(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 April 2011 (14.04.2011)

PCT

(10) International Publication Number
WO 2011/042212 A1

(51) International Patent Classification:
A61M 11/04 (2006.01) *A61L 9/03* (2006.01)
A61M 1/20 (2006.01)

(21) International Application Number:
PCT/EP2010/006198

(22) International Filing Date:
11 October 2010 (11.10.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12/576,951 9 October 2009 (09.10.2009) US

(71) Applicant *(for all designated States except US)*: **PHILIP MORRIS PRODUCTS S.A.** [CH/CH]; Quai Jean Renaud, 3, CH-2000 Neuchatel (CH).

(72) Inventors: **YANG, Zuyin**; 1413 Goswick Ridge Road, Midlothian, VA 23114 (US). **WRENN, Susan, E.**; 12130 Ivy Mill Road, Chesterfield, VA 23838 (US).

(74) Agent: **MARLOW, Nicholas, Simon**; Reddie & Grose, 16 Theobalds Road, London WC1X 8PL (GB).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP,

[Continued on next page]

(54) Title: AEROSOL GENERATOR INCLUDING MULTI-COMPONENT WICK

(57) Abstract: An aerosol generator includes a composite conduit (1, 2, 3, 4) to transport multiple liquids (5,6) to a heating element (7) at flow rates such that the liquids arrive at the heating element in desirable concentrations. The heating element volatilizes the liquids to form volatilized fluid, which mixes with ambient air to form an aerosol with desirable concentrations of the multiple liquids.

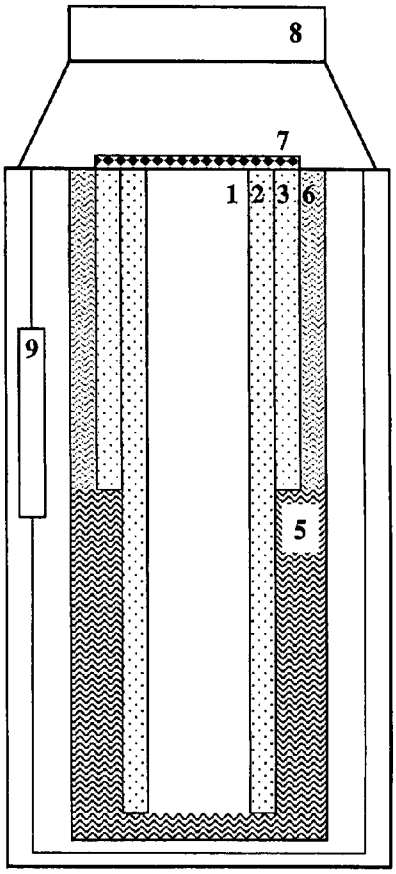

Figure 2

WO 2011/042212 A1

KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

AEROSOL GENERATOR INCLUDING MULTI-COMPONENT WICK

SUMMARY

Provided is an aerosol generator including a composite conduit to transport multiple liquids to a heating element such that the liquids arrive at the heating element in desirable concentrations. The heating element is operable to volatilize the liquids to form volatilized fluid, which mixes with ambient air to form an aerosol with desirable concentrations of the multiple liquids.

Also provided is a method of generating an aerosol comprising transporting first and second liquids through first and second wicks from at least one liquid supply to a heating element at rates such that the liquids are present at the heating element in desirable concentrations and volatilizing the liquids at the heating element to form volatilized fluid, which mixes with ambient air to form an aerosol with desirable concentrations of the liquids.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGs. 1a and 1b are schematics of an embodiment of an arrangement containing plural layers of wicking materials for transporting a multi phase solution. Specifically, FIG. 1a is a side view of the arrangement and FIG. 1b is a cross-sectional view of the arrangement.

FIG. 2 is a schematic of an embodiment of an aerosol generator for generating an aerosol from two immiscible liquids that comprise two phases.

FIG. 3a shows a schematic of another embodiment of an aerosol generator having a composite conduit with multiple passages.

FIG. 3b shows a cross section of the composite conduit shown in FIG. 3a.

FIG. 4 shows a schematic of still another embodiment of an aerosol generator having a composite conduit with multiple passages.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Provided is a device for generation of an aerosol. The device may be used for various purposes such as generating flavored aerosols, scented aerosols, or the like. The device volatilizes liquid material, which optionally condenses in ambient air to form an aerosol.

Aerosols are useful in a wide variety of applications. For example, it is often desirable to treat respiratory ailments with, or deliver drugs by means of, aerosol sprays of finely divided particles of liquid and/or solid, *e.g.*, powder, medicaments, etc., which are inhaled into a patient's lungs. For aerosols intended for human inhalation, a mass median particle diameter of particles of the aerosol less than 2μm (microns), preferably between 0.2μm and 2μm, and more preferably between 0.5μm and 1μm, is preferred.

Aerosols and the precursor vapor may also have applications in creating nano particles and other powders. The volatilization of metal containing liquids brings the possibility of producing micro ball bearings, foam metal and metal plating in a precise and cost effective manner. The uses of aerosols and the precursor vapor also have applications in the area of lubrication, where disbursement of the lubricant may be facilitated with the introduction of a concentration of particles of lubricant.

In a preferred embodiment, the device includes a composite conduit having plural passages which transport liquids to form an aerosol. The passages can be capillary tubes, wicks, wicks of various wicking material or a combination thereof. More specifically, the composite conduit can be used to transport liquids from at least one liquid supply to a heating element at rates such that the liquids are present at the heating element in desirable concentrations. The heating element volatilizes the liquids to form volatilized fluid, which mixes with ambient air to form an aerosol with desirable concentrations of the liquids.

As used herein, "desirable concentrations" refer to concentrations that will produce an aerosol with preferred characteristics, which is dependent upon the composition of the liquids that are volatized to form the aerosol. Accordingly, the ratio and amounts of the liquids transported to the heating element determines the composition of the aerosol formed.

In a preferred embodiment, the ratio and amounts of the liquids transported to the heating element may be controlled through selection of the passages (capillary tubes, wicks, wick material) and liquids. Preferably, two or more liquids are transported and the liquids preferably are immiscible in each other. If stored together in a single liquid supply, the immiscible liquids may form multiple phases. The wicks operate by capillary action and may be combined with one or more capillary tubes. In an example, two or more wicks and a capillary tube would be adapted to transport a plurality of liquids. Preferably, wicks contain numerous pores, which act as capillaries and cause the liquid to be drawn into them. Wicks may be selected based on their wettability for an immiscible liquid or phase. The capillary tube preferably has an internal diameter of 0.1mm to 10mm, preferably 0.5mm to 1mm, more preferable about 0.1mm to 0.5mm, and even more preferably about 0.15mm, corresponding to internal cross sectional areas of $8.10^{-5}mm^2$ to $80mm^2$, $0.002mm^2$ to $0.8mm^2$, $0.008mm^2$ to $0.2mm^2$, and about $0.02mm^2$, respectively. The dimensions of the capillaries and/or wicks are further factors that affect the amounts of liquids transported to the heating element.

Various geometries can be used for transporting the liquids at desired flow rates to the heating element. For example, multiple wicking materials, such as, for example, one or more synthetic fibers and cotton, may be combined to form a woven wick to transport one or more liquids. In an embodiment, wicking materials may be arranged in a concentric pattern around a central capillary tube, such as two or more tubes of wicking materials arranged in a concentric

pattern around a central capillary tube. The wicking materials may be separated by wire mesh, which may also act as a wicking material for liquid transport.

FIGs. 1a and 1b are schematics of an arrangement containing three layers of wicking materials for transporting a three phase solution. Specifically, FIG. 1a is a side view of a coaxial arrangement and FIG. 1b is a cross-sectional view of the arrangement. In particular, a capillary tube 1 is concentrically surrounded by three layers 2, 3, 4 of wicking materials. It is furthermore possible for a four phase solution to be transported, with the capillary tube 1 transporting one phase and the three layers 2, 3, 4 of wicking materials transporting three other phases. If desired, the capillary tube and/or the fourth wick can be omitted.

The immiscible liquid may comprise one or more hydrophobic liquids (*e.g.*, one or more essential oils) and one or more hydrophilic liquids (*e.g.*, propylene glycol, glycerol and/or other aerosol former). In a reservoir containing a multiphase liquid, the phases may separate into discrete layers with lower density phases forming over higher density phases. An arrangement for transporting immiscible liquids may comprise passages having different lengths adapted to be in contact with different layers of the multiphase liquid. In the case of a two phase immiscible liquid comprising a lighter flavor-rich phase and a heavier aerosol former phase, first and second wicks or capillary tubes for transporting the immiscible liquids may comprise a shorter wick or shorter capillary tube adapted to be in contact with the lighter flavor-rich liquid and a longer wick or longer capillary tube adapted to be in contact with the heavier aerosol former. Further, if the first and second wicks/capillary tubes for transporting the immiscible liquids are arranged in a concentric pattern, the shorter wick/capillary tube adapted to be in contact with the lighter flavor-rich liquid may surround the longer wick/capillary tube adapted to be in contact with the heavier aerosol former.

Thus, an aerosol generator can comprise an arrangement for transporting immiscible liquids from at least one liquid supply to a heating element at rates such that the liquids are present at the heating element in desirable concentrations. The heating element volatilizes the immiscible liquids to form volatilized fluid, which mixes with ambient air to form an aerosol with desirable concentrations of the immiscible liquids.

The heating element may comprise a wire mesh heater embedded in a downstream end of the wicks. The heating element may be a stainless steel wire mesh or a stainless steel serpentine strip. The heating element is connected to a power supply, which can be a portable power supply such as a direct current battery. However, the use of alternating current may also be effective. When the aerosol generator comprises one or more capillary tubes, the heating element is operable to volatilize the liquid(s) transported via the capillary tube(s) at the downstream end of the capillary tube(s), similar to the volatilization of the liquids transported via the wicks at the downstream end of the wicks.

The immiscible liquids preferably comprise multiple phases, which are transported from one liquid supply. However, the liquids can be supplied from different liquid supplies if desired. The immiscible liquids may comprise at least one hydrophobic liquid and at least one hydrophilic liquid such as a flavor system and aerosol former. The flavor system may comprise one or more essential oils. The aerosol former may comprise propylene glycol, glycerol, or mixtures thereof.

FIG. 2 is a schematic of an aerosol generator for generating an aerosol from two immiscible liquids that comprise two phases. A capillary tube 1 is concentrically surrounded by two layers 2, 3 of wicking materials, which transport liquids 5, 6, respectively, to the heating element 7. After the heating element 7 volatilizes the immiscible liquids to form volatilized fluid, the volatilized fluid may be transferred to a mouthpiece 8, from which formed aerosol may be inhaled. A control circuit 9 regulates the supply of power, preferably direct current, to the heating element 7. If desired, an additional phase may to be transported through the capillary tube 1.

FIG. 3a is a schematic of another embodiment of an aerosol generator 100 for generating an aerosol from three immiscible liquids that comprise three phases. A reservoir 116 of the aerosol generator 100 is filled with the three liquids. A first capillary tube 104 is concentrically surrounded by second 108 and third 114 capillary tubes. First capillary tube 104 transports first liquid 103 which may be a hydrophilic liquid, to the heating element 120 from the reservoir 116. Second 108 and third 114 capillary tubes transport second and third liquids 107 and 113, which may be neutral and hydrophobic liquids, respectively, to the heating element 120. After the heating element 120 volatilizes the immiscible liquids to form volatilized fluid, the volatilized fluid may be transferred to a mouthpiece 122, from which formed aerosol 140 may be inhaled. A control circuit 130 regulates the supply of power, preferably direct current, to the heating element 120.

The concentric capillary tubes 104, 108, 114 form a composite conduit of the aerosol generator 100. FIG. 3b shows a cross section of the composite conduit of FIG. 3a at AA. As shown in FIG. 3b, when concentric capillary tubes are used, the distance between capillary sidewalls is comparable to the inner diameter of the center capillary tube as mentioned previously. For example, the distance between the first 104 and second 108 capillary tubes or between the second 108 and third 110 capillary tubes in FIG. 3b. can be 0.1mm to 10mm, preferably 0.5mm to 1mm, more preferable about 0.1mm to 0.5mm, and even more preferably about 0.15mm. Preferably, the capillary tube can be glass, porous metal, synthetic material and combinations thereof.

FIG. 4 is a schematic of another embodiment of an aerosol generator 100 for generating an aerosol from three immiscible liquids that comprise three phases. A first wick 12 transports a

first phase which may be a hydrophilic liquid, of a liquid 111 to the heating element 120 from a reservoir 116. In this embodiment, liquid 111 can be an emulsion of immiscible liquids (*e.g.*, a hydrophilic liquid, a hydrophobic liquid and a neutral liquid or a combination of any two thereof). Second 14 and third wicks and 16 transport additional phases which may be neutral and hydrophobic liquids, respectively, of liquid 111 to the heating element 120. As shown in FIG. 4, the first 12, second 14 and third 16 wicks may transport the liquids through a cap 118 of the reservoir 116 and through a passage 132 or the like, to the heating element 120. After the heating element 120 volatilizes the immiscible liquids to form volatilized fluid, the volatilized fluid may be transferred to a mouthpiece 122, as described previously. A control circuit 130 regulates the supply of power to the heating element 120, also as described previously.

In a preferred embodiment, first 12, second 14 and third 16 wicks may be interwoven (*e.g.*, braided) or separate. Interwoven wicks can be of various materials to transport the various phases. For example, synthetic wick materials to transport the hydrophilic phase can include plastic or rubber molecules with OH groups having an affinity for the polar phase liquids. Non-polar plastic material without OH group constituents have an affinity for the non-polar phase liquid and natural materials such as cotton have an affinity for the neutral phase liquid. As such, first 12, second 14 and third 16 wicks can transport separate phases from liquid 111 to the heating element 120 such that the phases are present at the heating element in desirable concentrations.

Also provided is a method of generating an aerosol comprising transporting immiscible liquids from at least one liquid supply to a heating element at rates such that the liquids are present at the heating element in desirable concentrations and volatilizing the immiscible liquids at the heating element to form volatilized fluid, which mixes with ambient air to form an aerosol with desirable concentrations of the immiscible liquids.

While various embodiments have been described, it is to be understood that variations and modifications may be resorted to as will be apparent to those skilled in the art. Such variations and modifications are to be considered within the purview and scope of the claims appended hereto.

CLAIMS:

1. An aerosol generator comprising:

a composite conduit to transport multiple liquids to a heating element at flow rates such that the liquids arrive at the heating element in desirable concentrations,

wherein the heating element is operable to volatilize the multiple liquids to form volatilized fluid, which mixes with ambient air to form an aerosol with desirable concentrations of the multiple liquids.

2. The aerosol generator of Claim 1, wherein the composite conduit comprises:

a first wick operable to transport a first liquid and a second wick operable to transport a second liquid to a heating element at flow rates such that the first and second liquids arrive at the heating element in desirable concentrations.

3. The aerosol generator of Claim 2, wherein the first and second wicks are different lengths.

4. The aerosol generator of Claim 2, wherein the composite conduit further comprises a capillary tube operable to transport a third liquid to the heating element, wherein the heating element is operable to volatilize the third liquid.

5. The aerosol generator of Claim 2, wherein the first and second wicks are arranged in a concentric pattern or interwoven pattern.

6. The aerosol generator of Claim 2, further comprising a third wick operable to transport a third liquid to the heating element.

7. The aerosol generator of Claim 6, wherein

the multiple liquids comprise a combination of hydrophobic, hydrophilic and neutral liquids;

the first wick is of a material having an affinity to the hydrophilic liquid;

the second wick is of a material having an affinity to the hydrophobic liquid;

the third wick is of a material having an affinity to the neutral liquid.

8. The aerosol generator of Claim 1, wherein the liquids comprise first and second liquids that are immiscible in each other and are located in a single liquid supply.

9. The aerosol generator of Claim 1, wherein the liquids comprise at least one hydrophobic liquid and at least one hydrophilic liquid.

10. The aerosol generator of Claim 1, wherein the liquids comprise a flavor system and an aerosol former.

11. The aerosol generator of Claim 10, wherein the flavor system comprises one or more essential oils.

12. The aerosol generator of Claim 10, wherein the aerosol former comprises a material selected from the group consisting of propylene glycol, glycerol, and mixtures thereof.

13. A method of generating an aerosol comprising:

transporting first and second liquids through first and second wicks from at least one liquid supply to a heating element at rates such that the liquids are present at the heating element in desirable concentrations; and

volatilizing the liquids at the heating element to form volatilized fluid, which mixes with ambient air to form an aerosol with desirable concentrations of the liquids.

14. The method of Claim 13, wherein the first and second wicks are different lengths.

15. The method of Claim 13, further comprising transporting a third liquid through a capillary tube from the at least one liquid supply to the heating element.

16. The method of Claim 15, wherein the first and second wicks are arranged in a concentric pattern around the capillary tube.

17. The method of Claim 13, wherein the liquids comprise first and second liquids that are immiscible in each other and are located in a single liquid supply.

18. The method of Claim 13, wherein the liquids comprise at least one hydrophobic liquid and at least one hydrophilic liquid.

19. The method of Claim 13, wherein the liquids comprise a flavor system and aerosol former.

20. The method of Claim 19, wherein the flavor system comprises one or more essential oils.

21. The method of Claim 19, wherein the aerosol former comprises a material selected from the group consisting of propylene glycol, glycerol, and mixtures thereof.

22. The method of Claim 13, further comprising a third wick operable to transport a third liquid to the heating element.

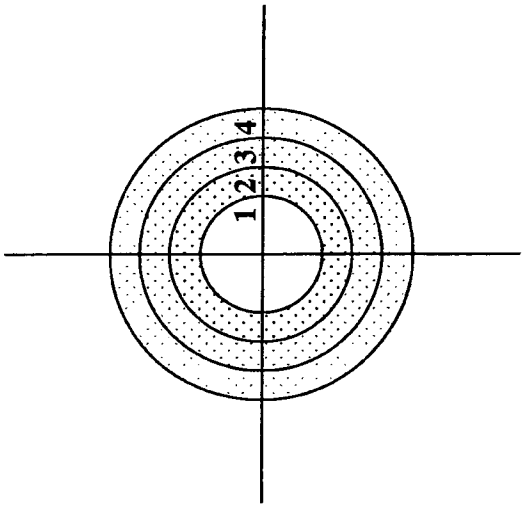

Figure 1b

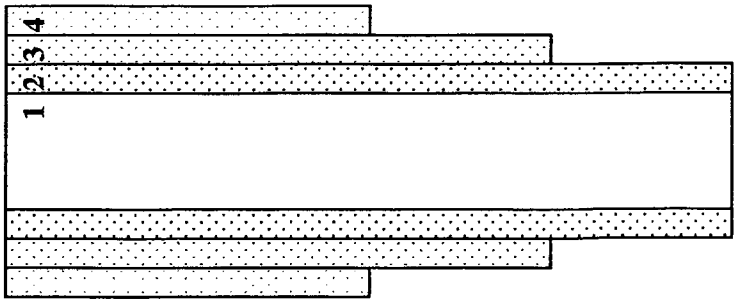

Figure 1a

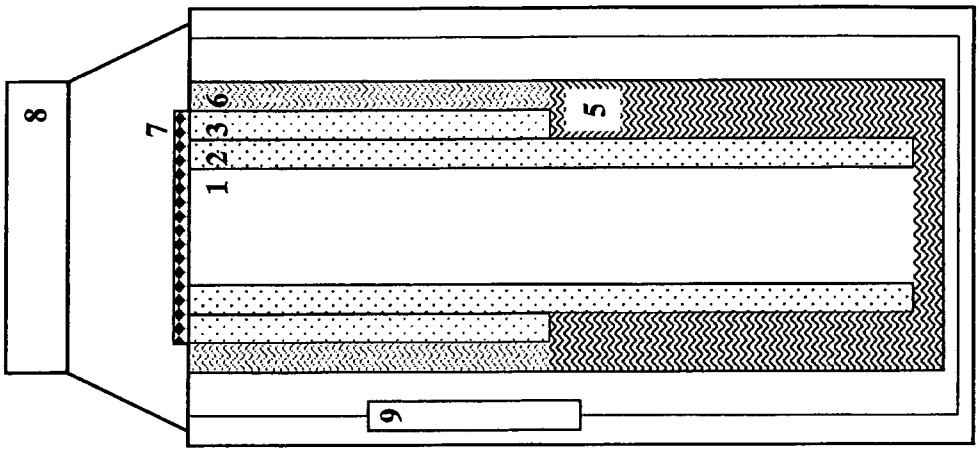

Figure 2

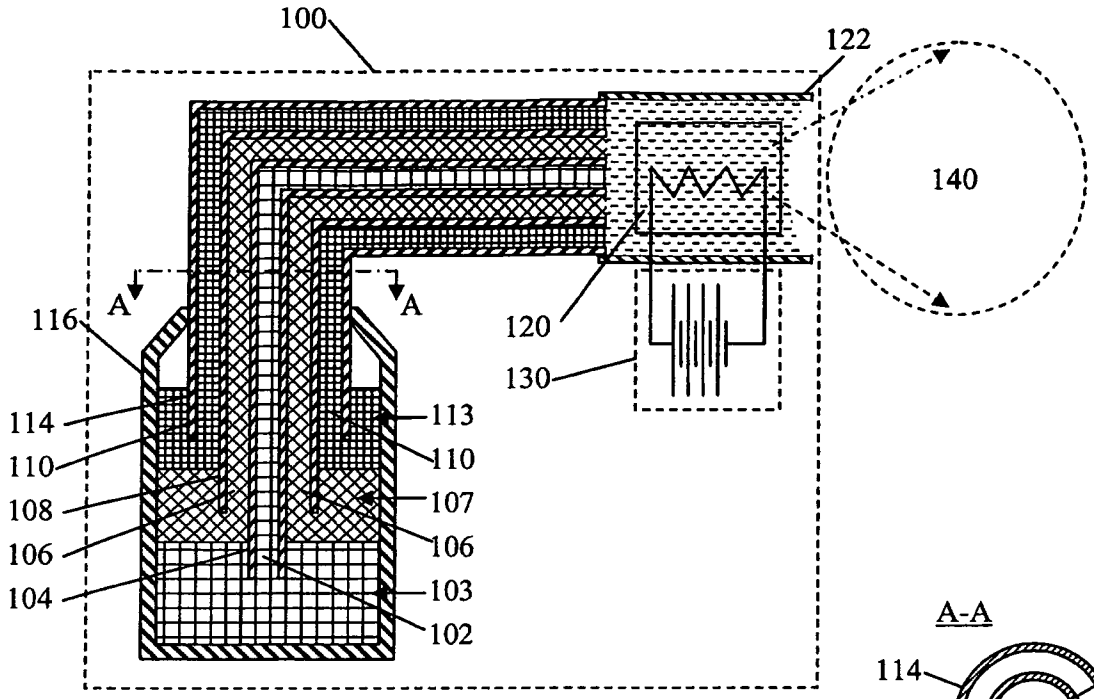

FIG. 3a

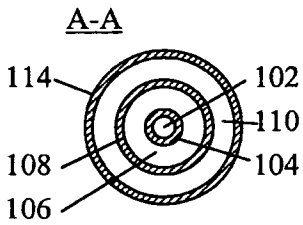

FIG. 3b

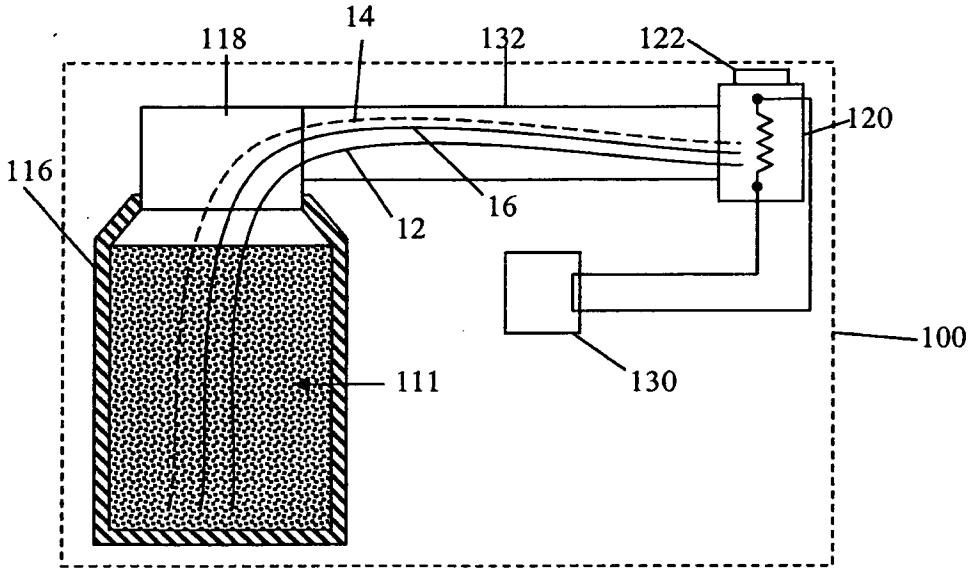

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/006198

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61M11/04 A01M1/20 A61L9/03
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61M A01M A61L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/032983 A1 (JOHNSON & SON INC S C [US]) 22 April 2004 (2004-04-22) The whole document, especially paragraphs [0007],[0037],[0047], Figures 2A-2D, 5A, 5B	1-22
X	US 7 055 764 B1 (MARTINEZ JOSE ANTONIO M [ES] ET AL MARTINEZ JOSE ANTONIO MUNOZ [ES] ET) 6 June 2006 (2006-06-06) The whole document, especially column 2, lines 3-16, Figures 2 and 4-6	1-22
X	WO 2006/004902 A1 (JOHNSON & SON INC S C [US]; VARANASI PADMA PRABODH [US]; ADAIR JOEL E) 12 January 2006 (2006-01-12) Whole document, especially paragraph [0008 and Figures 1-7]	1-22

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 December 2010	20/12/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Borowski, Aleksander

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/006198

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 450 134 A (RECKITT BENCKISER [GB]) 17 December 2008 (2008-12-17) paragraph [0078]; figure 1	1-22
A	GB 2 449 703 A (JEYES GROUP LTD [GB]) 3 December 2008 (2008-12-03) the whole document	1-22
A	US 2009/020625 A1 (TREVINO RUBEN E [US]) 22 January 2009 (2009-01-22) figure 4	1-22
A	US 2009/101729 A1 (NEWMAN RON [US]) 23 April 2009 (2009-04-23) the whole document	1-22
A	US 2003/168520 A1 (TRIPLETT CARL [US] ET AL) 11 September 2003 (2003-09-11) the whole document	1-22

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/006198

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2004032983 A1	22-04-2004	AT 413196 T	15-11-2008
		AU 2003275199 A1	04-05-2004
		CA 2500625 A1	22-04-2004
		CN 1700931 A	23-11-2005
		EP 1558297 A1	03-08-2005
		ES 2312809 T3	01-03-2009
		KR 20050072102 A	08-07-2005
		MX PA05003749 A	08-06-2005
		US 2004065749 A1	08-04-2004
		US 2006131439 A1	22-06-2006
US 7055764 B1	06-06-2006	NONE	
WO 2006004902 A1	12-01-2006	AT 476203 T	15-08-2010
		AU 2005260607 A1	12-01-2006
		CA 2572746 A1	12-01-2006
		EP 1784231 A1	16-05-2007
		EP 2213312 A1	04-08-2010
		JP 2008504932 T	21-02-2008
		KR 20070053664 A	25-05-2007
GB 2450134 A	17-12-2008	WO 2008152353 A1	18-12-2008
GB 2449703 A	03-12-2008	EP 2190489 A2	02-06-2010
		WO 2008146007 A2	04-12-2008
US 2009020625 A1	22-01-2009	NONE	
US 2009101729 A1	23-04-2009	NONE	
US 2003168520 A1	11-09-2003	AU 2003220000 A1	22-09-2003
		CA 2478179 A1	18-09-2003
		EP 1492576 A1	05-01-2005
		MX PA04008618 A	06-12-2004
		WO 03075967 A1	18-09-2003