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(54) **HEATING APPARATUS FOR AN AEROSOL GENERATING DEVICE**

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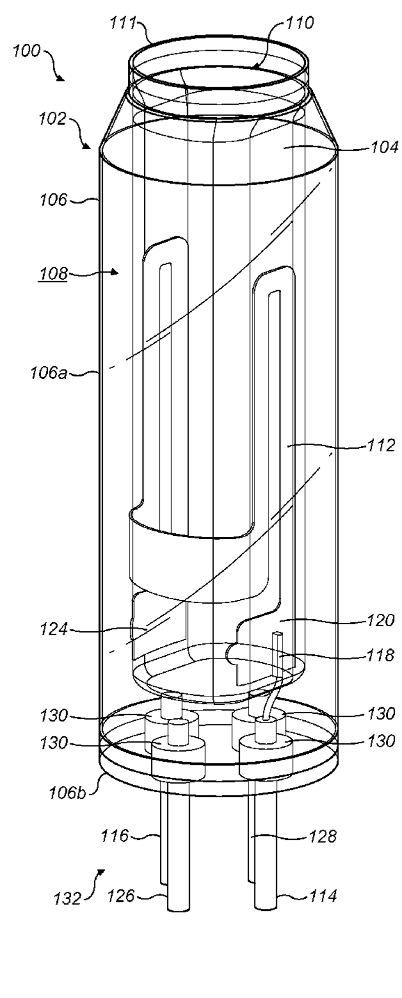
(57) **ABSTRACT**

A heating apparatus for an aerosol generating device includes a vacuum insulator having a main longitudinal axis and having an inner wall and an outer wall between which vacuum is enclosed; a cavity in which an aerosol forming substance can be received, positioned radially inwardly of the inner wall; a heater provided inside the vacuum insulator in thermal contact with the inner wall of the vacuum insulator, configured to heat an aerosol forming substance received in the cavity by thermal conduction to generate an aerosol; and one or more wires configured to connect the heater to a power source. The wires extend through at least one hole in the outer wall of the vacuum insulator. The wires are circumferentially surrounded by an insulator. The insulator includes glass and the one or more wires are made from a material that has thermal expansion characteristics that substantially match those of the insulator.



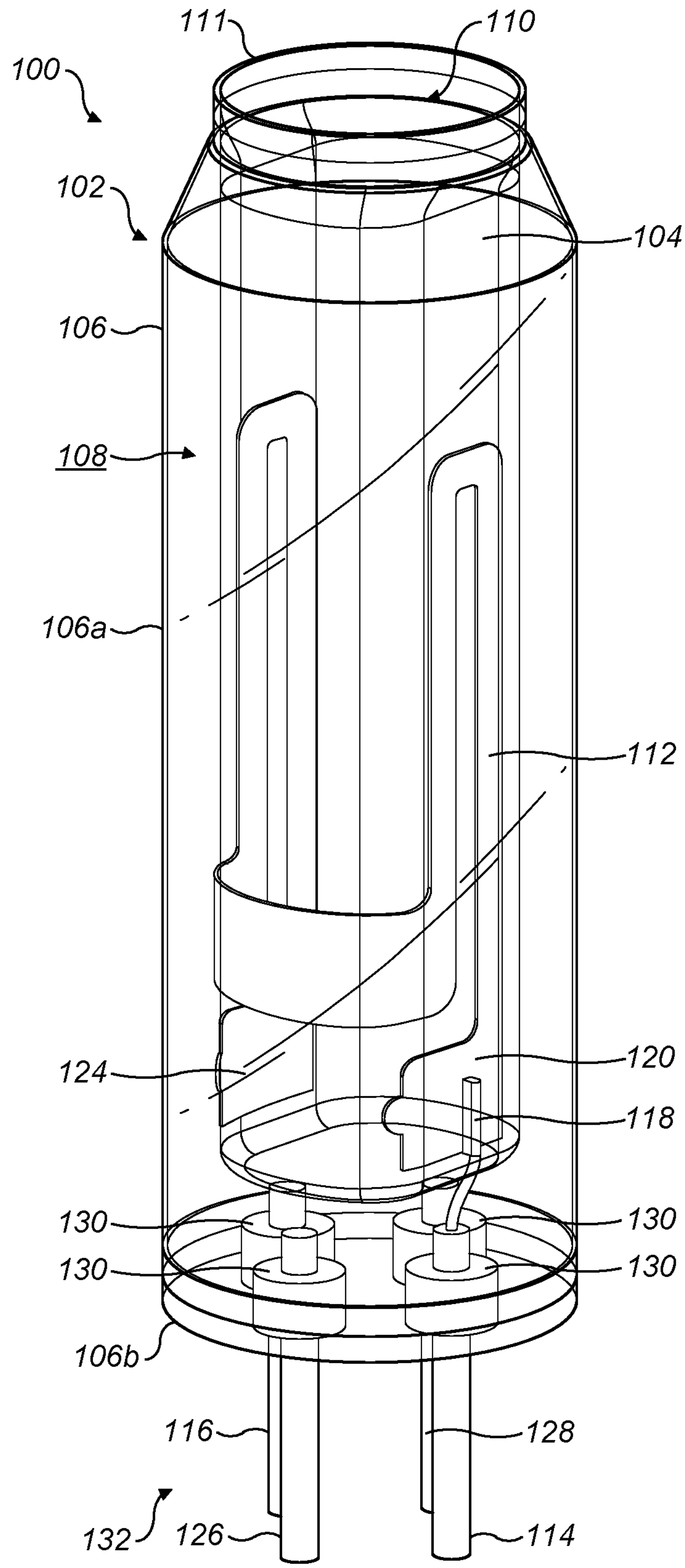

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FIG. 1

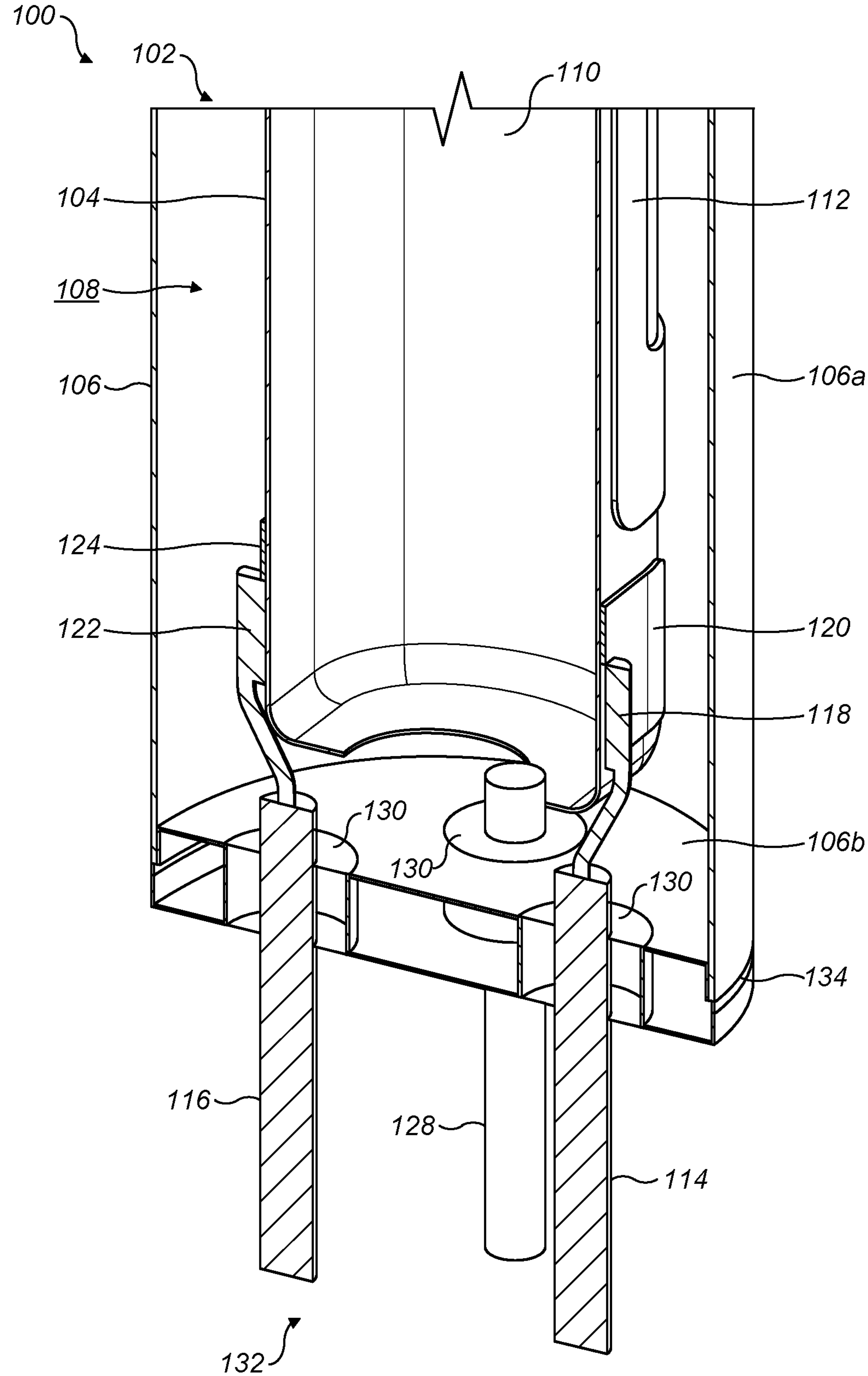
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FIG. 2

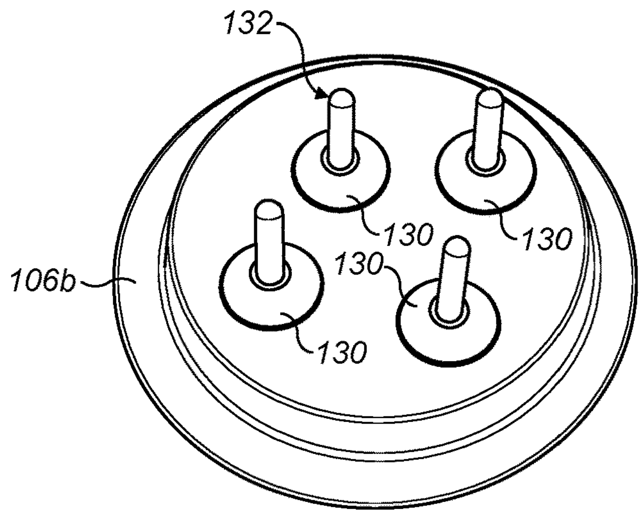

FIG. 3A

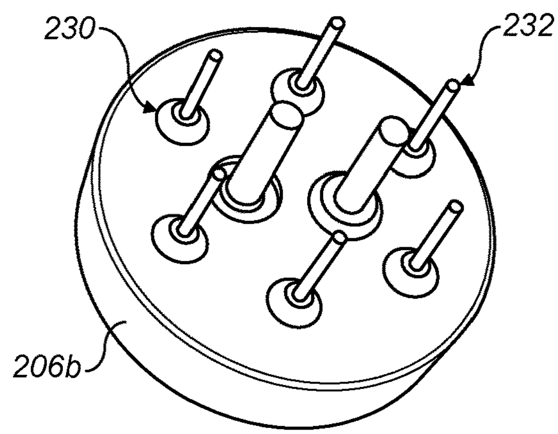

FIG. 3B

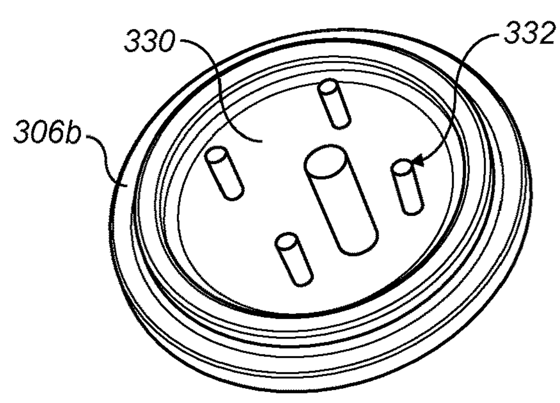

FIG. 3C

HEATING APPARATUS FOR AN AEROSOL GENERATING DEVICE

FIELD OF INVENTION

[0001] The invention relates to heating apparatuses for aerosol generating devices. Specifically, the invention relates to a heating apparatus with a vacuum insulator.

BACKGROUND TO THE INVENTION

[0002] One type of heating apparatus for aerosol generating devices uses a vacuum insulator and a heater provided in thermal contact with an inner wall of the vacuum insulator. The vacuum insulator typically comprises a central cavity, positioned adjacent the inner wall, in which an aerosol generating substance can be received. The heater can heat the aerosol generating substance in the cavity in order to generate an aerosol that can be inhaled. The vacuum insulator can thermally insulate outer surfaces of the aerosol generating device from the heater so that it can be held comfortably by a user.

[0003] One problem to overcome when producing this type of heating apparatus is how to provide electrical power from a power source outside the vacuum insulator to a heater while maintaining an effective vacuum. It is an object of the invention to address this problem.

SUMMARY OF INVENTION

[0004] According to an aspect of the invention, there is provided a heating apparatus for an aerosol generating device, comprising: a vacuum insulator having a main longitudinal axis and comprising an inner wall and an outer wall between which a vacuum is enclosed; a cavity in which an aerosol forming substance can be received, positioned radially inwardly of the inner wall; a heater provided inside the vacuum insulator in thermal contact with the inner wall of the vacuum insulator, configured to heat an aerosol forming substance received in the cavity by thermal conduction to generate an aerosol; and one or more wires configured to connect the heater to a power source, wherein the one or more wires extend through at least one hole in the outer wall of the vacuum insulator, and wherein the one or more wires are circumferentially surrounded by an insulator; wherein the insulator comprises glass and the one or more wires are made from a material that has thermal expansion characteristics that substantially match the thermal expansion characteristics of the insulator.

[0005] In this way, an effective vacuum can be maintained while allowing electrical connection between the heater and a power source. This can be achieved by threading the one or more wires through the one or more holes in the outer wall and providing the insulator between the wires and the vacuum insulator. The present invention provides a way in which the wires can be positioned through holes in the outer wall without compromising the vacuum.

[0006] Preferably, the insulator is a thermal insulator and an electrical insulator. Thermal insulation is advantageous because it prevents heat conducting along the wires and thereby heating up the walls of the vacuum insulator. Electrical insulation is advantageous because it allows the vacuum insulator to be made of a material that conducts electricity, such as a metal, without causing a short circuit between the two terminals of the power source.

[0007] The heater is preferably a track heater that is printed or coated on the vacuum insulator. The heater is preferably provided on an outer surface of the inner wall.

[0008] The outer wall may have a circumferential portion and a bottom portion. A surface normal vector on the outer wall may extend radially on the circumferential portion and axially on the bottom portion. The at least one hole may extend through the circumferential portion or through the bottom portion. In some embodiments, a first hole may extend through the circumferential portion and a second hole may extend through the bottom portion.

[0009] Preferably, the heating apparatus comprises a first wire that extends through a first hole in the outer wall and a second wire that extends through a second hole in the outer wall. In this way, separate respective holes can be provided for the first and second wires. It has been found that this can provide effective electrical isolation between the wires. This can also allow the wires to be spaced apart from one another for connection to different points of the heater.

[0010] Alternatively, the outer wall may comprise a hole through which both of the first wire and the second wire are positioned. In this case, the first wire and the second wire may be embedded in a shared sheet or piece of the insulator that circumferentially surrounds each wire. In this case, the first wire and the second wire can be spaced apart to avoid a short circuit between the terminals of a power source.

[0011] The insulator comprises glass. In one example, the insulator comprises borosilicate glass. In other embodiments, the insulator could comprise other suitable insulating glass materials.

[0012] The one or more wires are made from a material that has thermal expansion characteristics that substantially match the thermal expansion characteristics of the insulator. This can provide a tight and stable sealing of the vacuum chamber because the integrity of the mechanical joint is preserved over a wide temperature range. Each wire can be joined with the glass insulator in an oven to provide a very strong connection that is maintained even when the wire is heated by conduction due to its connection to the heater.

[0013] Preferably, the one or more wires comprise Kovar, which is a group of ferrous alloys. In one example a nickel-cobalt ferrous alloy can be used. These materials provide substantially the same thermal expansion properties as glass over a wide range of temperatures that extend from room temperature to at least the normal temperature of operation of the heater.

[0014] Preferably, the insulator comprises borosilicate glass and the one or more wires comprise Kovar. This combination provides a particularly effective seal for the vacuum across the operating temperatures of the heating apparatus.

[0015] Preferably, the heating apparatus comprises a sensor positioned within the vacuum insulator and a sensor wire that is connected to the sensor and extends through a further hole in the vacuum insulator, wherein the sensor wire is circumferentially surrounded by an insulator. This can allow sensors to be provided in the vacuum chamber, principally to monitor the operation and function of the heater, without compromising the integrity of the vacuum. This is preferably achieved using a Kovar sensor wire that is wrapped with a glass insulator. Any kind of sensor may be used such as a temperature sensor or a pressure sensor. In some embodiments, a plurality of sensors may be provided.

[0016] Preferably, the further hole extends through the outer wall of the vacuum insulator. The further hole may be provided on a circumferential portion or on a bottom portion of the outer wall.

[0017] Alternatively, the further hole extends between the inner wall and the outer wall of the vacuum insulator.

[0018] In some embodiments, the sensor wire may be provided at a different region of the vacuum insulator, or on a different face of the outer wall, compared to the one or more wires for the heater.

[0019] Preferably, the heater is a resistive heater. The heater may comprise an electrically resistive track that is printed or coated onto the inner wall. The resistive track could be provided on particular sections of the inner wall, or the resistive track could be coated or printed onto the inner wall to cover a substantially full amount of the inner wall. The resistive track may follow a serpentine or sinuous path on the inner wall from a first end to a second end of the track. In other examples, the heater could comprise one or more resistive heating plates or elements provided on the inner wall. The heating plates or elements could also be provided as a sinuous or serpentine resistive track.

[0020] Preferably, the heater comprises an exposed external surface having a material susceptible to an oxidation reaction in the presence of oxygen. Many heaters comprise materials that oxidise in the presence of oxygen, which can adversely affect the performance of the heater unless an anti-oxidation coating is provided. Allowing the heater to have an exposed external surface without an anti-oxidation coating in this way takes advantage of the heater being provided within the vacuum to make the heater less costly, have a lower mass, and/or easier to produce.

[0021] Preferably, the inner wall has a thickness of about 0.1 mm or less. In this way, the inner wall has a thickness corresponding to a threshold of significantly improved thermal efficiency of the vacuum insulator. The outer wall may have a thickness of about 0.25 mm.

[0022] Preferably, the one or more wires each extend through a different respective hole in the outer wall and each hole contains a corresponding insulator surrounding a corresponding wire. More preferably, each respective hole is sized mainly to accommodate the corresponding wire to minimise the amount of insulator in contact with the outer wall. In this way, each hole can be sized to minimise the circumference or perimeter of the outer wall in contact with the insulator, which better retains the vacuum within the vacuum insulator. The skilled person would appreciate that "sized mainly to accommodate a single wire" means each hole is made a small as possible to retain a single insulated wire while still enabling practical assembly of the insulator around each wire. Thus, in some examples, each hole may have a diameter that is about 1.5, 2, or 3 times the diameter of its corresponding wire. The insulator in each hole may surround the corresponding wire with a thickness roughly equal to the thickness of the corresponding wire, i.e., having a thickness of about 0.5 to 2 times that of the wire.

[0023] According to a further aspect of the invention, there is provided an aerosol generating device configured to generate an aerosol for inhalation by a user, comprising the heating apparatus as described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Embodiments of the invention are now described, by way of example, with reference to the drawings, in which:

[0025] FIG. **1** shows a schematic perspective view of a heating apparatus according to an embodiment of the invention;

[0026] FIG. **2** shows a cross-sectional schematic view of a portion of a heating apparatus according to an embodiment of the invention;

[0027] FIG. **3**A shows a perspective view of a portion of a heating apparatus according to an embodiment of the invention;

[0028] FIG. **3**B shows a perspective view of a portion of a heating apparatus according to an embodiment of the invention; and

[0029] FIG. **3**C shows a perspective view of a portion of a heating apparatus according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0030] FIG. **1** shows a schematic perspective view of a heating apparatus for an aerosol generating device according to an embodiment of the invention. FIG. **2** shows a cross-sectional schematic view of a portion of the heating apparatus shown in FIG. **1**.

[0031] With reference to FIGS. **1** and **2**, a heating apparatus **100** is provided and comprises a vacuum insulator **102** comprising an inner wall **104** and an outer wall **106**, spaced radially apart from one another so that a vacuum **108** is enclosed between them. The heating apparatus **100** comprises a cavity **110** that is provided adjacent the inner wall **104** and is configured to receive a consumable comprising a tobacco rod and a filter held together by a tipping wrapper. The consumable can be inserted into the cavity **110** by a user via an opening **111** to the cavity **110** to be held in place by friction with the inner wall **104**.

[0032] A heater **112** is provided within the vacuum **108** and on an outer surface of the inner wall **104**. The heater **112** is configured to be heated when an electrical current passes through it and to pass this heat on to the inner wall **104** by conduction. Heat is then transferred through the inner wall **104** by conduction so that the inner surface of the inner wall **104** heats the consumable and the air inside the cavity **110**. The heater **112** can be powered by a battery or any other power source provided on an aerosol generating device.

[0033] The outer wall **106** comprises a circumferential portion **106*a*** having a surface normal vector extending radially into the cavity **110** and a bottom portion **106*b*** having a surface normal vector parallel to a main longitudinal axis of the vacuum insulator **102**. A first heater wire **114** and a second heater wire **116** are each inserted through respective holes in the bottom portion **106*b*** and are configured to electrically connect the heater **112** to a power source and control electronics provided on an aerosol generating device. A first connection lead **118** is provided to electrically connect a first end **120** of the heater **112** to the first heater wire **114**. A second connection lead **122** is provided to electrically connect the second heater wire **116** to a second end **124** of the heater **112**. The first and second connection leads **118**, **122** may be welded to the heater **112** or to the inner wall **104**.

[0034] A temperature sensor (not shown) is provided within the vacuum insulator **102**. A first sensor wire **126** and a second sensor wire **128** are also provided through respective holes in the bottom portion **106***b*. The first sensor wire **126** and the second sensor wire **128** are configured to electrically connect the temperature sensor to a power source and control electronics provided on an aerosol generating device. The first sensor wire **126** and the second sensor wire **128** may also be attached to additional respective connections leads (not shown) configured to electrically connect each sensor wire to the temperature sensor.

[0035] The first and second heater wires **114**, **116** and the first and second sensor wires **126**, **128** may be referred to collectively as the "wires" **132**. As shown in FIGS. **1** and **2**, each of the wires **132** are provided through a respective hole in the bottom portion **106***b*. Each of the wires **132** are joined to the bottom portion **106***b* by one of a plurality of airtight seals **130** that prevents the intrusion of air into the interior of the vacuum insulator **102**. Each of the seals **130** comprises an insulator that circumferentially surrounds one of the wires **132**.

[0036] The vacuum insulator **102** is hollow and encloses a vacuum **108** between its curved inner wall **104** and its curved outer wall **106**. The vacuum insulator **102** has a substantially cylindrical shape that enables the vacuum insulator **102** to surround the consumable fully. The vacuum insulator **102** provides thermal insulation so that the heater **112** can heat an aerosol generating substrate effectively while not heating other portions of the aerosol generating device, especially portions of the aerosol generating device that are held by a user. The vacuum insulator **102** is elongate along its main longitudinal axis, as shown in FIG. **1**. This enables it to receive a consumable in the form of an elongate rod comprising tobacco. The vacuum insulator **102** has an approximately elliptical or circular cross-sectional shape when viewed along one of its ends, parallel to its longitudinal axis. However, in other embodiments the vacuum insulator **102** may have other types of cross sectional shape, for example shapes that are approximately square or polygonal.

[0037] The vacuum insulator **102** comprises an opening **111** for receiving the consumable at one longitudinal end and is closed at the opposite end. Thus, when viewed perpendicularly to its longitudinal axis as shown in FIGS. **1** and **2**, the vacuum insulator **102** has a cross-section that is cup-shaped. In other embodiments, the vacuum insulator **102** may be open at both longitudinal ends such that it has a tube-shaped cross-section when viewed perpendicularly to its longitudinal axis. In such cases, the outer wall **106** may comprise only or mainly a circumferential portion **106***a* and each of the wires **132** may be provided through a respective hole in the circumferential portion **106***a* while being surrounded by a respective seal **130**. In the embodiment of FIGS. **1** and **2**, the inner wall **104** and the outer wall **106** are joined or welded together at the same end of the vacuum insulator **102** at which the opening **111** can be found. The bottom portion **106***b* and the circumferential portion **106***a* are also joined or welded at a join **134** shown in FIG. **2**.

[0038] The opening **111** and the inner wall **104** have a cross-section that is the same across the full longitudinal extent of the inner wall **104**. In other embodiments, the opening **111** may be flared outwardly to enable a user to insert the consumable into the cavity **110** more easily.

[0039] The outer wall **106** comprises stainless steel. In other embodiments, the outer wall **106** could comprise other suitable materials, such as other metals, alloys, or plastics. The circumferential portion **106***a* of the outer wall **106** comprises a single curved face that is substantially or wholly cylindrical. The outer wall **106** could have other shapes in accordance with alternatively shaped vacuum insulators.

[0040] The inner wall **104** may have a thickness of about 0.1 millimetres (mm) or less. Having a relatively low thickness reduces the thermal mass of the vacuum insulator **102**, and increases the rate of heat conduction through the inner wall **104** to the cavity **110** and the consumable. In particular, less heat is conducted away from the cavity **110** by the outer face of the inner wall **104**. The threshold of 0.1 mm or less has been found to be significant in terms of improving the energy efficiency of the heating apparatus **100** by these mechanisms. In particular, an inner wall thickness of 0.1 mm has been found to have significantly improved thermal efficiency compared to an inner wall thickness of 0.25 mm.

[0041] The outer wall **106** may have a thickness of about 0.25 mm, which may be preferable to a thickness of 0.1 mm to give the vacuum insulator **102** increased mechanical sturdiness and thermal insulation properties.

[0042] The cavity **110** is substantially cylindrical and is positioned immediately adjacent the inner wall **104**. Preferably, the side of the inner wall **104** facing the cavity **110**, i.e., the "inner surface" of the inner wall **104**, is substantially or completely free of additional components so that the consumable can be in direct contact with the inner face when it is received in the cavity **110**. This can maximise the efficiency of heat transfer from the inner wall **104** to the consumable. Further, the lack of additional components keeps the thermal mass of the heating apparatus low, which can improve the amount of time required to heat the tobacco to aerosol generating temperatures.

[0043] In the embodiment of FIGS. **1** and **2**, the heater **112** is a resistance heater configured to generate heat when applied with an electric current. The heater **112** comprises a winding resistive heating track that extends from a first end **120** of the heater **112** to a second end **124**. The track follows a sinuous path along the length of the inner wall **104**, as shown in FIG. **1**. The first end **120** and the second end **124** of the heater **112** are connected to the first and second connection leads **118**, **122**, respectively. The first heater wire **114** is configured to be in electrical connection with a first terminal of a battery on an aerosol generating device, and the second heater wire **116** is configured to be in connection with the opposite terminal of the battery. Thus, during operation of the heating apparatus **100**, the battery can be used to provide an electric current through the heating track. The electrical resistance of the heater **112** then causes the heater **112** to generate heat in response to the current flowing through the heater **112** via the first heater wire **114** and the second heater wire **116**.

[0044] The heater **112** is printed or coated onto the outer face of the inner wall **104**. In other embodiments, the heater **112** can comprise a heating element or plate provided on and attached to the inner wall **104**. Thus, the heater **112** may provide "trace heating" to the cavity **110**. The heater **112** may have a sinuous shape on the surface of the inner wall **104** so that a substantially full length of the inner wall **104** receives heating, as shown in FIG. **1**. In other embodiments, the heater **112** may cover a substantially full circumference and/or area of the inner wall **104**.

[0045] The heater **112** may comprise a material susceptible to an oxidation reaction in the presence of oxygen, and also may be provided without an anti-oxidation coating. Exposing the heater **112** to the vacuum **108** in this way takes advantage of the lack of oxygen in the vacuum insulator **102** to make the heater **112** cheaper and/or easier to manufacture.

[0046] In this embodiment, each of the wires **132** comprise Kovar, which is a group of ferrous alloys configured to exhibit particular thermal expansion properties to match the properties of glass, such as borosilicate glass. In one example, Kovar may have thermal expansion properties of about 5×10^{-6}/K between 3° and 200° C., and about 10×10^{-6}/K at 800° C. Borosilicate glass may have a thermal expansion coefficient of 3×10^{-6}/K at 20° C. Borosilicate glass is particularly preferred because Kovar can be configured to have thermal expansion properties matching borosilicate glass. This allows the borosilicate glass to form a tight seal around Kovar wires across a large temperature range.

[0047] Each of the seals **130** comprise insulators that circumferentially surround one of the respective wires **132**. Each seal **130** is embedded in a respective hole in the bottom portion **106*b*** and each of the wires **132** are positioned through a respective hole. In this embodiment, the seals **130** comprise glass, which enables the Kovar wires **132** and the seals **130** to form an airtight joint over a wide range of temperatures. Having substantially matching thermal expansion properties is important because heat from the heater **112**, which typically operates at temperatures over 100° C., can reach the bottom portion **106*b*** by conduction through the inner wall **104** and the circumferential portion **106*a***. Thus, this particular selection of materials for the wires **132** and the seals **130** provides a particularly effective mechanical joint over a wide range of operating temperatures, thereby helping to preserve the integrity of the vacuum. Additionally, the glass electrically insulates the bottom portion **106*b*** from the wires **132**, thereby avoiding the need for a separate insulation layer to prevent electrical conduction from the wires **132** to the outer wall **106**.

[0048] During manufacturing of the heating apparatus **100**, the seals **130** may be preformed into an annular shape inside holes in the bottom portion **106*b*** before the insertion of the wires **132** through the seals **130**. Subsequently, the seals **130** and the wires **132** may be joined or welded together using an oven to create a strong permanent join after cooling. This may provide a convenient method of manufacturing the heating apparatus **100**.

[0049] In other embodiments, the wires **132** and the seals **130** may comprise other conducting and insulating materials, respectively. In particular, the wires **132** and the seals **130** may comprise materials selected to have substantially matching thermal expansion properties over typical operating temperatures of the heating apparatus **100**.

[0050] In the embodiment of FIGS. **1** and **2**, the wires **132** are provided through holes in the bottom portion **106*b*** of the outer wall **106**. However, in other embodiments, the wires **132** and seals **130** may be provided elsewhere on the outer wall **106**, for example through holes on the circumferential portion **106*a*** or at different positions on the bottom portion **106*b***.

[0051] The temperature sensor (not shown) may be provided within the vacuum insulator **102** on the inner face of the outer wall **106** or the outer face of the inner wall **104**. The temperature sensor can be configured to detect the temperature of the heater **112** or of the cavity **110** and transmit the detected temperature to a controller provided on an aerosol generating device incorporating the heating apparatus **100**. The temperature sensor may transmit the detected temperatures via one or more additional connection leads (not shown) attached to one or both of the first sensor wire **126** or the second sensor wire **128**. In one example, the temperature sensor may comprise a thermistor. In other embodiments, the temperature sensor could be provided alongside, or be replaced with, other types of sensors, such as a pressure sensor.

[0052] As described above, the heating apparatus **100** can be used with or provided in an aerosol generating device. The aerosol generating device would typically comprise a battery or other power source for powering the heater **112**, a button or other input mechanism to enable a user to initiate the heater **112**, and a controller to control the electronic components of the device, such as the heater **112**. The heating apparatus **100** may be provided within a housing of the aerosol generating device, wherein the housing comprises an opening aligned with the opening **111** of the heating apparatus **100**. The aerosol generating device may be configured as an electronic smoking device.

[0053] The heating apparatus **100** is configured to be used with a consumable comprising tobacco and a filter, which may be held together by a tipping wrapper. The consumable may be a cylindrical rod; however, other shapes of consumable designed to be received within the cavity **110** could also be used. Other forms of aerosol forming substance may be used alternatively or addition to tobacco.

[0054] Now, an example use of the heating apparatus **100**, as used within an aerosol generating device, will now be described with reference to FIGS. **1** and **2**.

[0055] In use, a user can insert the consumable through the opening **111** into the cavity **110**. When the user is ready to initiate vaporisation, the user may press a button provided on the aerosol generating device, after which the controller may allow a current to flow from the battery to the heater **112** via the first heater wire **114** and the second heater wire **116**. The heater **112** generates heat, due to its electrical resistance, that is transmitted to the inner wall **104** by conduction and radiation.

[0056] While the heater **112** is operating, the vacuum **108** within the vacuum insulator **102** inhibits the escape of heat from the cavity **110**. In this way, the cavity **110**, the heater **112**, and the vacuum insulator **102** form a highly efficient heating oven in which the tobacco within the consumable can be heated to a desired aerosol generating temperature. The controller may be configured to instruct the heater **112** to heat the tobacco to temperatures below the combustion temperature of tobacco. It may take several seconds for the cavity **110** to reach aerosol generating temperatures.

[0057] As the tobacco is heated, an aerosol is produced inside the cavity **110**. The user can then inhale the aerosol by drawing air from the cavity **110** via the filter. This may draw air into the cavity **110** through a periphery of the opening **111** so that the user can continuously inhale aerosol from the cavity **110**.

[0058] At the same time, while the heater **112** is operating, heat reaches the seals **130** and the wires **132** by radiation and by conduction through the walls of the vacuum insulator **102**. The wires **132** and the seals **130** comprise Kovar and glass, respectively, which enables the wires **132** and the seals **130** to expand thermally at substantially the same rate as their temperature increases. This provides a secure and airtight mechanical joint even while the heater **112** is turned on and the heating apparatus **100** reaches peak operating temperatures.

[0059] In the embodiment of FIGS. **1** and **2**, the heat from the heater **112** that is transmitted to the wires **132** and seals **130** by conduction through the vacuum insulator **102** has to travel upwards towards the join between the inner and outer walls **104**, **106** at the opening **111**. Subsequently, the heat then has to travel down the circumferential portion **106***a* before reaching the bottom portion **106***b* and heating up the wires **132** and seals **130**. Thus, for this embodiment, the bottom portion **106***b* substantially corresponds to a maximum "conduction path length" for heat from the heater **112** travelling via the vacuum insulator **102**. While heat is travelling by conduction, some heat is re-transmitted by radiation to the internal wall **104** or is lost from the vacuum insulator **102**. Accordingly, less heat reaches regions further, in terms of a minimum conduction path length, from the heater **112**. These further regions generally correspond to the coldest region of the vacuum insulator **102** during use. The coldest region will in general depend on the particular shape of the vacuum insulator and the location of the heater.

[0060] Thus, positioning the wires **132** and the seals **130** at the bottom portion **106***b* can increase the efficiency of the heating apparatus **100** by minimising the amount of heat that is lost from the cavity **110** by conduction through the walls of the vacuum insulator **102**.

[0061] FIGS. **3**A to **3**C show perspective views of a portion of a heating apparatus according to various embodiments of the invention. FIG. **3**A shows a perspective view of the bottom portion **106***b* of the vacuum insulator **102** of FIGS. **1** and **2**.

[0062] FIG. **3**B shows an alternative bottom portion **206***b* that may be used within the heating apparatus **100** as described above alternatively to the bottom portion **106***b*. The bottom portion **206***b* comprises a plurality of wires **232**, including two heater wires and two or more sensor wires. Each of the wires **232** are provided through a respective hole in the bottom portion **206***b* and sealed by one of a plurality of seals **230**. The bottom portion **206***b* may enable an additional number of sensors or other electronic components to be provided in the vacuum insulator **102**.

[0063] The wires **232** and seals **232** may be configured in the same manner as any of the embodiments of the wires **132** and seals **130** as described above. In particular, the wires **232** and the seals **230** may comprise Kovar and glass, respectively, or, alternatively, may comprise other suitable conductors and insulators as described above.

[0064] FIG. **3**C shows an alternative bottom portion **306***b* that may be used within the heating apparatus **100** as described above alternatively to the bottom portion **106***b*. The bottom portion **306***b* comprises a plurality of wires **332**, including a central paired heating wire comprising two individual heater wires for connection with either end of the heater **112**. The wires **332** also comprise four thinner wires provided for connection with two sensors provided in the vacuum insulator **102**. The bottom portion **306***b* comprises a ring of stainless steel (or any other suitable material) and an insulating sheet **330** comprising glass provided internally to the ring to form a substantially circular end of the outer wall **106**. Each of the wires **332** are provided through a respective hole in the insulating sheet **330** and joined to the insulating sheet **330** in an airtight manner. Thus, the insulating sheet **330** circumferentially surrounds each of the wires **332**. The wires **332** are spaced apart to prevent short circuits between any of the wires **332**. The insulation properties of the seal **330** prevents unwanted electrical connection between each of the wires **332**.

[0065] The wires **332** and the insulating sheet **330** may otherwise be configured in the same manner as embodiments of the wires **132** and seals **130** as described above. In particular, the wires **332** and the insulating sheet **330** may comprise Kovar and glass, respectively, or alternatively may comprise other suitable conductors and insulators.

[0066] Returning to the embodiment of FIG. **3**A, one additional advantage of this arrangement relates to the total circumference of the join between the bottom portion **106***b* and the seals **130**. In this embodiment, each wire **132** and a corresponding seal **130** is provided through a dedicated hole in the bottom portion **106***b*. Using a dedicated hole for each wire **132** means the hole can have a lower diameter, which minimises the total perimeter of contact between the seal **130** and the bottom portion **106***b*. This contributes to more reliable retention of the enclosed vacuum **108** because the bottom portion **106***b* may not have thermal expansion characteristics matching that of the seals **130**.

[0067] In contrast, the embodiment of FIG. **3**C, for example, uses a single insulating sheet **330** and a bottom portion **306***b* comprising a ring with an inner hole sized to accommodate several wires **332**. Thus, in FIG. **3**C the circumference of the join or interface between the insulating sheet **330** and the bottom portion **306***b* is equal to the inner circumference of the ring making up the bottom portion **306***b*. This arrangement may have a larger circumference in contact between the insulating sheet **330** and the bottom portion **306***b* compared to the arrangement of FIG. **3**A and may be less effective at retaining the vacuum **108** compared to embodiments similar to FIG. **3**A.

[0068] In the example of FIG. **3**A having four wires **132**, using dedicated holes for each wire **132** can significantly reduce the total circumference of interfacing portions between the seals **130** and bottom portion **106***b* by adjusting the size of each dedicated hole, compared to a similar arrangement of four wires using an insulating sheet.

[0069] The size of each hole may be made as small as possible without hindering construction of the vacuum insulator **102**, i.e., without making it overly difficult to assemble the seals **130** and wires **132** while maintaining a vacuum **108**. Thus, each hole may be sized mainly, in other words as far as practically possible, to minimise the contact perimeter between the seals **130** and the bottom portion **106***b*.

[0070] These advantages apply equally to the arrangement of FIG. **3**B, which uses similarly dedicated holes for each wire **232**. Dedicated holes used in this way may also be positioned elsewhere on the outer wall **106**.

1. A heating apparatus for an aerosol generating device, comprising:

a vacuum insulator having a main longitudinal axis and comprising an inner wall and an outer wall between which a vacuum is enclosed;

a cavity in which an aerosol forming substance is configured to be received, positioned radially inwardly of the inner wall;

a heater provided inside the vacuum insulator in thermal contact with the inner wall of the vacuum insulator, and configured to heat the aerosol forming substance received in the cavity by thermal conduction to generate an aerosol; and

one or more wires configured to connect the heater to a power source, wherein the one or more wires extend through at least one hole in the outer wall of the vacuum insulator, and wherein the one or more wires are circumferentially surrounded by an insulator;

wherein the insulator comprises glass and the one or more wires are made from a material that has thermal expansion characteristics that substantially match the thermal expansion characteristics of the insulator.

2. The heating apparatus of claim **1**, wherein the one or more wires comprise a first wire that extends through a first hole in the outer wall and a second wire that extends through a second hole in the outer wall.

3. The heating apparatus of claim **1**, wherein the one or more wires comprise Kovar.

4. The heating apparatus of claim **1**, further comprising a sensor positioned within the vacuum insulator and a sensor wire that is connected to the sensor and extends through a further hole in the vacuum insulator, and wherein the sensor wire is circumferentially surrounded by an insulator.

5. The heating apparatus of claim **4**, wherein the further hole extends through the outer wall of the vacuum insulator.

6. The heating apparatus of claim **4**, wherein the further hole extends between the inner wall and the outer wall of the vacuum insulator.

7. The heating apparatus of claim **1**, wherein the heater is a resistive heater.

8. The heating apparatus of claim **1**, wherein the heater comprises an exposed external surface having a material susceptible to an oxidation reaction in the presence of oxygen.

9. The heating apparatus of claim **1**, wherein the inner wall has a thickness of about 0.1 mm or less.

10. The heating apparatus of claim **1**, wherein the insulator comprises borosilicate glass.

11. The heating apparatus of claim **1**, wherein the one or more wires each extend through a different respective hole in the outer wall and each hole contains a corresponding insulator surrounding a corresponding wire.

12. The heating apparatus of claim **11**, wherein each respective hole is sized mainly to accommodate the corresponding wire to minimise the amount of insulator in contact with the outer wall.

13. An aerosol generating device configured to generate an aerosol for inhalation by a user, comprising the heating apparatus of claim **1**.

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