may comprise an identification means, which may, for example, be in the form of an RFID reader, a barcode or QR code reader. This identification means may be able to identify a characteristic (e.g. a type) of a consumable engaged with the main body. In this respect, the consumable may include any one or more of an RFID chip, a barcode or QR code, or memory within which is an identifier and which can be interrogated via the identification means.

[0050] The smoking substitute apparatus or main body may comprise a controller, which may include a micro-processor. The controller may be configured to control the supply of power from the power source to the heater of the smoking substitute apparatus (e.g. via the electrical contacts). A memory may be provided and may be operatively connected to the controller. The memory may include non-volatile memory. The memory may include instructions which, when implemented, cause the controller to perform certain tasks or steps of a method.

[0051] The main body or smoking substitute apparatus may comprise a wireless interface, which may be configured to communicate wirelessly with another device, for example a mobile device, e.g. via Bluetooth®. To this end, the wireless interface could include a Bluetooth® antenna. Other wireless communication interfaces, e.g. WiFi®, are also possible. The wireless interface may also be configured to communicate wirelessly with a remote server.

[0052] A puff sensor may be provided that is configured to detect a puff (i.e. inhalation from a user). The puff sensor may be operatively connected to the controller so as to be able to provide a signal to the controller that is indicative of a puff state (i.e. puffing or not puffing). The puff sensor may, for example, be in the form of a pressure

sensor or an acoustic sensor. That is, the controller may control power supply to the heater of the consumable in response to a puff detection by the sensor. The control may be in the form of activation of the heater in response to a detected puff. That is, the smoking substitute apparatus may be configured to be activated when a puff is detected by the puff sensor. When the smoking substitute apparatus is in the form of a consumable, the puff sensor may be provided in the consumable or alternatively may be provided in the main body.

[0053] The term "flavourant" is used to describe a compound or combination of compounds that provide flavour and/or aroma. For example, the flavourant may be configured to interact with a sensory receptor of a user (such as an olfactory or taste receptor). The flavourant may include one or more volatile substances.

[0054] The flavourant may be provided in solid or liquid form. The flavourant may be natural or synthetic. For example, the flavourant may include menthol, liquorice, chocolate, fruit flavour (including e.g. citrus, cherry etc.), vanilla, spice (e.g. ginger, cinnamon) and tobacco flavour. The flavourant may be evenly dispersed or may be provided in isolated locations and/or varying concentrations.

[0055] The invention includes the combination of the aspects and preferred features described except where such a combination is clearly impermissible or expressly avoided.

Summary of the Figures

[0056] So that the invention may be understood, and so that further aspects and features thereof may be appreciated, embodiments illustrating the principles of the invention will now be discussed in further detail with reference to the accompanying figures, in which:

Figure 1 is a schematic front view of a smoking substitute system, according to a first embodiment, in an engaged position;

Figure 2 is a schematic front view of the smoking substitute system of the first embodiment in a disengaged position;

Figure 3 is a schematic longitudinal cross sectional view of a smoking substitute apparatus of the first embodiment; and

Figure 4 is an enlarged schematic cross sectional view of part of the air passage and vaporisation chamber of the first embodiment;

Figure 5 is a view of an air flow passage of a smoking substitute apparatus illustrating features of the air flow passage for implementation in an embodiment of the invention;

Figure 6 is a detailed view of part of the air flow passage of Figure 5;

Figure 7 is a cross-sectional view through the air flow passage of Figure 6;

Figure 8 is a view showing air flow paths along the air flow passage of Figures 5 and 6; and

Figure 9 is a view showing results of modelling of air flow paths along the air flow passage of Figures 5 to 8.

Detailed Description of the Invention

[0057] Further background to the present invention and further aspects and embodiments of the present invention will now be discussed with reference to the accompanying figures. Further aspects and embodiments will be apparent to those skilled in the art. The contents of all documents mentioned in this text are incorporated herein by reference in their entirety.

[0058] Figures 1 and 2 illustrate a smoking substitute system in the form of an e-cigarette system 110. The system 110 comprises a main body 120 of the system 110, and a smoking substitute apparatus in the form of an e-cigarette consumable (or "pod") 150. In the illustrated embodiment the consumable 150 (sometimes referred to herein as a smoking substitute apparatus) is removable from the main body 120, so as to be a replaceable component of the system 110. The e-cigarette system 110 is a closed system in the sense that it is not intended that the consumable should be refillable with e-liquid by a user.

[0059] As is apparent from Figures 1 and 2, the consumable 150 is configured to engage the main body 120.

[0060] Figure 1 shows the main body 120 and the consumable 150 in an engaged state, whilst Figure 2 shows the main body 120 and the consumable 150 in a disengaged state. When engaged, a portion of the consumable 150 is received in a cavity of corresponding shape in the main body 120 and is retained in the engaged position by way of a snap-engagement mechanism. In other embodiments, the main body 120 and consumable 150 may be engaged by screwing one into (or onto) the other, or through a bayonet fitting, or by way of an interference fit.

[0061] The system 110 is configured to vaporise an aerosol precursor, which in the illustrated embodiment is in the form of a nicotine-based e-liquid 160. The e-liquid 160 comprises nicotine and a base liquid including propylene glycol and/or vegetable glycerine. In the present embodiment, the e-liquid 160 is flavoured by a flavourant. In other embodiments, the e-liquid 160 may be flavourless and thus may not include any added flavourant.

[0062] Figure 3 shows a schematic longitudinal cross sectional view of the smoking substitute apparatus forming part of the smoking substitute system shown in Fig-

ures 1 and 2. In Figure 3, the e-liquid 160 is stored within a reservoir in the form of a tank 152 that forms part of the consumable 150. In the illustrated embodiment, the consumable 150 is a "single-use" consumable 150. That is, upon exhausting the e-liquid 160 in the tank 152, the intention is that the user disposes of the entire consumable 150. The term "single-use" does not necessarily mean the consumable is designed to be disposed of after a single smoking session. Rather, it defines the consumable 150 is not arranged to be refilled after the e-liquid contained in the tank 152 is depleted. The tank may include a vent (not shown) to allow ingress of air to replace e-liquid that has been used from the tank. The consumable 150 preferably includes a window 158 (see Figures 1 and 2), so that the amount of e-liquid in the tank 152 can be visually assessed. The main body 120 includes a slot 157 so that the window 158 of the consumable 150 can be seen whilst the rest of the tank 152 is obscured from view when the consumable 150 is received in the cavity of the main body 120. The consumable 150 may be referred to as a "clearomizer" when it includes a window 158, or a "cartomizer" when it does not.

[0063] In other embodiments, the e-liquid (i.e. aerosol precursor) may be the only part of the system that is truly "single-use". That is, the tank may be refillable with e-liquid or the e-liquid may be stored in a non-consumable component of the system. For example, in such other embodiments, the e-liquid may be stored in a tank located in the main body or stored in another component that is itself not single-use (e.g. a refillable cartomizer).

[0064] The external wall of tank 152 is provided by a casing of the consumable 150. The tank 152 annularly surrounds, and thus defines a portion of, a passage 170 that extends between a vaporiser inlet 172 and an outlet 174 at opposing ends of the consumable 150. In this respect, the passage 170 comprises an upstream end at the end 151 of the consumable 150 that engages with the main body 120, and a downstream end at an opposing end of the consumable 150 that comprises a mouthpiece 154 of the system 110. Note that further features relevant to the structure and operation of the air flow passage 170 are set out further below.

[0065] When the consumable 150 is received in the cavity of the main body 120 as shown in Figure 3, a plurality of device air inlets 176 are formed at the boundary between the casing of the consumable and the casing of the main body. The device air inlets 176 are in fluid communication with the vaporiser inlet 172 through an inlet flow channel 178 formed in the cavity of the main body which is of corresponding shape to receive a part of the consumable 150. Air from outside of the system 110 can therefore be drawn into the passage 170 through the device air inlets 176 and the inlet flow channels 178.

[0066] When the consumable 150 is engaged with the main body 120, a user can inhale (i.e. take a puff) via the mouthpiece 154 so as to draw air through the passage 170, and so as to form an air flow (indicated by the dashed arrows in Figure 3) in a direction from the vaporiser inlet

172 to the outlet 174. Although not illustrated, the passage 170 may be partially defined by a tube (e.g. a metal tube) extending through the consumable 150. In Figure 3, for illustrative simplicity, the passage 170 is shown with a substantially circular cross-sectional profile with a constant diameter along its length. However, as will be understood from this disclosure, embodiments of the invention may require that the passage may have other cross-sectional profiles, to promote certain flow characteristics. Further, the cross sectional profile and/or the diameter (or hydraulic diameter) of the passage may vary along its longitudinal axis.

[0067] The smoking substitute system 110 is configured to vaporise the e-liquid 160 for inhalation by a user. To provide this operability, the consumable 150 comprises a heater having a porous wick 162 and a resistive heating element in the form of a heating filament 164 that is helically wound (in the form of a coil) around a portion of the porous wick 162. The porous wick 162 extends across the passage 170 (i.e. transverse to a longitudinal axis of the passage 170 and thus also transverse to the air flow along the passage 170 during use) and opposing ends of the wick 162 extend into the tank 152 (so as to be immersed in the e-liquid 160). In this way, e-liquid 160 contained in the tank 152 is conveyed from the opposing ends of the porous wick 162 to a central portion of the porous wick 162 so as to be exposed to the air flow in the passage 170.

[0068] The helical filament 164 is wound about the exposed central portion of the porous wick 162 and is electrically connected to an electrical interface in the form of electrical contacts 156 mounted at the end of the consumable that is proximate the main body 120 (when the consumable and the main body are engaged). When the consumable 150 is engaged with the main body 120, electrical contacts 156 make contact with corresponding electrical contacts (not shown) of the main body 120. The main body electrical contacts are electrically connectable to a power source (not shown) of the main body 120, such that (in the engaged position) the filament 164 is electrically connectable to the power source. In this way, power can be supplied by the main body 120 to the filament 164 in order to heat the filament 164. This heats the porous wick 162 which causes e-liquid 160 conveyed by the porous wick 162 to vaporise and thus to be released from the porous wick 162. The vaporised e-liquid becomes entrained in the air flow and, as it cools in the air flow (between the heated wick and the outlet 174 of the passage 170), condenses to form an aerosol. This aerosol is then inhaled, via the mouthpiece 154, by a user of the system 110. As e-liquid is lost from the heated portion of the wick, further e-liquid is drawn along the wick from the tank to replace the e-liquid lost from the heated portion of the wick.

[0069] The filament 164 and the exposed central portion of the porous wick 162 are positioned across the passage 170. More specifically, the part of passage that contains the filament 164 and the exposed portion of the

porous wick 162 forms a vaporisation chamber. In the illustrated example, the vaporisation chamber has the same cross-sectional diameter as the passage 170. However, in other embodiments the vaporisation chamber may have a different cross sectional profile as the passage 170. For example, the vaporisation chamber may have a larger cross sectional diameter than at least some of the downstream part of the passage 170 so as to enable a longer residence time for the air inside the vaporisation chamber.

[0070] Figure 4 illustrates in more detail the vaporisation chamber and therefore the region of the consumable 150 around the wick 162 and filament 164. The helical filament 164 is wound around a central portion of the porous wick 162. The porous wick extends across passage 170. E-liquid 160 contained within the tank 152 is conveyed as illustrated schematically by arrows 401, i.e. from the tank and towards the central portion of the porous wick 162.

[0071] When the user inhales, air is drawn from through the inlets 176 shown in Figure 3, along inlet flow channel 178 to vaporisation chamber inlet 172 and into the vaporisation chamber containing porous wick 162. The porous wick 162 extends substantially transverse to the air flow direction. The air flow passes around the porous wick, at least a portion of the air flow substantially following the surface of the porous wick 162. In examples where the porous wick has a cylindrical cross-sectional profile, the air flow may follow a curved path around an outer periphery of the porous wick 162.

[0072] At substantially the same time as the air flow passes around the porous wick 162, the filament 164 is heated so as to vaporise the e-liquid which has been wicked into the porous wick. The air flow passing around the porous wick 162 picks up this vaporised e-liquid, and the vapour-containing air flow is drawn in direction 403 further down passage 170.

[0073] The power source of the main body 120 may be in the form of a battery (e.g. a rechargeable battery such as a lithium ion battery). The main body 120 may comprise a connector in the form of e.g. a USB port for recharging this battery. The main body 120 may also comprise a controller that controls the supply of power from the power source to the main body electrical contacts (and thus to the filament 164). That is, the controller may be configured to control a voltage applied across the main body electrical contacts, and thus the voltage applied across the filament 164. In this way, the filament 164 may only be heated under certain conditions (e.g. during a puff and/or only when the system is in an active state). In this respect, the main body 120 may include a puff sensor (not shown) that is configured to detect a puff (i.e. inhalation). The puff sensor may be operatively connected to the controller so as to be able to provide a signal, to the controller, which is indicative of a puff state (i.e. puffing or not puffing). The puff sensor may, for example, be in the form of a pressure sensor or an acoustic sensor.

[0074] Although not shown, the main body 120 and consumable 150 may comprise a further interface which may, for example, be in the form of an RFID reader, a barcode or QR code reader. This interface may be able to identify a characteristic (e.g. a type) of a consumable 150 engaged with the main body 120. In this respect, the consumable 150 may include anyone or more of an RFID chip, a barcode or QR code, or memory within which is an identifier and which can be interrogated via the interface.

[0075] Figure 5 shows the passage, or air flow channel, 170 of the consumable 150 in more detail. Some other features of the consumable 150 are shown to give context. The air flow channel 170 extends downstream of the heater 164 and the wick 162. The location of the heater 164 and the wick 162 is shown for context, although features of the e-liquid reservoir and of the vaporisation chamber are not shown. The air flow channel 170 leads to an outlet 174. The air flow channel 170 has a longitudinal axis 101. The heater 164 is configured to generate an aerosol. The generated aerosol flows towards the outlet 174 along the air flow channel 170. The air flow channel 170 is configured to induce a helical or spiral flow path. The air flow channel 170 is configured to induce a helical or spiral flow path to at least an annular shaped portion of the generated aerosol alongside a wall of the air flow channel 170. In Figure 5 the air flow channel 170 has a helical guide 270 to induce a helical or spiral flow path. Note that the overall cross sectional shape of the air flow channel may be a shape other than circular. In particular the overall cross sectional shape of the air flow channel may be elliptical, oval or racetrack shape, and the expressions "helical" and "spiral" may be interpreted in conformity with this, and not necessarily implying a strictly circular overall cross sectional envelope for the helical or spiral flow path.

[0076] Figures 6 and 7 show the air flow channel 170 and the helical guide 270 in more detail. The helical guide 270 protrudes radially inwardly from a wall of the air flow channel 170. The helical guide 270 has a radially innermost edge 278. Edge 278 may be aligned parallel to the longitudinal axis 101. The helical guide 270 has a pitch 275. The pitch 275 is a distance, in the axial direction, between adjacent portions of the guide 270. The helical guide 270 has a width 276. The width 276 is a dimension of the guide along the axial direction, i.e. the width of the protrusion from the wall of the air flow channel. The width may be measured at the wall, at the inward extremity of the guide, or at some other position. In the example shown in Figure 6, the width 276 of the helical guide reduces from a first width closest to a wall of the air flow channel to a second width at the radially innermost edge 278 of the helical guide. The helical guide 270 has a depth 277. The depth 277 is a dimension of the guide in a radial direction, i.e. the amount by which the guide protrudes inwardly from the wall of the air flow channel 170. The value of the pitch 275, and/or of the width 276 and/or of the depth 277 may be constant along the air flow chan-

nel. Alternatively one or more of them may vary along the air flow channel in order to promote suitable air flow characteristics along the air flow channel.

[0077] Figures 7 and 8 show air flow along the air flow channel 170. A first portion of the total air flow follows a substantially straight flow path 271 in an axial direction, i.e. along, or parallel to, the longitudinal axis of the air flow channel. In the cross-section of Figure 7, the first portion of the air flow is directed into the page. A second portion of the total air flow follows a substantially helical flow path 272. By selection of the pitch 275 of the helical guide 270 it is possible to control the rate of swirling air. By selection of the depth 277 of the helical guide 270 it is possible to control the amount of swirling air, i.e. the portion which follows the helical flow path 272 compared to the portion which follows the straight flow path 271.

[0078] The depth 277 shown in Figure 6 is around 15% of the width of the channel 170. More generally, the depth may have a lower limit of around 5%. The depth may have an upper limit of around 40%. The depth may be 10%, or 15%, or 20%, or 25%, or 35% of the width of the channel. For air flow channels 170 which are circular when viewed in cross-section, the width may conveniently be expressed as a diameter of the air flow channel 170. For air flow channels 170 which are non-circular when viewed in cross-section (e.g. oval, elliptical or race-track) the dimension of the air flow channel may be more conveniently expressed as a width, or as a maximum/minimum dimension of the air flow channel 170. Figure 7 shows a maximum dimension 281 of the air flow channel 170 in a direction which is orthogonal to the longitudinal axis 101 of the air flow channel 170. Figure 7 also shows a minimum dimension 282 of the air flow channel 170 in a direction which is orthogonal to the longitudinal axis 101 of the air flow channel 170.

[0079] The pitch 275 may be defined in terms of a number of complete turns about the longitudinal axis 101 along the length of the air flow channel 170 where the guide 270 is present. A minimum number of turns is about 2.

[0080] Figure 9 shows results of air flow modelling of an embodiment of the air flow passage 170 with a helical guide 270. Figure 9 shows the first portion of air flow following the straight flow path 271 and the second portion of the air flow following the helical flow path 272. The helical flow path 272 is similar to a tornado. The tornado effect has been shown to be laminar in nature with little turbulence.

[0081] As shown in Figure 9, the swirling annular flow path surrounds a substantially axial flow path. The average magnitude of velocity of the flow in the substantially axial flow path is greater than average magnitude of velocity of the flow in the swirling annular flow path.

[0082] An advantage of the swirling annular flow is a decreased level of liquid reaching the mouth of the user. At the time of writing, without wishing to be bound by theory, the inventors speculate that this may be due to the swirling air flow being relatively laminar in nature.

This can reduce the number of droplets that impact the wall, and therefore reduce deposition on the wall. It is considered that leakage of liquid from the apparatus is reduced in view of a combination of the slow swirling annular flow and the faster axial flow. This is possibly because the slow swirling outer flow provides an "air curtain", which may act to reduce condensed liquid on the interior surface of the flow passage from being picked up by the flow and carried to the user's mouth. It is considered that the use of a swirling annular flow is an effective way to reduce flow velocity close to the wall. This is because it can result in little or no turbulence being generated, in contrast, for example, to a "bumpy" wall. It is considered that lower turbulence is advantageous in order to provide a suitable particle size distribution.

[0083] The features disclosed in the foregoing description, or in the following claims, or in the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for obtaining the disclosed results, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

[0084] While the invention has been described in conjunction with the exemplary embodiments described above, many equivalent modifications and variations will be apparent to those skilled in the art when given this disclosure. Accordingly, the exemplary embodiments of the invention set forth above are considered to be illustrative and not limiting. Various changes to the described embodiments may be made without departing from the spirit and scope of the invention.

[0085] For the avoidance of any doubt, any theoretical explanations provided herein are provided for the purposes of improving the understanding of a reader. The inventors do not wish to be bound by any of these theoretical explanations.

[0086] Any section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described.

[0087] Throughout this specification, including the claims which follow, unless the context requires otherwise, the words "have", "comprise", and "include", and variations such as "having", "comprises", "comprising", and "including" will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

[0088] It must be noted that, as used in the specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise. Ranges may be expressed herein as from "about" one particular value, and/or to "about" another particular value. When such a range is expressed, another embodiment includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by the use of the antecedent "about," it will be understood that

the particular value forms another embodiment. The term "about" in relation to a numerical value is optional and means, for example, +/- 10%.

[0089] The words "preferred" and "preferably" are used herein refer to embodiments of the invention that may provide certain benefits under some circumstances. It is to be appreciated, however, that other embodiments may also be preferred under the same or different circumstances. The recitation of one or more preferred embodiments therefore does not mean or imply that other embodiments are not useful, and is not intended to exclude other embodiments from the scope of the disclosure, or from the scope of the claims.

Claims

1. A smoking substitute apparatus comprising:

a housing;
 an air inlet and an air outlet provided at the housing, the air inlet is arranged to be in fluid communication with the air outlet through an air flow channel;
 an aerosol generator for generating an aerosol, wherein the aerosol generator is arranged to be in fluid communication with a downstream portion of the air flow channel so as to allow the generated aerosol to flow towards the air outlet via said downstream portion;
 wherein the downstream portion of the air flow channel is configured to induce a swirling annular flow path to a portion of the air flow in the air flow channel.

2. A smoking substitute apparatus according to claim 1, wherein the downstream portion of the air flow channel is configured to induce a swirling annular flow path to a portion of the generated aerosol alongside a wall of the air flow channel.

3. A smoking substitute apparatus according to claim 1 or 2, wherein the downstream portion of the air flow channel comprises a helical guide which protrudes from a wall of the air flow channel.

4. A smoking substitute apparatus according to claim 3, wherein the helical guide protrudes radially inwardly from a wall of the air flow channel.

5. A smoking substitute apparatus according to claim 4, wherein the downstream portion of the air flow channel has a width, orthogonal to a longitudinal axis of the air flow channel, and the helical guide protrudes radially inwardly from a wall of the air flow channel by at least 5% of the width of the air flow channel.

6. A smoking substitute apparatus according to claim 4 or 5, wherein the downstream portion of the air flow channel has a width, orthogonal to a longitudinal axis of the air flow channel, and the helical guide protrudes radially inwardly from a wall of the air flow channel by up to 40% of the width of the air flow channel.

7. A smoking substitute apparatus according to any one of claims 4 to 6, wherein a width of the helical guide, in a direction parallel to the longitudinal axis of the air flow channel, reduces from a first width closest to a wall of the air flow channel to a second width at a radially innermost extent of the helical guide.

8. A smoking substitute apparatus according to any one of claims 3 to 7, wherein the helical guide has at least two rotations about the longitudinal axis of the air flow channel.

9. A smoking substitute apparatus according to any of claims 3 to 8, wherein the helical guide extends continuously along the downstream portion of the air flow channel.

10. A smoking substitute apparatus according to any of one claims 1 to 9 wherein the downstream portion of the air flow channel is configured to induce the swirling annular flow path surrounding a substantially axial flow path, and wherein the average magnitude of velocity of the flow in the substantially axial flow path is greater than average magnitude of velocity of the flow in the swirling annular flow path.

11. A smoking substitute system comprising:

a main body; and
 a smoking substitute apparatus according to any of the preceding claims.

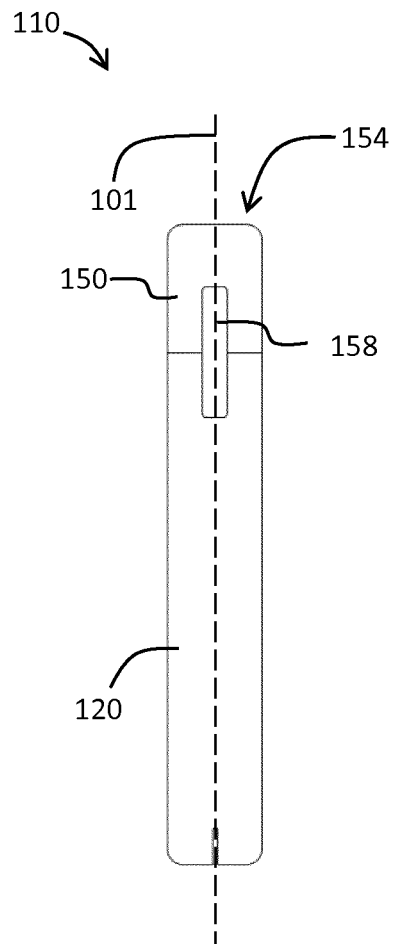


FIG. 1

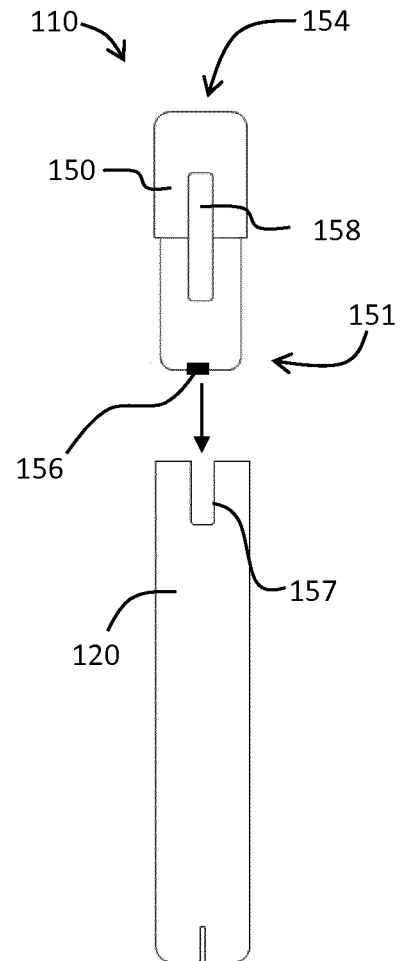
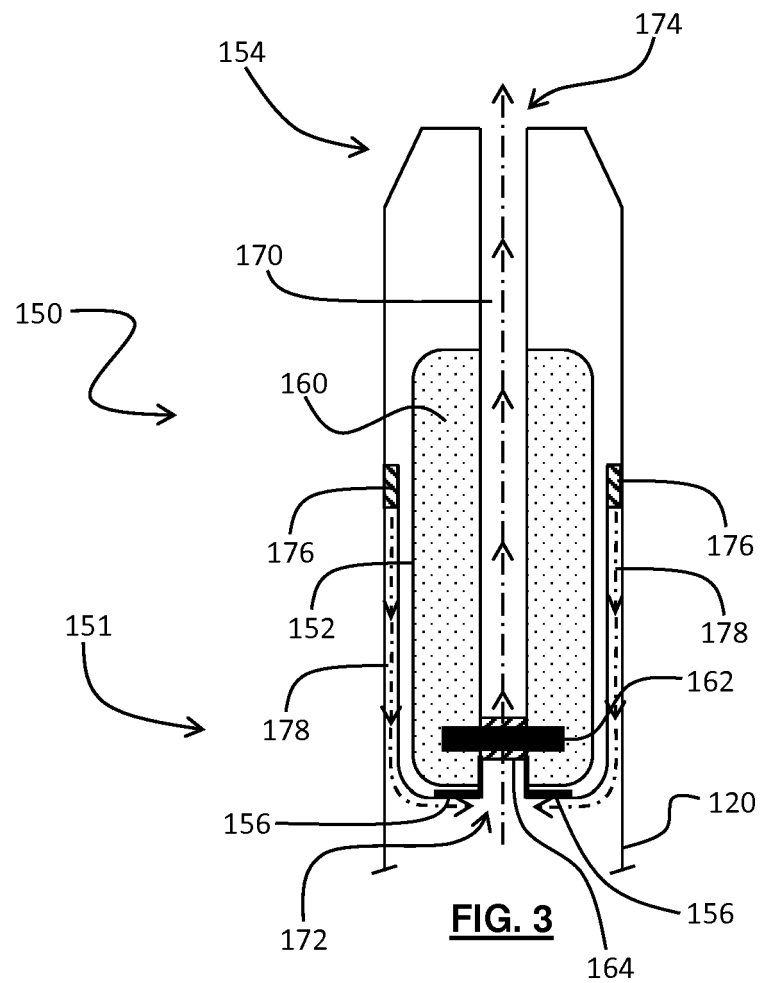


FIG. 2



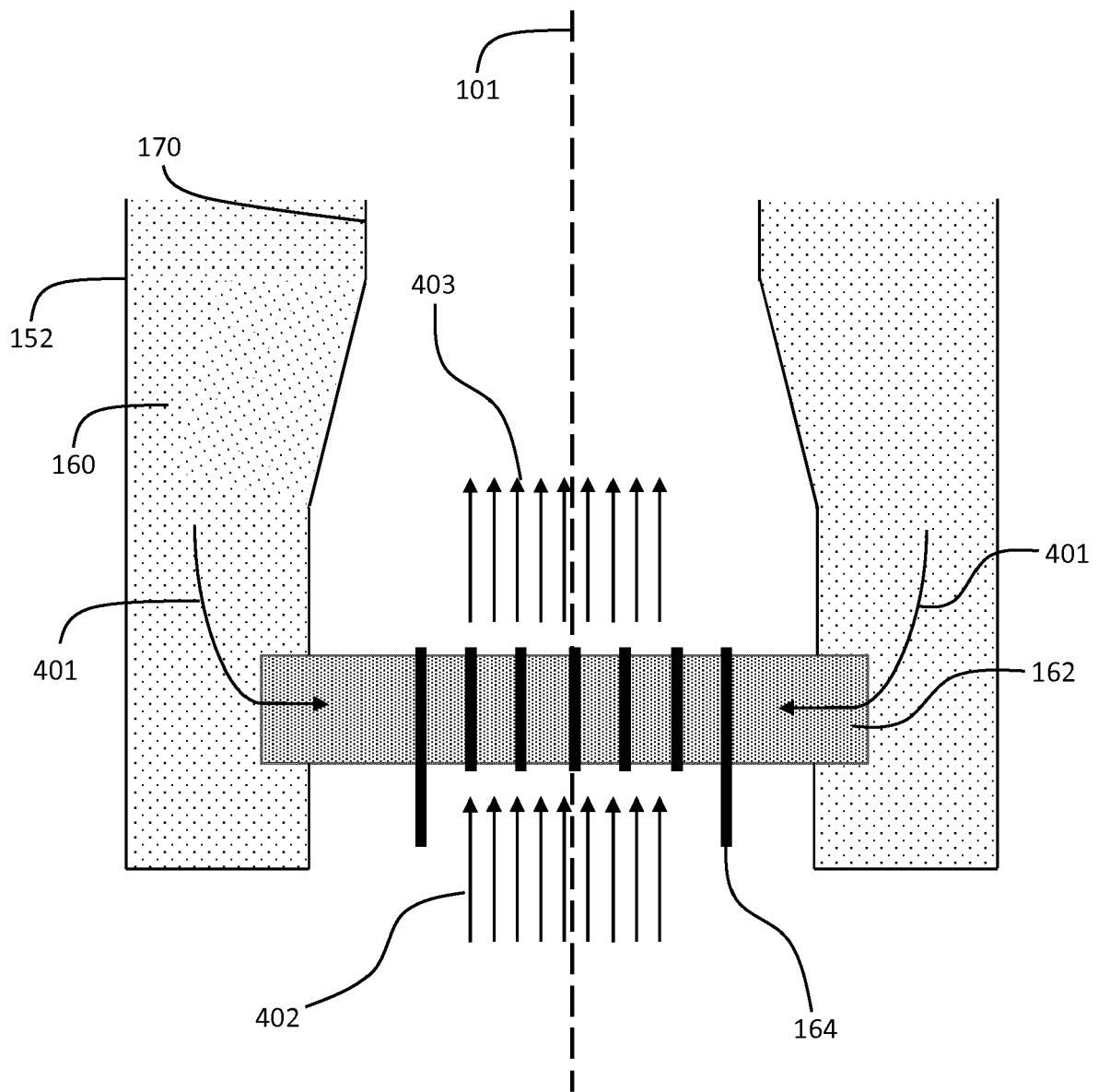


FIG. 4

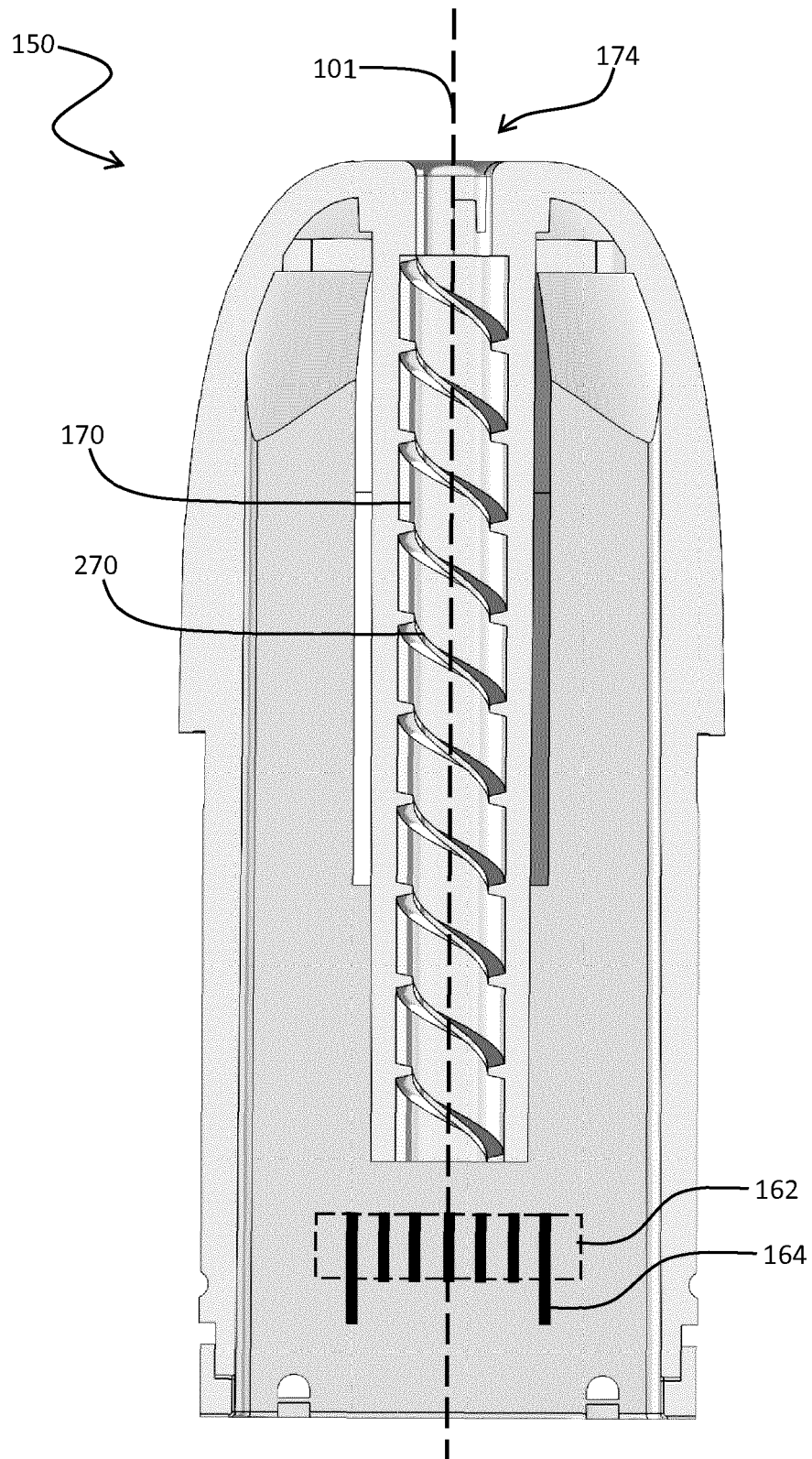


FIG. 5

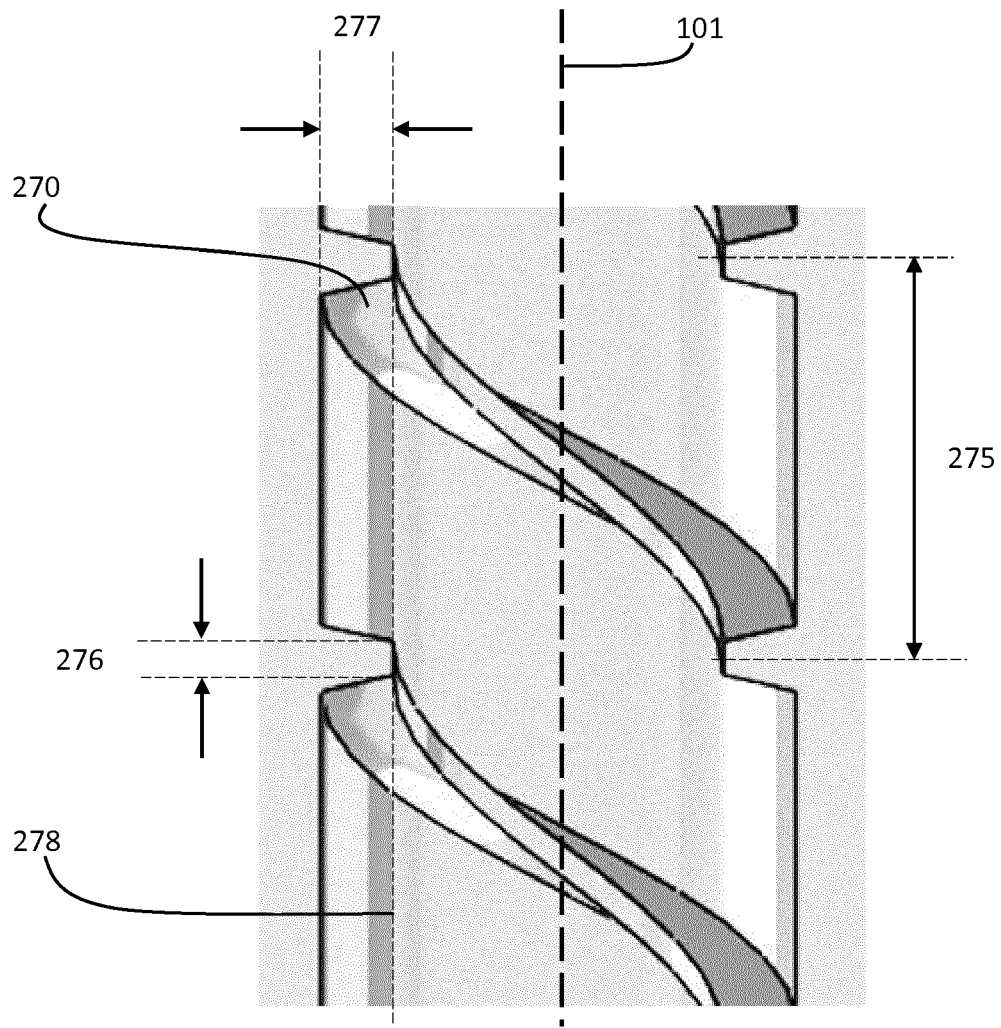


FIG. 6

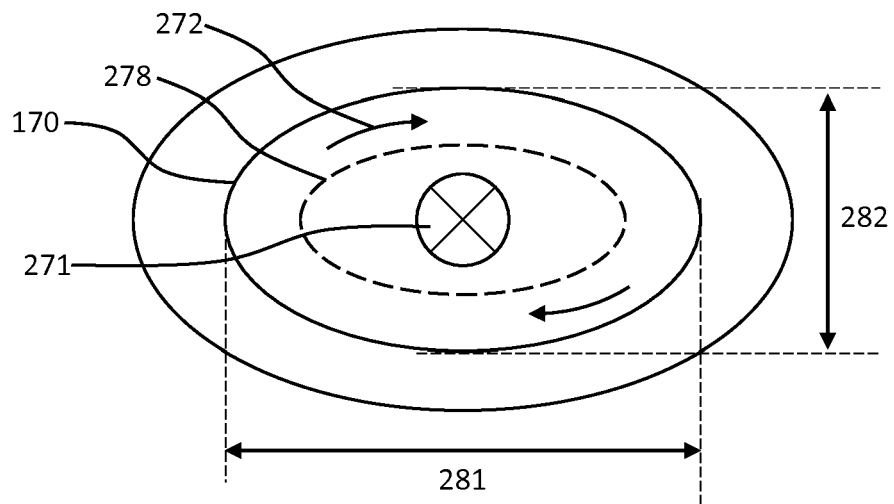


FIG. 7

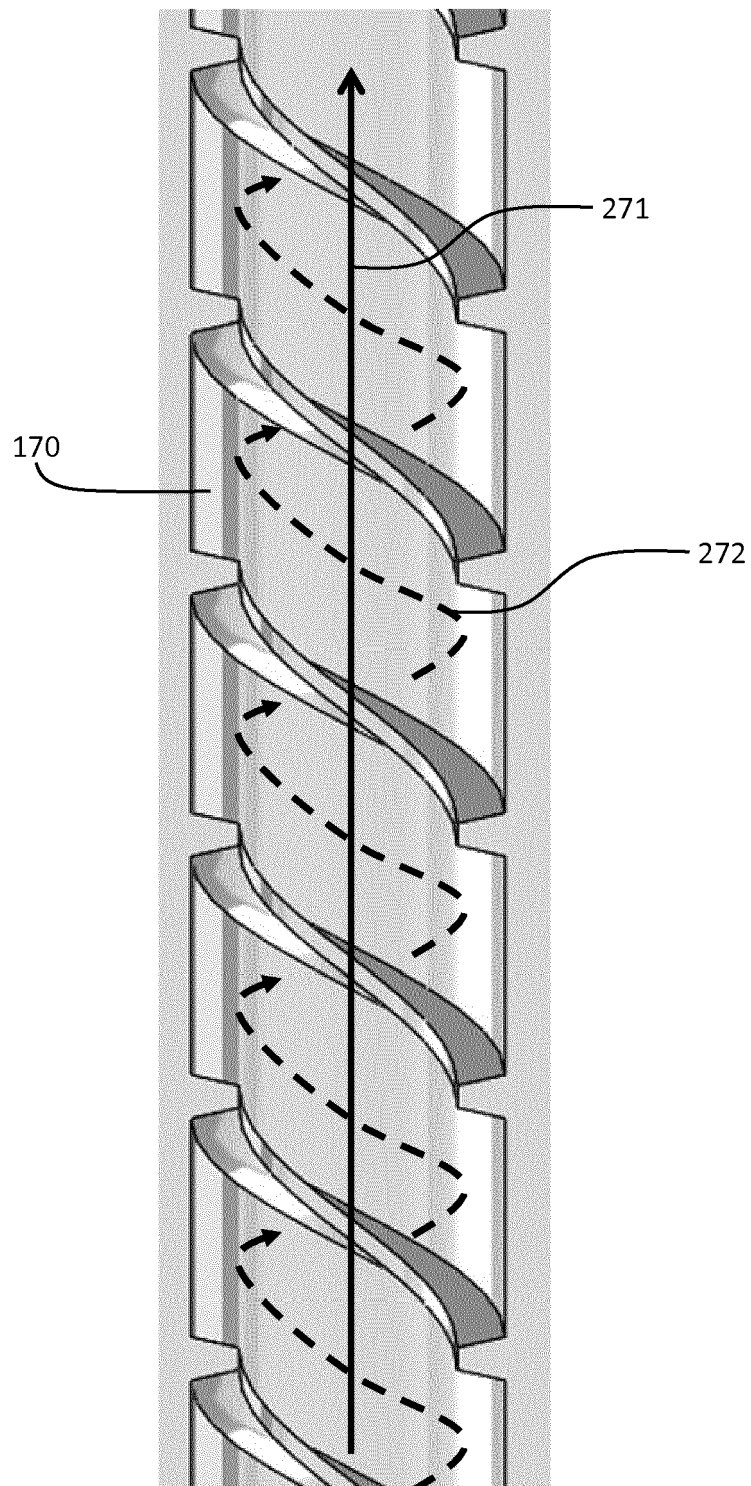


FIG. 8

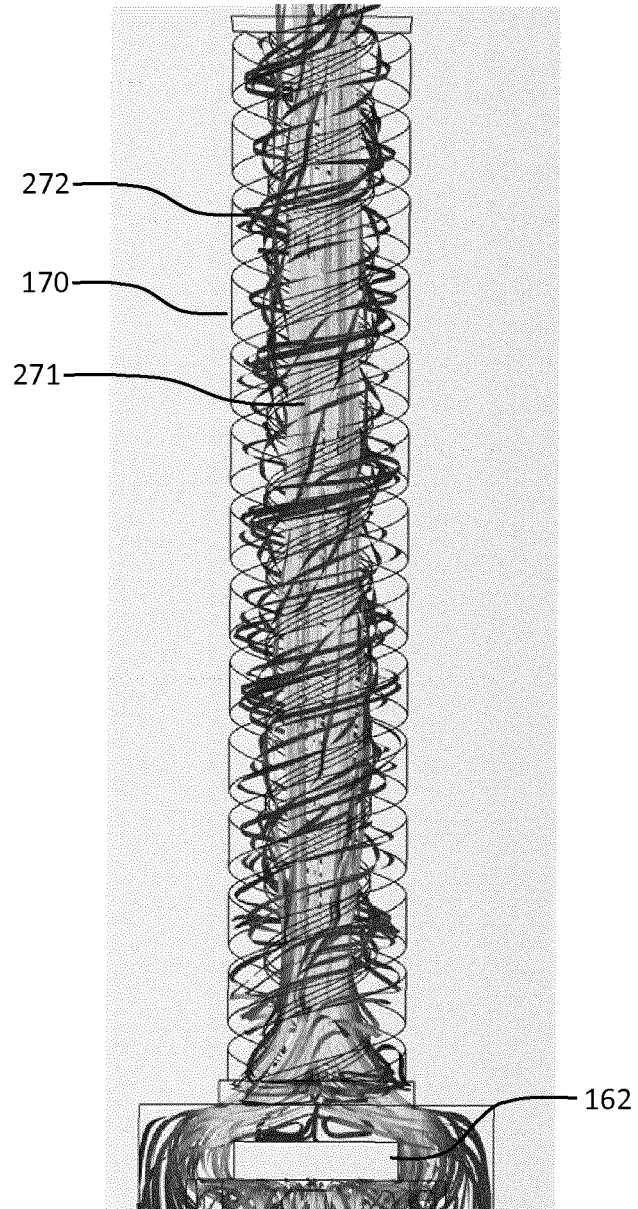


FIG. 9



EUROPEAN SEARCH REPORT

 Application Number
 EP 19 19 8574

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Place of search Munich		Date of completion of the search 25 March 2020	Examiner Caballero Martínez
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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