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(54) Safe fuel in ventless fireplaces or other wicked open geometry devices

(57) The present invention relates to a combination of a safe fuel and a ventless fireplace, or more in general, an open geometry wicked device. Open geometry wicked devices, such as so-called "ventless fireplaces" (or ventless ovens or ventless burners), burn gel or liquid fuel, and exist in a variety of forms. Such devices typically have several advantages over various more traditional fireplaces in that these cleanly burn their fuel (contrary to paraffin and oil based burners and solid material based burners, such as coal or wood burners, and also contrary to fuel containing additives which lead to undesirable by-products), are often portable, and may not require installation. Such fireplaces burn gel or liquid fuel that is dispensed from a fuel container into a fuel reservoir where the burning occurs.

To avoid safety problems, the present invention is directed to a product comprising a specific fuel and a wicked burner.

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Description

[0001] The present invention relates to a combination of a safe fuel and a ventless fireplace, or more in general, a wicked open geometry device.

[0002] Open geometry wicked devices, such as so-called "ventless fireplaces" (or ventless ovens or ventless burners), burn gel or liquid fuel, and exist in a variety of forms. Such devices typically have several advantages over more traditional fireplaces in that they burn their fuel cleanly (contrary to paraffin and oil based burners and solid material based burners, such as coal or wood burners, and also contrary to fuel containing additives which lead to undesirable by-products), are often portable, and may not require fixed installation. Such fireplaces burn gel or liquid fuel that is dispensed from a fuel container into a fuel reservoir where the burning occurs.

[0003] Ventless fireplaces, for instance, are a convenient way to provide a pleasant atmosphere in various places in and around the house, for example in living rooms or outside (garden, patio). These fireplaces do not need special vent constructions and are therefore easy to use and install.

[0004] Said devices are often fuelled with ethanol-based fuel, which is a highly flammable liquid. As a consequence, there is a clear risk of flame ingress into the fuel container, during refilling, leading to explosions and burns. The risk is particularly high when refilling the fireplace before it is completely extinguished and/or sufficiently cooled down. There is a serious risk of burning hands, face, arms *etc.* In addition, the flash flame or explosion usually causes one to drop or throw away the burning refilling bottle, thus causing still more risk of injury or starting a fire. Another risk of ethanol-fuelled devices is that fire spreads quickly if the ventless fireplace accidentally falls over.

[0005] Also quite often isopropyl alcohol is used as a fuel; it has similar drawbacks as ethanol.

[0006] In order to put less burden on the environment and provide a green solution bio-fuels are generally used, i.e. fuels made from renewable resources, such as bio-ethanol. However, also these suffer from the same drawbacks as mentioned above.

[0007] The risks associated with the mentioned alcohols are well recognized by the medical sector. Kraemer *et al.* describe in a journal of the American Burn Association, *viz.* in the Journal of Burn Care & Research, (2011), 32(2), 173-177, titled "Severe burn injuries caused by bioethanol-design fireplaces - an overview on recreational fire threats":

> *"Are bioethanol fireplaces going to become the future threat in domestic burn accidents beside common barbecue burns? Design fireplaces are being recognized as an increasing source of fuel and fire-related danger in the home. This risk may be underestimated by the uninformed customer, resulting in severe burn injuries. Because bioethanol-fuelled fireplaces have become more commonplace, they may overtake barbecue-related injury as the most common domestic burn injury."*

[0008] Also the Dutch "Brandwondenstichting" (Dutch institute for burn injuries) is concerned about this issue. In a presentation in respect of a television show (see the link: http://kassa.vara.nl/tv/afspeelpagina/fragment/bio-ethanol-in-sfeerhaard-levensgevaarlijk/speel/1/) said institute states the following (translated from Dutch):

> *"According to the "Brandwondenstichting" injuries from bio-ethanol happen all year. They think that in the summer barbecues are the main cause, while in wintertime ventless ovens cause these injuries. There are (in the Netherlands) about 30 serious injuries per year, and the trend is not downwards. The actual number of victims is believed to be much larger because the "Brandwondenstichting" is only informed of the major accidents. The main risk is when the oven has extinguished and the user refills it. When there is still a small flame or the metal is still hot a flash flame may occur. This may lead to 3rd degree injuries over the whole body. An example of α victim who required hospital care for 2 months is named. A root cause is that many people do not realize how flammable bio-ethanol is":*

[0009] Possible solutions in the art focus on, for example, a special safe refuelling system, such as the "Flame Arresting and Dispensing Cap for Gel and Liquid Fuels for Ventless Fireplaces" described in US-A-2013 / 0087581. However, some customers may dangerously tinker and may modify the fuel cap, for example, to increase flow rates. Another remaining risk is that the ventless fire place may accidentally fall over (some of them are used on tables) and spills the highly flammable ethanol over the floor, thereby lighting carpets, furniture, curtains and thereby causing burns to people or creating large fires.

[0010] It is an aim of the present invention to provide a product that is much safer in use than the hitherto used fuels. Particularly, it is desired to have an open geometry wicked device using a cleanly burning fuel, which is safe, or at least wherein refilling does not lead to dangerous situations, even if the device is still hot or when a fire is still burning, and wherein also the other risks sketched above should at least be minimized. The risks of flare-ups, flash fires or other sudden, intense fires, caused by ignition of a mixture of air and a dispersed flammable substance such as a solid (including dust), flammable or combustible liquid (such as an aerosol or fine mist), or a flammable gas, and characterized by high temperature, short duration, and rapidly moving flame fronts are decreased or even absent. Further, it is desired to have a product that does not produce toxic emissions, or at least hardly produces such emissions.

[0011] After extensive tests, the present inventors

found that if a propylene glycol based fuel is used, the sketched problems can be overcome. With such a fuel, the wick in the open geometry device is an essential requirement; without a wick the fuel can in practice not be used as a fuel.

[0012] The present invention, hence, resolves the sketched safety risks associated with, e.g., ventless ovens by using a much safer fuel that does not explode during refuelling a burning system, yet is combustible. For example when refilling a burning fire place - according to this invention - no explosion of flash flame will occur. Also, according to the invention, when, for example, a ventless fireplace falls over and spills the fluid over the floor the fire will generally extinguish by itself or will be easy to extinguish.

[0013] In a first aspect, the present invention is hence directed to a propylene glycol based fuel in an open geometry wicked device, wherein the propylene glycol based fuel has a flashpoint above 50°C and comprises at least 60 wt.% propylene glycol. For clarity's sake, the product of the invention is the combination of the open geometry wicked device and the propylene glycol based fuel.

[0014] The first essential part of the product of the present invention is propylene glycol (official name: propane-1,2-diol). Propylene glycol has a flashpoint (closed cup) of 101°C (determined according to ISO 3679); it has a boiling point of 188°C. This eliminates flash fires and flare-ups. With the term "propylene glycol based fuel", a fuel is meant that contains more than 60 wt.% propylene glycol, preferably more than 75 wt.% propylene glycol, and more preferably at least 90 wt.% propylene glycol. This fuel - when properly formulated - in practice is a non-flammable, yet combustible liquid. With "non-flammable" we mean that it does not catch fire at room temperature when brought in contact with a flame, like from a match; with "combustible" we mean that it can be made to burn under the right conditions. In tests, it was found to be prevented from catching fire in case of refilling a burning oven. Moreover, this liquid material when burning, extinguishes when being poured out on a "cold" (that is: ambient temperature) surface.

[0015] Propylene glycol can be industrially prepared from a reaction of propylene oxide with water. Nowadays, it is also available as biograde, made from bio-glycerol. In all examples used herein such bio-grade propylene glycol has been used, although industrial grades provide the same advantages with respect to fire safety.

[0016] The second essential part of the product of the present invention is the wick in the open geometry wicked device. With the term "open geometry wicked device" as used in this description and the appending claims, an open equipment device is meant for producing heat.

[0017] More specifically, an open geometry device is a device of which the horizontal surface area exposed to the open air is a fraction of at least 20% of the top surface area of the container containing the wick. The open geometry allows quick passage of fuel into the flame and thus supports a large highly decorative flame. Consequently, an open geometry wicked device is a device where there is essentially no restriction between the fuel and the open air. Consequently, the advantage of the present invention is that such an open device -when falling over- and spilling most of its liquid fuel contents within seconds - does not pose a great fire risk.

[0018] Examples of open geometry wicked devices are ventless fireplaces and table top burners. Such devices can be made of various materials, including steel, concrete, ceramics *etc.*

[0019] Wicked devices not meeting the open geometry criterion referred to herein-above, such as wicked torches and wicked fire pots, were found not to work on propylene glycol; their flames extinguish.

[0020] To produce a sizeable flame a minimal open area is needed. Such an open surface area per flame must be at least 4 square cm, preferably at least 10 square cm.

[0021] Also, in such equipment, large flames produce a significant amount of heat. Actually, the total power produced per flame may be at least 400 Watt (the power being calculated from the heat of combustion - Joule per gram (J/g) multiplied by rate of combustion in gram/second (g/s).

[0022] A wick, also called batting, can for example be made of fiber glass, ceramic fiber material, silicate fiber material or rock wool, or polymeric materials such as aromatic polyamides (Aramid, for example sold under the trade name Kevlar), cotton or porous materials such as pumice or other wick materials known in the art. Preferably, wick materials which are not consumed or burned are used. By capillary effects, liquid material is transported through a wick and becomes available as effective fuel. Suitable materials, as well as a suitable device, are described in for example DE 102009043341.

[0023] Another suitable example of such a wick is described in WO 2007/032667. Particularly, it is described therein as "a fuel receiving body from a form-retaining, isotropic, heat-resistant and porous material for retaining liquid fuel by means of absorption". This application, by the way, refers to ethyl alcohol and isopropyl alcohol as suitable fuels.

[0024] As noted herein-above, the product of the present invention has as a key component a fuel based on propylene glycol. In a preferred embodiment, this propylene glycol based fuel has a closed cup flashpoint above 50°C, preferably above 80°C, more preferably above 90°C. This flashpoint is important in respect of many of the safety considerations. Where herein-below reference is made to flashpoints, we mean closed cup flashpoints determined according to ISO 3679.

[0025] However, it is also important to establish that toxic gases in general, and the well-known toxic gas carbon monoxide in particular, are not formed in large amounts. Carbon monoxide is a known concern for all fire places and heating devices. The propylene glycol based fuel must be compounded in such a way that only

very low levels of toxic gases, carbon monoxide in particular, are formed. In that light, the product of the invention preferably is based on a propylene glycol based fuel comprising at least 60 wt.%, preferably at least 75%, most preferably at least 90 wt.% propylene glycol. In the most preferred embodiment, the product according to the invention is based on a propylene glycol based fuel consisting entirely of propylene glycol.

[0026] Incidentally, toxic compounds may also be formed when compositions are used as taught in EP-A-1 323 812 and in US-A-2002/0187445. EP-A-1 323 812 and US-A-2002/0187445 relate to lamp fuel compositions for producing coloured flames for interior decoration or festivals and so on. Thereto, these compositions contain a fuel containing colouring agents such as those based on metal salts, such as lithium and strontium salts. Also, when the flame extinguishes, the wick and fuel are still hot which typically produces the well known candle smoke, meaning that the fuel or the solution is evaporating. In case of EP 1 323 812 it will thus evaporate camphor, dimethylformamide *etc.* and thus cannot be considered a safe fuel as required by the present invention or a fuel with low smoke toxicity as required by the present invention. Even the smallest amounts of toxic chemicals cast doubts on the fuel and are therefore undesirable as the devices can be used in the presence of for example children and pregnant women.

[0027] As a consequence, the compositions of EP 1 323 812 are totally unsuitable for use in the present invention. So it is a clear advantage of the present invention that the used fuel compositions are not producing toxic fumes.

[0028] More particularly, EP-A-1 323 812 describes in § [0010] that propylene glycol is chosen as a solvent for colouring agents. Furthermore, this paragraph indicates that its high viscosity in fact makes propylene glycol unsuitable for transport through a wick in an oil lamp. To overcome these difficulties other liquids (ethers, ethanol *etc)* are to be added. All examples in EP 1 323 812 contain 5 to 10% ethanol. However, when as little as 5 to 10% ethanol is added to propylene glycol the flash point of the composition already drops to almost room temperature. This means that such compositions are unsuitable for use in the present invention which requires a flash point over 50°C. Moreover, in addition to the metal salts, this reference encompasses a long list of other ingredients which are known to be toxic, and hence lead to toxicity of the vapours - such as DMF and camphor. This is another reason why the compositions of EP 1 323 812 cannot be used in the present invention.

[0029] Also US-A-2002/0187445 refers to propylene glycol as one of the solvents rather than a fuel. In addition, it also notes that simple alcohols are advantageously added in the polyol containing composition with the aim of lowering the viscosity.

[0030] Also incidentally is the use of a high percentage glycol or glycol derivative in US-A-4,624,633. This document teaches however closed canisters containing the fuel together with a non-consumable wick immersed in the fuel reservoir. Particularly, the non-consumable wick has one end immersed in the fuel reservoir and the opposite end extending through an opening in the canister. However, these largely closed apparatuses also restrict the flow of fuel and therefore cannot produce the large decorative flames which are an essential aspect of the present invention.

[0031] With the above guidance, the skilled person will be able to formulate suitable propylene glycol based compositions. Particularly, he may for example add in the propylene based fuel based on the above guidances one or more compounds selected from the group consisting of glycerol and other glycerols; alcohols, such as butanol; and biodiesel oils and edible oils and esters.

[0032] In a further aspect, the present invention is also directed to the use of a propylene glycol based fuel as defined herein-above as a safe fuel. A safe fuel in the sense of the present description is a non-flammable, yet combustible liquid.

[0033] Such a use is not only as a fuel in ventless fireplaces, ventless ovens, ventless burners or the other wicked devices, but also for lighting a barbecue or in the use in decorative home furnaces containing a chimney.

[0034] The present invention will now be described in more detail, while referring to the following non-limiting examples and drawings, in which

Figure 1 is a schematic side view of a first example of a wicked device;
Figure 2 is a schematic perspective view of a second example of a wicked device; and
Figure 3 is a schematic perspective view of a wick for a wicked device.

[0035] Where in the examples, but also in the description and the claims, reference is made to percentages, these percentages are weight percentages drawn to the total composition, unless otherwise defined. In a preferred embodiment, the product of the invention uses an oven 1 as sketched in Fig. 1. In this embodiment, oven 1 is a cylindrical oven with an external diameter A and a height C. In this embodiment, the external diameter A is 70 mm, the height C is 110 mm and the total weight of the oven 1 is 175 gram. The oven 1 includes an outer cylinder 2 and an inner cylinder 4. In this embodiment the outer cylinder 2 and the inner cylinder 4 are manufactured from metal. The outer cylinder 2 has an external diameter A and a height C equal to that of the oven 1. The inner cylinder 4 has an external diameter B, in this example 55 mm, and a height D, in this example 105 mm. The outer cylinder is open at a first end 6 and closed at a second end 8. The inner cylinder 4 is open at a first end 10, and has a round circular opening 14 of 35 mm diameter at a second end 12. The inner cylinder 4 is inserted into the outer cylinder 2 such that a gap 16 is formed with a width E. In this embodiment the width E of the gap 16 is 7 mm. The gap 16 between the cylinders

is filled, in this example, with a coarse steel wool 18. The inner cylinder 4 is provided with a metal ring 20 which substantially closes off the gap 16 at the first end 10 of the inner cylinder 4. The open surface area per flame must be at least 4 square cm, preferably at least 6 and more preferably at least 9 square cm.

[0036] In this embodiment, the inner cylinder 4 is held in place by friction between the inner cylinder 4, the steel wool 18, and the outer cylinder 2. The metal ring 20 of the inner cylinder is at substantially the same level as the opening of the first end 6 of the outer cylinder 2. Due to the height difference between the outer cylinder 2 and the inner cylinder 4, a spacing 22 is formed between the outer cylinder 2 and the inner cylinder 4 at the second end 8, 12. Additionally, or alternatively, the metal ring 20 of the inner cylinder 4 may be manufactured to have a larger diameter, or provided with a lip, such that the metal ring 20 may rest on the outer cylinder 2 holding the inner cylinder in place.

[0037] The inner cylinder 4 forms a cavity 24. Any fluid poured into the cavity 24 of the inner cylinder 4 can freely move from the opening 14 at the second end 12 of the inner cylinder 4 through the spacing 22 and into the gap 16.

[0038] In this example 1, the cavity 24 of the inner cylinder 4 is filled with glass wool 26, such as typically used for thermal / building insulation, as a wick. The fiber insert is needed because it appeared not possible to light the propylene glycol based fuel; said fuel does not catch fire as a fluid without a so-called wick. In this example, the glass fiber insert acts as a wick. It will be clear that other suitable materials may be used as a wick.

[0039] In another preferred embodiment, the product of the invention uses an oven 1 as sketched in Fig. 2. The oven 1 shown in Fig. 2 is a ventless oven, in this example manufactured from metal. The oven is hollow and the metal walls are about 2 mm thick.

[0040] The oven 1 has a rectangular shape with an outer length F, a width G, and a height H. In this example the outer length F is 300 mm, the width G is 110 mm and the height H is 40 mm. The oven 1 has an inner cavity 28. The inner cavity 28 has a width J, a length I, and a height K. In this description the width J of the inner cavity 28 is 40 mm, the length I of the inner cavity 28 is 230 mm, and the height K is substantially equal to the height H of the oven 1. The open surface area exposed to air is 9200 mm^2. The oven 1 has a total weight of 2415 gram.

[0041] The wick 30 includes a glass wool insert 26 placed in a tray 32. The tray 32 is made from sheet metal and has dimensions smaller than that of the inner cavity 28 such that the wick 30 can be placed in the cavity 28 of the oven 1. Additionally, the tray 32 includes a cover 34, which is perforated with holes 36. In Fig. 3, the glass wool insert 26 is visible through the holes 36. It will be clear that the glass wool insert 26 is provided substantially throughout the tray 32. The holes 36 have a diameter L which in this case is 7 mm. The tray 32 is open at the bottom and any fluid in the tray can come in contact with the oven 1 and flow into its hollow areas. The walls of the oven forming the inner cavity 28 may not completely close off the inner cavity 28 from the remainder of the hollow oven. At least one of the walls of the inner cavity 28 may be provided with a plurality of openings 29, which can be round with a diameter of preferably 5 mm. This can provide fluid communication between the inner cavity 28 and the hollow oven. As in the previous example, the wick, here glass wool 26, is needed for the propylene glycol to catch fire.

Example 1 (Comparative)

[0042] Bio-ethanol (denaturated; ex Bio-blaze, Belgium) was burned in the small round ventless oven described herein-above in respect of Fig. 1. The inner cylinder was filled from the bottom up to halfway with glass wool such as typically used for building insulation. The oven was placed on a scale enabling to calculate continuously how much of the fluid was added and consumed.

[0043] Particularly, 53 grams of said bio-ethanol were poured into the inner cylinder. It was lit with a small flame from a gas torch. The fluid burned with a nice flame for 33 minutes.

[0044] During that time the CO concentration was regularly measured with a Toxirae-3 instrument (calibrated by the supplier) from RAE Benelux directly above the container. The CO concentration measured at 250 mm above the top of the burner was typically 5 to 8 ppm by weight; and at 450 mm above the top of the burner it was typically 3 to 6 ppm. At 1000 mm height no CO could be detected. When 80 wt.% of the alcohol was consumed, the flame started to burn irregularly and at that moment this part of the test was stopped.

[0045] Subsequently, fresh bio-ethanol was poured into the container. This fuel ignited immediately and created a very large flash-flame (larger than 500 mm).

[0046] At a later stage, the burning ventless oven was tilted and the ethanol made to flow over the stone floor, where it kept burning.

Example 2

[0047] 99.5% pure propylene glycol was burned in the same ventless oven as used in Example 1. The inner cylinder was filled to the top with glass wool such as typically used for building insulation. Like in Example 1, the oven was placed on a scale enabling to calculate continuously how much of the fluid was added and consumed.

[0048] Particularly, 56 grams of propylene glycol were poured into the inner cylinder. The fluid was lit with a small flame from a gas torch. The fluid burned with a nice flame for 27 minutes. During that time the CO concentration was regularly measured with a Toxirae-3 instrument from RAE Benelux. The CO concentration 250 mm above the top of the burner was typically zero ppm but reached measurable but irregular values of 10 to 35 ppm near the end of the burning time and at 450 mm above

the top of the burner it was typically zero ppm and at the very end fluctuated from 8 to 20 ppm. At 1000 mm height no CO could be detected. When about 70% of the fuel was consumed the flame started to burn irregularly and this part of the test was stopped.

[0049] Subsequently, fresh propylene glycol was poured into the container. Surprisingly, the added fluid did not flash, and in fact pouring the fuel too quickly - surprisingly - just caused the ventless oven to extinguish completely.

[0050] Then, the oven was lit again and the burning ventless oven was tilted, causing the propylene glycol to flow over the stone floor, where it - surprisingly - extinguished immediately.

[0051] This example illustrates that it is possible to have a nice and safe flame in a ventless oven according to the invention, while the risks associated with flashing flames during refilling are minimal, as well as risk associated with toxic off gases.

Example 3 (Comparative)

[0052] Bio-ethanol was burned in the large ventless oven described herein-above with reference to Fig. 2. No wick was present, therein.

[0053] The oven was placed on a scale enabling to calculate continuously how much of the fluid was added and consumed.

[0054] Particularly, 535 grams of bio-ethanol were poured into this oven. It was lit with a small flame from a gas torch. The fluid burned with a nice flame for 88 minutes. During that time the CO concentration was regularly measured with a Toxirae-3 instrument from RAE Benelux directly above the container. The CO concentration 450 mm above the top of the burner was typically 6 to 11 ppm. At a height of 1000 mm no CO could be detected. After 102 minutes the alcohol was consumed and the flame extinguished by itself, after having burned less regularly for about 10 minutes.

Example 4

[0055] 99.5% pure propylene glycol was burned in the same oven as used in Example 3, be it that this time the insert made of the same glass wool placed in a sheet metal tray perforated with holes of 7 mm diameter was used as a wick. Without the fiber insert, it appeared not possible to light the propylene glycol.

[0056] Again, the oven was placed on a scale enabling to calculate continuously how much of the fluid was added and consumed.

[0057] Particularly, 526 grams of propylene glycol were poured into this oven. It was lit with a small flame from a gas torch. The fluid burned with a nice flame for 92 minutes. During that time the CO concentration was regularly measured with a Toxirae-3 from RAE Benelux directly above the container. The CO concentration 450 mm above the top of the burner was typically 5 to 9 ppm. At a height of 1000 mm no CO could be detected. After 92 minutes about 65% of the fuel was consumed and the test was stopped.

[0058] The example illustrates that it is possible to create a nice and safe flame according to the invention, also with a large ventless oven.

Claims

1. Propylene glycol based fuel in an open geometry wicked device, wherein the propylene glycol based fuel has a flashpoint above 50°C and comprises at least 60 wt.% propylene glycol.

2. The product of claim 1, wherein the propylene glycol based fuel has a flashpoint above 80°C, preferably above 90°C.

3. The product of claim 1 or claim 2, wherein the propylene glycol based fuel comprises at least 75 wt.%, more preferably at least 90 wt. % propylene glycol.

4. The product according to any one of the preceding claims, wherein the propylene based fuel consists of propylene glycol.

5. The product according to claim 2 or claim 3, wherein the propylene based fuel comprises one or more compounds selected from the group consisting of glycerols, alcohols and edible oils.

6. The product according to any one of the preceding claims, wherein the open geometry wicked device is a ventless fireplace or a table top burner.

7. The product according to claim 6, wherein the open geometry wicked device is a ventless fireplace.

8. Use of a propylene glycol based fuel as defined in any one of the preceding claims as a safe fuel.

9. Use according to claim 8 for lighting a barbecue.

10. Use according to claim 8 in decorative home furnaces containing a chimney.

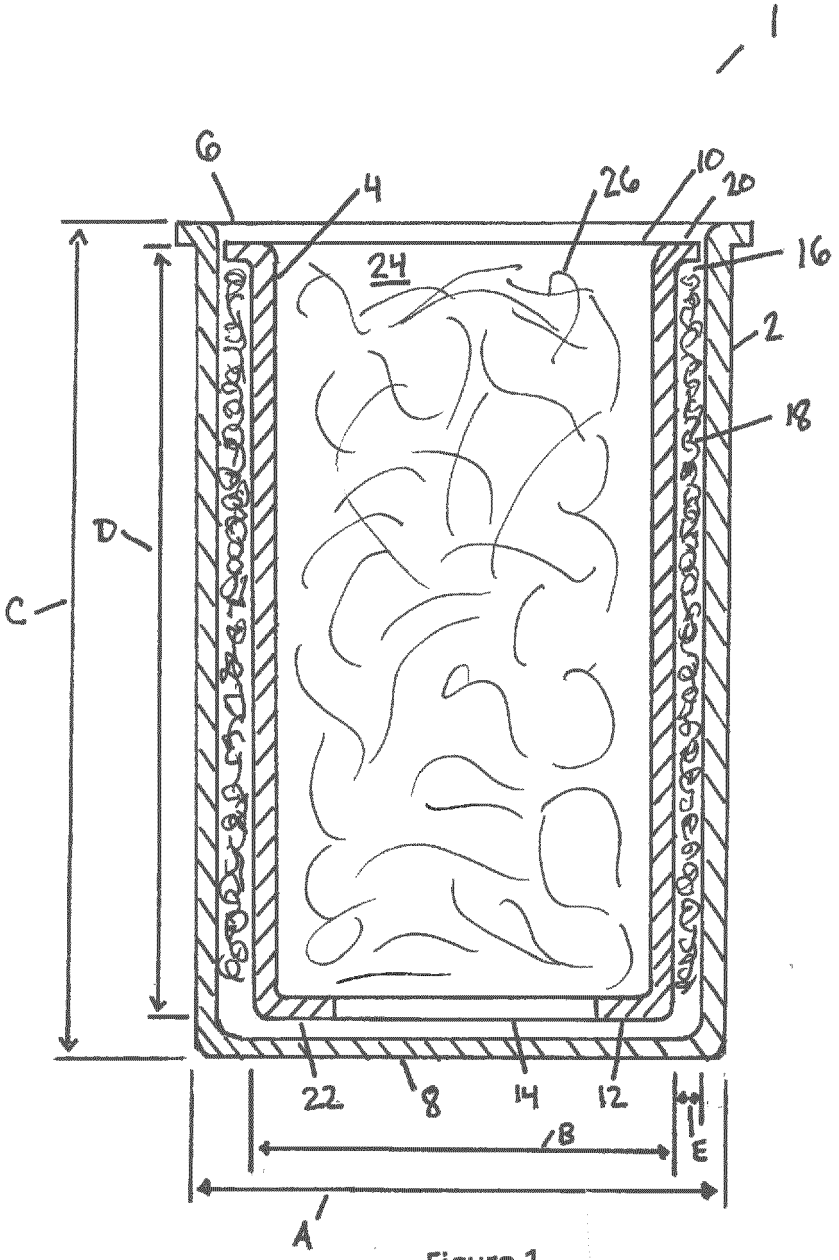

Figure 1

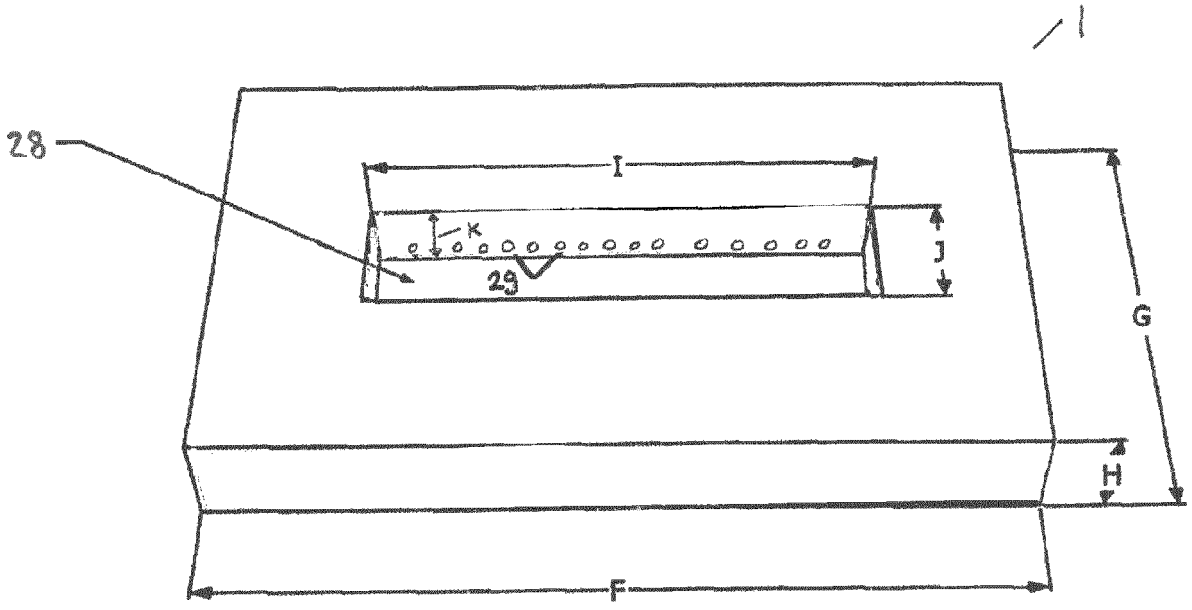

Figure 2

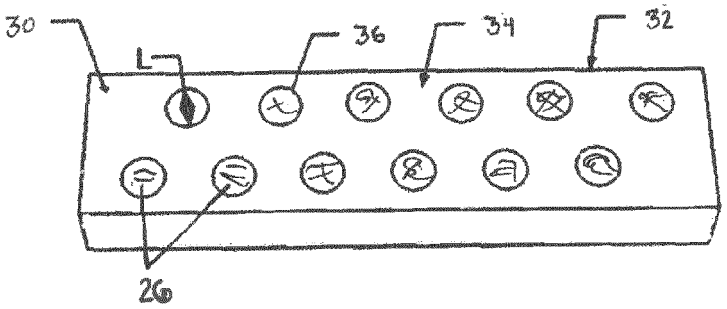

Figure 3

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EUROPEAN SEARCH REPORT

Application Number
EP 14 19 0050

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	Anonyme: "Propylène Glycol", Wikipédia L'encyclopédie libre , 5 October 2013 (2013-10-05), XP002736008, Retrieved from the Internet: URL:http://fr.wikipedia.org/w/index.php?title=Propyl%C3%A8ne_glycol&oldid=97243152 [retrieved on 2015-02-16] * table "Point d'Eclair" *	1-10	INV. C10L1/02 C07C31/20 C10L11/04 F23D3/18 F24C5/00
X	US 4 624 633 A (BANDEL DAVID [US]) 25 November 1986 (1986-11-25) * column 4, line 15 - line 20 * * claim 10 *	1-10	
A	US 2002/187445 A1 (LESESNE JOHN SHERMAN [US]) 12 December 2002 (2002-12-12) * paragraph [0048] - paragraph [0052] *	1-10	
A	EP 1 323 812 A2 (LIM JINMAN [KR] HWALIM TECHNOLOGICAL CO LTD [KR]) 2 July 2003 (2003-07-02) * tables 1-9 *	1-10	

TECHNICAL FIELDS SEARCHED (IPC)

C10L
C07C
F23D
F24C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	16 February 2015	Bernet, Olivier

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 19 0050

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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16-02-2015

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