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(57) A cooker is provided having a thin liquid layer (26) contained between a supporting layer (20) of the cooker and a cooking surface layer (24) overlaying the supporting layer (20) to provide a cooking surface (22). At least first and second actuators (40, 42) are provided alternately to raise and to lower a respective region (44).

46) of the cooking surface layer (24) thereby to induce a cyclic flow of liquid within the liquid layer (26). An elongate cooling channel (28) is provided such that when liquid flows within the liquid layer (26) it may pass into and out of the cooling channel (28), thereby to remove heat from the liquid.



Description

Technical Field

[0001] The present disclosure relates to a cooker and a method of cooling a cooking surface of a cooker.

Background

[0002] Induction cookers are known in which a varying electric current is passed through an induction coil, the coil therefore producing a corresponding varying electromagnetic field. The varying electromagnetic field induces a varying eddy currents in a ferromagnetic cooking vessel or the like when the cooking vessel placed in close proximity to the induction coil, which in turn heats the cooking vessel and therefore the contents of the cooking vessel.

[0003] One advantage of induction cookers is that the generated electromagnetic field does not itself cause heating of a cooking surface of the induction cooker. Any heating of the cooking surface itself is likely to arise from conduction of heat from a heated cooking vessel placed upon the cooking surface.

[0004] It is desirable, from a safety perspective, to avoid creating unexpectedly hot parts of the cooking surface and so avoid causing burns to users touching the cooking surface.

[0005] It is also desirable in any type of cooker to be able to cool a cooking surface more rapidly after cooking is finished.

Summary

[0006] According to a first aspect disclosed herein, there is provided a cooker, comprising:

- a planar supporting layer;
- a cooking surface layer extending over the planar supporting layer to provide a cooking surface;
- a liquid layer contained between the planar supporting layer and the cooking surface layer;
- an elongate cooling channel, arranged such that liquid in the liquid layer may flow between the cooling channel and the liquid layer, the cooling channel being formed of a thermally conducting material; and
- a first actuator controllable to raise and to lower a first region of the cooking surface layer and a second actuator controllable to raise and to lower a second region of the cooking surface layer thereby to generate a flow of liquid in the liquid layer, the first and second actuators being controllable alternately to raise and to lower the respective region of the cooking surface layer in a predetermined sequence, thereby to induce a flow of liquid within the liquid layer, including a flow of liquid from the liquid layer into the cooling channel and a flow of liquid out of the cooling channel into the liquid layer.

[0007] An induction cooker according to present invention therefore differs from a conventional induction cooker in that the cooking surface is formed by a thin partially flexible layer containing a thin trapped layer of liquid in which a flow of liquid may be induced both dissipate locally accumulated heat over a wider area of the cooking surface and to remove heat from the cooking surface by means of a cooling channel.

[0008] In an example embodiment, the cooling channel contains a porous mesh structure through which the liquid may permeate at a reduced rate in comparison with a rate of flow of liquid within the liquid layer. The mesh structure may for example comprise a woven cotton material.

[0009] In an example embodiment, the cooling channel contains one or more thermally conducting elements), thermally coupled to a thermally conducting wall of the cooling channel such that liquid entering the cooling channel comes into contact with the thermally conducting elements.

[0010] By including such additional thermally conducting elements within the cooling channel, the surface area of thermally conducting material is increased with the aim of removing more heat from the flowing liquid.

[0011] In an example embodiment, a thermally conducting structure is thermally coupled to an exterior surface of the wall of the cooling channel through which air may circulate. The thermally conducting structure may for example comprise one or more cooling fins. Such a structure is intended to increase the rate of heat removal from the cooling channel.

[0012] In an example embodiment, the first and second actuators have a mid-position and are controllable to raise the respective region of the cooking surface layer by displacement above the mid-position and to lower the respective region of the cooking surface layer by displacement below the mid-position. The displacement above or below the mid-position may be, for example, approximately 0.1mm.

[0013] In an example embodiment, the average depth of the liquid in the liquid layer is approximately 1mm.

[0014] In an example embodiment, the cyclic flow of liquid induced in the liquid layer by displacement of the first and second sets of actuators is substantially perpendicular the orientation of the elongate cooling channel.

[0015] In this way, the rate of flow of liquid into and out of the cooling channel may be expected to increase as compared with a more oblique flow relative to the orientation of the cooling channel.

[0016] In an example embodiment, the actuators are micro-electromechanical systems (MEMS) actuators.

[0017] In an example embodiment, the at least partially flexible layer is formed of glass or a ceramic material.

[0018] According to a second aspect disclosed herein, there is provided a method for cooling a cooking surface of a cooker comprising a liquid layer contained between a supporting layer of the cooker and a cooking surface layer providing a cooking surface (22) of the cooker, the

method comprising:

alternately raising and lowering a first region of the cooking surface layer while lowering and raising, respectively, a second region of the cooking surface layer, thereby to generate a flow of liquid in the liquid layer; and

passing the liquid flowing in the liquid layer through a thermally conducting elongate cooling channel thereby to remove heat from the flowing liquid layer.

[0019] By this method, a predetermined pattern of cyclic flow of liquid may be generated within the liquid layer, for example from the first edge towards the second edge or from the second edge towards the first edge, passing through a cooling channel provided in region, for example, mid-way between the first and second edges.

[0020] In an example embodiment of the method, the flow of liquid may be slowed when within the elongate cooling channel by means of a porous mesh structure provided substantially to fill the cooling channel. Such a mesh structure may be expected to increase the time over which the liquid is in contact with thermally conducting elements provided within the cooling channel and thereby increase the amount of heat removed from the liquid.

[0021] In an example embodiment of the method, the generated flow of liquid in the liquid layer is substantially perpendicular to the orientation of the elongate cooling channel.

Brief Description of the Drawings

[0022] To assist understanding of the present disclosure and to show how embodiments may be put into effect, reference is made by way of example to the accompanying drawings in which:

Figure 1 shows schematically a conventional induction cooker;

Figure 2 shows schematically a cooking surface of a cooker provided with a surface cooling arrangement according to the present disclosure; and

Figure 3 shows schematically a typical cycle of operation of the surface cooling arrangement of the present disclosure.

Detailed Description

[0023] Features of a conventional induction cooker will firstly be described in outline with reference to Figure 1 and features of an induction cooker of the present disclosure will then be described with reference to Figure 2.

[0024] Referring firstly to Figure 1, a sectional view of a portion of a conventional induction cooker 10 is schematically shown. The cooker has a planar layer 12 of

substantially rigid material such as glass or another material such as a ceramic material, providing a cooking surface 14 able to support a cooking vessel 16 when placed upon the cooking surface 14 in the region of a respective induction coil 18 mounted just below the planar layer. The induction coil 18 may be supplied with a varying electric current at a selected frequency by associated control electronics, not shown in Figure 1, thereby to generate a varying magnetic field. The varying magnetic field induces eddy currents in the cooking vessel 16, according to the ferromagnetic properties of the vessel 16, which thereby heat the cooking vessel 16. The induction coil 18 does not directly heat the material forming the planar layer 12 and so a user may not always expect to find harmfully hot areas on the cooking surface 14. Any heating of the planar layer 12 is in practice mainly due to heat conducted from a cooking vessel 16 being heated by electromagnetic induction.

[0025] According to the present disclosure, a surface cooling system may be included on the cooking surface of an induction cooker, as will now be described with reference to Figure 2, not only to help dissipate heat over the wider surface of the cooker, but also to remove heat from the cooking surface of the cooker generally.

[0026] Referring to Figure 2, a sectional view is provided of a portion of an induction cooker according to the present disclosure. A planar structural layer 20 is provided as in a conventional cooker, made from a glass or ceramic material for example, to provide a required level of structural support to cooking vessels as may be placed upon a cooking surface 22 of the cooker. A thin flexible sheet layer 24 of a glass or other material is applied over the planar structural layer 20 and arranged to trap a thin liquid layer 26 of water or other liquid between the thin flexible layer 24 and the structural layer 20. The thin flexible layer 24 provides the cooking surface 22 for the cooker and is made from glass, a ceramic material or other material having a required level of flexibility while providing a surface able to withstand impacts by a range of objects as may be expected to come into contact with a cooking surface of an induction cooker. The thin liquid layer 26 may have an average depth of 1mm, for example.

[0027] A cooling channel 28 is provided, shown in cross-section in Figure 2. The cooling channel 28 is formed by a slot-like aperture in the planar structural layer 20, extending across substantially a full width of a cooking surface 22, for example along a centre line of the cooking surface 22 of the induction cooker, and an open box structure attached beneath the aperture in the planar structural layer 20, having walls 30 and a base portion 32 made from a thermally conductive material such as aluminium. Liquid in the thin liquid layer 26 is able to flow into and out of the cooling channel 28 by means of the aperture in the planar structural layer 20 but the channel 28 is otherwise sealed by the walls 30 and the base portion 32 to contain liquid flowing into and out of the channel 28 from the thin liquid layer 26.

[0028] Cooling fins 34 are provided within the cooling

channel 28, made from a thermally conductive material such as aluminium, extending into the cooling channel 28 from the base portion 32 and intended to improve the removal of heat from liquid flowing into the channel from the thin liquid layer 26. A further thermally conducting structure 36 may be provided outside the cooling channel 28, thermally coupled to the cooling channel walls 30 or to the base portion 32 to conduct heat away from the cooling channel 28, for example by exposure to air passing through the structure 36 beneath the planar structural layer 20.

[0029] The cooling channel 28 is substantially filled with a woven cotton mesh structure 38 arranged to allow liquid from the thin liquid layer 26 to pass through the mesh structure 38, but at a relatively slow rate in comparison to the potential rate of flow of liquid within the liquid layer 26. The mesh structure 38 may be formed around the thermally conductive fins 34 within the channel 28 so that heat may be conducted from heated liquid passing through the mesh structure 38 by contact with the fins 34. The presence of the cotton mesh structure 38 slows the flow of liquid within the channel 28 with the intention to increase the time over which the liquid is in contact with the thermally conducting parts 30, 32, 34 of the cooling channel 28 and hence the amount of heat removed from the liquid before becoming available to re-enter the liquid layer 26.

[0030] To establish a flow of liquid within the thin liquid layer 26 and, in particular, a flow of liquid into and out of the cooling channel 28, an arrangement of actuators, for example micro-electromechanical systems (MEMS) actuators, is provided. The actuators are controllable to raise and to lower a respective edge portion of the thin flexible layer 24, for example at an edge of the cooking surface 22, as will now be described with reference to Figure 3.

[0031] Referring to Figure 3, three perspective views are provided of an induction cooker cooking surface according to the present disclosure. These illustrate one example of a cyclic cooling process as may be achieved by controlling the arrangement of four actuators 40, 42, arranged one at each corner of the cooking surface 22 to raise and to lower the thin flexible layer 24 by a small amount, typically 0.1mm, above and below a mid-position. A first pair of actuators 40 may be operated to raise and to lower one edge 44 of the cooking surface 22 and a second pair of actuators 42 may be operated to raise and to lower an opposite side 46 of the cooking surface 22.

[0032] Referring firstly to Figure 3a, when the first pair of actuators 40 is activated to raise the respective edge 44 of the thin flexible layer 24 above the mid-position and the second pair of actuators 42 is at the same time activated to lower a respective edge 46 of the thin flexible layer 24 below the mid-position, the liquid in the thin liquid layer 26 is displaced towards the edge 44 of the cooking surface 22 raised by the first pair of actuators 40, as can be seen in an exaggerated form in Figure 3a. In particular,

liquid from the opposite edge 46 of the cooking surface 22 flows into the channel 28 and is at least partially retained in the cooling channel 28 by the action of the cotton mesh structure 38. Similarly, a quantity of cooled liquid will be forced out of the cooling channel 28 into the thin liquid layer 26.

[0033] Referring to Figure 3b, when each of the first and second pairs of actuators 40 and 42 are activated to return to the mid-position, a substantially uniform depth of liquid in the thin liquid layer 26 is restored with a corresponding flow of liquid from the previously raised edge 44 of the cooking surface 22.

[0034] Referring to Figure 3c, when the second pair of actuators 42 is activated to raise the respective edge 46 of the thin flexible layer 24 above the mid-position and the first pair of actuators 40 is at the same time activated to lower the respective edge 44 of the thin flexible layer 24 below the mid-position, the liquid in the thin liquid layer 26 is displaced towards the edge 46 of the cooking surface 22 raised by the second pair of actuators 42, as can be seen in an exaggerated form in Figure 3c. In particular, liquid from the opposite edge 44 of the cooking surface 22 flows into the channel 28 and is at least partially retained in the cooling channel 28 by the action of the cotton mesh structure 38. Similarly, a quantity of cooled liquid will be forced out of the cooling channel 28 into the thin liquid layer 26.

[0035] Referring again to Figure 3b, to complete a cooling cycle, the first and second pairs of actuators 40, 42 are again activated to return to the mid-position, restoring a substantially uniform depth of liquid in the thin liquid layer 26 with a corresponding flow of liquid from the previously raised edge 46 of the cooking surface 22.

[0036] By repeating the cooling cycle illustrated in Figure 3, heat may be both dissipated across the cooking surface 22 and cooled by liquid flowing into and out of the cooling channel 28.

[0037] In an alternative cyclic cooling process, the first and second sets of actuators 40, 42 may be operate in unison, firstly to raise both the respective edges 44, 46 thereby to draw liquid out of the cooling channel 28 towards the edges 44, 46 and, secondly, to lower the respective edges 44, 46 thereby to force liquid into the cooling channel 28 from the edges 44, 46.

[0038] The actuators 40, 42 may be placed so as to raise and to lower different regions of the thin flexible layer 24, for example regions other than the edges 44, 46 of the cooking surface 22, to generate a flow of liquid within the thin liquid layer 26. Furthermore, additional actuators may be added and may be controlled in different combinations to raise and to lower respective regions of the thin flexible layer 24 to create any appropriate pattern of flow within the thin liquid layer 26. For example a pattern of liquid flow may be chosen according to the location of a detected high temperature region and the actuators may be controlled to achieve that pattern of liquid flow.

[0039] Flexibility of the thin flexible layer 24 may be varied by the choice of material or thickness of the layer

24. By adjusting the flexibility of the layer 24, an actuator 40, 42 may be arranged to raise and to lower a wider or smaller region of the cooking surface 22 in the vicinity of the actuator 40, 42. For example, an actuator 40, 42 located at some distance away from an edge 44, 46 of the cooking surface 22 may be expected to raise a wider region around the location of the actuator, potentially including an edge 44, 46 of the cooking surface 22, if a less flexible material is selected for the layer 24.

[0040] In another example embodiment of the present invention, a thin layer of an inflexible material may be used to provide the cooking surface 22, or at least a portion of the cooking surface 22, in place of the thin flexible layer 24 described above. In such an embodiment, an actuator located to raise and to lower a respective region of the cooking surface 22 may be expected to move a wider region of the cooking surface 22 as compared to when a flexible material is used. This may enable fewer actuators to be used to achieve a required liquid flow within the liquid layer 26.

[0041] In another example embodiment of the present invention, a thin layer 24 of an inflexible material may be used to provide the cooking surface 22 and one or more hinges may be provided within the layer 24. The hinges may enable respective regions of the cooking surface 22 to be raised and lowered by actuators 40, 42 relative to other regions of the cooking surface 22.

[0042] One or more temperature sensors may be provided to sense the temperature of the liquid in the thin liquid layer 26, or to measure the temperature of the cooking surface 22 itself. A controller (not shown in the figures) is provided to control the first and second pairs of actuators 40, 42 according to the sensed temperature to raise and to lower a respective edge of the thin flexible layer 24, thereby to implement a cooling cycle as described above with reference to Figure 3 in the event that the sensed temperature approaches, reaches or exceeds a predetermined safe operating limit.

[0043] Whereas example embodiments of the present invention have been described in the context of induction cookers in particular, embodiments of the present invention described above may be applied to cooling a cooking surface of other types of cooker. Examples of alternative cookers may include cookers having a ceramic cooking surface and heating elements providing direct heating of cooking vessels placed on the cooking surface.

[0044] The examples described herein are to be understood as illustrative examples of embodiments of the invention. Further embodiments and examples are envisaged. Any feature described in relation to any one example or embodiment may be used alone or in combination with other features. In addition, any feature described in relation to any one example or embodiment may also be used in combination with one or more features of any other of the examples or embodiments, or any combination of any other of the examples or embodiments. Furthermore, equivalents and modifications not described herein may also be employed within the scope

of the invention, which is defined in the claims.

Claims

1. A cooker, comprising:

a planar supporting layer (20);
a cooking surface layer (24) extending over the planar supporting layer to provide a cooking surface (22);
a liquid layer (26) contained between the planar supporting layer and the cooking surface layer;
an elongate cooling channel (28), arranged such that liquid in the liquid layer may flow between the cooling channel and the liquid layer, the cooling channel being formed of a thermally conducting material (30, 32); and
a first actuator (40) controllable to raise and to lower a first region (44) of the cooking surface layer and a second actuator (42) controllable to raise and to lower a second region (46) of the cooking surface layer thereby to generate a flow of liquid in the liquid layer,
the first and second actuators being controllable alternately to raise and to lower the respective regions of the cooking surface layer in a predetermined sequence, thereby to induce a flow of liquid within the liquid layer, including a flow of liquid from the liquid layer into the cooling channel and a flow of liquid out of the cooling channel into the liquid layer.

2. The cooker according to claim 1, wherein the cooling channel contains a porous mesh structure (38) through which the liquid may permeate at a reduced rate in comparison with a rate of flow of liquid within the liquid layer.

3. The cooker according to claim 2, wherein the mesh structure comprises a woven cotton material.

4. The cooker according to any one of claims 1 to 3, wherein the cooling channel contains one or more thermally conducting elements (34), thermally coupled to a thermally conducting wall (30, 32) of the cooling channel such that liquid entering the cooling channel comes into contact with the thermally conducting elements.

5. The cooker according to claim 4, comprising a thermally conducting structure (36) thermally coupled to an exterior surface of the wall (30, 32) of the cooling channel through which air may circulate.

6. The cooker according to claim 5, wherein the thermally conducting structure comprises one or more cooling fins (36).

7. The cooker according to any one of claims 1 to 6, wherein the first and second actuators have a mid-position and are controllable to raise the respective region of the cooking surface layer by displacement above the mid-position and to lower the respective region of the cooking surface layer by displacement below the mid-position. 5
8. The cooker according to claim 7, wherein the displacement above or below the mid-position is approximately 0.1mm. 10
9. The cooker according to any one of claims 1 to 8, wherein the average depth of the liquid in the liquid layer is approximately 1mm. 15
10. The cooker according to any one of claims 1 to 9, wherein the flow of liquid induced in the liquid layer by displacement of the first and second actuators is substantially perpendicular the orientation of the elongate cooling channel. 20
11. The cooker according to any one of claims 1 to 10, wherein the actuators are micro-electromechanical systems (MEMS) actuators. 25
12. The cooker according to any one of claims 1 to 11, wherein the cooking surface layer is formed of glass or a ceramic material. 30
13. A method for cooling a cooking surface of a cooker comprising a liquid layer (26) contained between a supporting layer (20) of the cooker and a cooking surface layer (24) providing a cooking surface (22) of the cooker, the method comprising: 35

alternately raising and lowering a first region (44) of the cooking surface layer while lowering and raising, respectively, a second region (46) of the cooking surface layer, thereby to generate a flow of liquid in the liquid layer; and 40

passing the liquid flowing in the liquid layer through a thermally conducting elongate cooling channel (28) thereby to remove heat from the flowing liquid layer. 45
14. The method according to claim 13, comprising:

slowing the flow of liquid when within the elongate cooling channel by means of a porous mesh structure (38) provided substantially to fill the cooling channel. 50
15. The method according to claim 14, wherein the generated flow of liquid in the liquid layer is substantially perpendicular to the orientation of the elongate cooling channel. 55

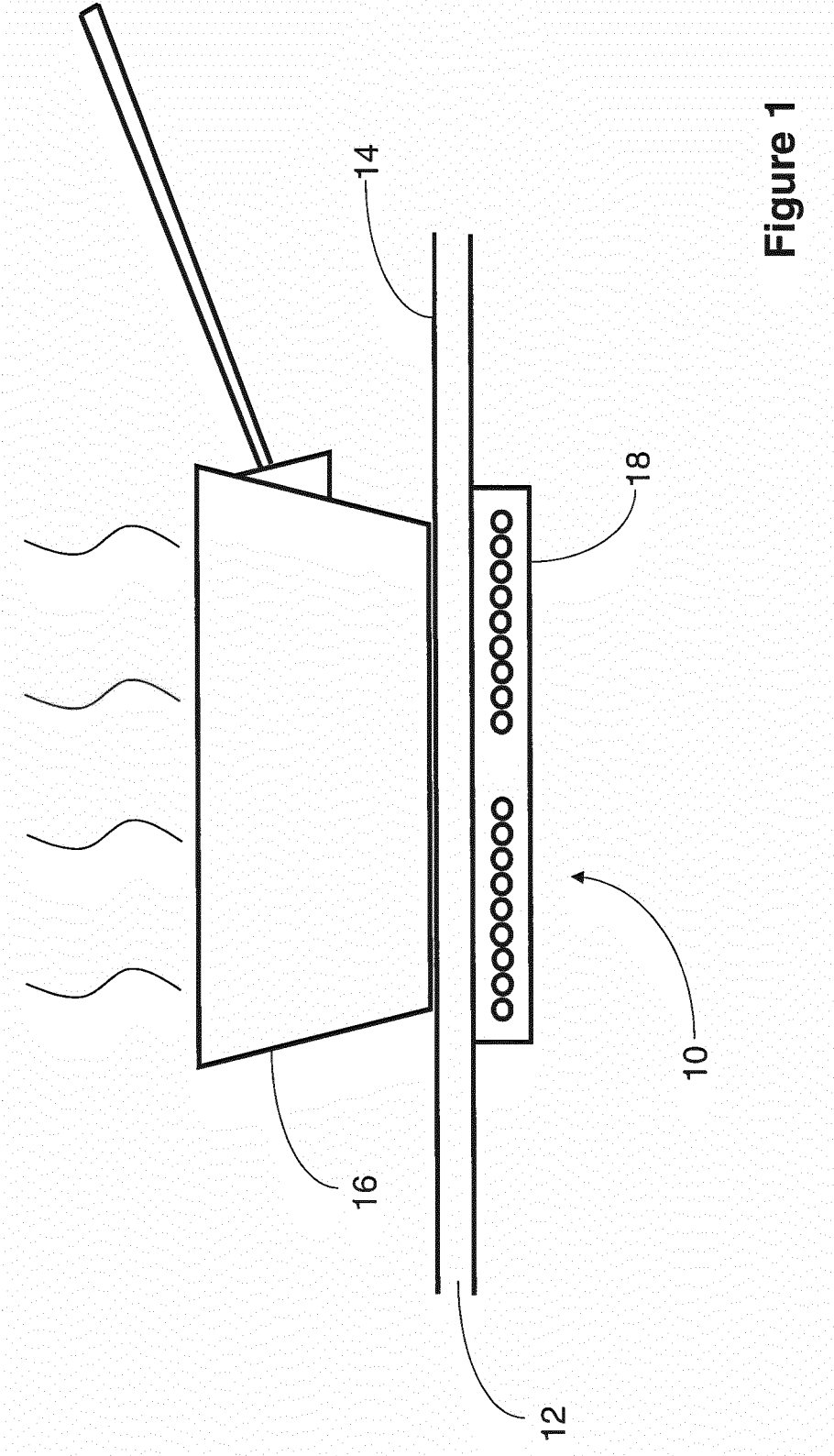
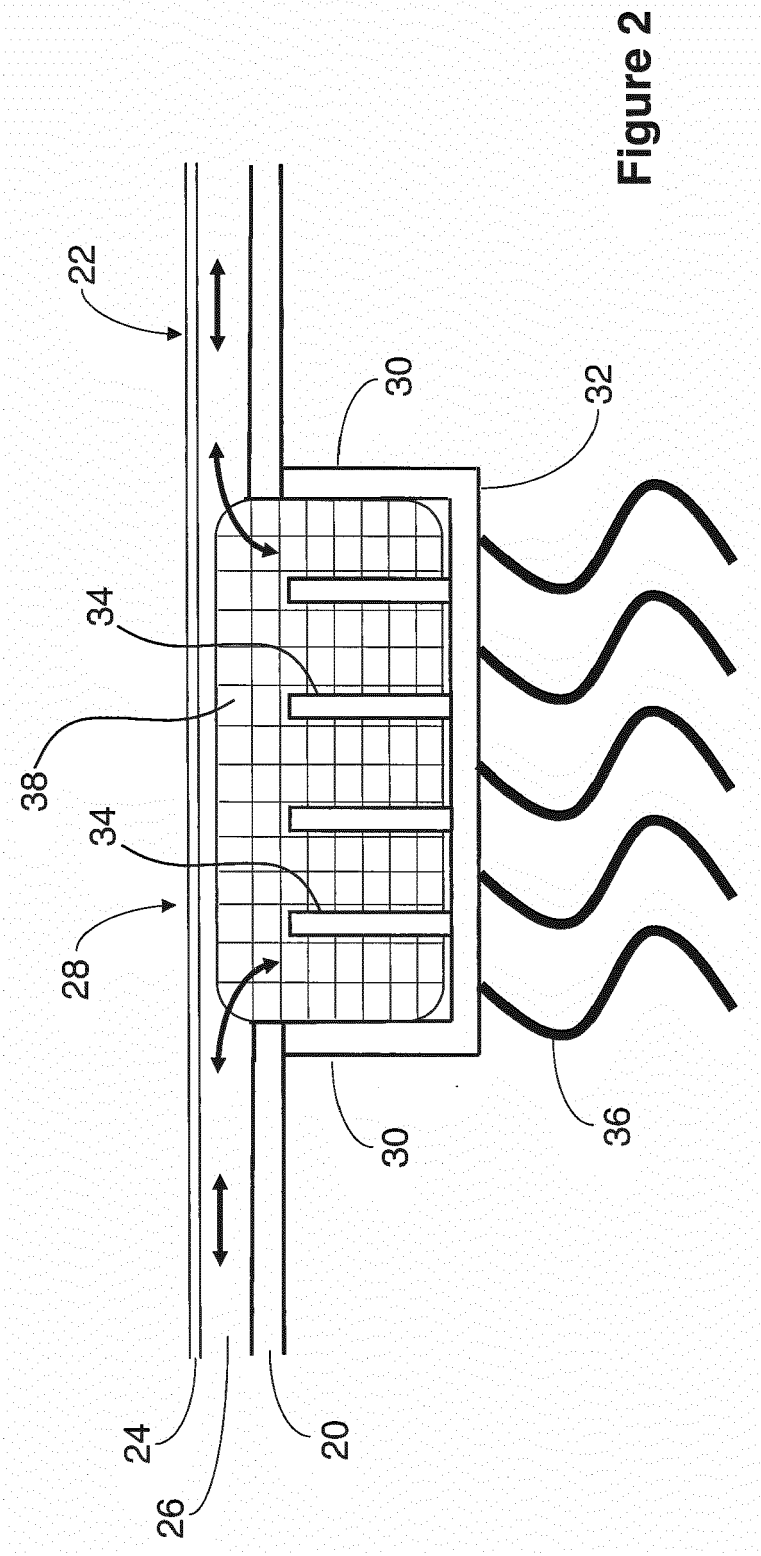
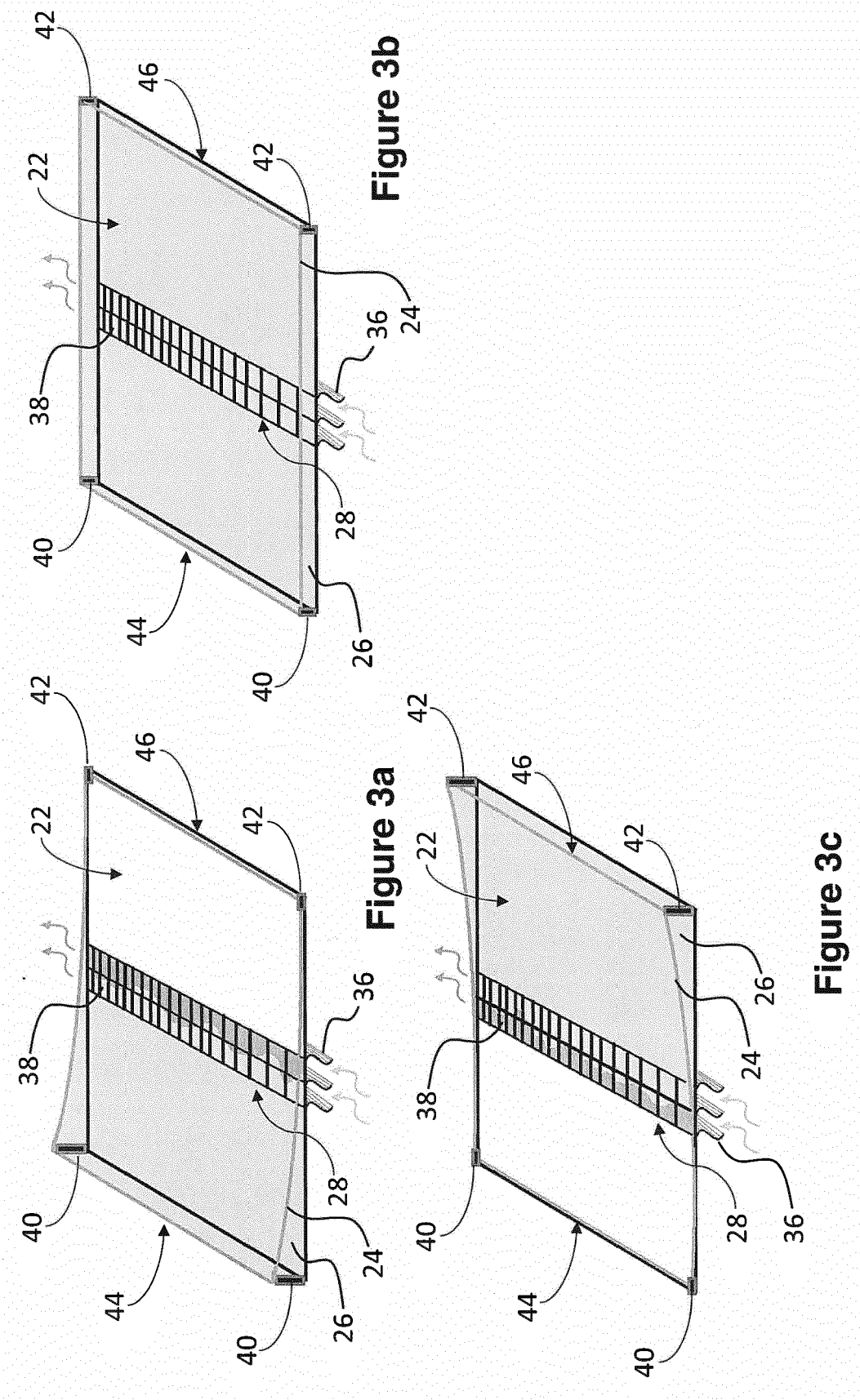


Figure 1







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Application Number
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Place of search Munich		Date of completion of the search 12 January 2018	Examiner Pierron, Christophe
CATEGORY OF CITED DOCUMENTS		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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**ANNEX TO THE EUROPEAN SEARCH REPORT
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