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(54) APPARATUS AND METHOD FOR FILLING LIQUID INTO A CARTRIDGE FOR A VAPOUR PROVISION SYSTEM

VORRICHTUNG UND VERFAHREN ZUM FÜLLEN VON FLÜSSIGKEIT IN EINE KARTUSCHE FÜR EIN DAMPFVERSORGUNGSSYSTEM

APPAREIL ET PROCÉDÉ D'INTRODUCTION D'UN LIQUIDE DANS UNE CARTOUCHE POUR UN SYSTÈME DE FOURNITURE DE VAPEUR

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Description

Field

[0001] The present disclosure relates to vapour provision systems such as electronic nicotine delivery systems (e.g. e-cigarettes), and in particular to an apparatus and method for filling liquid into a cartridge for such a vapour provision system.

Background

[0002] Vapour provision systems such as e-cigarettes generally contain a reservoir of liquid which is to be vaporised, typically nicotine. When a user inhales on the device, a heater is activated to vaporise a small amount of liquid, which is therefore inhaled by the user. The liquid may comprise nicotine in a solvent, such as ethanol or water, together with glycerine or propylene glycol to aid aerosol formation, and may also include one or more additional flavours. There are many designs of known e-cigarettes, see for example, US 2011/0094523 and US 2014/0144429.

Summary

[0003] The disclosure is defined in the appended claims.

[0004] A method and apparatus are provided for the automated filling of a cartridge with liquid for a vapour provision system. The method comprises inserting a compressible matrix into a filling tube; injecting liquid into the matrix within the filling tube using a liquid filling pump to produce a wetted matrix; and pushing the wetted matrix out of the filling tube into the cartridge.

Brief Description of the Drawings

[0005]

Figure 1 is a schematic (exploded) diagram of an e-cigarette in accordance with some embodiments of the disclosure.

Figure 2 is a schematic diagram of the main functional components of the body of the e-cigarette of Figure 1.

Figures 3A and 3B are schematic diagrams of the cartridge portion of an e-cigarette according to one design; in particular, Figures 3A and 3B are two sections taken in mutually orthogonal first and second planes that both include the longitudinal axis LA of the e-cigarette as shown in Figure 1.

Figure 4 is schematic diagram of the cartridge portion of the e-cigarette of Figure 3 and shows a section through the cartridge portion in a plane perpendicular to the longitudinal axis LA, taken approximately halfway along the length of the cartridge portion.

Figure 5 is an analogous view to Figure 3A, but showing a different implementation of the cartridge portion of an e-cigarette that involves latching or clipping.

Figure 6 is a schematic diagram illustrating an automated method for filling liquid into a cartridge for an electronic vapour provision system in accordance with some embodiments of the invention.

Figure 7 is a schematic diagram illustrating the insertion of a foam block into a filling tube as part of the overall method in accordance with some embodiments of the invention.

Figure 8 is a schematic diagram illustrating an automated apparatus for filling liquid into a cartridge for an electronic vapour provision system in accordance with some embodiments of the invention.

Figure 9 is a flowchart illustrating an automated method for filling liquid into a cartridge for an electronic vapour provision system in accordance with some embodiments of the invention.

Detailed Description

[0006] As described above, the present disclosure relates to a vapour provision system, such as an e-cigarette. Throughout the following description the term "e-cigarette" is used; however, this term may be used interchangeably with vapour provision system.

[0007] Figure 1 is a schematic (exploded) diagram of an e-cigarette 10 in accordance with some embodiments of the disclosure (not to scale). The e-cigarette comprises a body (control unit) 20, a cartridge 30 and a vaporiser 40. The cartridge includes an internal chamber containing a reservoir of liquid and a mouthpiece 35. The liquid in the reservoir typically includes nicotine in an appropriate solvent, and may include further constituents, for example, to aid aerosol formation, and/or for additional flavouring.

[0008] The cartridge reservoir may include a foam matrix or any other structure for retaining the liquid until such time that it is required to be delivered to the vaporiser. The control unit 20 includes a re-chargeable cell or battery to provide power to the e-cigarette 10 and a circuit board (or other electronics) for generally controlling the e-cigarette. The vaporiser 40 includes a heater for vaporising the nicotine and further includes a wick or similar device which transports a small amount of liquid from the reservoir in the cartridge to a heating location on or adjacent the heater. When a user draws air through the mouthpiece, this causes the controller 55 to switch on the battery 54 and provide power to the heater. The heater vaporises liquid which flows via capillary action from the cartridge to the heater via a wick. This in turn creates an aerosol for inhalation by the user.

[0009] The control unit 20 and the vaporiser 40 are detachable from one another, but are joined together when the device 10 is in use, for example, by a screw or bayonet fitting (indicated schematically in Figure 1 as 41A and 21A). The connection between the control unit and vaporiser provides for mechanical and electrical connectivity between the two. When the control unit is detached from the vaporiser, the electrical connection 21A on the control unit that is used to connect to the vaporiser also serves as a socket for connecting a charging device (not shown). The other end of the charging device can be plugged into a USB socket to re-charge the cell in the control unit of the e-cigarette. In other implementations, the e-cigarette may be provided with a cable for direct connection between the electrical connection 21A and a USB socket.

[0010] The control unit is provided with one or more holes (not shown in Figure 1) for air inlet. These holes connect to an air passage through the control unit to an air passage provided through the connector 21A. This then links to an air path through the vaporiser 40 and the cartridge 30 to the mouthpiece 35. The cartridge 30 and the vaporiser 40 are attached in use by connectors 41 B and 31 B (again shown schematically in Figure 1). As explained above, the cartridge includes a chamber containing a reservoir of liquid, and a mouthpiece. When a user inhales through the mouthpiece 35, air is drawn into the control unit 20 through one or more air inlet holes. This airflow (or the resulting change in pressure) is detected by a sensor, e.g. a pressure sensor, which in turn activates the heater to vaporise the liquid from the cartridge. The airflow passes from the control unit, through the vaporiser, where it combines with the vapour, and this combination of airflow and (nicotine) vapour then passes through the cartridge and out of the mouthpiece 35 to be inhaled by a user. The cartridge 30 may be detached from the vaporiser 40 and disposed of when the supply of nicotine is exhausted (and then replaced with another cartridge).

[0011] The e-cigarette 10 has a longitudinal or cylindrical axis which extends along the centre-line of the e-cigarette from the mouthpiece 35 at one end of the cartridge 30 to the opposing end of the body portion 20 (usually referred to as the tip end). This longitudinal axis is indicated in Figure 1 by the dashed line denoted LA.

[0012] It will be appreciated that the e-cigarette 10 shown in Figure 1 is presented by way of example, and various other implementations can be adopted. For example, in some embodiments, the cartridge 30 and the vaporiser 40 may be provided as a single unit (generally referred to as a cartomiser), and the charging facility may connect to an additional or alternative power source, such as a car cigarette lighter.

[0013] Figure 2 is a schematic diagram of the main functional components of the control unit 20 of the e-cigarette 10 of Figure 1 in accordance with some embodiments of the disclosure. These components may be mounted on the circuit board provided within the control unit 20, although depending on the particular configuration, in some embodiments, one or more of the components may instead be accommodated in the control unit to operate in conjunction with the circuit board, but are not physically mounted on the circuit board itself.

[0014] The control unit 20 includes a sensor unit 61 located in or adjacent to the air path through the control unit 20 from the air inlet to the air outlet (to the vaporiser). The sensor unit includes a pressure sensor 62 and temperature sensor 63 (also in or adjacent to this air path). The control unit further includes a Hall effect sensor 52, a voltage reference generator 56, a small speaker 58, and an electrical socket or connector 21A for connecting to the vaporiser 40 or to a USB charging device.

[0015] The microcontroller 55 includes a CPU 50. The operations of the CPU 50 and other electronic components, such as the pressure sensor 62, are generally controlled at least in part by software programs running on the CPU (or other component). Such software programs may be stored in non-volatile memory, such as ROM, which can be integrated into the microcontroller 55 itself, or provided as a separate component. The CPU may access the ROM to load and execute individual software programs as and when required. The microcontroller 55 also contains appropriate communications interfaces (and control software) for communicating as appropriate with other devices in the control unit 20, such as the pressure sensor 62.

[0016] The CPU controls the speaker 58 to produce audio output to reflect conditions or states within the e-cigarette, such as a low battery warning. Different signals for signalling different states or conditions may be provided by utilising tones or beeps of different pitch and/or duration, and/or by providing multiple such beeps or tones.

[0017] As noted above, the e-cigarette 10 provides an air path from the air inlet through the e-cigarette, past the pressure sensor 62 and the heater (in the vaporiser), to the mouthpiece 35. Thus when a user inhales on the mouthpiece of the e-cigarette, the CPU 50 detects such inhalation based on information from the pressure sensor. In response to such a detection, the CPU supplies power from the battery or cell 54 to the heater, which thereby heats and vaporises the liquid from the wick for inhalation by the user.

[0018] Figures 3A and 3B, plus Figure 4, are schematic diagrams of the cartridge portion 30 of e-cigarette 10 according to an existing design. Figure 4 shows a section through the cartridge portion in a plane perpendicular to the longitudinal axis LA, taken approximately halfway along the length of the cartridge portion. Figures 3A and 3B are two sections taken in first and second planes that both include the longitudinal axis LA. These first and second planes are orthogonal to another. For convenience, we will refer to the first plane shown in Figure 3A as a horizontal plane, and the second plane shown in Figure 3B as the vertical plane. However, it will be appreciated that although in normal use, the longitudinal axis LA of the e-cigarette 10 is approximately horizontal, a user may typically hold the e-cigarette at any rotational (azimuthal) angle around this longitudinal axis. Accordingly, the terms vertical and horizontal are adopted for ease of explanation, rather than particularly implying a given orientation of the device for use.

[0019] As shown in Figures 3A, 3B and 4, the cartridge contains two main portions: an outer housing 200 and an inner container 350. The outer housing 200 has a generally circular cross-section in a plane perpendicular to the longitudinal axis LA, as can be seen in Figure 4, thereby forming a generally cylindrical tube. The outer housing has opposing side walls 301A, 301B, plus opposing top and bottom walls 301C and 301D respectively. (It will be appreciated that these walls 301A-D are generally just different, circumferentially spaced, portions of the tube forming the outer housing 200).

[0020] One end of the outer housing tube, corresponding to the location of the mouthpiece 35, is partly closed by an end wall 39, which is perpendicular to the longitudinal axis LA. An aperture is formed in the centre of this end wall, and in particular, an inner tube 37 is formed, which is defined by inner wall 36. This inner wall 36 likewise forms a generally cylindrical tube, parallel to the main outer tube of the outer housing 200 formed by walls 301A-D. However, this inner tube only extends inwards (along the longitudinal axis LA) a relatively short distance from the radially innermost portion of end wall 39 (compared with the length of the outer tube).

[0021] The inner container 350 also has a generally circular cross-section in a plane perpendicular to the longitudinal axis LA, thereby forming a generally cylindrical tube. In particular, the inner container thereby defines a central cavity 360 which retains a reservoir of liquid which is to be vaporised, typically nicotine (in solution). This liquid may be held in a foam matrix.

[0022] The interior surface of the outer housing 200 may include a screw thread at the end opposite to the mouth end 35 to join to attach the cartridge 30 to the vaporiser portion 40 (see Figure 1). The attachment may cause a wick on the vaporiser portion to penetrate the cartridge (e.g. by puncturing a seal on the reservoir), thereby drawing liquid from the reservoir onto the vaporiser. (Please note that the details of the end of the outer housing 200 and the container 350 which are furthest from the mouthpiece 35, including the configuration of the wick, etc, are omitted for clarity from Figures 3A and 3B).

[0023] The horizontal side walls of the inner container 350 abut against the corresponding side walls 301A, 301B of the outer housing. In particular, there is an interference fit between the horizontal side walls of the inner container 350 and the corresponding side walls 301A, 301B of the outer housing, which is used to retain the inner container 350 within the outer housing 200. A portion of this interference fit is denoted by reference numeral 354 in Figure 3A, and is formed between the side wall 301A of the outer housing 200 and the corresponding side wall of the inner container. Note that in practice there is a slight taper on the outer housing 200 (not shown in Figure 3) in order to enable moulding and to support this interference fit - i.e. the outer housing tapers slightly inwards so as to be narrower at the mouth end.

[0024] The generally cylindrical tube of the inner container 350 is closed at the mouthpiece end by wall 370 and is open at the opposite end 352. In addition, the interference fit between the side wall 301A of the outer housing 200 and the corresponding side wall of the inner container generally prevents the flow of air along the e-cigarette 10. Accordingly, although the inner container 350 has a generally circular cross-section in a plane perpendicular to the longitudinal axis LA, the top-most portion of this circle is flattened to allow airflow through the e-cigarette 10.

[0025] In particular, the top wall 356 of the inner container 350 is formed (in the cross-section of Figure 4) by a chord, rather than by an arc. This therefore defines an air passage 355 between the top wall 301C of the outer housing 200 and the top wall 356 of the inner container 350. This air passage 355 is also shown in Figure 3B, together with arrows denoting the airflow from the vaporiser portion 40 out through the mouthpiece 35.

[0026] The end wall 370 of the inner container 350 which is adjacent the mouthpiece 35 is provided with a tab 358. This tab extends in a direction parallel to the longitudinal axis LA of the e-cigarette 10 to abut against the end wall 39 of the outer housing 200. The tab has a cross-section of an arc in a plane perpendicular to the longitudinal axis LA of the e-cigarette 10, and is located at the bottom of the inner container 350, i.e. opposite to the top wall 356. In this position, the tab 358 does not block the airflow from the passage 355 out through the mouthpiece 35.

[0027] In addition, the length of the tab 358 (in a direction parallel to the longitudinal axis LA) is greater than the length of the inner wall 36 which defines the mouthpiece tube 37. Consequently, the tab 358 serves to prevent the end wall 370 abutting against (and thereby closing) the inside end of the mouthpiece tube 37. This configuration therefore again helps to ensure that air flowing through the air passage 355 can then reach the mouthpiece tube 37 in order to exit through the mouthpiece 35.

[0028] It will be appreciated that the particular inner container 350 shown in Figures 3 and 4 is provided by way of example only, and other implementations may have different features. For example, the inner container may be arranged to latch or clip into the outer housing 200 (rather than being held in place by an interference fit), such as shown in Figure 5, which includes latching (clip) mechanism 500. In addition, the tab 358 may be shaped differently, or provided on the outer housing, or the mouthpiece may be designed to avoid having such a tab. Further modifications will be apparent to a person of ordinary skill in the art.

[0029] In some electronic vapour provision systems, the nicotine-containing liquid is held directly in liquid form in a sealed chamber in a cartridge. For example, opening 352 shown in Figure 3A may be closed with a thin wall, e.g. using metallic foil, to create the sealed chamber. Typically this chamber is then punctured when the cartridge is introduced into the electronic vapour provision system, so as to allow a flow of liquid from the cartridge to the vaporiser 40. However, care must be taken in the design of such devices to avoid leakage, whereby the liquid flows into undesired places - e.g. perhaps into the airflow path, even when the device is not being used. An alternative approach is therefore common, especially for relatively smaller devices, for example, those which are analogous in size and shape to a conventional cigarette (such as shown in Figure 1). In this approach, the liquid is held in an absorbing material, such as cotton or foam, within the cartridge. This helps to reduce the risk of unwanted leakage. It will be appreciated that even if such an absorbing material is utilised to hold liquid in the cartridge, a seal such as a metal foil may be still be provided for the reservoir chamber to help prevent leaks prior to installation of the cartridge into the e-cigarette.

[0030] The e-cigarette 10 shown in Figure 1, and in particular the inner container 350 of Figures 3 and 4, is intended to hold the nicotine-based liquid in a polyurethane foam. This foam has certain hydrophobic properties, which is useful to help transfer the liquid from the foam onto the wick to be conveyed to the heater in the vaporiser 40 during operation of the device (as described above). The foam is generally in the form of a rectangular block which has an approximately square cross-section as defined in a plane perpendicular to the longest axis of the block (other cross-sectional shapes could be used as appropriate - e.g. circular, elliptical, rectangular, etc). The length of this block (i.e. as measured in a direction parallel to the longest axis of the rectangular block) is slightly less than the length of the inner container 350 (in a direction parallel to LA), thereby allowing the foam block to be fully incorporated within the inner container. The cross-section of the block is slightly greater than the cross-section of the inner container (which is depicted in Figure 4). Accordingly, the foam block is compressed somewhat in a lateral direction (perpendicular to LA) in order to fit within the inner container 350. It will be appreciated that this compression of the foam helps to retain the foam within the inner container.

[0031] The insertion of the liquid into the foam, and of the foam into the inner container 350 (in whatever order), is an important part of the manufacturing process for the cartridge 30. This process must be relatively straightforward and cost-effective, since the cartridge 30 is a disposable (and replaceable) unit, and is therefore sold on a stand-alone basis in greater quantities than the e-cigarette 10 itself. Furthermore, the process is specified to achieve a fill accuracy of $\pm 1\%$ in terms of the amount of liquid filled into the cartridge. This ensures that the consumer receives at least the appropriate amount of liquid in the cartridge, but avoiding significant over-filling (above the nominal amount), which would otherwise increase costs. In addition, the $\pm 1\%$ tolerance also ensures a more consistent and reliable experience for the consumer in terms of cartridge lifetime, etc.

[0032] In a development stage of cartridge 30, the procedure for filling the liquid into the foam and then the foam into the inner container 350 was performed as a two-stage manual procedure. Firstly the blocks of foam were wetted (saturated) with the liquid. Next an instrument was used to insert each block in turn into a respective inner container 350. During this second stage, a certain amount of liquid was shed from the foam block onto the instrument. This was primarily an issue for the first foam block in each batch of foam blocks, when the instrument was initially dry. For subsequent foam blocks in the batch, the transfer of liquid from each foam block to the instrument would be in approximate equilibrium with the transfer of liquid back from the instrument into the foam block. In practice, this meant the inner container which received the first foam block from each batch was more likely to be outside the tolerance limits, and therefore had to be discarded. This had a somewhat deleterious impact on the efficiency and cost-effectiveness of the overall process.

[0033] Various modifications of the above set of manual operations were investigated, such as inserting the foam first into the inner container and then wetting with the liquid (rather than performing the wetting first followed by insertion). These investigations included compressing the foam prior to the wetting (and then allowing the foam to expand within the inner container), and inserting the liquid into the foam using a syringe at different depths within the inner container, e.g. at the bottom of the inner container, or at multiple different depths simultaneously. However, the results from these investigations were generally unsatisfactory. In some cases, the liquid was prone to overflow out of the inner container 350. This was primarily due to the hydrophobic nature of the foam, which would hinder wetting. It also was found to be more difficult to obtain an even distribution of liquid throughout the foam. Such an even distribution is important to ensure a consistent operation of the e-cigarette - i.e. a substantially uniform transfer rate of liquid from the foam onto the wick, and therefore a consistent vaporisation rate during user operation.

[0034] As noted above, the hydrophobic nature of the foam is believed to be a significant factor behind the problems described above. Accordingly, further investigations were performed to see if the foam could be suitably treated, e.g. by steam, in order to reduce these hydrophobic properties. Although such treatments were indeed found to be helpful in trying to avoid an uneven distribution of liquid in the foam, and also overflow of the liquid out of the inner container, they generally increased processing time, thereby reducing the overall efficiency and cost-effectiveness of the procedure.

[0035] Accordingly, Figure 6 is a schematic diagram of an automated method for filling liquid into a cartridge for an electronic vapour provision system in accordance with some embodiments. The first stage of the processing involves the supply or feed of a rectangular foam block 610. As described above, the foam block is generally made from a hydrophobic material such as polyurethane. It will be appreciated that the rectangular block shape of the foam allows the foam block to be easily cut (without wastage) from a larger foam structure (although other shapes could be used as appropriate).

[0036] The largest (longest) dimension of the block is indicated in Figure 6 by the arrow Z, and represents the longitudinal axis of the foam block. After the foam block has been inserted into the cartridge 30 of an e-cigarette 10, the longitudinal axis of the foam block is generally aligned (and coincident) with the longitudinal axis LA of the e-cigarette 10. The cross-sectional shape of the block in a plane perpendicular to this longitudinal axis is approximately square, which is suited to the generally circular cross-section of the inner container 350 in a plane perpendicular to the longitudinal axis of the e-cigarette 10. If the inner container had a different cross-section, e.g. substantially elliptical, then the cross-sectional shape of the foam block could be likewise modified (as would other components of the apparatus, such as the filling tube and piston described below).

[0037] The apparatus for filling liquid into a cartridge for an electronic vapour provision system includes a filling tube 620. This filling tube 620 comprises a hollow, straight tube or pipe, whereby the main longitudinal axis of the tube is set in a vertical direction. The cross-sectional shape of the filling tube 620 in a plane perpendicular to the longitudinal axis of the filling tube is approximately circular.

[0038] In some embodiments, the filling tube 620 is held in a substantially fixed location, with a vertical orientation for the tube. The underside of the tube 620 provides an open end 621 into which the foam block 610 may be inserted. In order to support such an insertion, the foam block 610 is fed so that the longitudinal axis of the foam block is aligned and coincident with the longitudinal axis of the filling tube 620, with the open end 621 of the filling tube 620 located above the top of the foam block 610 - as shown in stage 2 of Figure 6. For the configuration of Figure 6, the foam block 610 is therefore fed with its main longitudinal axis having a vertical orientation.

[0039] As shown in Figure 6, the cross-section of the foam block 610 is greater than the cross-section of the filling tube 620 (in particular, greater than the internal diameter of the hollow passage within the filling tube 620). Accordingly, the foam block 610 is compressed in a lateral direction, i.e. perpendicular to the longitudinal axis of the foam block, to produce a compressed foam block 610A - as shown in stage 3 of Figure 6. In some embodiments, this compression may be performed by tweezers or prongs (not shown in Figure 6) that have multiple sides (arms) that converge towards the central longitudinal axis of foam block 610 in order to perform the compression. For example, there may be 2, 3 or 4 (or more) sides, which have a straight or curved profile (when viewed in cross-section in a horizontal plane).

[0040] The compressed foam block 610A is now inserted into the filling tube 620 via the open end 621 of the filling tube, such that the foam block is fully located within the filling tube 620, but still adjacent the open end 621 - as shown in stage 4 of Figure 6. In this position, the compressed foam block 610A tries to expand outwards against the walls or sides of the hollow filling tube 620. This pressure creates a friction between the foam block 610A and the inner wall of the filling tube 620, which prevents the foam block from falling out of the open end 621 of the filling tube.

[0041] In some embodiments, the inner wall of the filling tube is provided with a textured or roughened surface. This texturing increases the effective friction between the foam block 610A and the inner wall of the filling tube 620, and so holds the compressed foam block 610A more securely in the filling tube 620. The roughness value (Ra) of the surface of the inner wall is important for achieving stability. For example, a roughness value between 2 and 5 typically gives good results, with especially good results being found from testing a particular implementation to occur with Ra between 3 and 4. Note that if Ra is too high, the foam may snag on exit, while if Ra is too low, the foam may be displaced by the liquid during initial pumping of the liquid into the tube 620.

[0042] There are various approaches than can be adopted for performing the insertion of the compressed foam block 610A into the filling tube 620. For example, in one embodiment, the tweezers or prongs used to perform the compression may also lift the compressed foam rod 610 until it is immediately adjacent to the open end 621 of the filling tube 620 (or the feed location of the compressed foam block 610 may be such that this positioning is achieved without performing any lifting of the compressed foam block 610A). An actuation device may then be used to push upwards on the underside of the compressed foam block 610A, thereby moving the compressed foam block 610A upwards and out of the tweezers into the open end 621 of the filling tube 620. Assuming that the top of the tweezers is located sufficiently close to the open end 621 of the filling tube 620, the compressed foam block 610A has little or no opportunity to (re)expand between the top of the tweezers and the open end of the filling tube.

[0043] In other embodiments, the tweezers may themselves fit within the filling tube, and therefore be used to lift the compressed foam block 610A at least partway into the filling tube 620. In these embodiments, it is necessary to ensure that the compressed foam block 610A remains within the filling tube 620 when the tweezers are withdrawn. One way of doing this is to provide some support underneath the bottom of the compressed foam block 610A, i.e. in effect at the open end 621 of the filling tube 620, which allows the tweezers to be withdrawn from the filing tube 620, but ensures that the compressed foam block 610A is retained therein.

[0044] Other implementations are also possible. For example, the foam may be compressed by the tweezers along two opposing sides, while being free on the other two sides which are not in contact with the tweezers. The two "free" sides can then be compressed by the walls of the filling tube. Next, the tweezers are allowed to open (at least partially), and the tweezers are then withdrawn or retracted from the filling tube 620. The friction between the two "free" sides and the inner surface of the filling tube 620 allows the foam to remain in place during the retraction of the tweezers.

[0045] The apparatus is arranged so that the top surface of the foam block 610 is proud of (extends beyond) the open (top) end of the tweezers during insertion. One reason for this is that the foam then bunches up around the top of the tweezers, which provides additional resistance to stop the foam from sliding back down the tweezers during insertion. In addition, this bunching allows the foam to make contact with the underside of piston 630 (as described below), and thereby helps to prevent the underside surface of the piston 630 from retaining a substantially sized droplet of liquid, which might otherwise lead to greater variability in the amount dispensed into different cartridges.

[0046] Although Figure 6 shows the compression of the foam block 610 and the insertion of the compressed foam block 610A into the filling tube 620 as separate stages (3 and 4), in other embodiments, the compression and insertion might be performed as a single, combined operation. This approach is illustrated in Figure 7, in which the open end 621 at the bottom of the filling tube 620 is provided with an outwardly directed flange 625 (i.e. it flares outwards). In this implementation, the bottom of the flanged portion 625 is large enough to accept the uncompressed foam block 610 (Figure 7A). However, as the foam block 610 is pushed further up into the filling tube 620, the diameter of the flange narrows, thereby compressing the top portion of the foam block into the filling tube 620 (Figure 7B). Eventually, the whole foam block is located in compressed form within the filling tube 620 (Figure 7C).

[0047] After the compressed foam block 610A has been located within the filling tube (by any suitable mechanism), the compressed foam block is now provided with liquid to produce a wetted foam block 610B. A positive displacement pump is used for the filling process. In particular, the positive displacement pump has a small bore, so that the amount of liquid provided per cycle of the pump is low volume - e.g. less than 0.1ml. Consequently, the total amount of liquid dispensed to a given foam block can be controlled very accurately by specifying the total number of cycles to be used to fill a given foam block. It will also be appreciated that because the liquid supply from the positive displacement pump is generated by the displacement of liquid using a component of known size, the amount of liquid dispensed per cycle is consistent and reliable, matching the known size of the moving component. This in turn therefore produces a consistent and reliable fill level of the compressed foam block 610A for use in an e-cigarette cartridge 30.

[0048] In some implementations, the feed from the positive displacement pump may pass down from the top of the filling tube 620. Alternatively, or additionally, the positive displacement pump may insert liquid into the compressed foam block 610A through a small opening in the side of the filling tube. In general, the liquid is injected into the foam block 610A itself (rather than, say, being dropped onto the foam block from above). This helps to give a better (more uniform) absorption of the liquid within the compressed foam block 610A. In addition, the point of injection may be located in the top half of the compressed foam block, since this location, combined with gravity, again helps to provide a more uniform absorption of liquid into the compressed foam block 610A. A further option is to have multiple points of liquid injection into the compressed foam block, e.g. at different distances from the open end 621 of the filling tube 620. Once again, this can help to support a more uniform and reliable absorption of liquid into the compressed foam block 610A.

[0049] The inner container 350 for a cartridge (such as shown in Figure 3) is now located adjacent the open end 621 of the filling tube 620, such that the longitudinal axis of the inner container is aligned and coincident with the longitudinal axis of the filling tube 620. The inner container is orientated so that the wall 370 and tab 358 point downwards (away from the open end 621 of the filling tube 620), while the open end 352 of the inner container 350 is directed upwards so that it faces the open end 621 of the filling tube 620 - as shown in stage 6 of Figure 6.

[0050] In some implementations, the filling tube is maintained in a fixed position, and first a foam block 610 is located beneath the open end 621 of the tube (as per stage 2), and then later the inner container is located beneath the open end 621 of the tube (as per stage 6). In other implementations, the filling tube is itself moved so as to locate the open end 621 of the tube with respect to the foam block 610 and/or the inner container 350.

[0051] Note that the filling tube 620 may have a smaller cross-section than the inner container 350. This then allows the inner container 350 to be raised slightly (and/or the filling tube 620 to be lowered slightly) so that there is a small overlap between the two. In other words, the bottom of the filling tube 620 is then located slightly within the inner container 350. This overlap can help to ensure that the compressed (and wetted) filling block 610B passes easily out of the open end of the filling tube into the inner container without the risk of liquid loss. However, the overlap is generally small enough to preserve room (depth) within the inner container 350 to accommodate the compressed foam block 610B (once ejected from within the filling tube 620). Other implementations may not have any such overlap between the filling tube and the inner container (as measured in the vertical direction), although the open end 621 of the filling tube may nevertheless be very close to the open end 352 of the inner container 350.

[0052] As also shown in Figure 6, a piston (pusher) rod 630 is located within the filling tube. This piston rod is pushed downwards through the filling tube 620 in order to expel the wetted foam block 610B from the open end 621 of the filling tube into the inner container 350. Note that this expulsion process may also help to distribute the liquid more evenly through the foam block.

[0053] In general, the motion of the piston rod 630 is sufficient to drive the wetted foam block 610B all the way into the inner container 350, so that the bottom of the wetted foam block 610B sits against the end wall 370 of the inner container - as shown in stage 7A of Figure 6. For this purpose, the piston rod 630 is actuated downwards so that the lower end of the piston rod reaches at least close to the open end 621 of the filling tube 620. Indeed, the piston rod 630 may slightly protrude from the open end 621 of the filling tube 620 at this point.

[0054] In some embodiments, the piston rod 630 is provided with a double-hit action. In other words, after the initial pushing by the piston rod 630 to expel the wetted foam block 610B into the inner container 350, there is a short and rapid partial retraction of the piston rod (i.e. upwards), followed by another short and rapid downward stroke, before the piston rod 630 is finally withdrawn from the inner container. This double-hit action can help to provide a clean separation of the piston rod 630 from the wetted foam block, as newly inserted into the inner container 350, as well as a more consistent shaping and arrangement of the foam block within the inner container 350.

[0055] In other embodiments, the piston rod 630 and filling tube 620 may provide a different way of expelling the wetted foam block 610B from the filling tube 620. For example, one possibility would be for the filling tube and piston rod to start from the position shown in stage 6 of Figure 6, and then to be jointly lowered into the inner container, assuming that the cross-section of the latter is greater than the cross-section of the former (or alternatively, the inner container 350 could be lifted around the outside of the filling tube 620). Once the wetted foam block 610B was in approximately the correct location within the inner container, the filling tube could then be retracted upwards, while the position of the piston rod 630 was maintained steady - thereby arriving at the configuration shown in stage 6 of Figure 6.

[0056] Whichever approach is used to expel the wetted foam block 610B from the filling tube 620, the process arrives at the situation shown at stage 7B of Figure 6, whereby the insertion of the wetted foam block 610B into the inner container 350 has been completed. The inner container can now be removed for suitable further processing, such as assembly into cartridge 30, a cartomiser, or any other such component.

[0057] Figure 8 is a schematic diagram of an apparatus 800 for the automated filling of liquid into a cartridge 30 for an electronic vapour provision system in accordance with some embodiments of the invention. This apparatus includes a filling tube or pipe 620 as previously described arranged in a vertical configuration. A piston or pusher rod 630 is located in the top portion of the filling tube 620, while the bottom of the filling tube has an open end. The apparatus has a mechanism for feeding a foam block 610 at a time to the position (denoted by arrow 850) underneath the open end 621 of the filing tube. The apparatus 800 further includes a mechanism for compressing and lifting the foam block 610 into the filling tube (as per stage 4 of Figure 6).

[0058] A positive displacement pump 810 is provided as part of apparatus 800 to dispense a precisely controlled amount of liquid into the foam block in the filling tube 620 through a side opening in the filling tube. When this filling operation has been completed (or while it is in progress), and inner container for a cartridge is fed to the position 850. The piston rod is then activated to expel the wetted foam block 610 from the filling tube into the inner container 350.

[0059] The apparatus 800 therefore provides an automated, high-volume mechanism for the filling of e-cigarette cartridges (including cartomisers, etc). The apparatus may be operated in a semi-automated intermittent, fully automated intermittent, or fully automated continuous mode. Typical implementations of the apparatus 800 support run rates in the range of 5-300 capsules filled per minute.

[0060] The apparatus supports a complete wetting of the foam block 610 with a very consistent fill level of liquid per cartridge - typically greater than 99% accuracy by weight. The automated processing also brings additional benefits over existing manual procedures. For example, there is lower risk of human contamination of the e-cigarette cartridges, or of undesired exposure of manual operators to the e-cigarette liquids. Furthermore, the accurate and reliable automated filling process can lead to cost savings, and a more consistent (and hence generally improved) user experience.

[0061] The flowchart of Figure 9 provides a flowchart of an automated method of filling a cartridge with liquid for an electronic vapour provision system in accordance with some embodiments of the invention. In this context, a cartridge should be understood to include any unit of an electronic vapour provision system that receives and contains a liquid for vaporisation, such as cartridge 30 as shown in Figure 1, a cartomiser, or any chamber or liquid container to be provided in such a device, e.g. such as inner container 350 from Figure 3. The liquid to be filled typically comprises nicotine in combination with other constituents, such as a solvent, one or more flavourings, and/or a component to assist in aerosol formation during the vaporisation process. However, the method is not limited to nicotine-based liquids, but rather applies to any such liquid for use in an electronic vapour provision system (such as an e-cigarette).

[0062] The method shown in Figure 9 includes inserting a block of foam into a filling tube (operation 910), for example using tweezers or a pushing rod. The foam is formed from a hydrophobic material, for example, polyurethane. The filling tube may have a roughened or textured internal surface to help retain the foam within the filling tube. The method further includes injecting liquid into the foam block within the filling tube using a positive displacement pump to produce a wetted foam block. The positive displacement pump may be provided with a small bore (pumped amount per cycle) to provide an accurate and consistent amount of liquid fill per foam block. The method further comprises pushing the wetted foam block out of the filling tube into the cartridge, for example using a piston rod. This expulsion of the foam block may involve a double-hit of the foam block by the piston rod to provide improved consistency in placement of the foam block within the container.

[0063] The method shown in Figure 9 supports automation, together with consistent, highly accurate fill rates of liquid into the foam blocks of each cartridge. Such a method can therefore help to produce a set of multiple cartridges filled with liquid held in a foam block for use in a vapour provision system, wherein each cartridge in said the contains the same amount of liquid within a tolerance of ±1 per cent (the tolerance can be defined, for example, as representing 2, 2.5. or 3 σ, wherein σ represents the standard deviation of liquid amounts across the set/sample or overall population of cartridges).

[0064] The skilled person will be aware of many potential variations on the various implementations described above. By way of example only, rather than using a positive displacement pump, some other form of liquid filling pump may be utilised to provide a consistent amount of liquid for filling the cartridges, for example, a syringe pump. In addition, rather than using a foam block to hold the liquid in the cartridges, some other suitable compressible matrix may be utilised instead.

[0065] In order to address various issues and advance the art, this disclosure shows by way of illustration various embodiments in which the claimed invention(s) may be practiced. The advantages and features of the disclosure are of a representative sample of embodiments only, and are not exhaustive and/or exclusive. They are presented only to assist in understanding and to teach the claimed invention(s). It is to be understood that advantages, embodiments, examples, functions, features, structures, and/or other aspects of the disclosure are not to be considered limitations on the disclosure as defined by the claims or limitations on equivalents to the claims, and that other embodiments may be utilised and modifications may be made without departing from the scope of the claims. Various embodiments may suitably comprise, consist of, or consist essentially of, various combinations of the disclosed elements, components, features, parts, steps, means, etc other than those specifically described herein.

Claims

1. An automated method of filling a cartridge (30) with liquid for a vapour provision system (10), the method comprising:

    inserting a compressible matrix (610) into a filling tube (620);
    injecting liquid into the matrix within the filling tube using a liquid filling pump to produce a wetted matrix; and
    pushing the wetted matrix out of the filling tube into the cartridge.

2. The method of claim 1, further comprising compressing the matrix in a lateral direction perpendicular to a main longitudinal axis of the matrix prior to inserting the matrix into the filling tube, optionally wherein tweezers are used to compress the matrix in a lateral direction and to insert the matrix into the filling tube, and further optionally wherein the matrix is held such that a portion of the matrix is proud of the end of the tweezers during insertion of the matrix into the filling tube.

3. The method of any preceding claim, wherein the filling tube has an internal surface which is roughened, optionally wherein the internal surface of the filling tube has a roughness value Ra in the range 2 to 5, preferably in the range 3 to 4.

4. The method of any preceding claim, wherein the filling tube has an open end (621), and the matrix is inserted into the filling tube through this open end, and pushed out of the filling tube into the cartridge through this open end, optionally wherein the filling tube has a substantially vertical orientation, and the open end is at the bottom of the filling tube.

5. The method of any preceding claim, wherein the liquid filling pump is a positive displacement pump.

6. The method of any of claims 1 to 4, wherein the liquid filling pump is a syringe.

7. The method of any preceding claim, wherein the liquid filling pump has a bore of 0.5 ml or less, optionally wherein the liquid filling pump has a bore of 0.1 ml or less.

8. The method of any preceding claim, wherein the liquid is injected into the matrix within the filling tube by the liquid filling pump through one or more locations in the side of the filling tube, optionally wherein the wetted matrix is pushed out of an open end of the filling tube, and wherein liquid is injected into a portion of the matrix which Is further from the open end of the filling tube than the centre of the matrix is.

9. The method of any preceding claim, wherein the wetted matrix is pushed out an open end of the filling tube into an open end of the cartridge, and wherein prior to pushing the wetted matrix out of the filling tube, the open end of the filling tube is located within the open end of the cartridge, optionally wherein the open end of the filling tube is inserted a distance into

the open end of the cartridge prior to pushing out the wetted hydrophobic matrix, wherein said distance is small compared to the depth of the cartridge.

10. The method of any preceding claim, wherein a piston rod is used to push the wetted matrix out of the filling tube into the cartridge, optionally wherein the piston rod makes double hit to push the wetted matrix out of the filling tube into the cartridge.

11. The method of any preceding claim, wherein said matrix comprises a block of foam (61).

12. The method of any preceding claim, wherein said matrix is formed from a hydrophobic material.

13. An apparatus configured to perform an automated filling of a cartridge with liquid for a vapour provision system, the apparatus including a filling tube (620) and further comprising:

a mechanism for inserting a compressible matrix into the filling tube;
a liquid filling pump for injecting liquid into the matrix within the filling tube to produce a wetted matrix; and
a piston mechanism for pushing the wetted matrix out of the filling tube into the cartridge.

14. A set of multiple cartridges filled with liquid held in a matrix for use in a vapour provision system, wherein each cartridge in said set is obtained by the method according to any of claims 1 to 12, so that each contains the same amount of liquid within a tolerance of ±1 per cent.

15. The set of cartridges of claim 14, comprising at least 2 or more, 5 or more, 10 or more, 50 or more, or 100 or more cartridges.

Patentansprüche

1. Automatisiertes Verfahren zum Füllen von Flüssigkeit in eine Kartusche (30) für ein Dampfversorgungssystem (10), wobei das Verfahren umfasst:

Einsetzen einer kompressiblen Matrix (610) in ein Füllrohr (620);
Einspritzen von Flüssigkeit in die Matrix innerhalb des Füllrohrs unter Verwendung einer Flüssigkeitsfüllpumpe zur Herstellung einer benetzten Matrix; und
Drücken der benetzten Matrix aus dem Füllrohr in die Kartusche.

2. Verfahren nach Anspruch 1, ferner umfassend das Komprimieren der Matrix in einer seitlichen Richtung senkrecht zu einer Hauptlängsachse der Matrix vor dem Einsetzen der Matrix in das Füllrohr, gegebenenfalls wobei eine Pinzette verwendet wird, um die Matrix in einer seitlichen Richtung zu komprimieren und die Matrix in das Füllrohr einzusetzen, und ferner gegebenenfalls wobei die Matrix so gehalten wird, dass beim Einsetzen der Matrix in das Füllrohr ein Teil der Matrix am Ende der Pinzette vorsteht.

3. Verfahren nach einem vorhergehenden Anspruch, wobei das Füllrohr eine Innenfläche aufweist, die aufgeraut ist, gegebenenfalls wobei die Innenfläche des Füllrohrs einen Rauheitswert Ra im Bereich von 2 bis 5, vorzugsweise im Bereich von 3 bis 4, aufweist.

4. Verfahren nach einem vorhergehenden Anspruch, wobei das Füllrohr ein offenes Ende (621) aufweist und die Matrix durch dieses offene Ende in das Füllrohr eingeführt und durch dieses offene Ende aus dem Füllrohr in die Kartusche gedrückt wird, gegebenenfalls wobei das Füllrohr eine im Wesentlichen vertikale Ausrichtung aufweist und das offene Ende am Boden des Füllrohrs liegt.

5. Verfahren nach einem vorhergehenden Anspruch, wobei die Flüssigkeitsfüllpumpe eine Verdrängerpumpe ist.

6. Verfahren nach einem der Ansprüche 1 bis 4, wobei die Flüssigkeitsfüllpumpe eine Spritze ist.

7. Verfahren nach einem vorhergehenden Anspruch, wobei die Flüssigkeitsfüllpumpe eine Bohrung von 0,5 ml oder weniger aufweist, gegebenenfalls wobei die Flüssigkeitsfüllpumpe eine Bohrung von 0,1 ml oder weniger aufweist.

8. Verfahren nach einem vorhergehenden Anspruch, wobei die Flüssigkeit durch die Flüssigkeitsfüllpumpe durch eine oder mehrere Stellen in der Seite des Füllrohrs in die Matrix innerhalb des Füllrohrs eingespritzt wird, gegebenenfalls wobei die benetzte Matrix aus einem offenen Ende des Füllrohrs herausgedrückt wird, und wobei Flüssigkeit in einen Abschnitt der Matrix eingespritzt wird, der weiter als die Mitte der Matrix vom offenen Ende des Füllrohrs entfernt ist.

9. Verfahren nach einem vorhergehenden Anspruch, wobei die benetzte Matrix aus einem offenen Ende des Füllrohrs in ein offenes Ende der Kartusche gedrückt wird, und wobei vor dem Herausdrücken der benetzten Matrix aus dem Füllrohr das offene Ende des Füllrohrs sich innerhalb des offenen Endes der Kartusche befindet, gegebenenfalls wobei das offene Ende des Füllrohrs vor dem Herausdrücken der benetzten hydrophoben Matrix eine Strecke in das offene Ende der Kartusche eingeführt wird, wobei diese Strecke im Vergleich zur Tiefe der Kartusche gering ist.

10. Verfahren nach einem vorhergehenden Anspruch, wobei eine Kolbenstange dazu verwendet wird, die benetzte Matrix aus dem Füllrohr in die Kartusche zu drücken, gegebenenfalls wobei die Kolbenstange einen Doppelstoß ausführt, um die benetzte Matrix aus dem Füllrohr in die Kartusche zu drücken.

11. Verfahren nach einem vorhergehenden Anspruch, wobei die Matrix einen Schaumstoffblock (61) umfasst.

12. Verfahren nach einem vorhergehenden Anspruch, wobei die Matrix aus einem hydrophoben Material gebildet ist.

13. Vorrichtung, die dazu eingerichtet ist, ein automatisiertes Füllen von Flüssigkeit in eine Kartusche für ein Dampfversorgungssystem durchzuführen, wobei die Vorrichtung ein Füllrohr (620) aufweist und ferner Folgendes umfasst:

einen Mechanismus zum Einführen einer kompressiblen Matrix in das Füllrohr;
eine Flüssigkeitsfüllpumpe zum Einspritzen von Flüssigkeit in die Matrix innerhalb des Füllrohrs, um eine benetzte Matrix herzustellen; und
einen Kolbenmechanismus zum Drücken der benetzten Matrix aus dem Füllrohr in die Kartusche.

14. Satz von mehreren Kartuschen, die mit Flüssigkeit gefüllt sind, die in einer Matrix zur Verwendung in einem Dampfversorgungssystem gehalten wird, wobei jede Kartusche in dem Satz durch das Verfahren nach einem der Ansprüche 1 bis 12 erhalten wird, sodass jede die gleiche Menge an Flüssigkeit innerhalb einer Toleranz von ±1 Prozent enthält.

15. Satz von Kartuschen nach Anspruch 14, umfassend mindestens 2 oder mehr, 5 oder mehr, 10 oder mehr, 50 oder mehr oder 100 oder mehr Kartuschen.

Revendications

1. Procédé automatique de remplissage d'une cartouche (30) avec un liquide pour un système de fourniture de vapeur (10), le procédé comprenant :

l'insertion d'une matrice compressible (610) dans un tube de remplissage (620) ;
l'injection de liquide dans la matrice au sein du tube de remplissage à l'aide d'une pompe de remplissage de liquide pour produire une matrice mouillée ; et
la poussée de la matrice mouillée hors du tube de remplissage jusque dans la cartouche.

2. Procédé selon la revendication 1, comprenant en outre la compression de la matrice dans une direction latérale perpendiculaire à un axe longitudinal principal de la matrice avant d'insérer la matrice dans le tube de remplissage, dans lequel facultativement des pinces sont utilisées pour comprimer la matrice dans une direction latérale et pour insérer la matrice dans le tube de remplissage, et dans lequel en outre facultativement la matrice est maintenue de sorte qu'une portion de la matrice fasse saillie de l'extrémité des pinces pendant l'insertion de la matrice dans le tube de remplissage.

3. Procédé selon l'une quelconque des revendications précédentes, dans lequel le tube de remplissage a une surface interne qui est rugosifiée, dans lequel facultativement la surface interne du tube de remplissage a une valeur de rugosité Ra dans la plage de 2 à 5, de préférence dans la plage de 3 à 4.

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel le tube de remplissage a une extrémité ouverte (621), et la matrice est insérée dans le tube de remplissage à travers cette extrémité ouverte, et poussée hors du tube de remplissage jusque dans la cartouche à travers cette extrémité ouverte, dans lequel facultativement le tube de remplissage a une orientation sensiblement verticale, et l'extrémité ouverte est au niveau du fond du tube de remplissage.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel la pompe de remplissage de liquide est une pompe volumétrique.

6. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel la pompe de remplissage de liquide est une seringue.

7. Procédé selon l'une quelconque des revendications précédentes, dans lequel la pompe de remplissage de liquide a un alésage de 0,5 ml ou moins, dans lequel facultativement la pompe de remplissage de liquide a un alésage de 0,1 ml ou moins.

8. Procédé selon l'une quelconque des revendications précédentes, dans lequel le liquide est injecté dans la matrice au sein du tube de remplissage par la pompe de remplissage de liquide à travers un ou plusieurs emplacements dans le côté du tube de remplissage, dans lequel facultativement la matrice mouillée est poussée hors d'une extrémité ouverte du tube de remplissage, et dans lequel du liquide est injecté dans une portion de la matrice qui est plus éloignée de l'extrémité ouverte du tube de remplissage que ne l'est le centre de la matrice.

9. Procédé selon l'une quelconque des revendications précédentes, dans lequel la matrice mouillée est poussée hors d'une extrémité ouverte du tube de remplissage jusque dans une extrémité ouverte de la cartouche, et dans lequel avant de pousser la matrice mouillée hors du tube de remplissage, l'extrémité ouverte du tube de remplissage est située au sein de l'extrémité ouverte de la cartouche, dans lequel facultativement l'extrémité ouverte du tube de remplissage est insérée sur une distance dans l'extrémité ouverte de la cartouche avant de pousser au dehors la matrice hydrophobe mouillée, dans lequel ladite distance est petite en comparaison à la profondeur de la cartouche.

10. Procédé selon l'une quelconque des revendications précédentes, dans lequel une tige de piston est utilisée pour pousser la matrice mouillée hors du tube de remplissage jusque dans la cartouche, dans lequel de préférence la tige de piston réalise un coup double pour pousser la matrice mouillée hors du tube de remplissage jusque dans la cartouche.

11. Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite matrice comprend un bloc de mousse (61).

12. Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite matrice est composée d'un matériau hydrophobe.

13. Appareil configuré pour effectuer un remplissage automatique d'une cartouche avec un liquide pour un système de fourniture de vapeur, l'appareil comportant un tube de remplissage (620) et comprenant en outre :

un mécanisme pour insérer une matrice compressible dans le tube de remplissage ;
une pompe de remplissage de liquide pour injecter du liquide dans la matrice au sein du tube de remplissage pour produire une matrice mouillée ; et
un mécanisme de piston pour pousser la matrice mouillée hors du tube de remplissage jusque dans la cartouche.

14. Ensemble de cartouches multiples remplies d'un liquide maintenu dans une matrice pour leur utilisation dans un système de fourniture de vapeur, dans lequel chaque cartouche dudit ensemble est obtenue par le procédé selon l'une quelconque des revendications 1 à 12, de sorte que chacune contienne la même quantité de liquide avec une tolérance de ± 1 pour cent.

15. Ensemble de cartouches selon la revendication 14, comprenant au moins 2 cartouches ou plus, 5 cartouches ou plus, 10 cartouches ou plus, 50 cartouches ou plus, ou 100 cartouches ou plus.

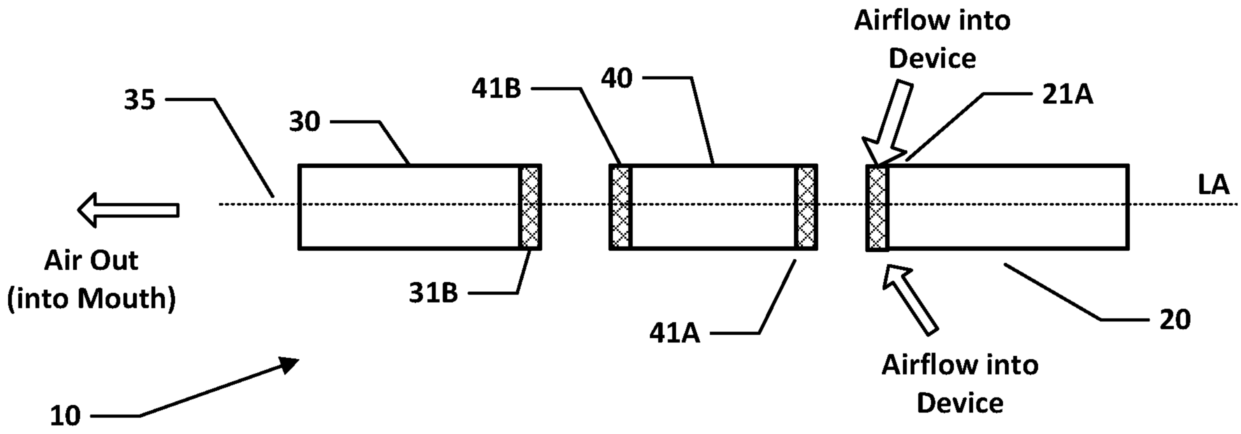

Figure 1

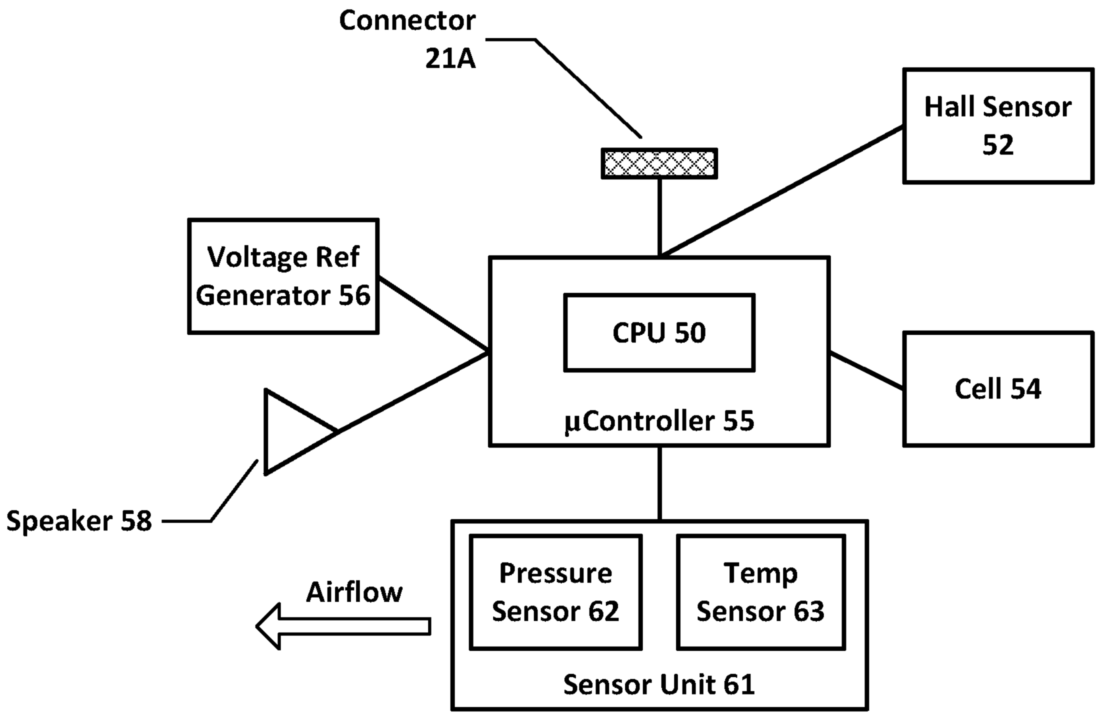

Figure 2

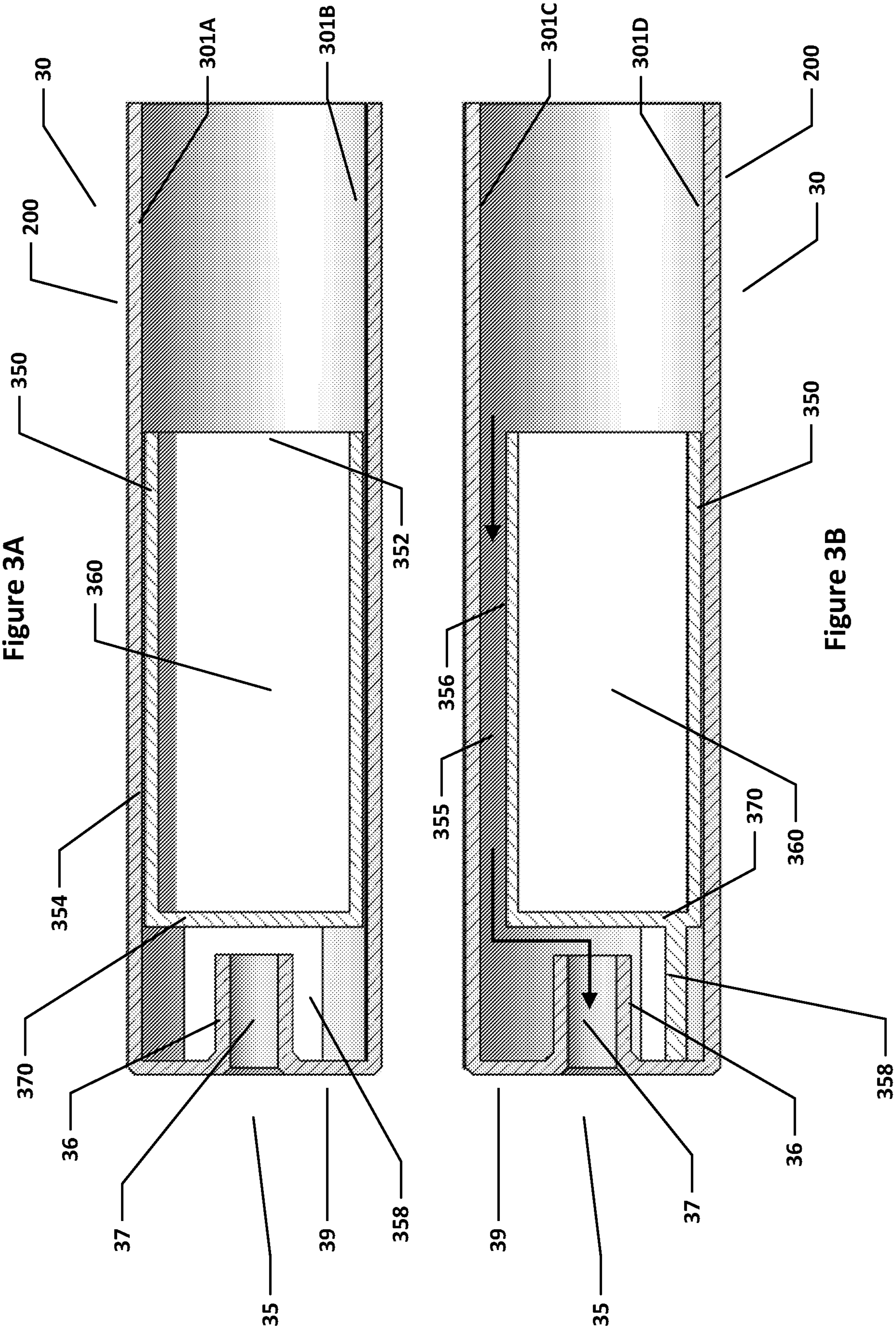

Figure 3A

Figure 3B

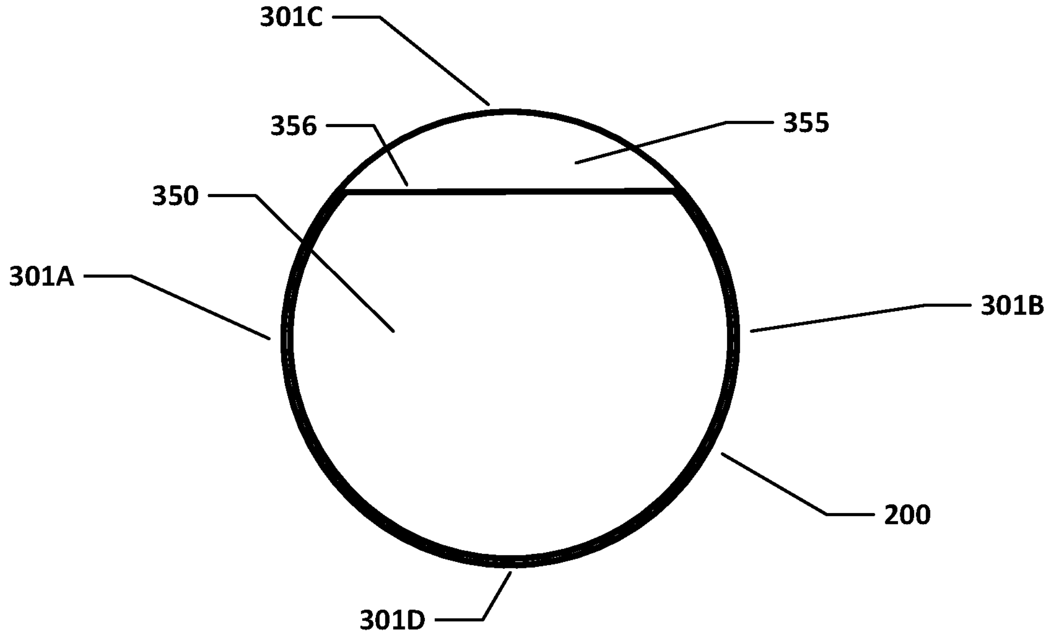

Figure 4

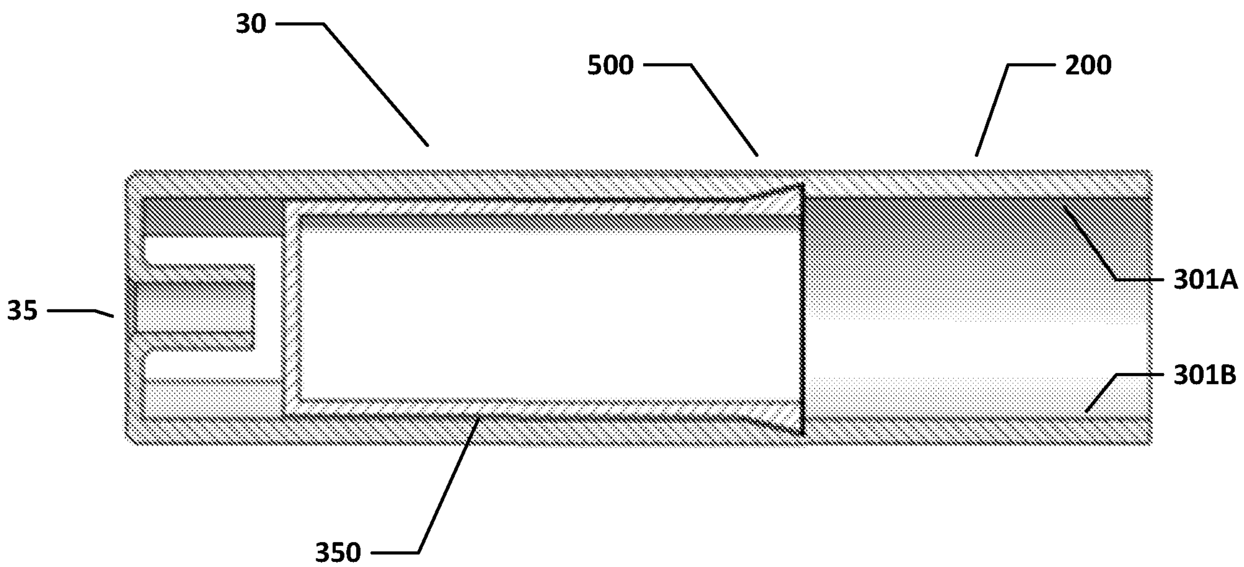

Figure 5

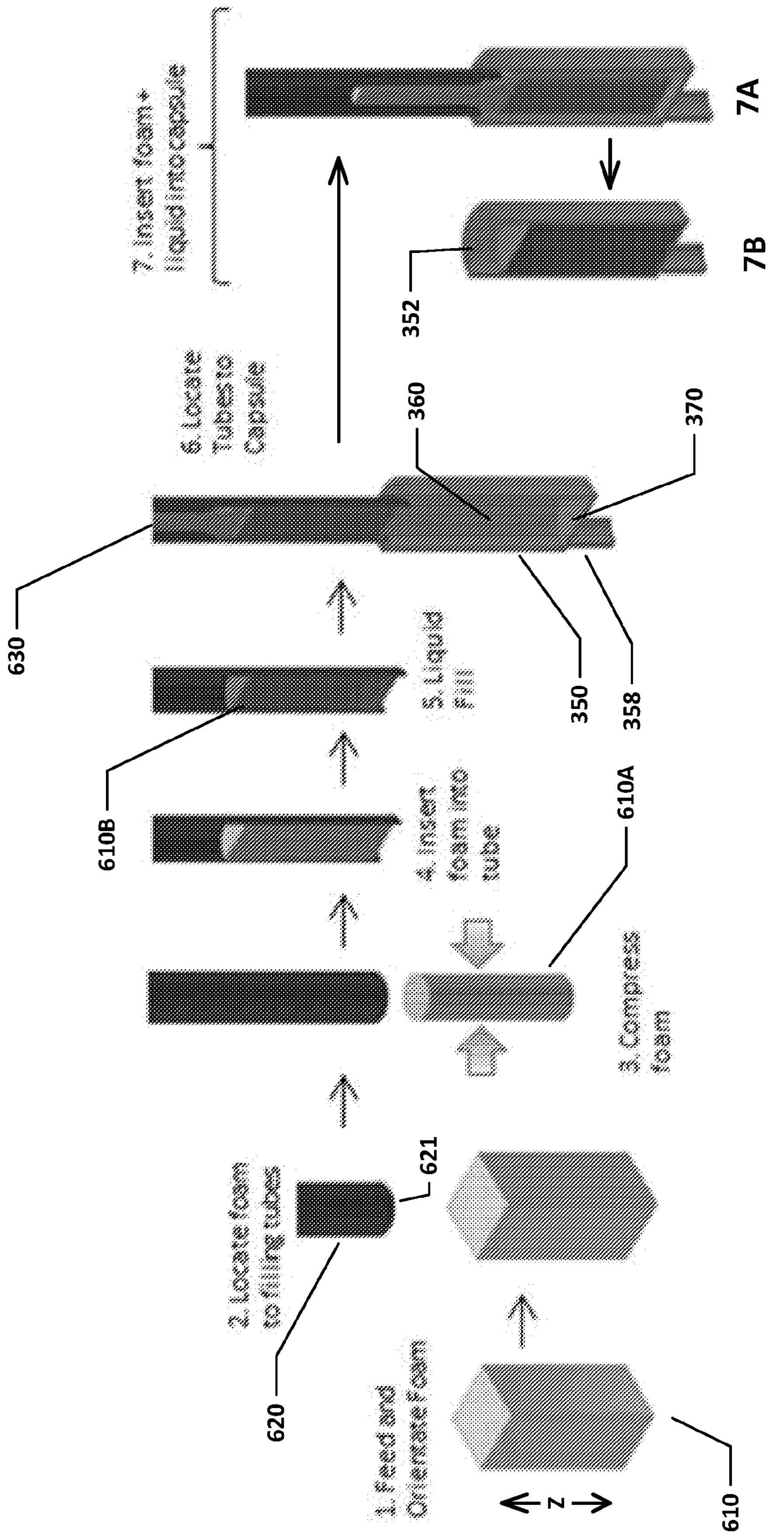
1. Feed and Orientate Foam
Z
610
2. Locate foam to filling tubes
620
621
3. Compress foam
610A
4. Insert foam into tube
610B
5. Liquid Fill
630
6. Locate Tubes to Capsule
360
370
350
358
7. Insert foam + liquid into capsule
352
7A
7B

Figure 6

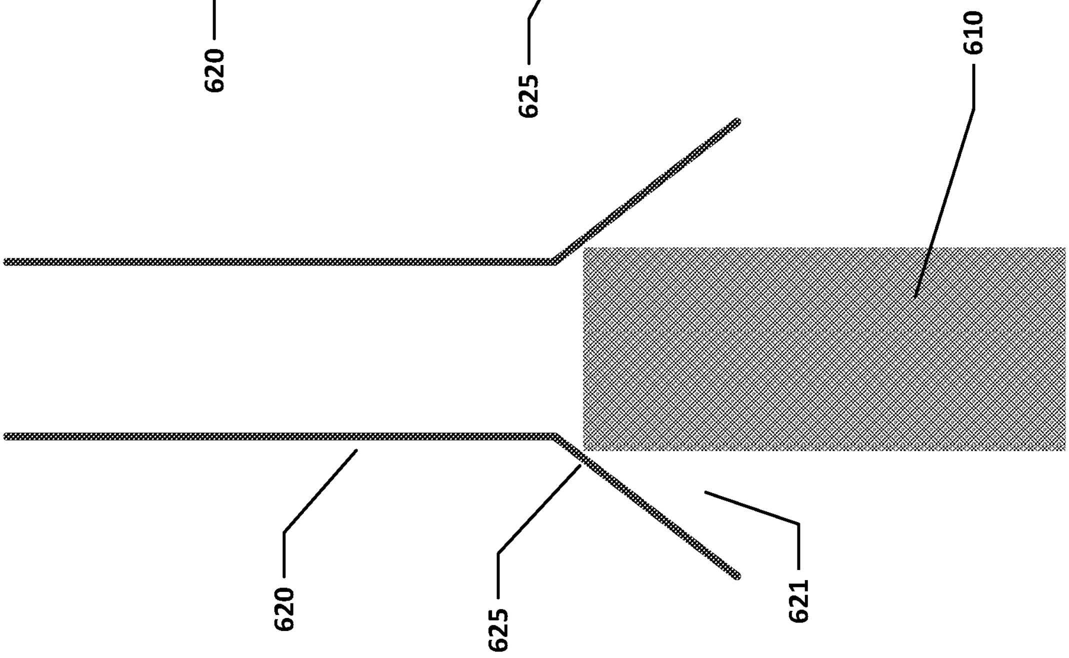

Figure 7A

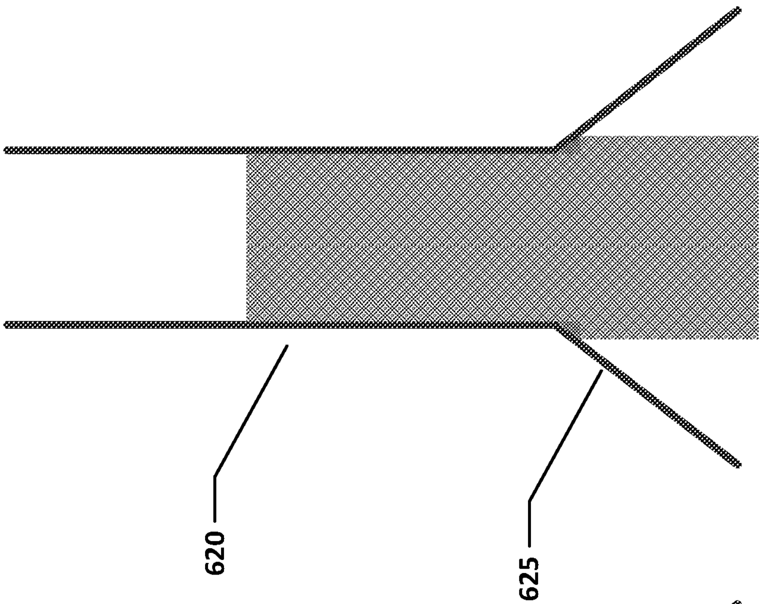

Figure 7B

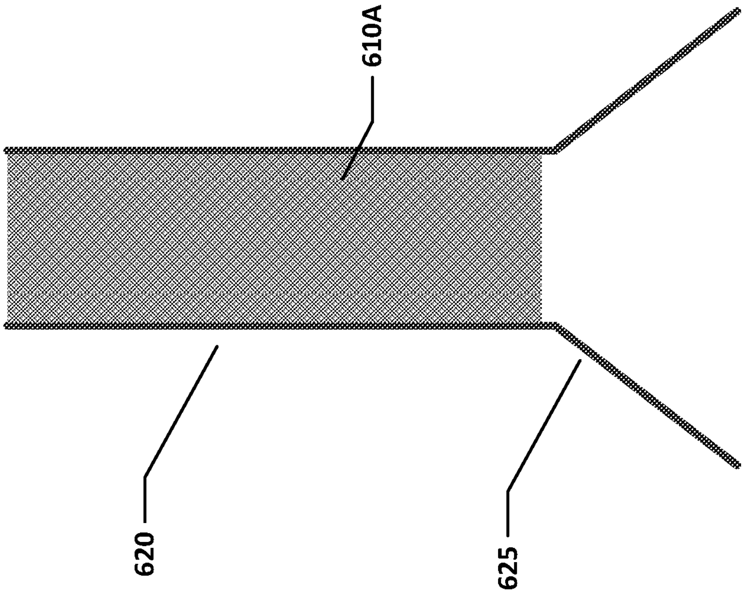

Figure 7C

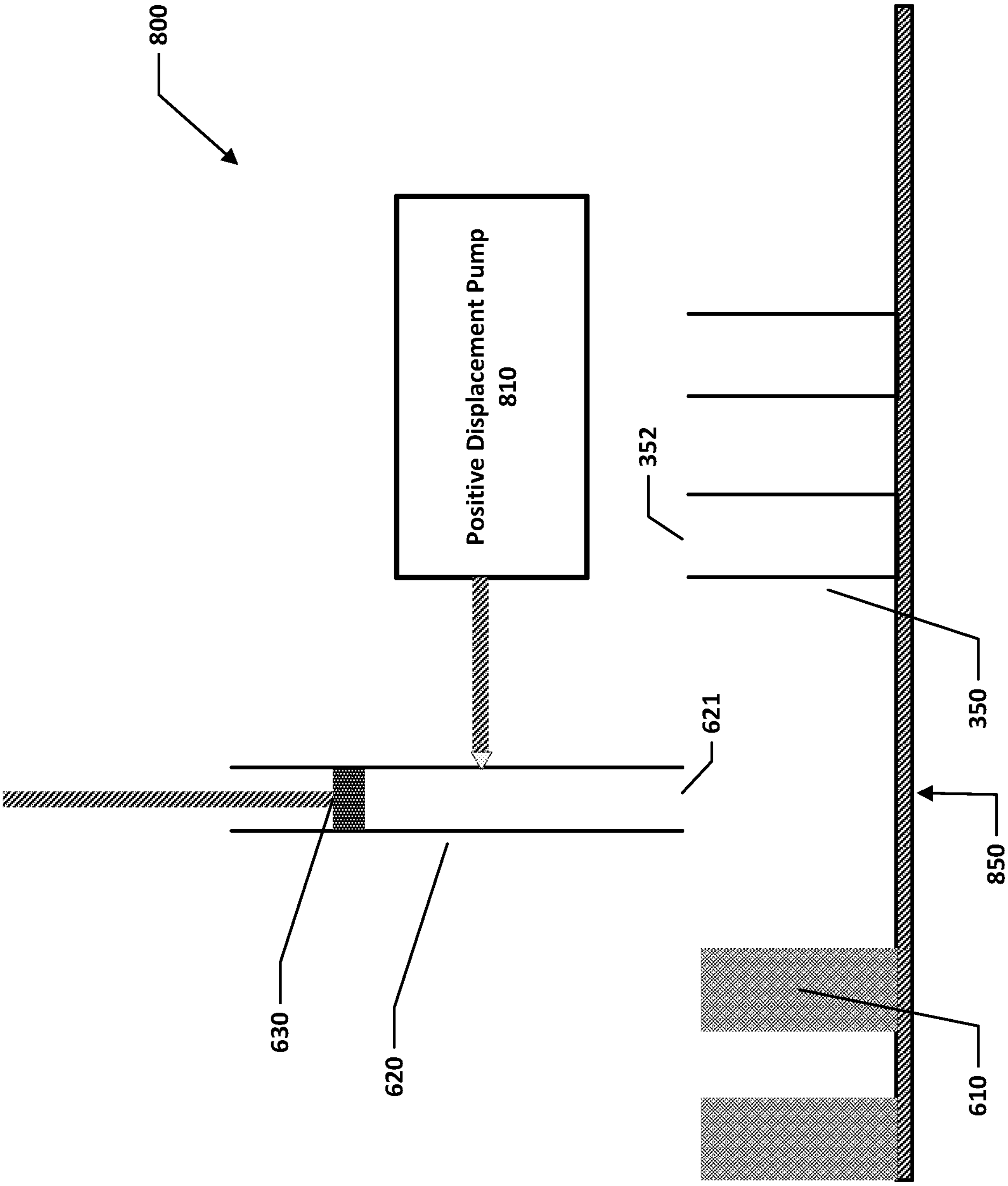
800
Positive Displacement Pump
810
352
621
350
850
630
620
610

Figure 8

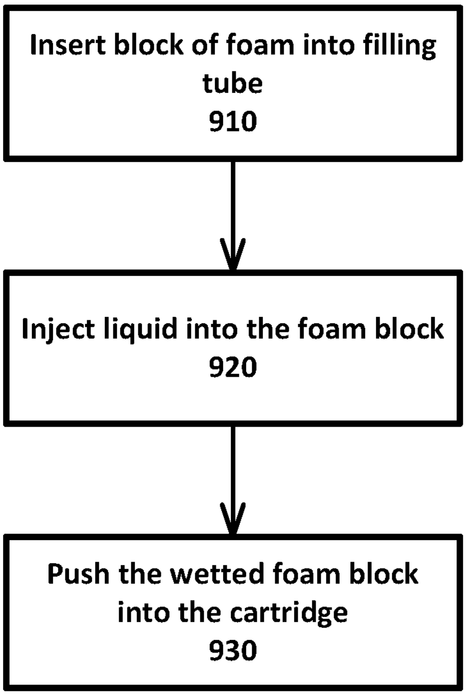
Insert block of foam into filling tube
910
Inject liquid into the foam block
920
Push the wetted foam block into the cartridge
930

Figure 9

REFERENCES CITED IN THE DESCRIPTION

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- US 20140144429 A **[0002]**