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(54) Radiator, particularly for heating systems or the like, with high thermal performance and very quiet operation

(57) A radiator (1a), particularly for heating systems or the like, with high thermal performance and very quiet operation, comprising a radiator body (2a) in which there is a chamber (3a) which is separated hermetically from the outside environment, the chamber (3 a) being filled partially with a liquid (4a) which gathers on the bottom of the chamber and being in partial vacuum at ambient temperature, the radiator (1a) being provided with means (5a) for heating the liquid (4a) which are separated with a liquid-tight seal from the liquid by a heat exchange surface (6a), the heat exchange surface (6a) emerging at least partially from the free surface of the liquid (4a) contained in the chamber (3a), a capillary structure (7a) being provided which lies at least between the free surface of the liquid (4a) and the heat exchange surface (6a) and being adapted to convey the liquid (4a) onto the heat exchange surface (6a).

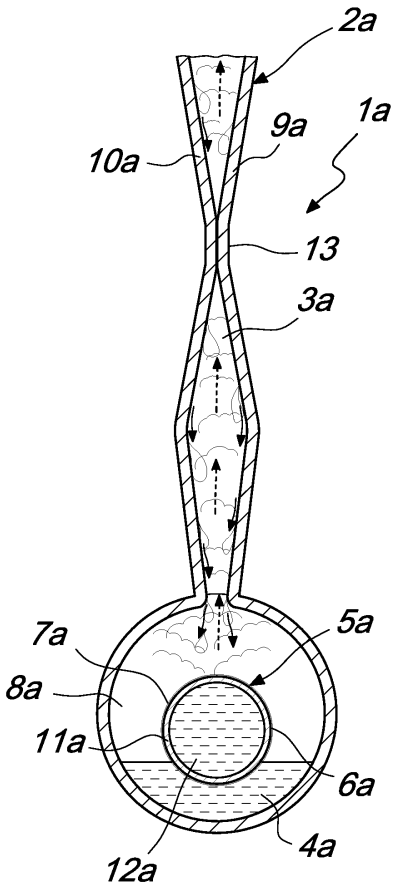

Fig. 2

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Description

[0001] The present invention relates to a radiator, particularly for heating systems or the like, with high thermal performance and very quiet operation.

[0002] Several types of radiators for heating systems are known. Generally, such radiators are hollow bodies made of cast iron or welded steel or composed of pressure die-cast and assembled light alloy modules, which have an inlet connector and an outlet connector in order to be connected to the circuit of the heating system by means of which the heating fluid, usually constituted by water, at a temperature on the average around 60-70°C, is made to flow inside the body of the radiator.

[0003] In order to increase the efficiency of the radiators in the exchange of heat with the environment to be heated, different solutions have been studied which are aimed mainly at increasing the heat exchange surface between the radiator and the environment.

[0004] Also with this goal, radiators have been proposed which use, for heat exchange with the environment, the liquid-vapor phase transition of a liquid, constituted generally by water, which is introduced in the radiator in partial vacuum. One of these radiators is disclosed for example in FR 2357850 A1. Radiators of this type have a body which forms internally a hermetically sealed chamber which is subjected to a partial vacuum and is partially filled with a liquid, constituted generally by water, which, when the radiator is installed gathers at the bottom of the chamber. In this region, inside the body of the radiator, a duct passes which is immersed in the liquid which gathers in such region and is connected to the circuit of the heating system and is separated hermetically from the chamber in partial vacuum. In these radiators, when the heating system starts to operate, the duct, which is connected to the heating system, heats the liquid contained in the radiator, which due to the partial vacuum conditions evaporates and distributes on the inner walls of the radiator, heating them. The outer walls of the radiator transfer heat to the surrounding environment and the vapor, as a consequence of the transfer of heat to the walls of the radiator, condenses and gathers, in liquid form, on the lower side of the chamber, where it is again heated and converted into vapor.

[0005] Such radiators have a considerably higher thermal efficiency than traditional types of radiators, but suffer the problem of a certain noisiness during their operation, which is due mainly to the turbulent motions generated by the boiling of the liquid that gathers on the bottom of the chamber in partial vacuum.

[0006] The noise that is generated is usually modest; however, in a dwelling in which the background noise level is very low it can be unpleasant.

[0007] The aim of the present invention is to solve the problem described above by providing a radiator which ensures high thermal performance and very quiet operation.

[0008] Within this aim, an object of the invention is to provide a radiator which uses the partial vacuum evaporation method but reduces considerably the turbulence and therefore the noise generated by the evaporation of the liquid that is used.

[0009] Another object of the invention is to propose a radiator which can be provided, in a simple and economically competitive manner, in several configurations, so as to meet the most disparate aesthetic and/or functional requirements.

[0010] Still another object of the invention is to provide a radiator which can work with a wide range of temperatures.

[0011] This aim and these and other objects, which will become better apparent hereinafter, are achieved by a radiator, particularly for heating systems or the like, comprising a radiator body in which there is a chamber which is separated hermetically from the outside environment, said chamber being filled partially with a liquid which gathers on the bottom of said chamber and being in partial vacuum at ambient temperature, means for heating said liquid being provided which are separated with a liquid-tight seal from said liquid by a heat exchange surface, characterized in that said heat exchange surface emerges at least partially from the free surface of the liquid contained in said chamber, a capillary structure being provided which lies at least between the free surface of said liquid and said heat exchange surface and is adapted to convey said liquid onto said heat exchange surface.

[0012] Further characteristics and advantages of the invention will become better apparent from the description of two preferred but not exclusive embodiments of the radiator according to the invention, illustrated by way of non-limiting example in the accompanying drawings, wherein:

Figure 1 is a perspective view of a radiator according to the invention, in a first embodiment;

Figure 2 is a schematic sectional enlarged-scale view, taken along a transverse vertical plane, of a portion of the radiator shown in Figure 1;

Figure 3 is a view of a detail of the radiator according to the invention in the first embodiment, related to the heating means and to the capillary structure;

Figure 4 is a schematic sectional view, similar to Figure 2, of a portion of the radiator according to the invention, in a second embodiment;

Figure 5 is an enlarged-scale view of a detail of Figure 4;

Figure 6 is a view of a constructive variation of the body of the radiator.

[0013] With reference to Figures 1 to 5, the radiator according to the invention, generally designated in the two illustrated embodiments by the reference numerals 1a, 1b, comprises a radiator body 2a, 2b, inside which a chamber 3a, 3b is provided, which is separated hermetically from the outside environment. The chamber 3a, 3b is partially filled with a liquid 4a, 4b, which gathers at the

bottom of the chamber 3a, 3b, and is in partial vacuum at ambient temperature. The radiator is provided with means 5a, 5b for heating the liquid 4a, 4b, which are separated with a liquid-tight seal from the liquid 4a, 4b by a heat exchange surface 6a, 6b.

[0014] According to the invention, the heat exchange surface 6a, 6b at least partially emerges from the free surface of the liquid 4a, 4b contained in the chamber 3a, 3b and there is a capillary structure 7a, 7b which lies at least between the free surface of the liquid 4a, 4b and the heat exchange surface 6a, 6b and is adapted to convey the liquid 4a, 4b onto the heat exchange surface 6a, 6b.

[0015] Preferably, the chamber 3a, 3b has, at the side of the body of the radiator 2a, 2b that is designed to be located, upon installation, proximate to the lower end of the radiator body 2a, 2b, a receptacle 8a, 8b for collecting the liquid 4a, 4b.

[0016] The body of the radiator 2a, 2b can be composed of a pair of plate-like elements 9a, 10a, 9b, 10b, preferably made of stainless steel, which face each other and are welded to each other perimetrically so as to form between them the chamber 3a, 3b, which is separated hermetically from the outside environment. Optionally, the pairs of plate-like elements 9a, 10a, 9b, 10b can be welded together not only along the perimeter but also at points 13 which are arranged within the perimeter, so as to stiffen the body of the radiator 2a, 2b as a whole.

[0017] The receptacle 8a, 8b is formed preferably by a wider region of the chamber 3a, 3b proximate to the end of the radiator body 2a, 2b which, when the radiator is installed, is designed to constitute the lower end of the body of the radiator 2a, 2b.

[0018] The quantity of liquid 4a, 4b that is introduced in the chamber 3a, 3b is such as to fill the receptacle 8a, 8b only partially.

[0019] As shown in the first embodiment, the means 5a for heating the liquid 4a comprise a duct 11a for the transit of a heating fluid 12a which passes within the chamber 3a. The interior of the transit duct 11a, which is designed to be connected to means for circulating the heating fluid 12a of a known type, which are not illustrated for the sake of simplicity, is separated hermetically from the chamber 3a.

[0020] More particularly, the transit duct 11a can be inserted, through holes provided for this purpose in the body of the radiator 2a, in the receptacle 8a, sealing appropriately the holes crossed by the transit duct 11a.

[0021] The heating fluid 12a that is conveyed into the transit duct 11a can be constituted simply by hot water or by diathermic oil, depending on the requirements and on availability at the installation site of the radiator according to the invention. Thus, for example, the transit duct 11a can be connected to a central boiler-type heating system or to a diathermic oil heating circuit.

[0022] Conveniently, the transit duct 11a, which is designed to be arranged predominantly so that its axis is horizontal, is partially immersed in, or only skims with its lower end, the free surface of the liquid 4a collected in the receptacle 8a.

[0023] In this first embodiment, the capillary structure 7a is applied to the outer lateral surface of the transit duct 11a so that although the transit duct 11 a is only partially immersed in, or skims with its lower end, the free surface of the liquid 4a collected in the receptacle 8a, the liquid 4a is able to arrange itself, by capillary action, substantially on the entire heat exchange surface 6a of the transit duct 11a.

[0024] As an alternative, the heating means can be constituted by an electric resistor which is arranged in the receptacle 8a and which, preferably, is inserted in a tubular containment body which is inserted in the receptacle 8a, like the transit duct 11a. In this case also, the electric resistor or the tubular body for accommodating the electric resistor is partially immersed in the liquid 4a that is collected in the receptacle 8a or skims only with its lower end the free surface of the liquid 4a collected in the receptacle 8a. In this case, the capillary structure 7a is applied to the outer surface of the electric resistor or of the tubular body for accommodating the electric resistor so as to convey, by capillary action, the liquid 4a substantially on the entire heat exchange surface 6a constituted by the exposed surface of the electric resistor or by the lateral outer surface of the tubular body for accommodating the electric resistor.

[0025] As shown in the second embodiment, the heating means 5b can be constituted by an electric resistor 11b, which is applied to the outer surface of the body of the radiator 2b. The electric resistor 11b can be constituted by a flat electric resistor, which is rigid or flexible so as to adapt without problems to any non-flat shape of the outer surface of the body of the radiator 2b to which it is applied.

[0026] The electric resistor 11b is applied to the outer surface of the body of the radiator 2b proximate to the receptacle 8b, preferably so that it is arranged at least partially above the free surface of the liquid 4b collected in the receptacle 8b.

[0027] In this case, the capillary structure 7b is applied to the face that is located inside the chamber 3b of the region of the body of the radiator 2b to which the electric resistor 11b is applied. In practice, the capillary structure 7b affects substantially all the heat exchange surface 6b between the electric resistor 11b and the inside of the chamber 3b and immerses itself partly in the liquid 4b collected in the receptacle 8b or at least skims, with its lower end, the free surface of the liquid 4b collected in the receptacle 8b.

[0028] The capillary structure 7a, 7b, in the two embodiments, is preferably constituted by a metallic net with extremely fine mesh composed of filaments which preferably have a diameter of less than 0.05 mm.

[0029] The liquid 4a, 4b introduced in the chamber 3a, 3b is preferably constituted by distilled or demineralized water.

[0030] The pressure inside the chamber 3a, 3b before

introducing liquid 4a, 4b is substantially equal to, or lower than, 0.1 millibars (10 Pa).

[0031] The body of the radiator 2a, 2b, although the embodiments shown in Figures 1 to 5 are preferred, can have different shapes.

[0032] Merely by way of indication, Figure 6 illustrates a possible different shape of the body of the radiator, which in this constructive variation is designated by the reference numeral 2c. In this constructive variation, the body of the radiator 2c is constituted by a tubular structure, like the tubular radiators that are currently commercially available. In this case, the receptacle 8a for the liquid introduced in the chamber defined inside the body of the radiator 2c can be formed at the lower end of the body of the radiator 2c and the heating means can be constituted, in a manner similar to what is described with reference to the first embodiment, by a transit duct 11a for a heating fluid which is introduced within the receptacle 8a and is sealed hermetically with the body of the radiator 2c.

[0033] It should be noted that the capillary structure 7a, 7b, besides performing the function of conveying the liquid 4a, 4b on the heat exchange surface 6a, 6b between the heating means 5a, 5b and the liquid 4a, 4b, provides a plurality of microcavities on the heat exchange surface 6a, 6b which facilitate, during evaporation, the formation of a large number of microbubbles of vapor with a consequent increase in thermal efficiency.

[0034] Operation of the radiator according to the invention is as follows.

[0035] The presence of the capillary structure 7a, 7b conveys by capillary action the liquid 4a, 4b onto the heat exchange surface 6a, 6b. The heat provided by the heating means 5a, 5b to the liquid 4a, 4b which is on the heat exchange surface 6a, 6b produces the progressive evaporation of the liquid 4a, 4b and the generated steam rises, contacting the inner surface of the body of the radiator 2a, 2b, 2c which is at a lower temperature. This contact causes the cooling of the vapor and therefore its condensation and a heating of the body of the radiator 2a, 2b, 2c which transmits such heat to the surrounding environment and cools. The condensate collects inside the receptacle 8a, 8b, where it is again conveyed onto the heat exchange surface 6a, 6b by the capillary structure 7a, 7b, where it undergoes a new heating and evaporates again, rising and contacting again the inner surface of the body of the radiator 2a, 2b, 2c, which by being at a lower temperature again causes the condensation of this vapor, continuing the cycle that has already been described.

[0036] It should be noted that if the radiator according to the invention is used to heat rooms, it can work with heating temperatures of the liquid 4a, 4b which are even relatively low, for example around 40-50°C, ensuring high thermal efficiency thanks to the heat exchange that occurs with vapor condensation.

[0037] Owing to the fact that the evaporation of the liquid 4a, 4b affects substantially exclusively the liquid that is conveyed on the heat exchange surface 6a, 6b by the capillary structure 7a, 7b, turbulent motions during evaporation within the liquid 4a, 4b collected in the receptacle 8a, 8b are significantly reduced or even eliminated. For this reason, the radiator according to the invention is capable of ensuring very quiet operation.

[0038] Moreover, due to the fact that there is no air in the chamber 3a, 3b, with the radiator according to the invention there is no danger, as instead occurs in traditional radiators, of having an uneven heating of the radiator.

[0039] In practice it has been found that the radiator according to the invention fully achieves the intended aim, since due to the arrangement of the heat exchange surface with respect to the free surface of the liquid to be evaporated and due to the presence of the capillary structure it ensures very quiet operation and high heat exchange efficiency, which add to the already high heat exchange efficiency that derives from the utilization of the heat released by the liquid during phase transition.

[0040] In the exemplary embodiments described above, individual characteristics, given in relation to specific examples, may actually be interchanged with other different characteristics that exist in other exemplary embodiments.

[0041] The radiator thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the appended claims; all the details may further be replaced with other technically equivalent elements.

[0042] In practice, the materials used, although the use of stainless steel is preferred for the provision of the body of the radiator, as well as the dimensions, may be any according to requirements and to the state of the art.

[0043] The disclosures in Italian Patent Application no. MI2007A001332, from which this application claims priority, are incorporated herein by reference.

[0044] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. A radiator, particularly for heating systems or the like, comprising a radiator body in which there is a chamber which is separated hermetically from the outside environment, said chamber being filled partially with a liquid which gathers on the bottom of said chamber and being in partial vacuum at ambient temperature, means for heating said liquid being provided which are separated with a liquid-tight seal from said liquid by a heat exchange surface, **characterized in that** said heat exchange surface emerges at least par-

tially from the free surface of the liquid contained in said chamber, a capillary structure being provided which lies at least between the free surface of said liquid and said heat exchange surface and is adapted to convey said liquid onto said heat exchange surface.

2. The radiator according to claim 1, **characterized in that** said chamber has, at the side of said body of the radiator that is designed to be located, upon installation, proximate to the lower end of said body of the radiator, a receptacle for collecting said liquid.

3. The radiator according to claims 1 and 2, **characterized in that** said means for heating said liquid comprise a duct for the transit of a heating fluid which passes through said chamber, the interior of said transit duct being separated hermetically from said chamber.

4. The radiator according to one or more of the preceding claims, **characterized in that** said transit duct is partially immersed in, or skims with its lower end, the free surface of the liquid collected in said receptacle.

5. The radiator according to one or more of the preceding claims, **characterized in that** said capillary structure is applied to the outer lateral surface of said transit duct.

6. The radiator according to one or more of the preceding claims, **characterized in that** said means for heating said liquid comprise an electric resistor which is inserted in said chamber at said receptacle.

7. The radiator according to one or more of the preceding claims, **characterized in that** said electric resistor is inserted in a tubular accommodation body which is inserted in said receptacle.

8. The radiator according to one or more of the preceding claims, **characterized in that** said electric resistor or said tubular body for accommodating the electric resistor is partially immersed in the liquid collected in said receptacle or skims with its lower end the free surface of the liquid collected in said receptacle.

9. The radiator according to one or more of the preceding claims, **characterized in that** said capillary structure is applied to the outer surface of said electric resistor or of said tubular body for accommodating the electric resistor.

10. The radiator according to one or more of the preceding claims, **characterized in that** said means for heating said liquid comprise an electric resistor which is applied to the outer surface of said body of the radiator.

11. The radiator according to one or more of the preceding claims, **characterized in that** said electric resistor is applied to the outer surface of said body of the radiator proximate to said receptacle.

12. The radiator according to one or more of the preceding claims, **characterized in that** said electric resistor is applied to the outer surface of said body of the radiator proximate to said receptacle and is arranged at least partially above the free surface of the liquid collected in said receptacle.

13. The radiator according to one or more of the preceding claims, **characterized in that** said capillary structure is applied to the face arranged inside said chamber of the region of the body of the radiator to which said electric resistor is applied, said capillary structure being immersed in the liquid collected in said receptacle or skimming, with its lower end, the free surface of the liquid collected in said receptacle.

14. The radiator according to one or more of the preceding claims, **characterized in that** said capillary structure is constituted by a metallic net with a very fine mesh.

15. The radiator according to one or more of the preceding claims, **characterized in that** said capillary structure is constituted by a metallic net with a very fine mesh composed of filaments which have a diameter of less than 0.05 mm.

16. The radiator according to one or more of the preceding claims, **characterized in that** said body of the radiator is composed of a pair of mutually facing plate-like elements, which are welded to each other perimetrically and form between them said chamber which is separated hermetically from the outside environment.

17. The radiator according to one or more of the preceding claims, **characterized in that** said body of the radiator is composed of a tubular structure.

18. The radiator according to one or more of the preceding claims, **characterized in that** said body of the radiator is made of stainless steel.

19. The radiator according to one or more of the preceding claims, **characterized in that** said liquid is constituted by distilled or demineralized water.

20. The radiator according to one or more of the preceding claims, **characterized in that** pressure in said chamber, before the introduction of said liquid, is substantially equal to, or lower than, 0.1 millibars (10 Pa).

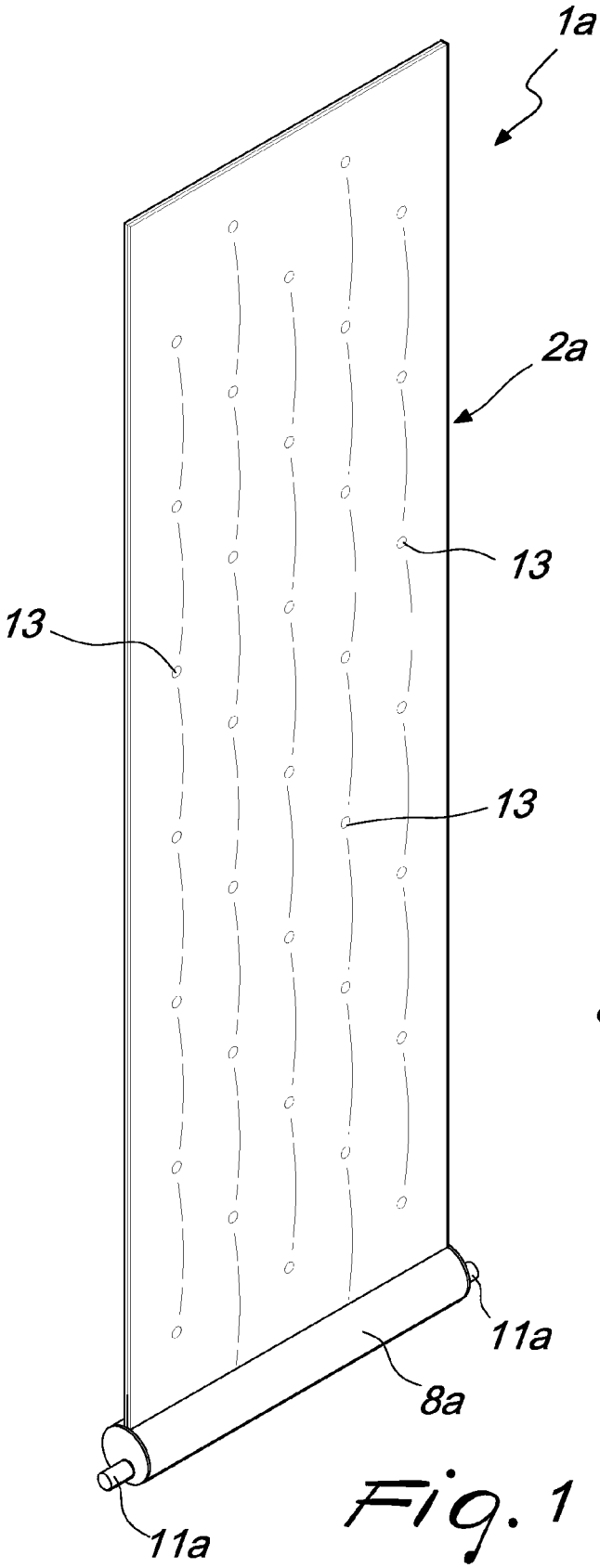

Fig. 1

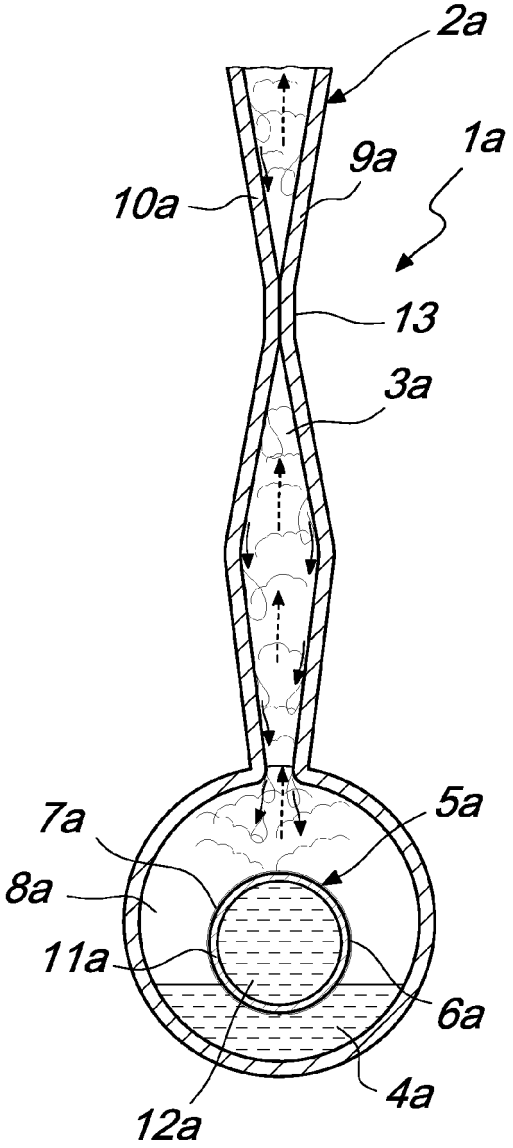

Fig. 2

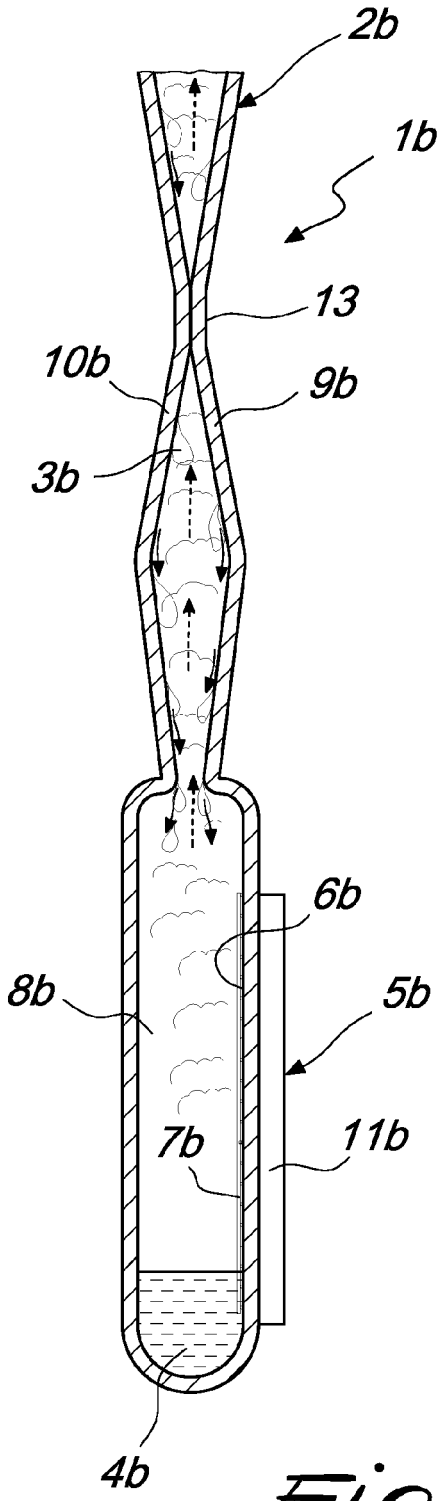

Fig. 4

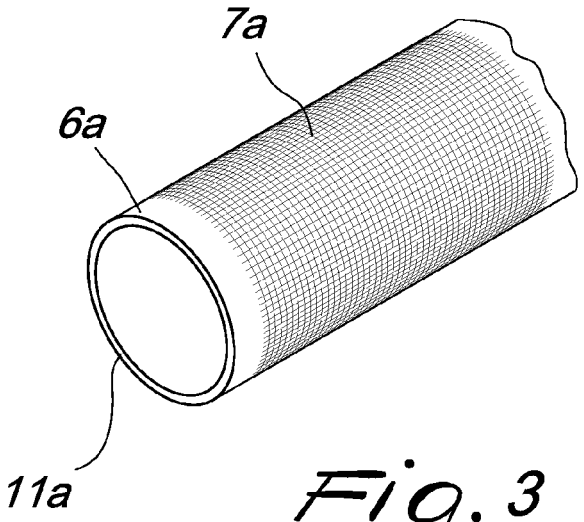

Fig. 3

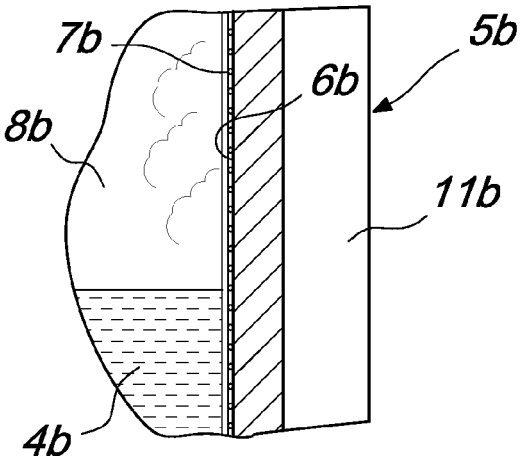

Fig. 5

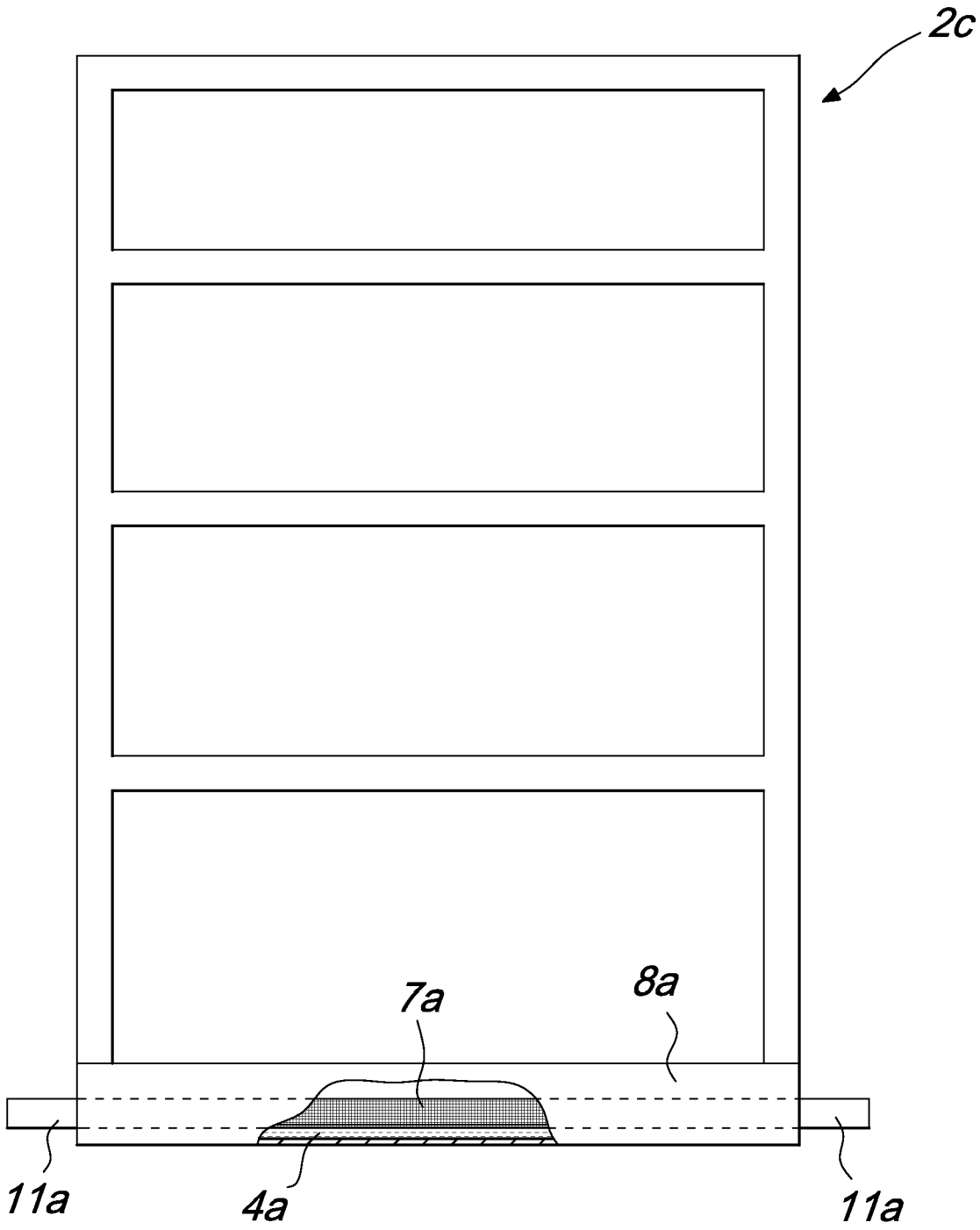

Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- FR 2357850 A1 **[0004]**
- IT MI20071332 A **[0043]**