



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
29.07.2015 Bulletin 2015/31

(51) Int Cl.:
F22B 1/28 (2006.01)

(21) Application number: **15152434.5**

(22) Date of filing: **26.01.2015**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME

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(30) Priority: **27.01.2014 FI 20145074**

(54) **Heating unit, heating device and method for generating steam from liquid and heating gas in a heating unit**

(57) The invention relates to a heating unit (1) for generating steam from liquid and for heating gas and comprises a fluid container (2) having a wall (20), said wall (20) comprising an inner surface (21) and an outer surface (22), and a heating element (3) in contact with the wall (20) of the fluid container (2), said heating element (3) is arranged to the wall (20) such that liquid arranged in the fluid container (2) is indirectly heated via the inner surface (21) of the wall (20) such that steam is

generated from the liquid in the fluid container (2), and said heating element (3) is arranged to heat gas on the side of the outer surface (22) of the wall (20) of the fluid container (2). The invention further relates to a heating device comprising a heating unit (1), a liquid connection and a fan. The invention relates also to a method for generating steam from liquid and for heating gas in a heating unit (1).

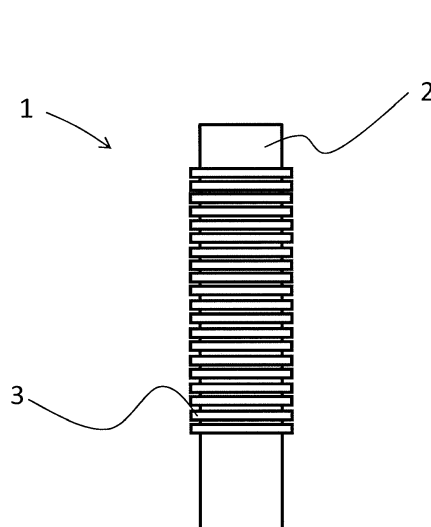


Fig.1a

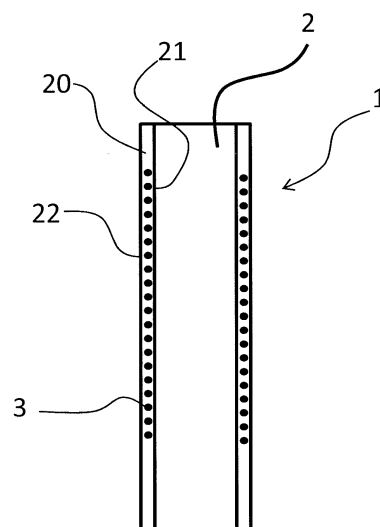


Fig.1b

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a heating unit according to claim 1, and more particularly to a heating unit as defined in the preamble of independent claim 1.

[0002] The present invention relates also to a heating device according to claim 10, and more particularly to a heating device as defined in the preamble of independent claim 10.

[0003] The present invention also relates to a method for generating steam from liquid and heating gas in a heating unit according to claim 12, and more particularly to a method as defined in the preamble of independent claim 12.

BACKGROUND OF THE INVENTION

[0004] Typically when steam generation and gas heating is needed in a bakery oven, in a cooking appliance or in a sauna, a heating unit for heating gas and a separate heating unit for heating liquid are required. The steam generation is typically achieved by boiling water with a heating element immersed in water.

[0005] Steam can be introduced into cooking chamber of bakery ovens or cooking appliances also by spraying water into the cooking chamber, either directly to atmosphere, on hot surfaces, onto the heating elements or onto the steam generating surfaces heated by hot air flow. All these alternatives have a limited steam generating capacity and the effect of short steam pulses is difficult to control. Additionally, thermal shocks caused by steam generation can cause deformation of the structures and consequent premature failure.

[0006] One of the disadvantages associated with the above arrangement is that they require two different heating units and therefore much space and higher costs.

BRIEF DESCRIPTION OF THE INVENTION

[0007] An object of the present invention is thus to provide a heating unit, a heating device and a method for generating steam and heating gas and so as to alleviate the above disadvantages. The objects of the invention are achieved by a heating unit, a heating device and a method which is characterized by what is stated in the independent claims. The preferred embodiments of the invention are disclosed in the dependent claims.

[0008] The invention is based on the idea of a compact heating unit for generating steam and heating gas either simultaneously or separately.

[0009] According to the invention a heating unit for generating steam from liquid and for heating gas comprises a fluid container and a heating element. The fluid container has a wall comprising an inner surface and an outer surface and the heating element is in contact with the wall of the fluid container. The heating element is ar-

ranged to the wall such that liquid arranged in the fluid container is indirectly heated via the inner surface of the wall of the fluid container such that steam is generated from the liquid in the fluid container, and said heating element is also arranged to heat gas on the side of the outer surface of the wall of the fluid container, i.e. outside of the fluid container.

[0010] The fluid container is preferably a cylindrical container being small in diameter but substantially high comprising an inlet for receiving fluid and an outlet for steam to exit the fluid container. The heating element is preferably arranged to the wall of the fluid container such that the heating element forms at least part of the outer surface of the wall for directly heating gas outside of the fluid container, i.e. on the side of the outer surface of the wall of the fluid container.

[0011] In another embodiment of the invention the heating element is arranged within the wall of the fluid container between the inner surface and the outer surface of the wall for indirectly heating gas outside of the fluid container, i.e. on the side of the outer surface of the wall of the fluid container.

[0012] The idea of a heating unit according to the invention is that it can be used for heating liquid such that steam is generated from the liquid and also for heating gas in a free air circulation, forced air convection or as a radiant heating element. Another idea of the heating unit is that both functions, i.e. steam generation and heating, can be operated simultaneously, in sequence or separately and still the heating unit is such that it can be placed in a small space especially in a convection oven.

[0013] In a method according to the invention a heating unit is arranged for generating steam from liquid and for heating gas in a heating unit such that the method comprises the steps of supplying liquid into the fluid container, supplying gas toward the heating unit and operating the heating element such that steam is generated from the liquid in the fluid container and/or that gas is heated outside the heating unit. The steps of supplying liquid and supplying gas can be carried out simultaneously, separately or in sequence for generating steam and heating gas. The heating element that is in connection with the wall of the fluid container heats the wall of the fluid container such that the inner surface of the wall which is in contact with the liquid conducts heat from the heating element through the wall to the liquid such that liquid boils and steam is generated. The heating element is brazed, cast in the body of the fluid container or otherwise firmly connected to the fluid container. The gas outside of the fluid container is heated with the energy that the outer surface of the fluid container transfers from the heating element arranged in contact with the fluid container. The outer surface of the fluid container is preferably enlarged for intensifying the heating of the gas. The enlargement can be accomplished for example with ribs protruding from the outer surface of the wall of the fluid container. The heating element may form at least part of said ribs.

[0014] In a preferred embodiment of the invention the

heating unit is arranged to heat the gas such that forced air convection is arranged onto the heating element which the heating element is arranged at least partly on the outer surface of the fluid container and air is arranged to flow perpendicularly toward a longitudinal axis of the heating unit. The heating unit comprising the fluid container is preferably arranged such that the longitudinal axis goes through the fluid container from the bottom part of the fluid container to the top part of the fluid container. The fluid container is preferably a flow-through container such that a channel or a passage is arranged through the container for liquid to enter the fluid container and the steam to exit the fluid container. In other words when liquid is arranged to flow to the fluid container from below of the fluid container in the direction upward or substantially upward the passage in the fluid container is such that steam generating from liquid boiling in the fluid container will be released from the fluid container also in the direction upward or substantially upward from the fluid container.

[0015] The fluid container comprises an inlet for receiving liquid, i.e. for the liquid to enter the fluid container, and an outlet for steam to exit the fluid container. In one embodiment of the invention the fluid container comprises a bottom and said inlet is arranged in the bottom or in the wall near the bottom. The fluid container also comprises a top in which the outlet is arranged. The outlet may alternatively be arranged in the wall near the top, the top being the end of the container. The fluid container is preferably a flow-through container, for example a tube or a tube-like structure comprising a flow through passage for the liquid and steam.

[0016] The heating element is in a preferred embodiment of the invention a rod-shaped element that is brazed or welded on the outer surface of the fluid container and preferably around the fluid container forming multiple laps being as a coil like structure. In other words the heating element may be a coil structure arranged around the fluid container. The coil structure of the heating element makes the outer surface of the heating unit larger so that heat transfer to the gas is most effective. In another embodiment of the invention the fluid container is a casting piece or extrusion piece and the heating element may be completely or at least partly inside the wall of said fluid container. In the case where the fluid container is a casting piece the heating element is arranged in contact with the fluid container during the casting process or the heating element may be connected to the fluid container by pressing it to the fluid container. The fluid container preferably comprises ribs protruding from the outer surface of the wall of the fluid container and the heating element may form at least part of said ribs. Especially as a casting piece but also in other embodiments of the invention the fluid container and the heating element may be fixedly connected together such that the heating element is an integral part of the fluid container.

[0017] The idea of the invention is that the same heating unit is used for two different kind of heating process

which can be operated simultaneously, in sequence or separately. Heating of the liquid is arranged such that the heating element is not directly in contact with the liquid but heating of the liquid is arranged via the wall of the fluid container such that heat transfer through the wall is so effective that the liquid in the fluid container boils and steam is generated. In a preferred embodiment of the invention the heating element is arranged on the outer surface of the fluid container or at least partly on the outer surface of the fluid container and is in contact with the wall of the fluid container in such a way that thermal energy is transferred through the wall of the fluid container from the outer surface of the wall of the fluid container to the inner surface of the wall of the fluid container and to the liquid in the fluid container such that the liquid heats up and starts to boil and generate steam. Typically air heating/radiant heating and steam generation are carried out separately or in sequence, but they can as well be carried out simultaneously.

[0018] In the method according to the invention the liquid level in the fluid container is arranged in a predetermined level by supplying liquid into the fluid container before or at the same time when the heating element starts to operate and heat the liquid for boiling it. When the liquid boils in the fluid container and steam is generated, the volume of liquid in the container starts to decrease so that corresponding volume of liquid has to be brought into the fluid container so that the predetermined liquid level is maintained. This can be achieved by a liquid level controlling container which is in a fluid communication with the fluid container but in which the temperature is so low that the liquid does not boil and functions by virtue of the communicating vessel principle. By maintaining the predetermined liquid level in the liquid level controlling container, constant volume of liquid is maintained in the fluid container. Because the liquid does not boil in the liquid level controlling container, the control of liquid volume in the fluid container is easy. Volume of liquid in the fluid container has to be such that when the liquid boils there is not excessive splashing. On the other hand the liquid level may not be too low because then the upper part of the fluid container may heat up too much and cause premature failure of the heating unit.

[0019] So the heating device according to the invention comprises a heating unit for generating steam from liquid and for heating gas. The heating unit comprises a fluid container having a wall comprising an inner surface and an outer surface, and a heating element in contact with the wall. The heating element is arranged to the wall such that liquid arranged in the fluid container is indirectly heated via the inner surface of the wall such that steam is generated from the liquid in the fluid container. The heating element is arranged to heat gas on the side of the outer surface of the wall of the fluid container. The fluid container comprises an inlet for the liquid to enter the fluid container and an outlet for steam to exit the fluid container. The heating device further comprises a liquid connection for supplying liquid to the fluid container

through the inlet and a fan for directing gas toward the heating unit.

[0020] The heating device according to a preferred embodiment of the invention comprises a heating unit and a liquid level controlling container in a fluid communication with the fluid container of the heating unit for controlling volume of liquid in the fluid container by virtue of communicating vessel principle. So the heating device comprises a liquid connection for supplying liquid to the fluid container through the inlet in the fluid container and the liquid is preferably supplied from the liquid level controlling container. The heating device according to the invention also comprises a fan for directing gas toward the heating unit. According to one embodiment of the invention the heating device comprises a plurality of heating units arranged in a fluid communication with the liquid level controlling container.

[0021] So the method further comprises the steps of providing a liquid level controlling container in a fluid communication with the fluid container and controlling liquid level in the fluid container by virtue of communicating vessel principle. The liquid level in the fluid container is preferably maintained on a level which minimizes the splashing of liquid droplets away from the fluid container or prevents the liquid from boiling over the edge of the fluid container. The upper part of the fluid container maintains a moderate temperature while the generated steam cools it on the way out of the fluid container. The volume of liquid in the fluid container is controlled by virtue of the communicating vessel principle such that the heating unit may further comprise a liquid level controlling container which is a separate container and in a fluid communication with the fluid container for controlling the volume of liquid in the fluid container.

[0022] Before starting the steam generation the liquid level in the fluid container is arranged to an optimum level and this level is kept during the evaporation process in which the steam is generated. If there is less than an optimum volume of liquid the temperature in the upper part of the fluid container in which there is no liquid will become too high. If there is too much liquid in the fluid container the boiling of the liquid will cause splashing of liquid which is an unfavorable situation. Keeping the optimum liquid level during the entire evaporation process is difficult when using conventional liquid level adjustment because in the conventional liquid level adjustment there is no clear liquid level but instead a two-phase system comprising liquid and gas. This problem can be solved with the communicating vessel principle. The liquid level controlling container is arranged such that the liquid inside of said container does not boil. This way the control of the liquid level is much easier.

[0023] Optimum volume of liquid in the fluid container at the start of the evaporation process depends on the measurements of the fluid container and on the watts density on the inner surface of the fluid container. Relatively high watts density is preferred. An example of an embodiment of the invention is a fluid container compris-

ing a tube-like stainless steel container having an inner diameter of 19mm and outer diameter of 22mm. Outside of the container is a spiral formed metal sheathed heating element. The height of the container comprising the spiral formed heating element is 28cm and the power of the heating element is 1500W so the watts density is 9W/cm². In such a container, experience has shown that the optimum liquid level is between 7,5 and 12 cm when measured from the lower part of the spiral formed heating element.

[0024] In one embodiment of the invention the heating unit further comprises a drop separator for preventing liquid drops escaping together with steam from a fluid container. The drop separator is arranged at least partly inside the fluid container in the upper part of it and comprises plurality of flow restraints. The drop separator is according to one embodiment of the invention separate from the fluid container and the flow restraints are connected together through a connection structure. The drop separator is manufactured from a metal plate as a single piece and bent in the final form. In another embodiment of the invention the drop separator is an integral part of the fluid container and said flow restraints are fixedly connected to an inner surface of the fluid container for preventing liquid droplets reaching the outlet of the fluid container. The restraints are preferably made of plates and arranged inside the fluid container such that the plates directly or indirectly stop the movement of the liquid droplets. The restraints are preferably arranged staggered or imbricated. The number, the shape and the distance of restraints have to be modified according to the geometry of the fluid container so that the steam flow is not restricted excessively. In a preferred embodiment of the invention the drop separator can be made as a single piece that is cut of a metal plate and bent into the desired shape. The restraints partly fill the cross-section of the fluid container such that the restraints are arranged at regular intervals to a ribbon or banded structure which forms a frame for the drop separator. The restraints are arranged such that the steam stream will not be prevented too much but still the droplets are prevented from escaping the fluid container. One embodiment of the drop separator is a structure that comprises three plates in a horizontal alignment in an approximately 2, 5 cm distance from each other. The form of the plate is preferably a half-circle. Another embodiment of the drop separator is such that the plate is half or more than half of the cross-section of the fluid container and comprises cut-outs, holes or otherwise shaped parts that prevent the drop from escaping. In another embodiment of the drop separator the plates are arranged in an inclined position to the fluid container.

[0025] In one embodiment of the invention the heating unit further comprises an intermediate tank in a fluid communication with the fluid container and with the liquid level controlling container for connecting said fluid container and said liquid level controlling container. The intermediate tank may comprise an inlet for adding addi-

tional liquid to the fluid container and/or removing liquid from the fluid container. This additional liquid can be for example decalcifying liquid for descaling the fluid container. When adding the decalcifying liquid the fluid container is preferably heated with the heating element so that the dissolution will be accelerated.

[0026] When stopping the steam generation no more liquid is added to the fluid container. The remaining liquid in the fluid container is either drained or is allowed to boil out. The fluid container may heat up too much when the liquid decreases so preferably forced air convection is arranged to the fluid container.

[0027] An advantage of the heating unit and method of the invention is that there is no need for separate elements for heating gas and generating steam but both operations can be achieved with one single element. This is advantageous for example in a steam oven or similar, in which the space is limited.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

Figure 1 a shows a heating unit according to one embodiment of the invention;

Figure 1b shows a heating unit according to another embodiment of the invention; and

Figure 2 shows the heating unit shown in figure 1 with liquid level controlling element.

DETAILED DESCRIPTION OF THE INVENTION

[0029] Figure 1 a shows one embodiment of the heating unit 1 according to the invention said heating unit 1 comprising a fluid container 2 and a heating element 3. The heating element 3 is arranged on the outer surface of the wall of the fluid container 2 such that the heating element 3 and the fluid container 2 are in contact with each other for transferring the heat from the heating element 3 through the wall of the fluid container 2 to liquid inside the fluid container 2 such that the liquid starts to boil and steam is generated. The heating element 3 is arranged on the outer surface of the fluid container such that gas flow arranged toward the heating element 3 is directly heated up with the heating element 3 and liquid arranged in the fluid container 2 is indirectly heated up with the heating element 3.

[0030] Figure 1b shows another embodiment of the heating unit 1 according to the invention in which the heating element 3 is arranged within the wall 20 of the fluid container 2 between the inner surface 21 and the outer surface 22 for indirectly heating gas on the outer surface of the fluid container 2 and indirectly heating the fluid arranged in the fluid container 2. The heating element 3 may be arranged inside the wall 20 by casting or some other way.

[0031] Figure 2 shows the same heating unit 1 as shown in figure 1 together with liquid level controlling container 4 as a sectional view. The heating unit 1 comprises a heating element 3 arranged on the outer surface 22 of the wall 20 of the fluid container 2. The heating element 3 is preferably brazed to the fluid container 2 such that a firm connection is formed. The fluid container 2 is in a fluid communication with a liquid level controlling container 4 for controlling the liquid level in the fluid container 2. Liquid is added to the liquid level controlling container 4 wherefrom it goes through an inlet in the bottom 5 of the fluid container 2 and enters to the fluid container 2. When the liquid in the fluid container 2 boils steam is generated and the generated steam exits the fluid container 2 via outlet 2b on top of the fluid container 2. Liquid droplets that are present in the steam exiting the fluid container 2 are removed from the steam with a drop separator 6 comprising restraints 7. In this embodiment the restraints 7 are plate-like elements arranged in the inner surface 21 of the wall 20 of the fluid container 2. The restraints 7 may also be of another form, for example a single piece drop separator 6 that is formed by bending a plate such that multiple different restraints 7 are formed in the separator 6 which can be attached to the fluid container 2 by hanging it in the outlet 2b or by attaching it in some other way. In this embodiment 3 restraints 7 are arranged but the amount, size and shape may vary according to the shape and size of the fluid container 2.

[0032] There may be an additional inlet in the fluid container 2 for adding for example decalcifying liquid to the fluid container 2 (not shown in the figure) or the inlet for adding another liquid to the fluid container may be in some suitable place in between the fluid container 2 and the liquid level controlling container 4.

[0033] The heating device may comprise multiple heating units 1 arranged in series and communicating with the liquid level controlling container 4. The heating element 3 can be electrically heated or it can be heated with fuel.

[0034] It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

Claims

1. A heating unit (1) for generating steam from liquid and for heating gas, **characterized in that** the heating unit (1) comprising:
 - a fluid container (2) having a wall (20), said wall (20) comprising an inner surface (21) and an outer surface (22), and
 - a heating element (3) in contact with the wall (20) of the fluid container (2), said heating ele-

- ment (3) is arranged to the wall (20) such that liquid arranged in the fluid container (2) is indirectly heated via the inner surface (21) of the wall (20) such that steam is generated from the liquid in the fluid container (2), and said heating element (3) is arranged to heat gas on the side of the outer surface (22) of the wall (20) of the fluid container (2).
2. A heating unit (1) according to claim 1, **characterized in that**:
 - the heating element (3) is arranged to the wall (20) such that the heating element (3) forms at least part of the outer surface (22) of the wall (20) for directly heating gas outside of the fluid container (2); or
 - the heating element (3) is arranged within the wall (20) of the fluid container (2) between the inner surface (21) and the outer surface (22) for indirectly heating gas on the outer surface of the fluid container (2).
 3. A heating unit (1) according to any previous claim, **characterized in that** the outer surface (22) of the wall (20) of the fluid container (2) comprises ribs protruding from said wall (20).
 4. A heating unit (1) according to claim 3, **characterized in that** the heating element (3) forms at least part of said ribs.
 5. A heating unit (1) according to any preceding claims, **characterized in that** the fluid container (2) comprises an inlet (2a) for the liquid to enter the fluid container (2) and an outlet (2b) for steam to exit the fluid container (2).
 6. A heating unit (1) according to claim 5, **characterized in that** said fluid container (2) comprises a bottom, and said inlet (2a) is arranged in the bottom or in the wall (20) near the bottom, and a top, and the outlet (2b) is arranged in the top or near the top.
 7. A heating unit (1) according to any preceding claims, **characterized in that** the heating element (3) is a coil structure arranged around the fluid container (2).
 8. A heating unit (1) according to any preceding claims, **characterized in that** the heating unit (1) further comprises a drop separator (6) for preventing drops of liquid escaping from the fluid container (2).
 9. A heating unit (1) according to any preceding claims, **characterized in that** the fluid container (2) and the heating element (3) are fixedly connected together such that the heating element (3) is an integral part of the fluid container (2).
 10. A heating device, **characterized in that** the heating device comprises:
 - a heating unit (1) for generating steam from liquid and for heating gas, said heating unit (1) comprising a fluid container (2) having a wall (20) comprising an inner surface (21) and an outer surface (22), and a heating element (3) in contact with the wall (2), said heating element (3) is arranged to the wall (20) such that liquid arranged in the fluid container (2) is indirectly heated via the inner surface (21) of the wall (20) such that steam is generated from the liquid in the fluid container (2), and said heating element (3) is arranged to heat gas on the side of the outer surface (22) of the wall (20) of the fluid container (2), said fluid container (2) comprises an inlet (2a) for the liquid to enter the fluid container (2) and an outlet (2b) for steam to exit the fluid container (2),
 - a liquid connection for supplying liquid to the fluid container (2) through the inlet (2a); and
 - a fan for directing gas toward the heating unit (1).
 11. A heating device according to claim 10, **characterized in that** the heating device further comprises a liquid level controlling container (4) in a fluid communication with the fluid container (2) for controlling volume of liquid in the fluid container (2) by virtue of the communicating vessel principle.
 12. Method for generating steam from liquid and for heating gas in a heating unit (1) according to claim 1, **characterized in that** the method comprising the steps of:
 - a) supplying liquid into the fluid container (2),
 - b) supplying gas toward the heating unit (1), and
 - c) operating the heating element (3) such that steam is generated from the liquid in the fluid container (2) and/or that gas is heated outside the heating unit (1).
 13. Method according to claim 12, **characterized in that** the steps a) and b) are carried out simultaneously for generating steam and heating gas simultaneously.
 14. Method according to claim 12, **characterized in that** the steps a) and b) are carried out separately or in sequence.
 15. Method according to any of claims 12 - 14, **characterized in that** the method further comprising the steps of:
 - d) providing a liquid level controlling container

(4) in a fluid communication with the fluid container (2), and
e) controlling liquid level in the fluid container (2) by virtue of the communicating vessel principle.

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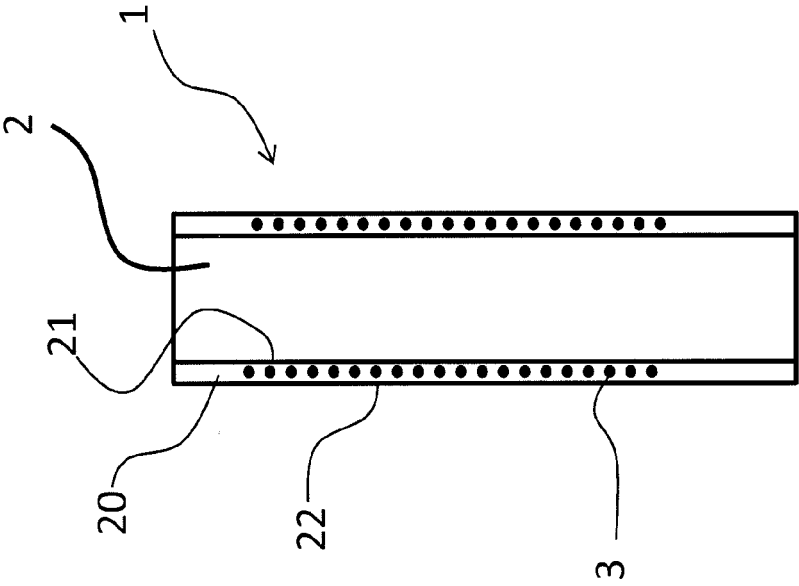


Fig.1a

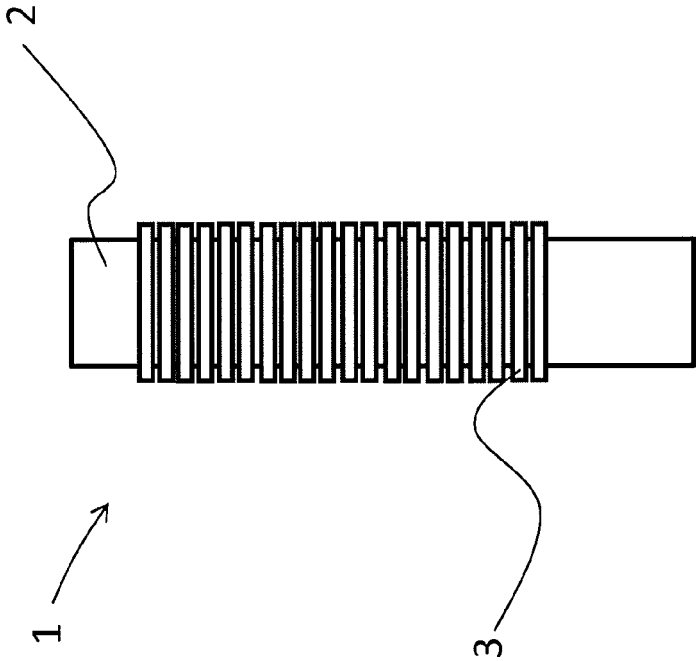


Fig.1b

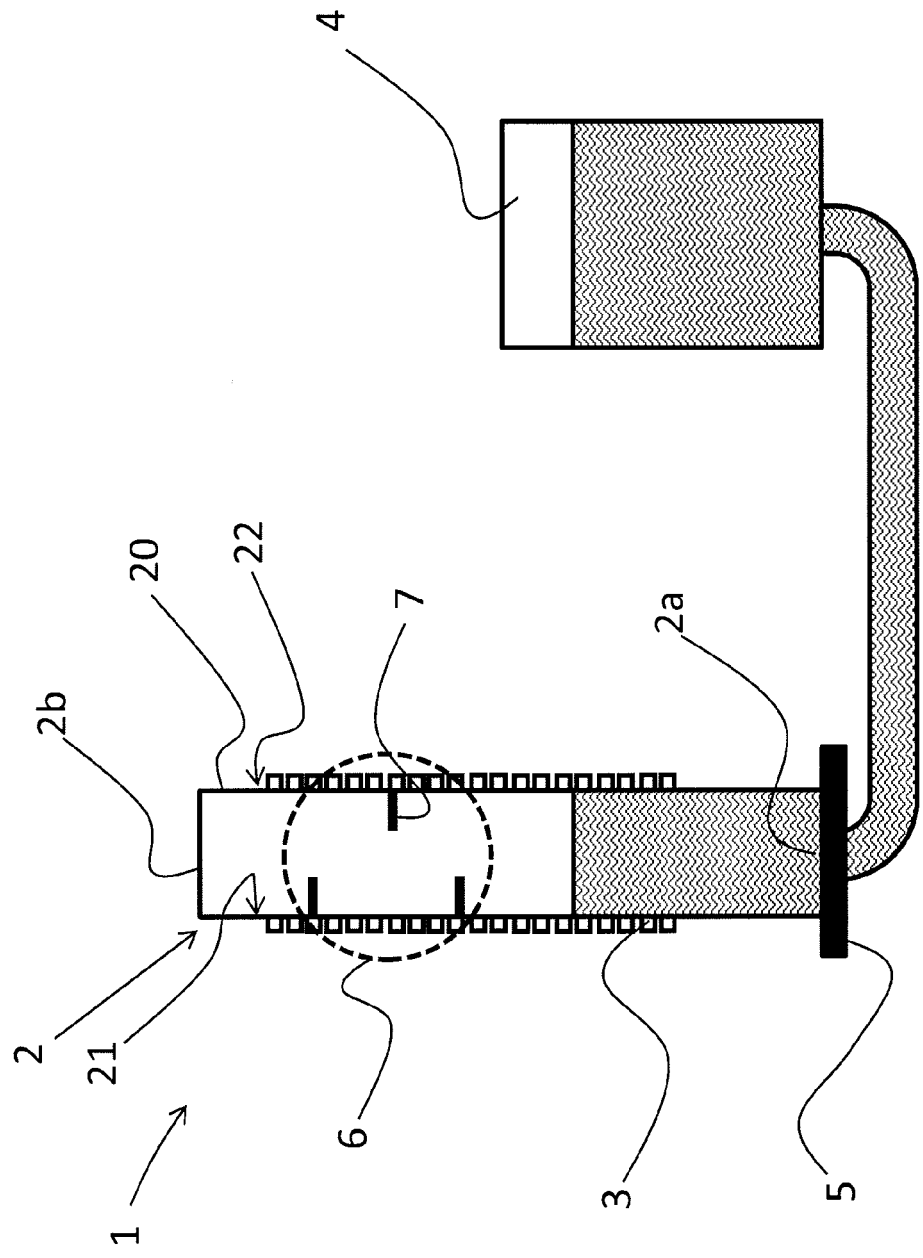


Fig.2



EUROPEAN SEARCH REPORT

Application Number
EP 15 15 2434

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	JP H09 4803 A (MATSUSHITA ELECTRIC IND CO LTD) 10 January 1997 (1997-01-10) * abstract; figures 1, 4, 5, 6 * * paragraphs [0001], [0005], [0009] - [0011] *	1-15	INV. F22B1/28
X	JP 2000 266302 A (SHOKUHI SANGYO DENSHI RIYO GI) 29 September 2000 (2000-09-29) * abstract; figures 1, 2, 3, 6 * * paragraphs [0001], [0005], [0014] - [0020] *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			F22B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 20 May 2015	Examiner Varelas, Dimitrios
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 O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention 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	

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EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 15 15 2434

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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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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82