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(54) A MOUTHPIECE AND HEATER ASSEMBLY FOR AN INHALATION DEVICE

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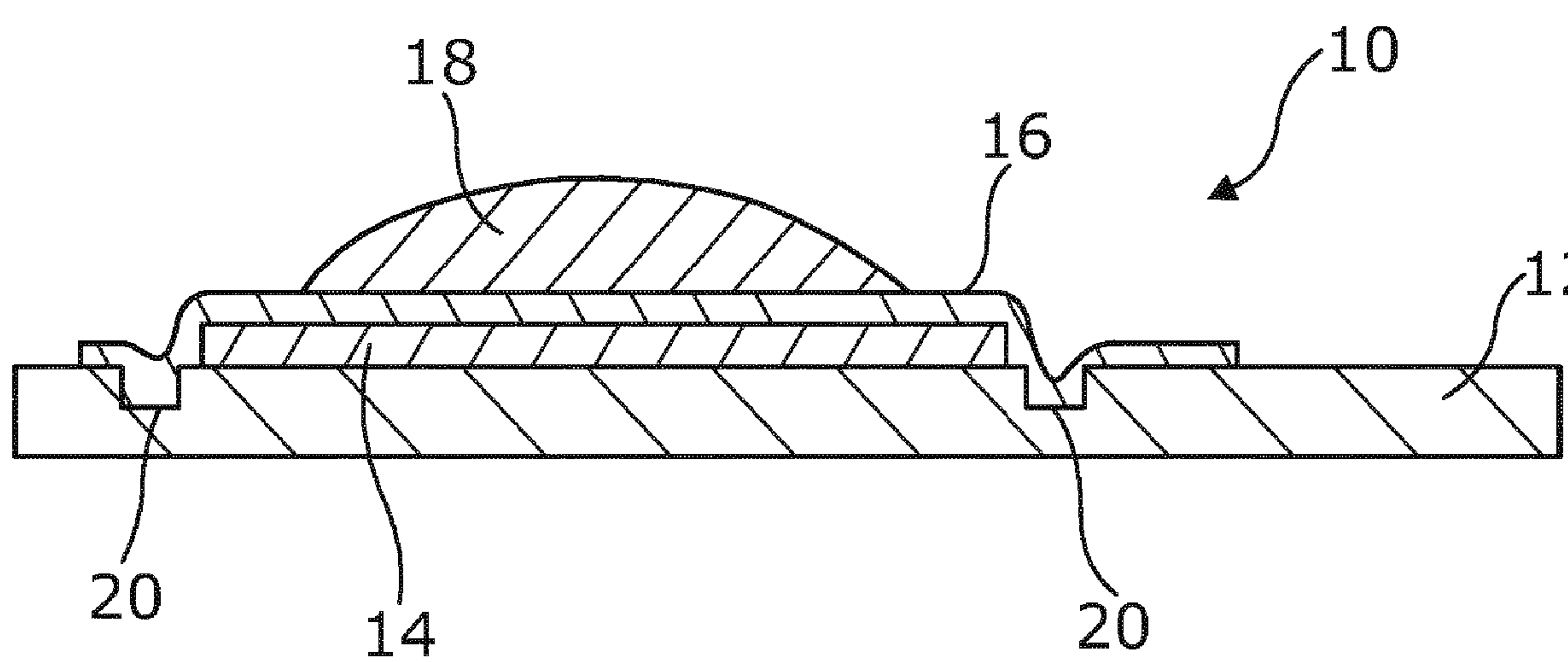
(57) **ABSTRACT**

An inhalation device includes a mouthpiece and a heater having a rigid planar substrate which supports at least one resistive element portion applied over a first region of at least one surface of the substrate, and a pair of contacts each connected to the at least one resistive element portion at one end of the contacts and applied over a second region of the at least one surface of the substrate. The substrate supports an aerosolizable composition deposited on the substrate above the resistive element portion of the heater. The mouthpiece has at least a fluid inlet and a fluid outlet proximate rear and front ends thereof respectively. The heater is disposed within the mouthpiece with at least portions of the contacts being both exposed and accessible so that an electrical connection can be readily achieved when the rear end of the mouthpiece is connected to the inhalation device.



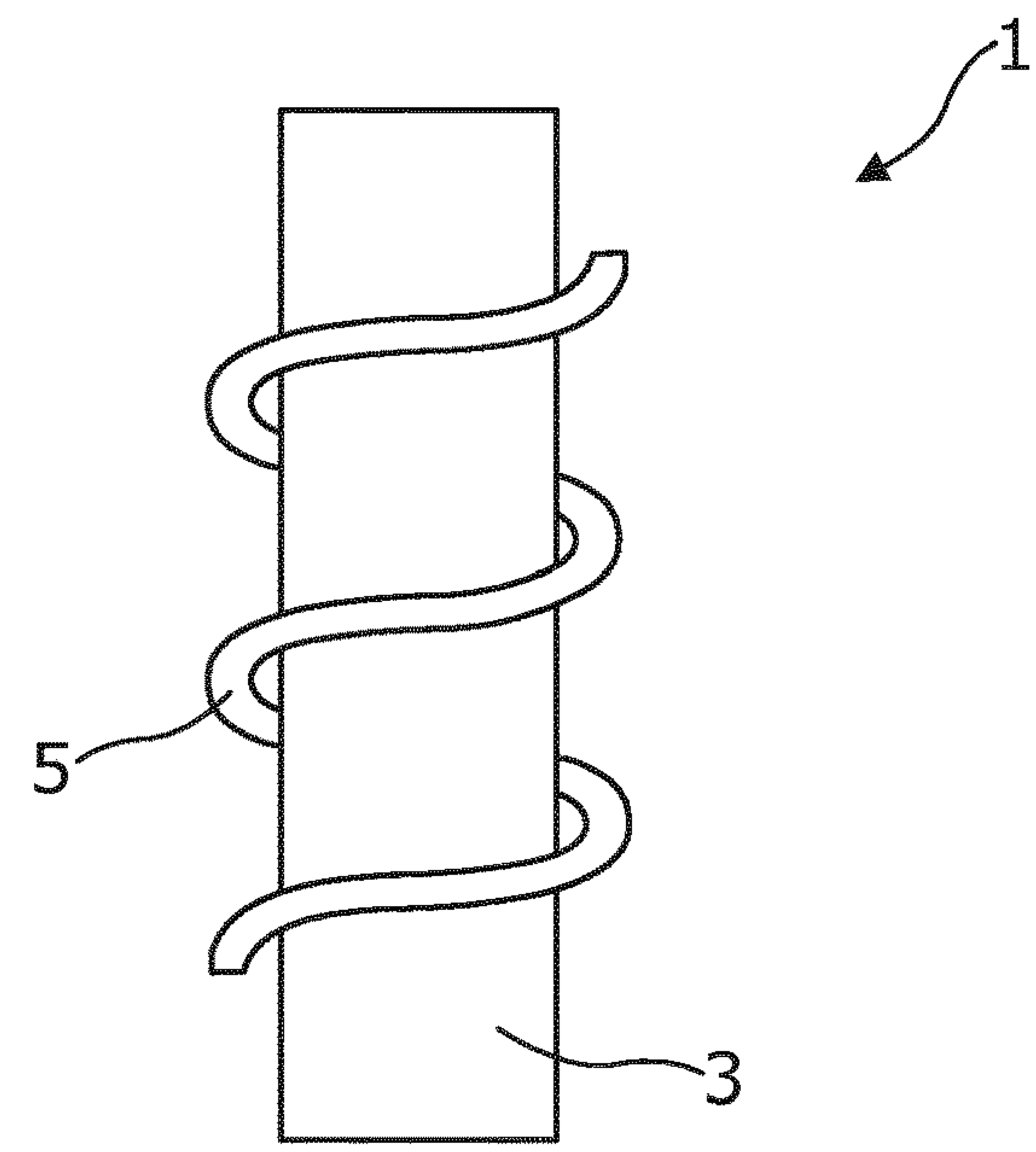


Fig. 1
(Prior Art)

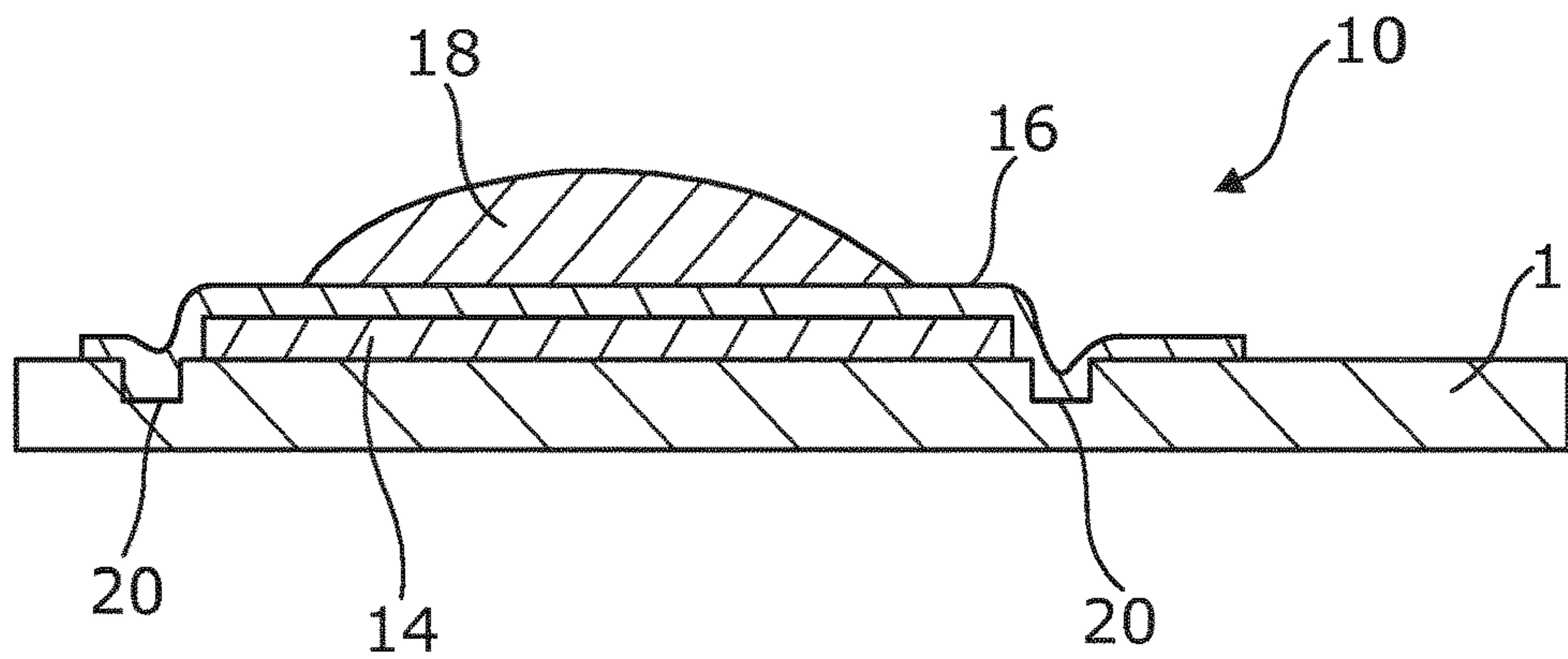


Fig. 2

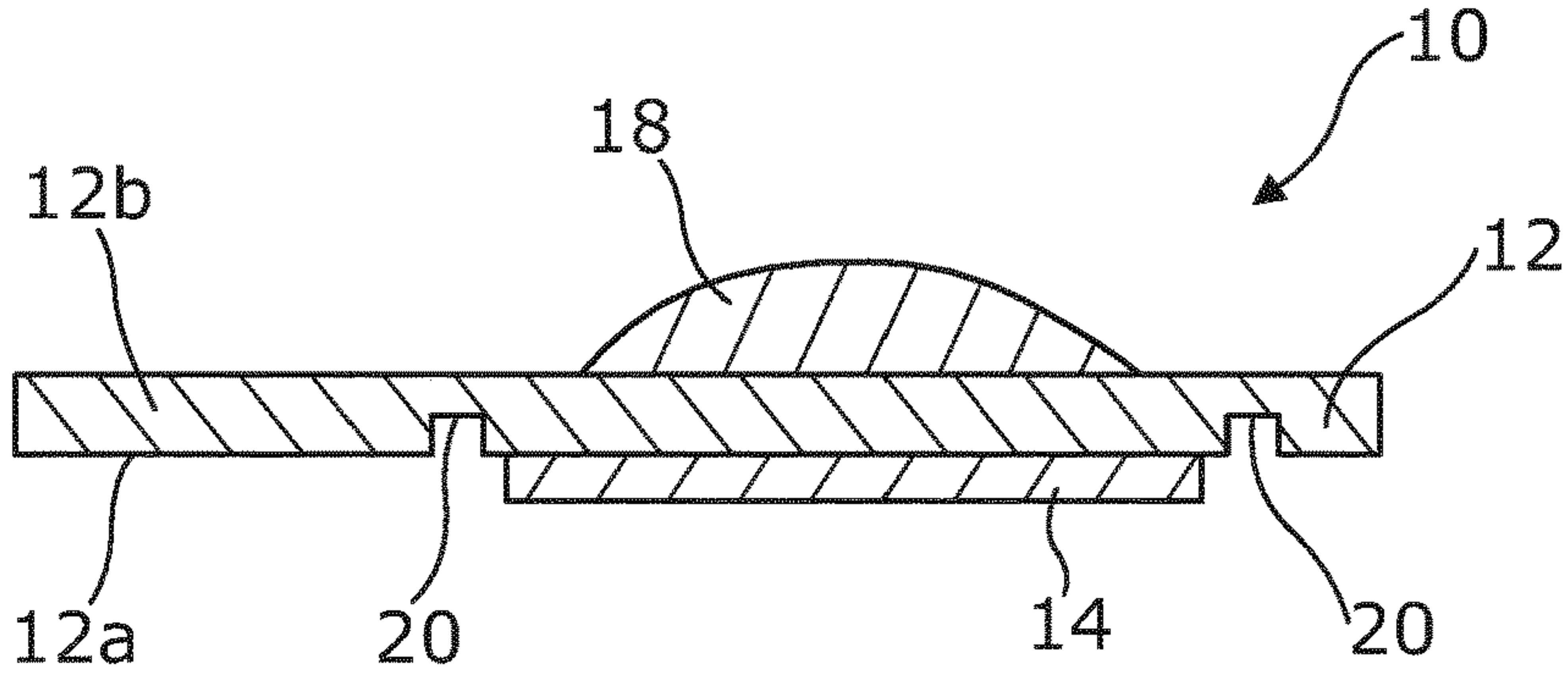


Fig. 2A

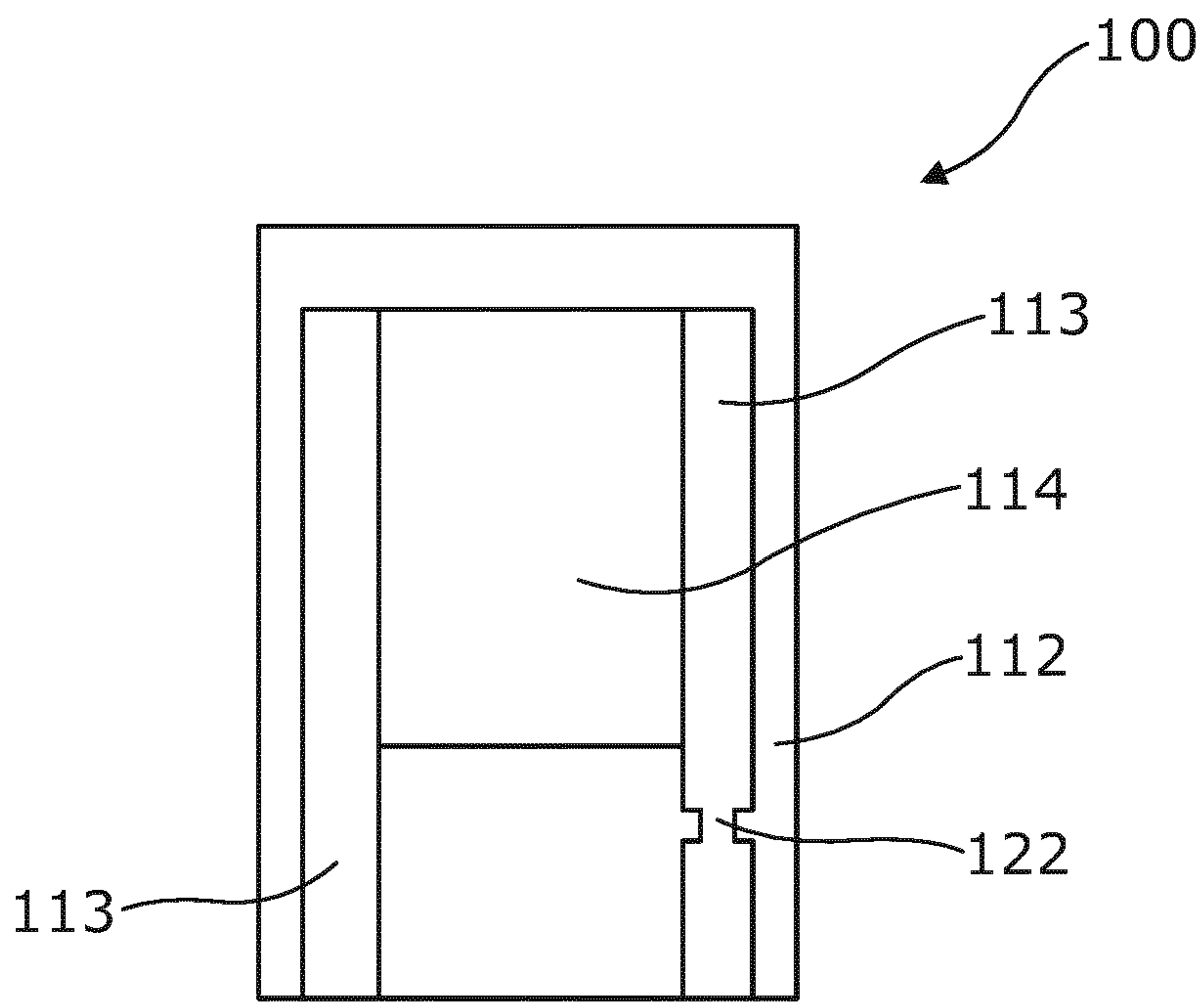


Fig. 3

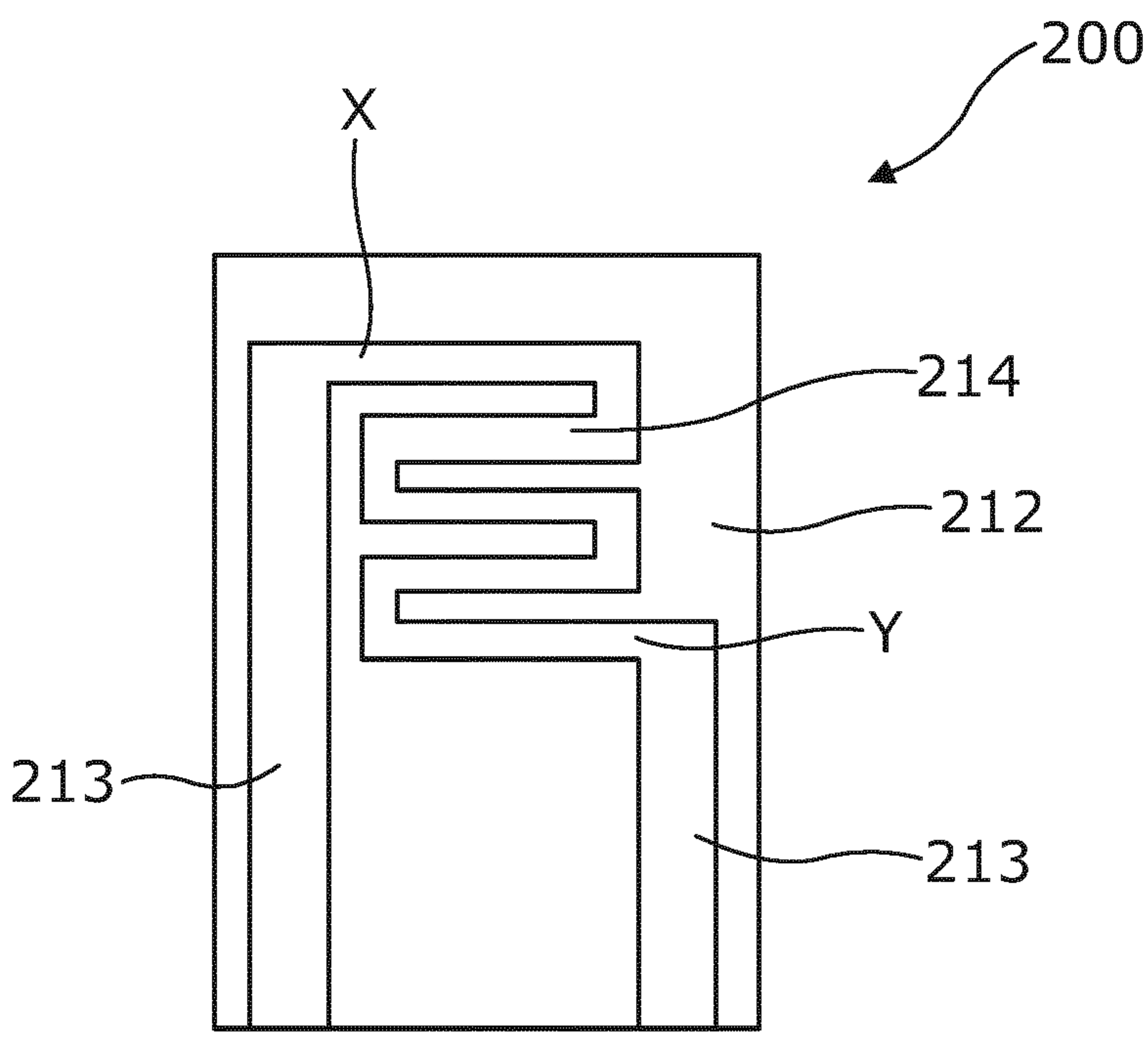


Fig. 4

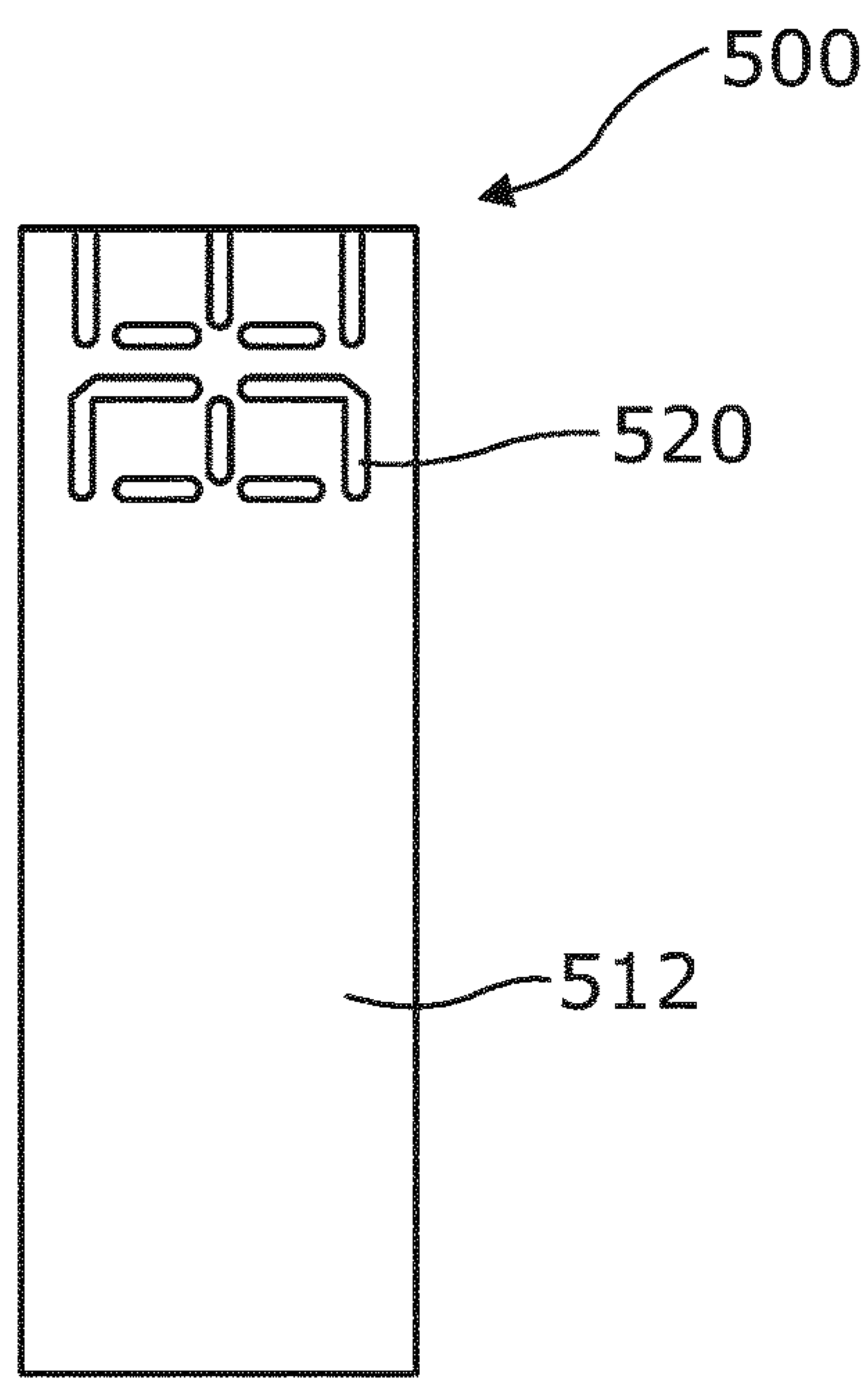


Fig. 5A

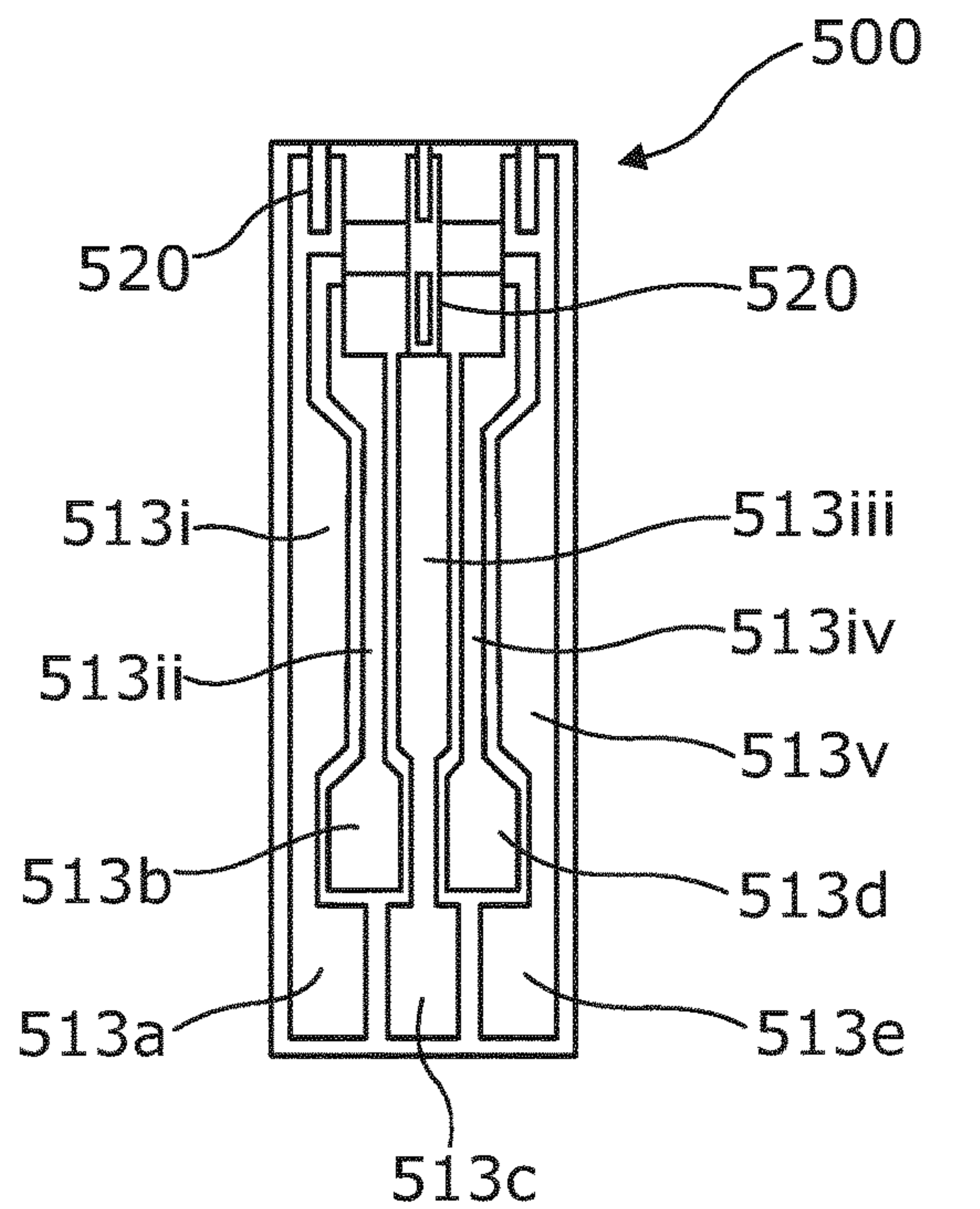


Fig. 5B

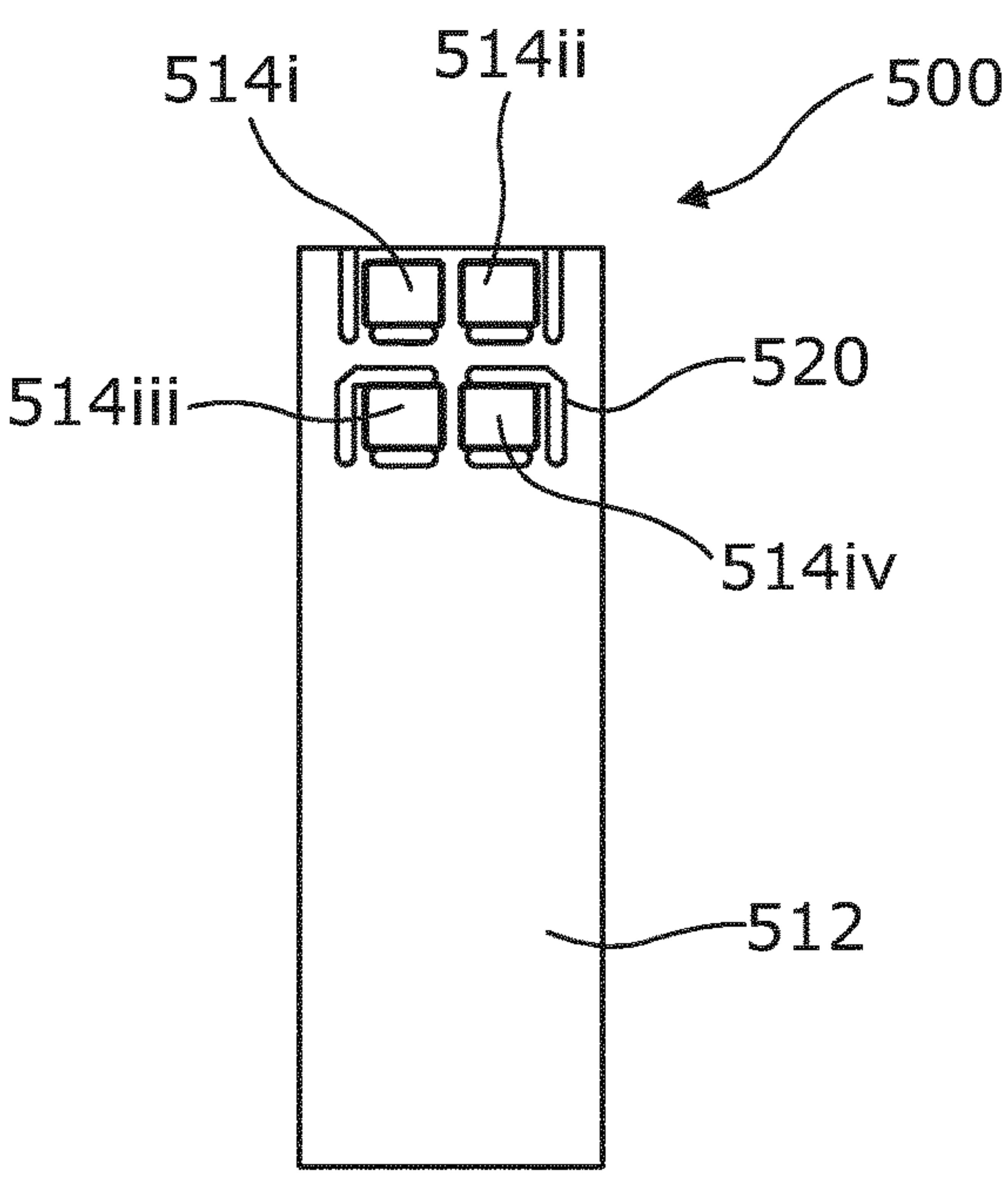


Fig. 5C

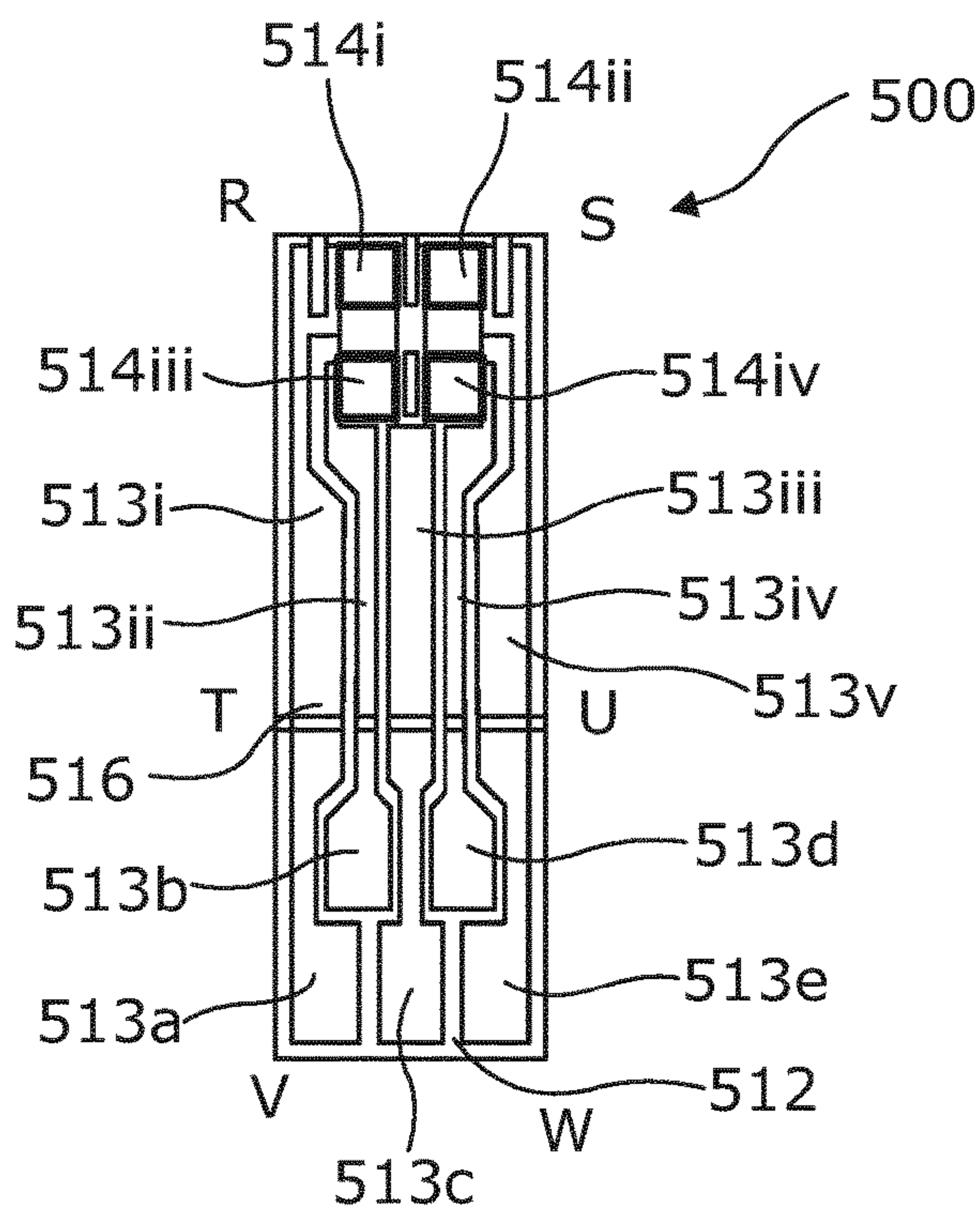


Fig. 5D

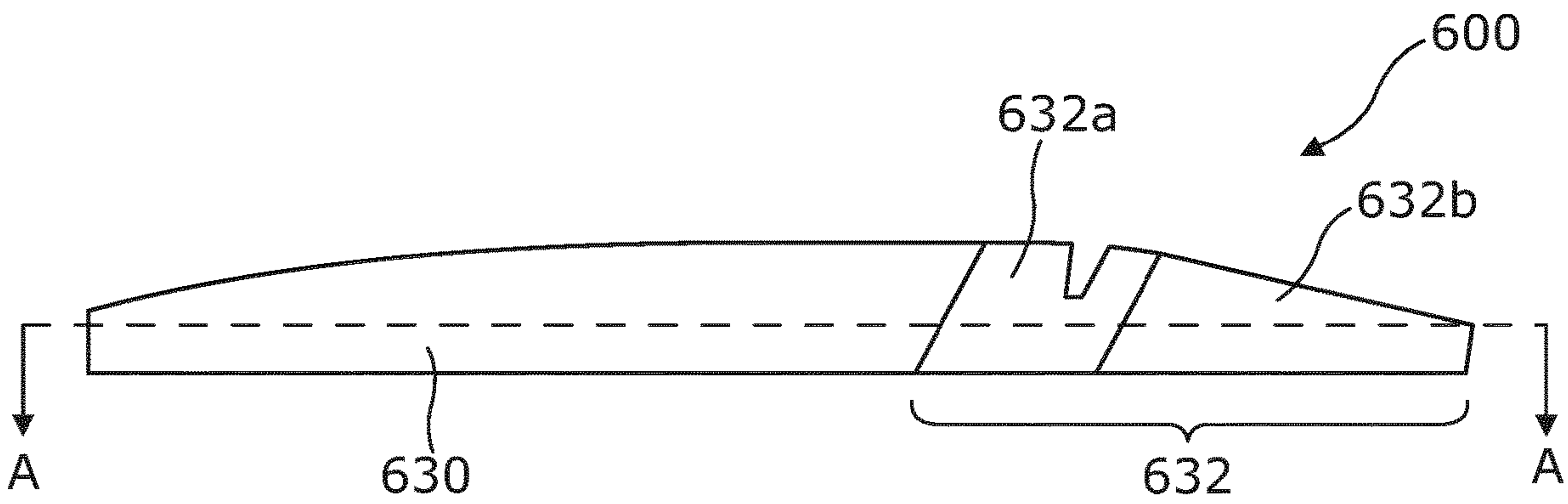


Fig. 6

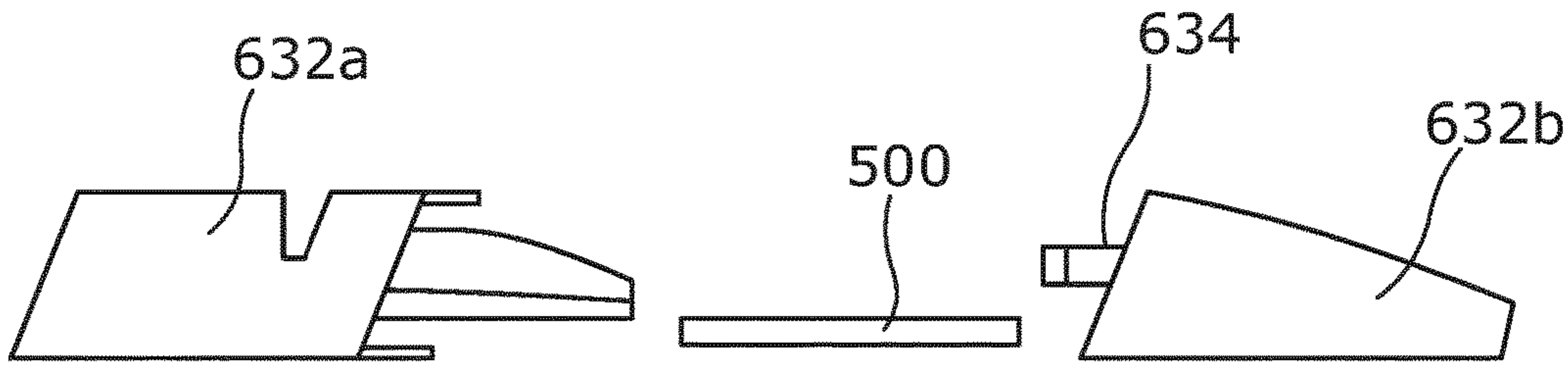


Fig. 7A

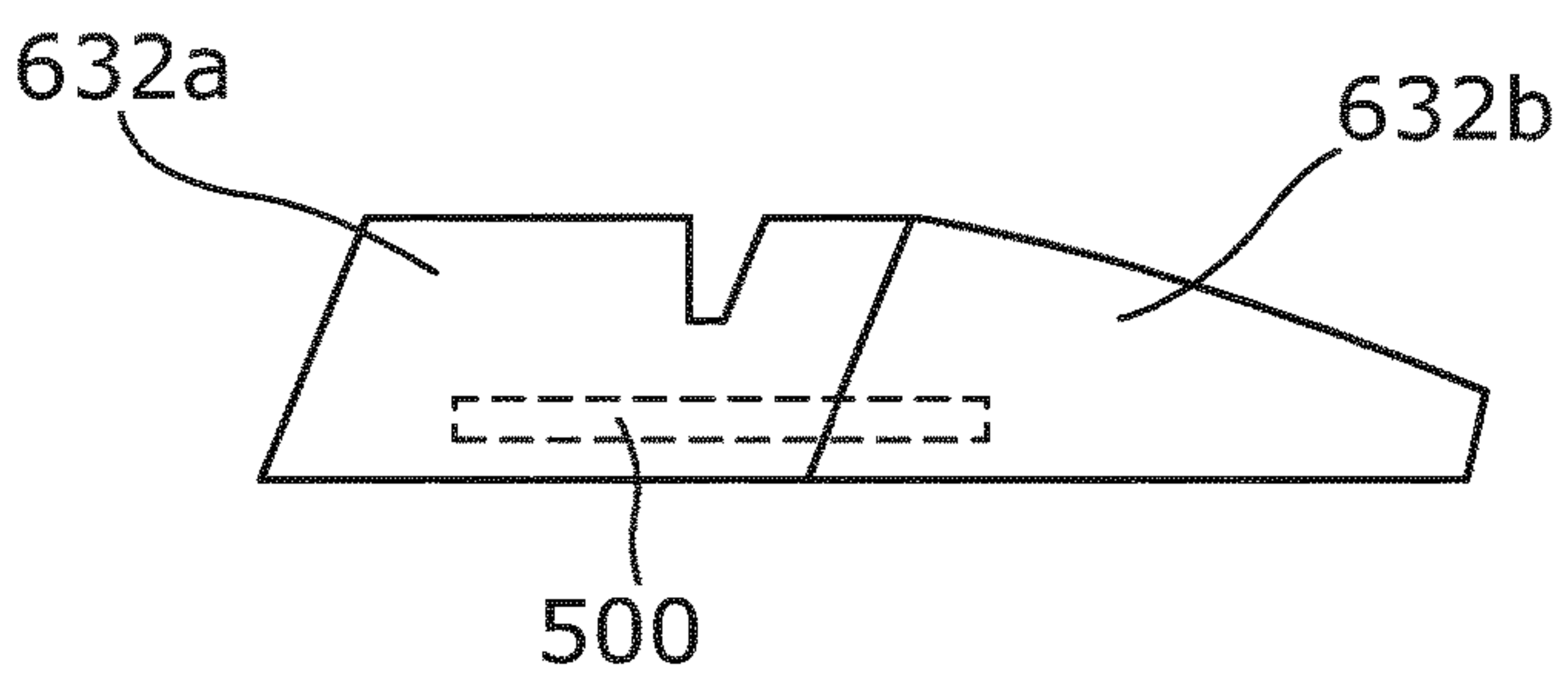


Fig. 7B

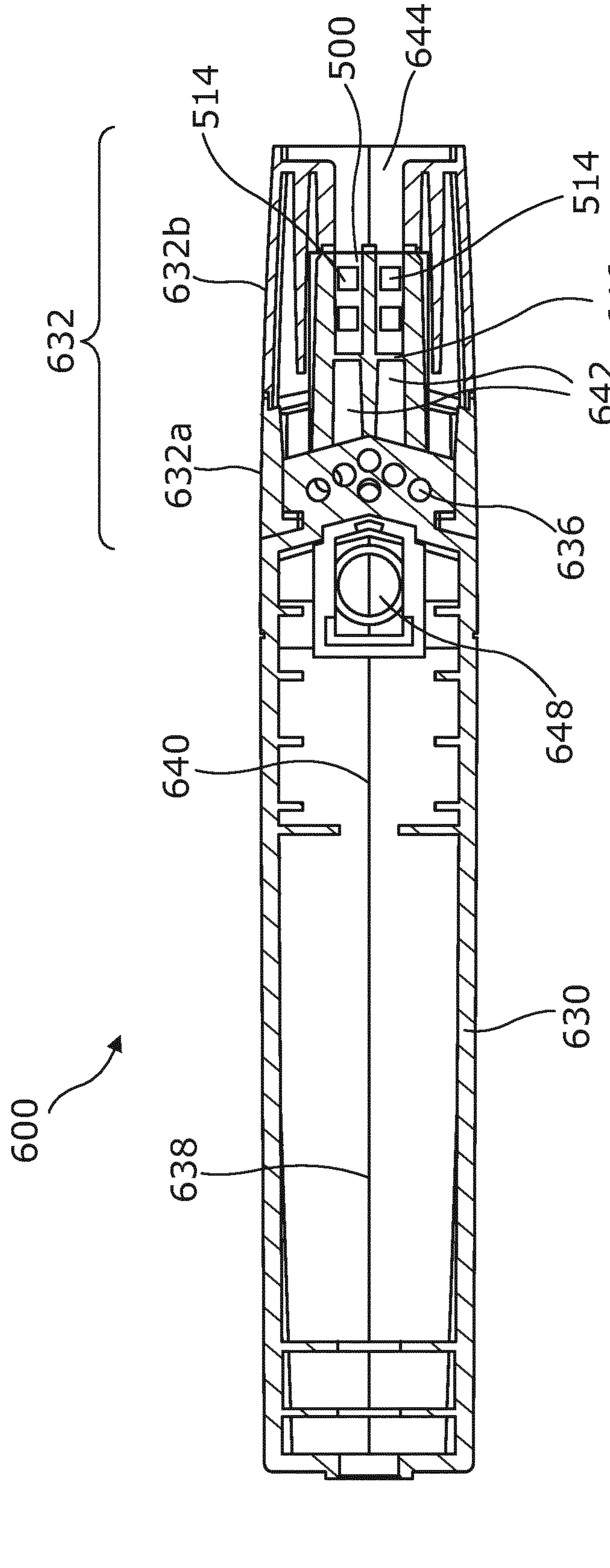


Fig. 8

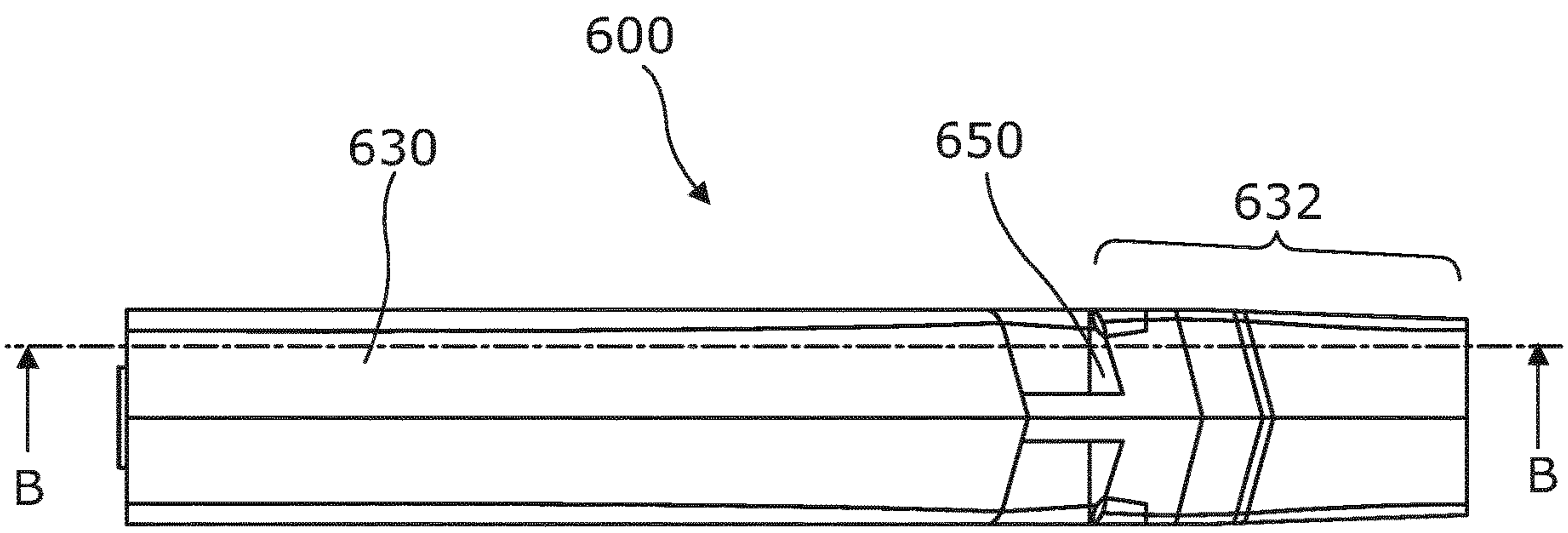


Fig. 9A

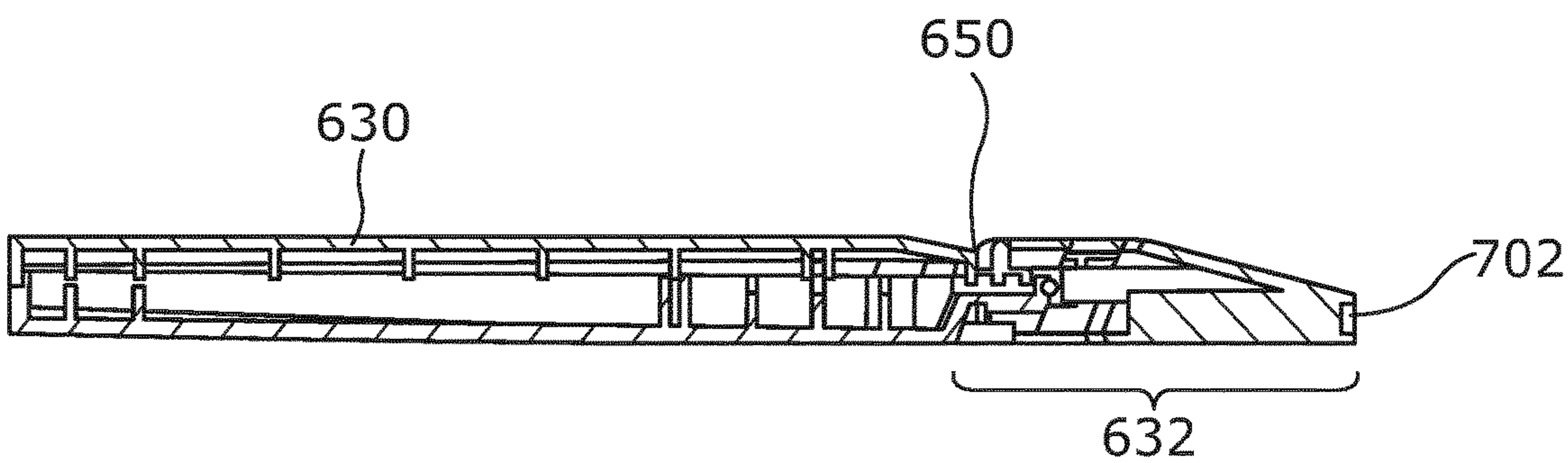


Fig. 9B

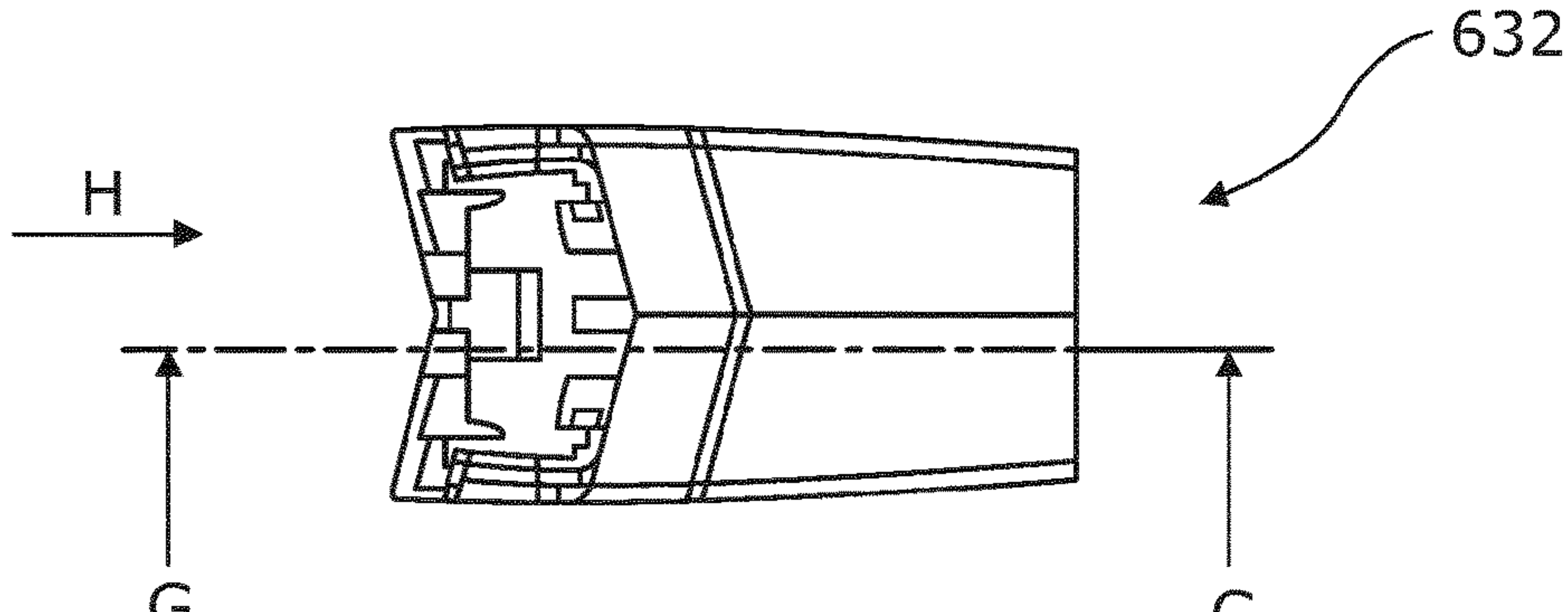


Fig. 10A

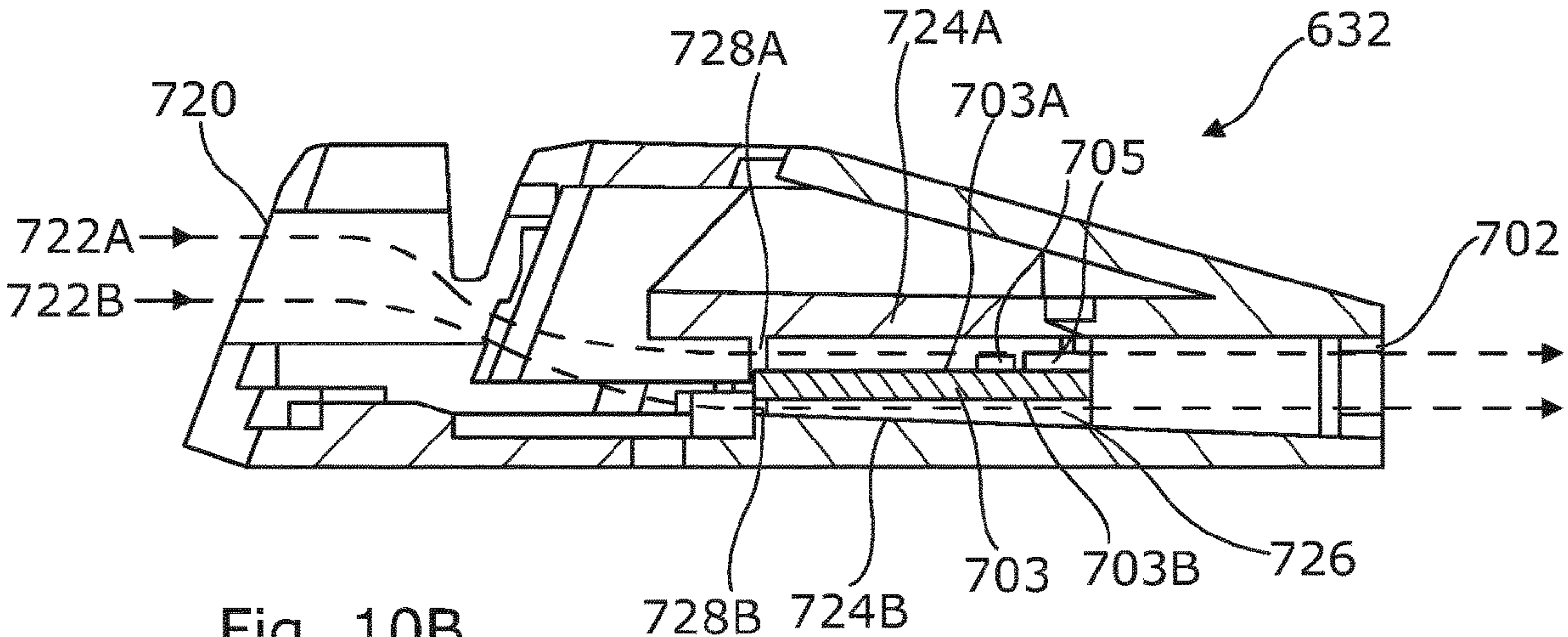


Fig. 10B

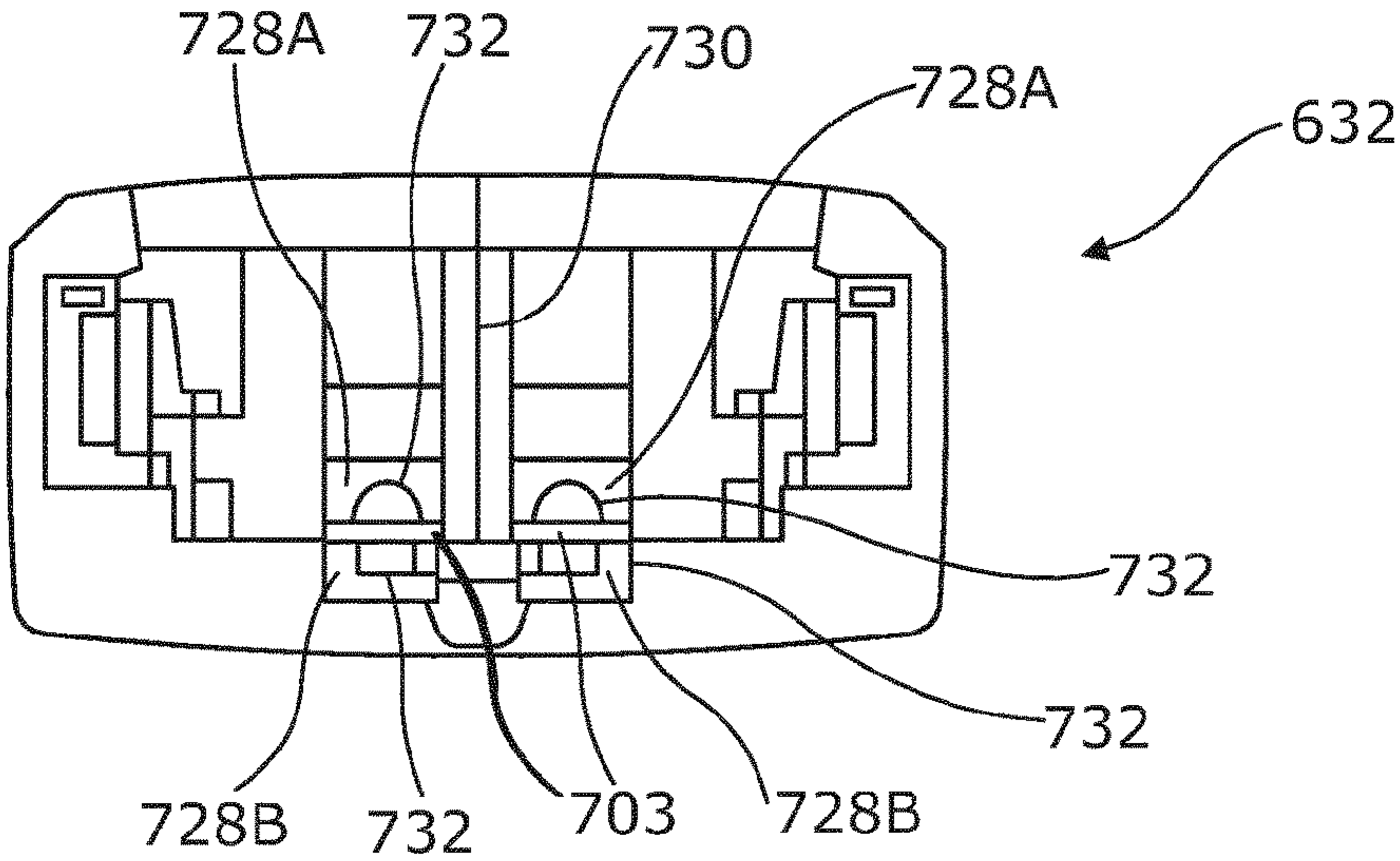


Fig. 10C

A MOUTHPIECE AND HEATER ASSEMBLY FOR AN INHALATION DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a 371 of International Application No. PCT/EP2018/056429, filed on Mar. 14, 2018, which is incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates to a mouthpiece and heater assembly for an inhalation device. The heater is configured to heat a composition to generate an aerosol for inhalation by a user. In particular, but not exclusively, the present invention relates to a heater for a nicotine replacement therapy or a smoking-substitute device. Furthermore, the present invention relates to a mouthpiece comprising the heater, an inhalation device comprising the heater and a method of manufacturing the heater.

[0003] Although the present application will focus on heating compositions containing nicotine for inhalation by user, it will be appreciated that the heater can be used for heating compositions comprising other compounds, for example, medicaments or flavorings.

BACKGROUND

[0004] Nicotine replacement therapies are aimed at people who wish to stop smoking and overcome their dependence on nicotine. One form of nicotine replacement therapy is an inhaler or inhalator, one example of which is sold by Johnson & Johnson Limited under the brand name Nicorette®. These generally have the appearance of a plastic cigarette and are used by people who crave the behavior associated with consumption of combustible tobacco—the so-called hand-to-mouth aspect—of smoking tobacco. An inhalator comprises a replaceable nicotine cartridge. When a user inhales through the device, nicotine is atomized from the cartridge and is absorbed through the mucous membranes in the mouth and throat, rather than travelling into the lungs. Nicotine replacement therapies are generally classified as medicinal products and are regulated under the Human Medicines Regulations in the United Kingdom.

[0005] In addition to passive nicotine delivery devices such as the Inhalator, active nicotine delivery devices exist in the form of electronic cigarette which generally use heat and/or ultrasonic agitation to vaporize/aerosolize a formulation comprising nicotine and/or other flavoring, propylene glycol and/or glycerol into an aerosol, mist, or vapor for inhalation. The inhaled aerosol mist or vapor typically bears nicotine and/or flavorings without the odor and health risks associated with combustible tobacco products, and in use, the user experiences a similar satisfaction and physical sensation to those experienced from combustible tobacco products, particularly as regards exhalation because aerosol mist or vapor is of similar appearance to the smoke exhaled when smoking a conventional combustible tobacco product.

[0006] The skilled reader should appreciate that the term "smoking-substitute device" as used herein includes, but is not limited to, electronic nicotine delivery systems (ENDS), electronic cigarettes, e-cigarettes, e-cigs, vaping cigarettes, pipes, cigars, cigarillos, vaporizers and devices of a similar nature that function to produce an aerosol mist or vapor that is inhaled by a user. Some substitute devices are disposable; others are reusable, with replaceable and refillable parts. The present invention is primarily concerned with the latter, and particularly with "active" devices which require or possess a source of power in order to effect the aerosolization.

[0007] Smoking-substitute devices typically resemble a traditional cigarette and are cylindrical in form with a mouthpiece at one end through which the user can draw the aerosol, mist or vapor for inhalation. These devices usually share several common components: a power source such as a battery, a reservoir for holding the liquid to be vaporized (often termed an e-liquid), a vaporization component such as a heater for atomizing and/or vaporizing the liquid and to thereby produce an aerosol, mist or vapor, and control circuitry operable to actuate the vaporization component responsive to an actuation signal from a switch operative by a user or configured to detect when the user draws air through the mouthpiece by inhaling.

[0008] The most common form of active smoking substitute device is known as a wick-and-coil device, an example of which is schematically depicted in FIG. **1**. The vaporization component comprises a wick (**3**), which may be solid or flexible, saturated in e-liquid with a heating coil (**5**) wrapped around it. The wick-and-coil arrangement is usually disposed inside a fluid-containing reservoir in order that liquid therein can be absorbed by the wick. The complete assembly is often termed a "cartomizer" (being a conflation of the words cartridge and atomizer). In use, an electric current is passed through the coil (**5**) resistively heating it, such heat being transferred to the e-liquid in the wick (**3**) causing it to evaporate. The usually soaked wick (**3**) generally contains more e-liquid than would be vaporized during a single inhalation. This increases the thermal mass of the wick (**3**) and means that the heat generated by the coil (**5**) is unnecessarily expended in heating all of the e-liquid rather than the amount that actually needs to be vaporized. Heating surplus liquid reduces the energy efficiency of the device. Furthermore, the coil (**5**) is spaced apart from the wick (**3**) to prevent the coil (**5**) from burning the wick (**3**). This reduces heat transfer to the wick and means that the coil (**5**) has to be excessively powered to compensate for the radiative dissipation of heat from the coil and inefficiencies of heating a large substrate and volume of liquid. This again reduces the energy efficiency of the device. Moreover, surplus e-liquid and repeated heating to a higher temperature increases the risk that a user will receive a larger dose of nicotine than intended and increases the potential for degradation of both nicotine and excipients.

[0009] Another problem with known e-cigarette heaters is that their design does not lend itself to automation.

[0010] A further problem with known e-cigarettes is that a user can refill their device with e-liquids which are not intended for that device and consequently may have higher levels of nicotine or additives which undergo an adverse reaction upon heating. As a result, a user may be exposed to excessive levels of nicotine or potentially harmful by-products.

[0011] The popularity and use of smoking-substitute devices has grown rapidly in the past few years. Although originally marketed as an aid to assist habitual smokers wishing to quit combustible tobacco, consumers are increasingly viewing smoking substitute devices as desirable lifestyle accessories. Furthermore the change in regulatory paradigm to that of a tobacco harm reduction one has further boosted consumer uptake of these products. This has caused concern that smoking-substitute devices may be becoming attractive to children, young adults and those currently not engaged in consumption of combustible tobacco products. Furthermore, there is on-going scientific debate about the long-terms effects on health from the prolonged use of smoking-substitute devices and concerns, particularly from healthcare professions, regarding the lack of information available to consumers regarding the use of smoking-substitute devices and associated liquids that prevent them from making informed decisions regarding their use. One area of particular concern is the quality and provenance of many e-liquids currently available on the market.

[0012] In response to safety and quality concerns, the European Union has agreed on a revised Tobacco Products Directive (Tobacco and Related Products Regulations 2016). The TPD has introduced regulations applicable to smoking-substitute devices that will:

[0013] limit the risks of inadvertent exposure to nicotine by setting maximum sizes for refill reservoirs, containers, tanks, and cartridges (Article **20.3**(*a*));

[0014] limit the concentration of nicotine in the liquid to 20 mg/ml (Article **20.3**(*b*));

[0015] prohibit the use of certain additives in the liquid (Article **20.3**(*c*));

[0016] require that only high-purity ingredients are used in the manufacture of liquids (Article **20.3**(*d*));

[0017] require that all ingredients (except nicotine) do not pose a risk to human health in heated or unheated form (Article **20.3**(*e*));

[0018] require that all smoking-substitute devices deliver doses of nicotine at consistent levels under normal conditions of use (Article **20.3**(*f*));

[0019] require that all products include child and tamper-proof labelling, fasteners and opening mechanisms (Article **20.3**(*g*)); and

[0020] require that all products meet certain safety and quality standards and to ensure that products do no break or leak during use or refill (penultimate and final sentences, paragraph **41** of the recitals).

[0021] However, even despite the introduction of such nicotine dosing control measures on manufacturers and suppliers of nicotine-containing formulations intended for use in electronic cigarettes, wick-and-coil devices are inherently rudimentary and as a result will always suffer significant variability in dose between inhalations. Furthermore, because such devices require refilling by end users over which legal frameworks such as the TPD above inevitably have little or no control, such end users will always be capable of using their own, possibly adulterated liquid formulations, possibly to the detriment of their own health and that of others.

[0022] Aspects and embodiments of the invention were devised with the foregoing in mind.

BRIEF SUMMARY OF THE PRESENT INVENTION

[0023] In a first aspect, there is provided an assembly for an inhalation device comprising a mouthpiece and a heater, said heater comprising a substrate which supports:

[0024] at least one resistive element portion applied over a first region of at least one surface of said substrate,

[0025] at least a pair of contacts each connected to the at least one resistive element portion at one end of said contacts and applied over a second region of the said at least one surface of said substrate,

[0026] an amount of an aerosolizable composition deposited on the substrate above said first region on said at least one surface thereof or a surface opposite thereto such that heat generated by the resistive heating element is directly or indirectly conducted to the aerosolizable composition to cause at least some aerosolization thereof,

[0027] said mouthpiece being provided with at least a fluid inlet and a fluid outlet proximate rear and front ends thereof respectively, fluid communication means being provided internally of said mouthpiece between said inlet and said outlet,

[0028] characterized in that the heater is disposed substantially within the mouthpiece with at least portions of the contacts being both exposed and accessible to facilitate the making of an electrical connection with said contacts when the rear end of the mouthpiece is connected to said inhalation device, and further characterized in that the substrate surface on which the aerosolizable composition has been deposited is disposed within or adjacent said fluid communication means such that when fluid is flowing therein and aerosolization of the composition is simultaneously occurring, the aerosol generated is entrained in the fluid flowing through said fluid communication means.

[0029] An advantage of using a heater to heat the composition compared to the medicinal inhaler or inhalator devices of the prior art described above is that the formulation can be specifically designed to deliver the compound of interest either to the lung or to the buccal cavity. For compositions containing nicotine, this means that the user experiences an enhanced "hit", i.e. an increased rate of absorption of nicotine. Consequently, this may assist in allaying a craving for nicotine more quickly, with fewer inhalations, thereby helping a user to gradually reduce their intake of nicotine.

[0030] A further advantage of the heater of the present invention compared to, for example, the heater of a conventional e-cigarette, is that the composition can be placed in direct contact with the substrate and thus be conductively heated. Heat is conductively transferred from the resistive element portion directly into the composition. In one particular embodiment in which the heater is applied to one surface of the substrate and the composition applied to another opposite surface of the substrate, but in the same general region thereof as that of the other surface over which the heater is applied, the heat from the heater is first conducted through the material of the substrate before being conductively transferred directly into the composition. In both cases, there is no space for an air gap between the composition and the heater. This means that the heater can vaporize the required amount of liquid at much lower temperatures compared to the wick-and-coil heaters of the prior art. This increases energy efficiency and reduces degradation of the heater.

[0031] When a composition is provided on the heater, the heater is configured to heat the composition so that at least a proportion of the composition vaporizes or aerosolizes. The skilled person should understand that an "aerosolized composition" and cognate expressions thereof appearing herein are not limited to an aerosol per se but may also comprise a proportion of the composition in the vapor phase.

[0032] Furthermore, the amount of composition deposited on the heater can be carefully controlled so that the heater only heats the necessary amount of composition. Therefore, the energy lost, for example, by heating the excess e-liquid in an e-cigarette is eliminated. As a result, the heater of the present invention has a much lower thermal mass and requires less energy to heat than the heaters of the prior art. This benefit combined with lower heated temperatures assists in increasing the efficiency of the device. Furthermore, this avoids the repeated heat-cool cycle observed in e-cigarettes which may lead to in-use instability of formulation and formation of toxicants.

[0033] Preferably, the first region is more proximate a forward or leading edge of the substrate, and the second region more proximate a rearward or trailing edge of said substrate, and the substrate is disposed within the mouthpiece with the rearward or trailing edge substantially adjacent the rear end of the mouthpiece.

[0034] Preferably, at least portions of the contacts are exposed and accessible towards the rear end of the mouthpiece.

[0035] In the embodiment where the composition is deposited on the same surface of the substrate to that to which the heater has been applied, the heater, or the at least one resistive element portion thereof, may further comprise a barrier layer for inhibiting undesirable by-products generated during the heating of the resistive element portions from mixing with the composition.

[0036] Depending on how they are formed, some resistive heaters release undesirable bi-products when they are heated by the application of an electric current. For example, materials or chemicals which are added to the resistive heater during manufacture are sometimes released as volatiles which may react with other chemicals during heating to form potentially harmful by-products. It is preferable that a user does not inhale these by-products. The barrier layer assists in inhibiting undesirable by-products generated during the heating of the at least one resistive heater from mixing with the composition or aerosolized composition by providing a physical barrier or obstacle between the resistive heater and the composition.

[0037] Optionally, the barrier layer may be formed of a material selected from one or more of a ceramic, a plastic and glass. These materials have been found to be suitable at providing an effective barrier layer.

[0038] In an alternative embodiment, where the composition is deposited on an opposite surface of the substrate to that to which the heater has been applied, the substrate itself provides a barrier to prevent undesirable by-products of heating from mixing with the composition.

[0039] The heater may comprise at least two contacts supported by the substrate, wherein a first end of each of the at least two contacts is connected to the resistive element portion and a second end of each of the at least two contacts is arranged to be connectable to an electric power source. This allows the second end of each of the two contacts to be connected to a power source which is separate or remote from the substrate. For example, the second ends could form part of a connector which is configured to connect to a complementary connector that in turn is connected to a power source.

[0040] The application of the resistive element portion and the contacts to one or other surface of the substrate may be achieved by a variety of different techniques, such as screen printing, thin and/or thick film printing, laser ablation, or some combination of these techniques. An advantage of printing the resistive element portion and/or contacts is that it is cost-effective and automatable, which contrasts with the slow manual process of winding a coil around a wick.

[0041] Optionally, the at least one resistive element portion and contacts may be formed of the same material but the at least one resistive element portion has a smaller cross-sectional area than the contacts such that it has a higher resistance. This allows the resistive element portion and contacts to be deposited in a single print run.

[0042] Optionally a part of the material deposited during the single print run may be ablated, for example by laser etching, to form at least one resistive element portion having a region of reduced cross-sectional area such that the region of reduced cross-sectional area has a relatively higher resistance than the remainder of the material. This step reduces the printing step to a single print run over the entire area to be occupied by the resistive element portion such that any detail or finishing required can be provided later by the ablating step.

[0043] Alternatively, the at least one resistive element portion and contacts may comprise different materials and be deposited on the substrate using separate print runs. This provides flexibility in the process and allows the properties of the resistive element portion and conductors to be modified by modifying the proportions of various material constituents contained therein.

[0044] The at least one resistive element portion may have a length longer than the straight-line distance between the points where the at least one resistive element portion is connected to the contacts. This increases the resistance of the resistive element portion. The resistance of the resistive heater can be controlled by changing the length of the resistive element portion.

[0045] Optionally, the at least one resistive element portion may follow a meandering path between the conductors. This has been found to provide a space-efficient configuration of the at least one resistive element portion.

[0046] Optionally, the at least one resistive element portion comprises one of carbon or other elements such as silver, ruthenium, palladium. Carbon has been found to have suitable resistive properties for the heater of the present invention. Silver on the other hand has a relatively high temperature coefficient of resistance compared to carbon, and the use of resistive element portions comprising silver results in a greater increase in resistance compared to the use of carbon alone. This makes it easier to monitor changes in resistance and hence the temperature of the resistive element portion.

[0047] Optionally, the heater resistive element portions may have a resistance of between 5 ohms and 15 ohms at a temperature of 130° C. This has been found to be a particularly suitable resistance for the resistive element portions and the temperature represents a relatively low operating temperature compared to, for example, a conventional e-cigarette. This resistance range also enables energy to be input to the heater using a standard lithium polymer battery whilst enabling differentiation in resistances between temperatures.

[0048] The heater may comprise a plurality of resistive element portions and a corresponding number of contacts. This provides flexibility as to which heaters are activated at any one time.

[0049] Optionally, the conductors may comprise a contact for each of the plurality of resistive element portions and a further contact which forms a common ground for each of the plurality of resistive elements portions. This provides a space-efficient arrangement on the substrate.

[0050] The substrate may be substantially rigid, and substantially planar. This assists in reducing deformation of the substrate during heating of the resistive element portion and allows a force to be applied to the substrate to help with inserting the substrate into an inhalation device.

[0051] Optionally, the substrate may comprise a material selected from one or more of a ceramic, a plastic or glass. These materials have been found to be particularly suitable for the substrate of the present invention at least in terms of their thermal and mechanical properties.

[0052] The substrate may comprise an indentation, formed for example by laser cutting, in the region surrounding the at least one resistive element portion or plurality of resistive element portions. The indentation reduces the cross-sectional area of the substrate in the region surrounding the resistive element portion thereby reducing heat transfer away from the resistive element portion through the substrate. This reduces the thermal mass (i.e. the amount of the substrate which needs to be heated during a heating cycle) of the part the substrate underlying the resistive heater, which means that less energy is required to heat this part of the substrate. Accordingly, the energy efficiency of the heater is increased. The indentation may also serve to prevent migration of formulation from the resistive heater area.

[0053] The at least one resistive element portion or at least one of the contacts may have a region of reduced cross-sectional area such that the reduced cross-sectional area region acts as a fuse which fails if the electric current flowing through the reduced cross-sectional area region exceeds a certain threshold value. The fuse acts as a safety device which prevents overheating of the heater. The fuse also acts as a failsafe in the event other safety precautions fail, for example, in the event the electronic or software control of an aerosol generation device fails. This assists in the heater complying with the strict safety regulations in place for medical devices.

[0054] The deposition of the aerosolizable composition on the substrate may occur at the time of manufacture using, for example, screen printing techniques such that the substrate is provided both with a heater and already charged with a composition to be aerosolized. The composition could comprise a predetermined number of doses. Optionally, the composition may comprise nicotine.

[0055] The mouthpiece may comprise first and second parts, which may be detachably connected to one another. The first mouthpiece part may include a slot or recess to receive the heater. The heater may be held in place within the first mouthpiece part by the attachment of the second mouthpiece part thereto. The attachment of the first and second mouthpiece parts may be achieved by means of snap fit connectors provided one or both of the first mouthpiece part and the second mouthpiece part. The mouthpiece is ideally releasably attachable to the main body part.

[0056] In most preferred embodiments, the fluid communication means provided internally of the mouthpiece which connects the inlet with the outlet, and the at least one resistive element portion of the heater is arranged in the vicinity of an outlet of said airflow channel. This reduces the length and/or surface area of the airflow channel on which the aerosolized composition could condense, if indeed an aerosolized composition has time to reach the internal surfaces of the airflow channel before exiting through the outlet.

[0057] The airflow channel may comprise rails for holding the heater within the interior of the airflow channel. The airflow channel may comprise first and second portions between which the heater may be disposed such that air flowing within the first portion flows over and above the surface of the heater on which the composition has been deposited, and air flowing within the second portion flows underneath the heater, beneath and over the opposite surface of the substrate to that one which the composition has been deposited.

[0058] The first and/or second airflow channel portion may be defined by at least one flat surface, which assists in creating a laminar airflow past the heater thus inhibiting the aerosolized composition from contacting the internal surfaces of the airflow channel.

[0059] The airflow channel may include a constriction orifice for restricting the flow of air therewithin. Employing a constriction orifice within the airflow channel results in a pressure drop within the airflow channel and may permit the velocity of the airflow to be controlled more accurately (e.g. by the Venturi effect) in the region of the constriction orifice allowing airflow over the heater to travel faster compared to the airflow entering the mouthpiece. The constriction orifice also restricts the flow of air through the airflow channel which provides a similar user experience to inhaling through a conventional cigarette.

[0060] Optionally, the constriction orifice may be located upstream of the heater. This provides time and space to assist the turbulent air exiting the constriction orifices in returning to laminar flow by the time it passes over the heater.

[0061] Optionally, both the first and second airflow channel portions may comprise a constriction orifice, and ideally the dimensions and fluid flow characteristics are selected such that the airflows in the first and second airflow channel portions are similar, i.e. air flowing in a channel portion is travelling at generally the same speed and mass flow rate.

[0062] The mouthpiece and heater assembly may together form a replaceable consumable item which, when new, comes already charged with a composition, and which can be simply disposed of when all the composition initially present has been aerosolized and the consumable item is thus spent.

[0063] In a further aspect of the present invention, there is provided an inhalation device comprising the above-described mouthpiece and heater assembly, a main body part, the main body part comprising: a power source for the device; and a control unit.

[0064] Such an inhalation device may provide controlled and accurate dosing, would require minimal maintenance (e.g. no cleaning of the mouthpiece is necessary), and would be more hygienic (e.g. reduces build-up of residues from previous use within the inhalation device). Such an inhalation device may also maintain a more consistent level of performance (e.g. avoid blockages within the mouthpiece) since the mouthpiece can be replaced.

[0065] The main body part of such an inhalation device may additionally include a fluid inlet and fluid outlet in communication with one another, the latter of which cooperates with the fluid inlet of the mouthpiece when connected to the main body part thus completing the airflow channel.

[0066] Optionally, the main body part fluid inlet may be located proximate the end of said main body part free to which the mouthpiece is attached.

BRIEF DESCRIPTION OF THE DRAWINGS

[0067] One or more specific embodiments in accordance with aspects of the present invention will be described, by way of example only, and with reference to the following drawings in which:

[0068] FIG. **1** is a schematic diagram of a prior art e-cigarette wick-and-coil heater.

[0069] FIGS. **2** and **2**A provide cross-sectional views of heaters in accordance with different embodiments of the present invention wherein an amount of a composition is deposited on, firstly, the same surface of the substrate as that over which the heater is applied, and secondly on the opposite surface as that over which the heater is applied.

[0070] FIG. **3** is a schematic plan view of a heater in accordance with an embodiment of the present invention.

[0071] FIG. **4** is a schematic plan view of a heater in accordance with another embodiment of the present invention.

[0072] FIGS. **5**A-**5**D are plan views of a heater in accordance with an embodiment of the present invention during various stages of manufacture.

[0073] FIG. **6** is a side view of an inhalation device in accordance with an embodiment of the present invention.

[0074] FIGS. **7**A and **7**B are side views of a mouthpiece for the device of FIG. **6** shown in disassembled and assembled form respectively.

[0075] FIG. **8** is a cross-sectional view of the device of FIG. **6** taken along the line A-A in FIG. **6**.

[0076] FIG. **9**A is a plan view of the inhalation device of FIG. **6**,

[0077] FIG. **9**B is a cross-sectional side view of the inhalation device along the line B-B in FIG. **9**A.

[0078] FIG. **10**A is a plan view of the mouthpiece according to one or more embodiments of the present invention.

[0079] FIG. **10**B is a cross-sectional side view of the mouthpiece along the line G-G in FIG. **10**A.

[0080] FIG. **10**C is a rear view of the mouthpiece viewed in the direction of arrow H in FIG. **10**A.

DETAILED DESCRIPTION OF THE INVENTION

[0081] FIG. **2** shows a heater **10** for an inhalation device according to the present invention comprising a substrate **12** and a resistive heating element **14**, which is supported by a portion of the substrate **12**. The resistive element portion is connectable to an electric power source (not shown) by means of contacts (not shown). A barrier layer **16** overlies the resistive element portion **14** and part of the substrate **12**. The heater **10** is shown with an amount of composition **18** which has been deposited on the barrier layer **16**.

[0082] When an electric current flows through resistive element portion **14** the temperature of the resistive element portion **14** increases and heat is transferred through the barrier layer **16** to the composition **18**. At least a portion of the composition **18** vaporizes and is dispersed into the air above the heater **10**. As the composition **18** evaporates away from the heater it cools and some of the vaporized composition condenses to form liquid droplets of composition suspended in air, i.e. an aerosolized composition. This aerosolized composition can be inhaled by a user.

[0083] The barrier layer **16** provides a seal over the resistive element portion and part of the substrate, which inhibits undesirable by-products that may be generated when the resistive heater element is heated from mixing with the composition **18** or evaporating and mixing with the aerosolized composition which is inhaled by a user.

[0084] Indentations **20** have been formed in the substrate **12** near to either side of resistive heater element **14**. Although not shown in the cross-section of FIG. **2**, it will be appreciated that indentations **20** extend in a direction into and out of the plane of the cross-section to form a trench on either side of resistive element portion **14**. Further indentations (not shown) may also be formed parallel to the plane of the cross-section near to the other two sides of the resistive element portion **14**. Indentations or trenches are therefore formed in the region surrounding the at least one resistive element portion **14**. The indentations **20** reduce the cross-sectional area of the substrate **12** and hence heat transfer through the substrate in the region of the indentations **20**. This provides a degree of thermal isolation for the region of the substrate **12** underlying the resistive element portion **14** and inhibits heat being dissipated throughout the whole of the substrate **12**. This reduces the volume of the substrate **12** being heated by the resistive element portion **14** during any particular heating cycle, i.e. the thermal mass of the heater **10**. As less heat is dissipated in the substrate **12**, more heat is transferred to the composition **18**, thereby improving the thermal efficiency of the heater **10**.

[0085] The heater **10** can be manufactured by providing a substrate **12** and forming indentations **20** in the region where the resistive element portion **14** will be supported, for example, by using a laser cutting process. A resistive element portion **14** can then be deposited in the region surrounded by the indentations **20** using a screen printing process. This deposits a thick film of conductive ink having a suitable resistance on the substrate. If contacts (not shown) are to be provided on the substrate, these can also be deposited on the substrate **12** using a screen printing process. Screen printing provides a cost-effective and automatable method of depositing the resistive element portion and contacts. The contacts will have a higher conductivity than the resistive element portion **14**. An etching process may be used to finalize the outline of the screen printed features.

[0086] Substrate **12** is made from a ceramic. However, the skilled person will appreciate that materials such as a plastic or glass or a combination of the aforementioned materials may be used. The dimensions of the substrate are 15 mm long by 10 mm wide and 0.5 mm thick, which is relatively small compared to the wick-and-coil heaters of a conventional pre-cigarette. This reduces the thermal mass of the heater **10** and helps to improve thermal efficiency. The skilled person will appreciate that the substrate can have other suitable dimensions.

[0087] The conductive ink used to form the resistive element portion **14** comprises carbon particles and silver particles. Other constituents may comprise a resin or binder and a solvent. However, the skilled person will appreciate that other mixtures can be used.

[0088] The conductive ink used to form contacts comprises conductive particles, e.g. metallic particles. However, the skilled person will appreciate that other types of particles can be used, e.g. graphite particles.

[0089] The above compositions of the conductive inks may be adapted to a particular screen printing process or to achieve a desired resistance for a particular orientation/layout of resistor shape or size.

[0090] Once the resistive heater element **14** and contacts have been screen printed on the substrate **12**, the heater will generally undergo a heating process in which any volatile solvents are driven off. The heater may then undergo a sintering process at a higher temperature to sinter the conductive or resistive constituents of the conductive inks.

[0091] The barrier layer **16** is made from a layer of glass, which is thermally welded to the substrate **12** and resistive element portion **14**. However, the skilled person will appreciate that barrier layer **16** can be made from any suitable material which forms an effective seal against the egress of undesirable volatile by-products such as a ceramic or a plastic or a combination of any of the aforementioned materials.

[0092] In addition, a composition to be aerosolized can also be deposited on the heater **10** during manufacture such that a heater is provided already pre-charged with a composition. Such composition can also be screen printed onto the heater **10**.

[0093] By contrast, in FIG. **2**A (in which like reference numerals have been used to those of FIG. **2** to signify like parts), a heater **10** is shown in inverted orientation with the resistive element portions of the heater now provided on a bottom, downwardly facing surface **12***a* of the substrate **12**, i.e. a first surface of the substrate, and an amount of composition **18** has been deposited on a top or upwardly facing surface **12***b* of the substrate **12**, i.e. an opposing second surface. In this arrangement, the substrate itself provides a barrier between the composition **18** and the resistive element portions **14** of the heater, although heat therefrom is still directly conducted through the substrate **12** into the composition to cause aerosolization thereof and for the aerosol so created to be dispersed into the air above. Again, indentations **20** may be formed in the substrate **12** near to either side of resistive element **14**.

[0094] As mentioned previously, various types of conductive ink can be used to form the resistive element portions and contacts. For example, carbon-based ink can be used to form the resistive element portions, whereas ink comprising conductive elements such as metals or graphite can be used to form the contacts. Other constituents may comprise a solvent to enable such inks to be printed. In addition, one ink can be used to print both the resistive element portions and the contacts. Ceramic and glass inks both contain a glass phase which provides the resistivity, and metallic phases which provide the conductivity and high temperature coefficient of resistance. The metallic phase may comprise elements such as, for example, silver, ruthenium, palladium or other suitable metals. The above compositions of the conductive inks may be adapted to a particular screen printing process or to achieve a desired resistance for a particular orientation/layout of resistor shape or size. Once the resistive heater element portions **14** and contacts have been printed on the substrate **12**, the substrate and printed heater will then generally undergo a heating process to evaporate or vaporize the solvents, after which a further heating process may be used to sinter the metals and melt the glass.

[0095] FIGS. **3** and **4** show further embodiments of heaters according to the present invention which can be made using different manufacturing processes. It should be noted that these figures show simplified schematic views. Certain features such as the indentations and the barrier layer have been omitted for clarity. However, the skilled person will appreciate that such omitted features, and other features, could be used with these described embodiments also.

[0096] Referring firstly to FIG. **3**, a heater **100** comprises a substrate **112**, a resistive element portion **114** and two contacts **113**. The resistive element portion **114** and contacts **113** are formed of different materials, i.e. they have different compositions, for example the compositions described above, such that the contacts **113** are more conductive than the resistive element portion **114**. Consequently, the resistive element portion **114** and contacts are deposited in separate print runs. One print run will deposit a more resistive conductive ink to form the resistive element portion **114** and another print run will deposit a more conductive ink to form the contacts **113**. Either the resistive element portion **114** can be deposited first and the contacts **113** second or vice versa.

[0097] One of the contacts **113** of the heater **100** has a region of reduced cross-sectional area **122** which acts as a fuse and fails if the electric current flowing through this region exceeds a certain threshold value. Producing the region of reduced cross-sectional area can be done as part of the printing process by simply printing this pattern onto the substrate, thereby negating the need to add a further component to the heater **100**. Alternatively, the fuse can be formed using an ablative process such as laser cutting. The fuse acts as a safety device and prevents the heater **100** from overheating.

[0098] Referring to FIG. **4**, a heater **200** comprises a substrate **212**, a resistive element portion **214** and contacts **213**. The resistive element portion **214** and contacts **213** are formed of the same material, i.e. the same conductive ink. This conductive ink will generally be more conductive than the conductive ink used to print a standalone resistive heater element or may comprise a composition having a conductivity between the two compositions described above. The resistive element portion **214** is formed by providing a printed track of conductive ink having a smaller cross-sectional area or thinner width or thickness than the remainder of the printed track such that it has a higher resistance. The remainder of the printed track, i.e. the part having the larger cross-sectional area or wider width or thickness forms the contacts **213**.

[0099] The resistance of the resistive element portion **214** can also be increased relative to the resistance of the contacts **213** by making the resistive heater element longer than the straight-line distance between the points X and Y where the resistive element portion **214** is connected to the contacts **213**. This is achieved by giving the resistive element portion **214** a meandering or undulating pattern.

[0100] As a result of the resistive element portion **214** and contacts **213** being formed of the same material, these features can be deposited on the substrate **212** in a single print run. The pattern of the resistive element portion **214** can either be printed onto the substrate or the resistive heater element **214** can be printed as a larger block and the pattern achieved by ablating a part of the resistive heater block, for example, using a laser etching or cutting process.

[0101] In FIGS. **3** and **4**, contacts **113** and **213** extend to and terminate at an edge of the substrates **112** and **212**

respectively. This arrangement means that the heaters **100** and **200** are connectable to an electric power source (not shown) which is separate from or remote to the heater. For example, the edge of the substrates **112** and **212** could be inserted into a connector so that the contacts **113** and **213** make electrical contact with connections to an electric power source.

[0102] FIGS. **5**A-**5**D show a heater of the present invention during various stages of manufacture. Referring firstly to FIG. **5**A, a heater **500** comprises a substrate **512** having a series of indentations **520** formed in a surface of the substrate **512**. The heater **500** is configured to support four resistive heater elements (not shown in FIG. **5**A) arranged in a 2×2 configuration at one end of the substrate **512**. The indentations **520** are arranged in the region surrounding each of the resistive element portions. Not all the indentations **520** are joined together such that there is a gap between some of the indentations in which gap the substrate **512** has its full thickness. This is to avoid overly weakening the substrate **512** in the region of the four resistive element portions. The indentations **520** could be formed by a suitable ablative process for example laser etching or cutting.

[0103] FIG. **5**B shows the substrate of FIG. **5**A in which an arrangement of contacts **513***i*-**513***v* is supported on the substrate **512**. The contacts **513***i*-**513***v* have been deposited using a screen printing process. A first end of each of the contacts **513***i*-**513***v* is arranged to be connected to the resistive element portions (not shown in FIG. **5**B) at one end of the substrate **512**. Conductor **513***iii* is configured as a common ground connection and is arranged to be connected at its first end to each of the resistive element portions. Conductor **513***iii* is arranged in the middle of the contacts **513***i*-**513***v* and resistive heater elements as this is the most convenient arrangement whereby it can be connected to each of the resistive element portions. Contacts **513***i*, **513***ii*, **513***iv* and **513***v* are arranged to be connected at their first ends to a respective one of each of the four resistive element portions.

[0104] A second end of the contacts **513***i*-**513***v* terminates in a respective series of contact pads **513***a*-**513***e* at an end of the substrate **512** opposite the end where the resistive heater elements are located. Contact pad **513***c* is configured to be connectable to a common ground or negative potential of an electric power source such that each of the resistive heater elements can be connected to a ground potential via conductor **513***iii*. Contact pads **513***a*, **513***b*, **513***d* and **513***e* are configured to be connectable to a an electric power source such that a potential difference can be generated across each of the resistive element portions via one of contacts **513***i*, **513***ii*, **513***iv* and **513***v* and common ground conductor **513***iii*.

[0105] FIG. **5**C shows a substrate **512** supporting four resistive heater elements **514***i*-**514***iv*. Contacts **513***i*-**513***v* have been omitted for the sake of clarity. Resistive heater elements **514***i*-**514***iv* are arranged in a 2×2 pattern at one end of the substrate **512**. Each of resistive element portions **514***i*-**514***iv* is surrounded by a formation of indentations **520**. The resistive element portions **514***i*-**514***iv* have been deposited using a screen printing process.

[0106] FIG. **5**D shows a fully assembled heater **500** comprising a substrate **512**, contacts **513***i*-**513***v*, resistive element portions **514***i*-**514***iv*, a barrier layer **516** and a composition containing nicotine (not shown) deposited on each of the resistive element portions **514***i*-**514***iv*. Each of the resistive element portions **514***i*-**514***iv* has been connected across a respective one of the contacts **513***i*, **513***ii*, **513***iv* and **513***v* and the common ground conductor **513***iii*. When a potential difference is generated across one of the resistive heater elements **514***i*-**514***iv* an electric current flows through the resistive element portion, thereby activating the resistive element portion and causing its temperature to increase. For example, applying a positive potential to contact pad **513***a* and a ground or negative potential to contact pad **513***c* activates resistive heater element **514***i* and causes it to generate heat. Each of the resistive element portions **514***i*-**514***iv* is therefore independently activatable by applying a positive potential to any one of contact pads **513***a*, **513***b*, **513***d* and **513***e* and a ground potential to contact pad **513***c*.

[0107] The barrier layer **516** provides a seal over the resistive element portions **514***i*-**514***iv* and part of the contacts **513***i*-**513***v*. The barrier layer **516** extends over an area of the heater **500** denoted by points RSTU in FIG. **5**D. The area of the heater denoted by points TUVW is not covered by the barrier layer so not to insulate the contact pads **513***a*-**513***e* and allow these to make an electrical connection to an electric power source.

[0108] The nicotine containing compositions (not shown) are deposited on top of the barrier layer **516** above each of the resistive element portions **514***i*-**514***iv*. The compositions contain 0.5 mg of nicotine in total (at 40% concentration). A screen printing process has been used to deposit the compositions, although the skilled person will appreciate that other methods of deposition could be used. The amount of nicotine containing composition deposited above each of the resistive element portions **514***i*-**514***iv* may comprise a single or multiple doses of nicotine per inhalation.

[0109] FIG. **6** shows an inhalation device **600** according to one embodiment of the present invention comprising a main body part **630** and a mouthpiece **632**. The mouthpiece **632** is releasably attachable to the main body part **630**. Furthermore, the mouthpiece **632** is formed of separate first **632***a* and second **632***b* parts which are assembled during manufacture. However, the skilled person will appreciate that the inhalation device **600** can also be formed from a single piece, e.g. a single tube.

[0110] FIG. **7**A shows the mouthpiece **632** in disassembled form. First mouthpiece part **632***a* has a slot or recess (not shown) for receiving the heater **500** of FIG. **5**D. During manufacture, heater **500** is inserted into the slot or recess of the first mouthpiece part **632***a* and is held in place by the attachment of the second mouthpiece part **632***b* to the first mouthpiece part **632***a*. The second mouthpiece part **632***b* is attached to the first mouthpiece part **632***a* by means of snap fit connectors **634** on either side of the second mouthpiece part **632***b*.

[0111] FIG. **7**B shows the mouthpiece **632** in assembled form. Heater **500** is held securely within the mouthpiece **632**. As described above, heater **500** comprises nicotine containing compositions deposited on the resistive element portions and therefore the mouthpiece **62** comprises a replaceable consumable which can be releasably connected to the main body part **630** of inhalation device **600**.

[0112] FIG. **8** shows a cross-section through inhalation device **600** along the line A-A in FIG. **6**. Mouthpiece **632** containing heater **500** is connected to main body part **630**. The end of main body part **630** to which mouthpiece **632** is connected comprises a number of contact pins **636** which are arranged to make electrical contact with respective ones of contact pads **513***a*-**513***e* of heater **500**.

[0113] The main body part has a first interior space **638** for accommodating an electric power source (not shown) and a second interior space for containing a control unit (not shown) for controlling electrical activation of resistive element portions **514**. Contact pins **636** are connected to the electric power source via the control unit. A button **648** is also provided on the main body part **630** to enable a user to activate the heater **500**. Alternatively, the skilled person will appreciate that a sensor responsive to a user's inhalation could be used to activate the heater.

[0114] Mouthpiece **632** has channels **642** which overlie resistive element portions **514** when heater **500** is installed in the mouthpiece **632**. The channels **642** are in fluid communication with an air inlet (not shown) arranged on the main body part **630** and an air outlet **644** of the mouthpiece **632**. A constriction **646** is arranged in channels **642** immediately prior to the resistive element portions **514** to accelerate the airflow and provide a pressure drop in this region of the channel. This assists entrainment of the aerosolized composition in the airflow.

[0115] The device **600** of FIGS. **6** to **8** is configured to be highly accurate and to comply with the requirements of the Human Medicines Regulations Such a device is therefore suitable as a nicotine replacement therapy.

[0116] In use, a user will seal his lips around the mouthpiece **632** of the inhalation device **600** and inhale. Air is drawn into the air inlet, through channels **642** and over the heater **500** in the region of resistive element portions **514** before exiting the inhalation device via air outlet **644**. At the same time as inhaling the user presses button **648** to activate heater **500**. Dependent on the dose to be delivered, the control unit will activate one or more of resistive element portions **514** by directing an electric current through these resistive element portions **514** causing them to generate heat. At least a portion of the compositions deposited above the respective one or more resistive element portions is vaporized and forms an aerosolized composition above the heater **500** which becomes entrained in the moving airflow. Since the composition is in direct conductive contact with the heater, aerosolization of the required amount of composition can be achieved at much lower temperatures, i.e. 140° C., compared to conventional wick-and-coil heaters which typically heat to around 300° C. The aerosolized composition is then inhaled by a user via outlet **644**. The device then resets in preparation for the next inhalation.

[0117] Referring now to FIGS. **9**A and **9**B, the inhalation device **600** is shown with air inlet **650** arranged in a top surface of the main body part **630**. The air inlet **650** is laterally spaced apart from the central longitudinal axis of the inhalation device **600** and is located in the region where the mouthpiece **632** attaches to the main body part **630**. FIG. **9**B shows a cross-sectional view through inhalation device **900** along the line B-B in FIG. **9**A. The air inlet **650** is in fluid communication with the mouthpiece **632** and air exits the inhalation device **600** via an outlet **702** (part of which is shown in FIG. **9**B). An airflow channel passes from the air inlet **650** on the main body part **630** to the outlet **702** of the mouthpiece **632**. The main portion of the airflow channel which passes through the mouthpiece **632** is not visible in FIG. **9**B because it passes closer to the central longitudinal axis of the device, i.e. in the region of line G-G in FIG. **10**A.

[0118] Referring to FIG. **10**A, this shows a plan view of the mouthpiece **632** alone, i.e. detached from the main body part **630**. FIG. **9**B shows a cross-sectional view through the mouthpiece along the line G-G in FIG. **10**A. Air enters the mouthpiece **632** via an opening **720** at the rear of the mouthpiece **632**, which opening **720** is in fluid communication with the air inlet **650** (see FIGS. **9**A and **9**B). The air flows through the mouthpiece **632** to the outlet **702** via an enclosed airflow channel or fluid passage. The airflow through the airflow channel is denoted by dotted lines **722*a*** and **722*b*** in FIG. **10**B.

[0119] A heater **703** is arranged inside the mouthpiece **632** within the airflow channel. In the vicinity of the heater **703**, the airflow channel comprises a first airflow channel portion **724*a*** and a second airflow channel portion **724*b***. The first airflow channel portion **724*a*** is arranged to direct a portion of the airflow (denoted by dotted line **722*a***) past and above the first upwardly facing surface **703*a*** of the heater **703** and its the resistive element portions **705**. The resistive element portions **705** are located at the downstream end of the heater **703** in the vicinity of or near to the outlet **702** of mouthpiece **632**. The second airflow channel portion **724*b*** is arranged to direct a portion of the airflow (denoted by dotted line **722*b***) past and beneath the second downwardly facing surface **703*b*** of the heater **703**. The upper and lower surfaces of the first **724*a*** and second **724*b*** airflow channel portions respectively are flat to encourage laminar airflow past the resistive element portions **705**.

[0120] The heater **703** is supported on rails **726** which run parallel to the longitudinal axis of the mouthpiece and hold the heater at a central region within the airflow channel such that air can flow both above and below the heater **703**. Protrusions **728*a*** and **728*b*** extend from the upper and lower surfaces of the first **724*a*** and second **724*b*** airflow channel portions respectively and contact the heater **703** near its upstream end to assist in holding the heater **703** in place within the mouthpiece **632**. Each of protrusions **728*a*** and **728*b*** has a constriction orifice or channel restriction (not shown in FIG. **10**B, see FIG. **10**C) passing through it. The purpose of the constriction orifices is to increase resistance to inhalation by restricting the airflow in the region of the protrusions **728*a*** and **728*b*** and provide a more realistic feel to the inhalation device **600** for smokers of traditional tobacco products. The protrusions **728*a*** and **728*b*** are located sufficiently upstream of the resistive heater elements **705** such that turbulent air exiting the constriction orifices has space to return to laminar flow by the time it passes over the resistive heater elements **705**. Laminar flow assists in inhibiting the aerosolized composition from reaching the surfaces of the airflow channel because the aerosolized composition tends to flow through the device entrained with the streamlined flow.

[0121] FIG. **10**C shows a rear view of the mouthpiece **632**, i.e. a view in the direction of arrow H in FIG. **10**A. The mouthpiece **632** has a central vertical dividing wall **730** which divides the airflow channel in two. The portion of the mouthpiece **632** to the left of the dividing wall **730** is essentially a mirror image of the portion of the mouthpiece **632** to the right of the dividing wall **730**. The left-hand portion of the mouthpiece **632** repeats the features of the mouthpiece **632** to the right of the dividing wall **730**.

[0122] As can be seen from FIG. **10**C, protrusions **728*a*** and **728*b*** contact the heater **703** to assist in holding it in place within the mouthpiece **632**. Each of protrusions **728*a*** and **728*b*** has a constriction orifice **732** passing through it. The constriction orifice is semi-circular in shape, although any suitable shape can be used. The size or diameter of the constriction orifices **732** is less than the size of the airflow channel in which they are situated in order to restrict the airflow in the region of the protrusions **728***a* and **728***b* as described above.

[0123] In use, a user places the mouthpiece **632** in their mouth and inhales through the inhalation device **600**. Air flows in through the air inlet **650** and through the airflow channel to the outlet **650** of the mouthpiece **632**. A sensor (not shown) may be provided to detect a drop in pressure within the airflow channel and sends a signal to the control circuitry to heat or activate the resistive heater elements **705**. However, the skilled person will appreciate that a button (e.g. **648**, FIG. **8**) pressed by the user could be used instead of a sensor to activate the resistive heater elements **705**. Once activated, heat from the resistive heater elements **705** is transferred to a composition overlying the resistive heater elements **705**. At least a portion of the composition evaporates to form an aerosolized composition which becomes entrained in the airflow passing over the upper first surface **703***a* of the heater **703** and is inhaled by the user.

[0124] Since the resistive heater elements **705** are located at the downstream end of the heater **703** in the vicinity or near to the outlet **702**, there is insufficient time and/or insufficient length or surface area of the airflow channel for condensation to form. Consequently, a greater proportion of the nicotine containing composition reaches the user. Furthermore, this arrangement inhibits the formation of condensation droplets within the mouthpiece **632**, which can be unpleasant if inhaled by a user.

[0125] In the described embodiment, airflow not only passes over the upper surface of the heater **703** but a portion of the airflow channel, i.e. the second airflow channel portion **724***b*, is located below the heater **703**. It has been found by the inventors that the lower second airflow channel portion **724***b* may assist in inhibiting condensation of the aerosolized composition on the lower surfaces of the substrate and mouthpiece.

[0126] As the user inhales, air has to be drawn through the constriction orifices **732**. As discussed above, this increases resistance to inhalation by restricting the airflow and provides a more realistic feel to the inhalation device **100** for smokers of traditional tobacco products. A constriction orifice **732** is located in both the upper first airflow channel portion **724***a* and the lower second airflow channel portion **724***b* so that the upper and lower airflows are restricted equally, i.e. both airflows are travelling at generally the same speed and mass flow rate. This assists in the smooth flow of air through the device, which further inhibits the formation of condensation.

[0127] The present invention may be further exemplified by one, or a combination of one or more of, the following statements:

[0128] 1. A heater for an inhalation device, the heater being configured to heat a composition to generate an aerosolized composition for inhalation by a user, the heater comprising:

[0129] a substrate; and

[0130] at least one resistive heater element supported by the substrate, wherein the at least one resistive heater is arranged to be connectable to an electric power source.

[0131] 2. A heater according to statement 1 above, wherein the heater further comprises a barrier layer for inhibiting undesirable by-products generated during the heating of the at least one resistive heater element from mixing with the composition. In an alternative arrangement, the substrate itself may be configured as the barrier layer. In this latter arrangement, the at least one resistive heater element is supported by a first surface of the substrate and an opposing second surface of the substrate is arranged for receiving a composition.

[0132] 3. A heater according to statement 2 above, wherein the barrier layer is arranged to overly at least a portion of the at least one resistive heater element. The barrier layer and/or the substrate may be formed of a material selected from one or more of a ceramic, a plastic and glass, and the substrate may be rigid, and may additionally comprise one or more indentations in the region surrounding the at least one resistive heater element or plurality of resistive heater elements. The indentations may be formed by laser cutting.

[0133] 4. A heater according to any one of statements 1-3 above further comprising at least two contacts supported by the substrate, wherein a first end of each of the at least two contacts is connected to the resistive heater element and a second end of each of the at least two contacts is arranged to be connectable to an electric power source. Either or both of said resistive heater element and the at least two contacts may be printed on the substrate, optionally as a film (thick or thin), optionally by printing, optionally in a single print run, for example by screen printing. Additionally, the at least one resistive heater element and contacts may be formed of the same material, with the at least one resistive heater having a smaller cross-sectional area than the contacts such that it has a higher resistance. When printed in a single print run, a part of the material deposited may be ablated, for example by laser etching, to form resistive heater element having a region of reduced cross-sectional area such that the region of reduced cross-sectional area has a relatively higher resistance than the remainder of the material. Alternatively, the resistive heater element and contacts comprise different materials and are deposited on the substrate using separate print runs.

[0134] 5. A heater according to statement 4 above wherein the at least one resistive heater element has a length longer than the straight-line distance between the points where the at least one resistive heater element is connected to the contacts. Additionally, the at least one resistive heater element may follow a meandering path between the contacts, which in certain embodiments may be formed of different materials. For example, the at least one resistive heater element may comprise any one or more of the following: carbon, silver, ruthenium, palladium.

[0135] 6. A heater according to any one of the statements wherein the heater comprises a plurality of resistive heater elements and a corresponding number of contacts. For example, a contact may be provided for each of the plurality of resistive heater elements and a further contact may be provided to form a common ground for each of the plurality of resistive heater elements.

[0136] 7. A heater according to any one of the preceding statements, wherein either the at least one resistive heater element or at least one of the contacts has a region of reduced cross-sectional area which acts as a fuse which fails if the electric current flowing through the reduced cross-sectional area region exceeds a certain threshold value.

[0137] 8. A heater according to any one of the preceding statements, further comprising a composition supported by the barrier layer or the substrate as the case may be. The composition may comprise nicotine, and may be deposited on the barrier layer or substrate by printing.

[0138] 9. A heater according to any one of the preceding statements, wherein the resistive heater element has a resistance of between 5 ohms and 15 ohms at a temperature of 130° C.

[0139] 10. A mouthpiece for an inhalation device, the mouthpiece comprising the heater as prescribed in any one of the preceding statements.

[0140] 11. An inhalation device comprising the mouthpiece as prescribed in statement 10 and including a main body part which comprises a power source for the device and a control unit.

[0141] 12. An inhalation device comprising a heater configured to heat a composition to generate an aerosolized composition for inhalation by a user; and an airflow channel passing through at least a portion of the device and arranged to receive the aerosolized composition; wherein the heater is arranged in the vicinity of an outlet of the airflow channel.

[0142] 13. An inhalation device according to statement 12 wherein the heater is arranged within an interior of the airflow channel, which may comprise rails for holding the heater within the interior of the airflow channel. Said rails may hold the heater at a central region within the airflow channel.

[0143] 14. An inhalation device according to either of statements 12 or 13, wherein the heater comprises a substrate having opposing first and second surfaces, the first surface supporting at least one resistive heater element.

[0144] 15. An inhalation device according to statement 14 wherein the airflow channel and the heater are arranged such that an airflow is directed past at least the first surface of the substrate supporting the at least one resistive heater element. The airflow channel in the vicinity of the heater may comprise a first airflow channel portion which is arranged to direct an airflow past the first surface of the substrate and a second airflow channel which is arranged to direct an airflow past the second surface of the substrate. The first and/or second airflow channel portion may be defined by at least one flat surface, and a constriction orifice may be provided within the airflow channel for restricting the flow of air within the airflow channel in the region of the constriction orifice. The constriction orifice may be located upstream of the at least one resistive heater element, and both the first and second airflow channel portions may comprise such a constriction orifice.

[0145] 16. An inhalation device according to any one of statements 12-15 further comprising a mouthpiece, wherein the mouthpiece comprises the outlet of the airflow channel. At least a portion of the heater or the entire heater may be arranged within the mouthpiece. The inhalation device may further comprise a main body part to which the mouthpiece may be releasably attachable. The main body part may comprise an inlet of the airflow channel, which may be located in the region where the mouthpiece attaches to the main body part. The length of the mouthpiece may be less than half, or less than a third, of the overall length of the device.

[0146] Various modifications will be apparent to those skilled in the art. For example, the resistive element portions, contacts and compositions could be deposited by a process other than screen printing, for example, by inkjet printing or 3D printing. Additionally pellets comprising a composition could be supported by or attached to the heater. Upon the application of heat the pellets melt and release a composition which is aerosolized.

[0147] As used herein any reference to "one embodiment" or "an embodiment" means that a particular element, feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. The appearances of the phrase "in one embodiment" or the phrase "in an embodiment" in various places in the specification are not necessarily all referring to the same embodiment.

[0148] As used herein, the terms "comprises," "comprising," "includes," "including," "has," "having" or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. Further, unless expressly stated to the contrary, "or" refers to an inclusive or and not to an exclusive or. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

[0149] In addition, use of the "a" or "an" are employed to describe elements and components of the invention. This is done merely for convenience and to give a general sense of the invention. This description should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

[0150] In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

[0151] The scope of the present disclosure includes any novel feature or combination of features disclosed therein either explicitly or implicitly or any generalization thereof irrespective of whether or not it relates to the claimed invention or mitigate against any or all of the problems addressed by the present invention. The applicant hereby gives notice that new claims may be formulated to such features during prosecution of this application or of any such further application derived therefrom. In particular, with reference to the appended claims, features from dependent claims may be combined with those of the independent claims and features from respective independent claims may be combined in any appropriate manner and not merely in specific combinations enumerated in the claims.

1-20. (canceled)

21. An assembly for an inhalation device comprising:

a mouthpiece; and

a heater including a substrate which supports:

at least one resistive element portion applied over a first region of at least one surface of the substrate;

at least a pair of contacts each connected to the at least one resistive element portion at one end of the contacts and applied over a second region of the at least one surface of the substrate, wherein the first region is proximate a forward or leading edge of the substrate, and the second region is proximate a rearward or trailing edge of the substrate; and

an amount of an aerosolizable composition deposited on the substrate above the first region on the at least one surface of the substrate or deposited on a surface opposite the at least one surface of the substrate, such that heat generated by the at least one resistive element portion is directly or indirectly conducted to the aerosolizable composition to cause at least some aerosolization of the aerosolizable composition;

wherein the mouthpiece has:

a fluid inlet at an upstream rear end thereof;

a fluid outlet at a downstream front end thereof; and

fluid communication means internal to the mouthpiece between the fluid inlet and the fluid outlet;

wherein the heater is disposed substantially within the mouthpiece in or adjacent the fluid communication means and arranged such that the substrate leading edge is proximate the mouthpiece fluid outlet and the substrate trailing edge is substantially adjacent the rear end of the mouthpiece such that at least portions of the contacts are both exposed and accessible towards the rear end of the mouthpiece, and such that when fluid is flowing through the fluid communication means and aerosolization is simultaneously occurring, aerosol is generated which is entrained in the fluid flowing within the mouthpiece through the fluid communication means;

wherein the mouthpiece includes first and second parts, the first mouthpiece part having a slot which receives the heater which is held in place within the mouthpiece when the second mouthpiece part is attached to the first mouthpiece part, the entire assembly being releasably attachable to a main body part of the inhalation device at the rear end of the mouthpiece; and

wherein an electrical connection with the exposed accessible contacts is achieved when the mouthpiece rear end is attached to the main body part.

22. The assembly according to claim **21**, wherein the substrate supports a plurality of resistive element portions and a corresponding number of pairs of contacts connected thereto.

23. The assembly according to claim **22**, wherein the heater is supported within the mouthpiece by rails which run parallel to a longitudinal axis of the mouthpiece and which hold the heater at a central region within the fluid communication means such that air flows both above and below the heater.

24. The assembly according to claim **22**, wherein the mouthpiece has a central vertical dividing wall which vertically divides the fluid communication means internal to the mouthpiece into two separate airflow channels.

25. The assembly according to claim **23**, wherein the mouthpiece has a central vertical dividing wall which vertically divides the fluid communication means internal to the mouthpiece into two separate airflow channels.

26. The assembly according to claim **21**, wherein the aerosolizable composition is deposited on the same surface of the substrate as that to which the at least one resistive element portion of the heater has been applied.

27. The assembly according to claim **21**, wherein the aerosolizable composition is deposited on the surface of the substrate opposite to that to which the at least one resistive element portion of the heater has been applied.

28. The assembly according to claim **22**, wherein the aerosolizable composition is deposited on the surface of the substrate opposite to that to which the at least one resistive element portion of the heater has been applied.

29. The assembly according to claim **23**, wherein the aerosolizable composition is deposited on the surface of the substrate opposite to that to which the at least one resistive element portion of the heater has been applied.

30. The assembly according to claim **24**, wherein the aerosolizable composition is deposited on the surface of the substrate opposite to that to which the at least one resistive element portion of the heater has been applied.

31. The assembly according to claim **26**, wherein the at least one resistive element portion of the heater is covered by a barrier layer.

32. The assembly according to claim **31**, wherein the barrier layer is formed of a material selected from at least one of: a ceramic, a plastic and glass.

33. The assembly according to claim **21**, wherein the at least one resistive element portion follows meandering paths between points wherein each at least one resistive element is connected to a respective contact.

34. The assembly according to claim **21**, wherein the at least one resistive element portion has a resistance of between **5** ohms and **15** ohms at a temperature of 130° C.

35. The assembly according to claim **22**, wherein the heater includes:

a first contact for each of the plurality of resistive element portions; and

a second contact which forms a common ground for each of the plurality of resistive elements portions and which acts as the alternate common contact in the pair of contacts between which each resistive element portion is connected.

36. The assembly of claim **21**, wherein the main body part of the inhalation device includes:

a power source for the inhalation device; and

a control unit.

37. An inhalation device comprising:

a mouthpiece; and

a heater including a substrate which supports:

at least one resistive element portion applied over a first region of at least one surface of the substrate;

at least a pair of contacts each connected to the at least one resistive element portion at one end of the contacts and applied over a second region of the at least one surface of the substrate, wherein the first region is proximate a forward or leading edge of the substrate, and the second region is proximate a rearward or trailing edge of the substrate; and

an amount of an aerosolizable composition deposited on the substrate above the first region on the at least one surface of the substrate or deposited on a surface opposite the at least one surface of the substrate, such that heat generated by the at least one resistive element portion is directly or indirectly conducted to the aerosolizable composition to cause at least some aerosolization of the aerosolizable composition;

wherein the mouthpiece has:

a fluid inlet at an upstream rear end thereof;

a fluid outlet at a downstream front end thereof; and

fluid communication means internal to the mouthpiece between the fluid inlet and the fluid outlet;

wherein the heater is disposed substantially within the mouthpiece in or adjacent the fluid communication means and arranged such that the substrate leading edge is proximate the mouthpiece fluid outlet and the substrate trailing edge is substantially adjacent the rear end of the mouthpiece such that at least portions of the contacts are both exposed and accessible towards the rear end of the mouthpiece, and such that when fluid is flowing through the fluid communication means and aerosolization is simultaneously occurring, aerosol is generated which is entrained in the fluid flowing within the mouthpiece through the fluid communication means;

wherein the mouthpiece includes first and second parts, the first mouthpiece part having a slot which receives the heater which is held in place within the mouthpiece when the second mouthpiece part is attached to the first mouthpiece part, the entire assembly being releasably attachable to a main body part of the inhalation device at the rear end of the mouthpiece; and

wherein an electrical connection with the exposed accessible contacts is achieved when the mouthpiece rear end is attached to the main body part.

38. The inhalation device according to claim **37**, wherein the at least one resistive element portion has a resistance of between 5 ohms and 15 ohms at a temperature of 130° C.

39. The inhalation device comprising:

a main body part;

a mouthpiece; and

a heater including:

a substrate;

at least one resistive element portion applied over a first region of at least one surface of the substrate;

at least a pair of contacts each connected to the at least one resistive element portion at one end of the contacts and applied over a second region of the at least one surface of the substrate, wherein the first region is proximate a forward or leading edge of the substrate, and the second region is proximate a rearward or trailing edge of the substrate; and

an amount of an aerosolizable composition deposited on the substrate above the first region on the at least one surface of the substrate or deposited on a surface opposite the at least one surface of the substrate, such that heat generated by the at least one resistive element portion is directly or indirectly conducted to the aerosolizable composition to cause at least some aerosolization of the aerosolizable composition;

wherein the mouthpiece has:

a fluid inlet at an upstream rear end thereof;

a fluid outlet at a downstream front end thereof; and

fluid communication means internal to the mouthpiece between the fluid inlet and the fluid outlet;

wherein the heater is disposed substantially within the mouthpiece in or adjacent the fluid communication means and arranged such that the substrate leading edge is proximate the mouthpiece fluid outlet and the substrate trailing edge is substantially adjacent the rear end of the mouthpiece such that at least portions of the contacts are both exposed and accessible towards the rear end of the mouthpiece, and such that when fluid is flowing through the fluid communication means and aerosolization is simultaneously occurring, aerosol is generated which is entrained in the fluid flowing within the mouthpiece through the fluid communication means;

wherein the mouthpiece includes first and second parts, the first mouthpiece part having a slot which receives the heater which is held in place within the mouthpiece when the second mouthpiece part is attached to the first mouthpiece part, the entire assembly being releasably attachable to the main body part at the rear end of the mouthpiece; and

wherein an electrical connection with the exposed accessible contacts is achieved when the mouthpiece rear end is attached to the main body part.

40. The inhalation device according to claim **39**, wherein the at least one resistive element portion has a resistance of between 5 ohms and 15 ohms at a temperature of 130° C.

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