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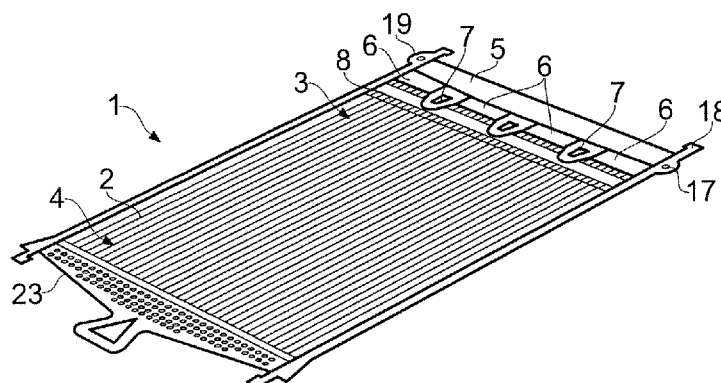


FIG. 1

(57) Abstract: A fuel cell flow plate for forming a fuel cell stack comprising a plurality of fuel cells, the flow plate configured to re-
ceive a reactant at a first end and provide an exhaust at a second end, the flow plate having a delivery channel between the first and
second ends configured to deliver a reactant to an active area of an associated fuel cell, the flow plate having a liquid storage reser-
voir configured to store a quantity of water for supply to the fuel cell and including a delivery conduit configured to direct liquid
stored in the liquid storage reservoir into the delivery channel.

FUEL CELL

This invention relates to a fuel cell flow plate and a fuel cell stack. It also relates to a liquid or water storage reservoir associated with at least one of a plurality flow plates that form each fuel cell in the fuel cell stack.

Conventional electrochemical fuel cells convert fuel and oxidant, generally both in the form of gaseous streams, into electrical energy and a reaction product. A common type of electrochemical fuel cell for reacting hydrogen and oxygen comprises a polymeric ion (proton) transfer membrane, with fuel and air being passed over respective sides of the membrane. Protons (that is, hydrogen ions) are conducted through the membrane, balanced by electrons conducted through a circuit connecting the anode and cathode of the fuel cell. To increase the available voltage, a stack may be formed comprising a number of such membranes arranged with separate anode and cathode fluid delivery channels. Such a stack is typically in the form of a block comprising numerous individual fuel cell plates held together by end plates at either end of the stack. The anode delivery channels are formed in flow plates that extend between an anode inlet manifold and an anode outlet manifold. The cathode delivery channels are also formed in flow plates between a cathode inlet manifold and a cathode outlet manifold. The fuel cell plates may have the anode delivery channels on one side and the cathode delivery channels on the other side. The anode inlet manifold delivers fuel to the anode delivery channels for the fuel cells in the stack and any excess fuel leaves the stack by the anode outlet manifold. The cathode inlet manifold delivers the oxidant to the cathode delivery channels for the fuel cells in the stack and any excess oxidant and reaction products leave the stack by the cathode outlet manifold.

In a hydrogen-oxygen fuel cell, one of the reaction products is water. An aqueous solution or water may also be used to hydrate the polymeric ion transfer membrane. Water may also be injected into the anode and/or cathode delivery channels for evaporative cooling of the fuel cell stack and/or for hydration of the membrane. Accordingly, a water storage tank may be provided with conduits to deliver water from the tank to the fuel cell stack.

If the fuel cell is stored or operated in sub-zero conditions, the water in the water tank and stack may freeze. Frozen water may cause damage to the fuel cell stack. If water is or other liquid is used as a coolant, it may not be available when the fuel cell stack is restarted after experiencing freezing conditions.

It is known to provide a heater in the fuel cell stack and/or water tank, which operates on stored energy, such as from a battery, and maintains the fuel cell stack/water tank at an above-zero temperature to prevent freezing occurring. The battery power is however
5 limited and the fuel cell system may experience freezing if the battery fails or becomes discharged.

According to a first aspect of the invention we provide a fuel cell flow plate for forming a fuel cell stack comprising a plurality of fuel cells, the flow plate configured to receive a
10 reactant at a first end and provide an exhaust at a second end, the flow plate having a delivery channel between the first and second ends configured to deliver a reactant to an active area of an associated fuel cell, the flow plate having a liquid storage reservoir configured to store a quantity of liquid for supply to the fuel cell and including a delivery conduit configured to direct liquid stored in the liquid storage reservoir into the delivery
15 channel.

This is advantageous as the reservoir is configured to hold a quantity of liquid, such as water, for the fuel cell of which the flow plate forms part. This is advantageous as it may obviate the need for a water (i.e coolant or hydration liquid) tank external to the fuel cell
20 stack. Instead, a quantity of liquid can be stored in the reservoir of each plate for its associated fuel cell. By closely associating the reservoir and fuel cell, performance in freezing conditions can be improved as heat from the stack can quickly thaw any frozen liquid in the reservoirs.

25 The conduit and/or reservoir may include a valve for controlling flow between the delivery channel and the liquid storage reservoir. This is advantageous as the valve may maintain a head of liquid in the reservoir. The valve may be configured to prevent flow from the reservoir into the delivery channel when the pressure in the reservoir is below a threshold pressure. Thus, the valve may be configured to allow flow when the pressure
30 in the reservoir is above the threshold. The threshold pressure may be such that a quantity of liquid is held in the reservoir at least when the fuel cell stack is not operating. It will be appreciated that the valve may operate based on the pressure difference between the reservoir and the delivery channels. The valve may be located in the reservoir or in the conduit.

35 The valve may comprise a check valve arranged to prevent flow from the delivery channel to the water storage reservoir. This is advantageous during a "blow down"

operation in which reactant, at an elevated pressure, is passed through the inlet manifold to blow out any accumulated water in the manifold and delivery channels. The blow down may be performed at regular intervals, as required or on shut down of the fuel cell stack. Removing water from the manifolds and channels may reduce the risk of damage or poor performance should the fuel cell experience freezing conditions. The check valve will prevent the reactant pressure from displacing the water stored in the reservoir.

The conduit may be configured to direct the liquid from the reservoir into the delivery channel of a cathode side of the associated fuel cell. Alternatively, the conduit may direct liquid to an anode side.

The flow plate may include an inlet manifold configured to receive reactant and direct it to the first end of the delivery channel. The flow plate may be configured to provide a flow path for reactant received via the inlet manifold that passes over the reservoir prior to its connection with the delivery channel at the first end. By passing the reactant over the reservoirs, frozen liquid in the reservoirs can be thawed if necessary.

The flow plate may include a further manifold arranged such that it extends between the delivery channel and the reservoir. The further manifold may be configured to provide an exit path for reactant received via the reactant inlet manifold that bypasses the active area. Thus, the inlet manifold and further manifold may allow a fluid to be passed over the reservoirs without it passing into the active area. This is advantageous as very hot air may be used for biological control of bacteria and the like in the reservoir, which is able to leave the fuel cell stack via the further manifold without flowing through the active area of the fuel cell.

The delivery conduit may span the further manifold. The reservoir may define part of the inlet manifold and/or further manifold.

The inlet manifold may extend between the delivery channel and the reservoir. The conduit may span the inlet manifold.

The liquid storage reservoir may include a liquid inlet for filling the liquid reservoir. The liquid storage reservoir may include a liquid outlet separate from the delivery conduit. The liquid inlet and liquid outlet may be arranged to allow liquid to be circulated through the reservoir.

The liquid storage reservoir may be configured such that when filled with liquid in use, an air gap is provided within the reservoir for compensating for expansion of the liquid in the event of freezing. The liquid inlet and liquid outlet may be arranged to provide the air gap.

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The liquid storage reservoir may comprise a body connected to the flow plate and configured to define the volume of the water storage reservoir when placed adjacent a further flow plate.

10 The body may include a surface configured and arranged to define an internal surface of the liquid storage reservoir, the surface having a plurality of projections configured to space a further body of a further flow plate from the surface to form the volume of the reservoir.

15 According to a second aspect of the invention we provide a fuel cell stack including a plurality of fuel cell flow plates as defined in the first aspect of the invention, the fuel cell flow plates arranged with a plurality of fuel cell active areas to form a plurality of fuel cells, the fuel cell stack thereby comprising a plurality of liquid storage reservoirs associated with each flow plate in the stack.

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The liquid storage reservoirs may arranged adjacent one another and include an expansion gap therebetween. The expansion gap allows for expansion of the reservoirs should the liquid therein freeze.

25 The liquid inlet may extend from a liquid inlet manifold, the manifold common to the plurality of liquid reservoirs for delivering liquid to the respective liquid inlets. The liquid outlet may extend from a liquid outlet manifold, the manifold common to the plurality of liquid reservoirs for receiving liquid from the respective liquid outlets.

30 The stack may be configured to reverse a reactant flow direction during a thawing operation such that reactant heated by operation of the fuel cell stack is flowed over the reservoirs for thawing any frozen liquid therein. Thus, in normal operation the flow of reactant is in a first direction in which it passes over the reservoir and then enters the delivery channel but in a thawing operation the reactant passes through the delivery
35 channel (and is therefore heated by the active area) prior to passing over the reservoir.

The fuel cell stack may include a reactant inlet manifold on a first side of the reservoirs and a further manifold on an opposite side of the reservoirs, the further manifold located between the reservoirs and the delivery channel, the inlet manifold and further manifold providing a flow path over the reservoirs that bypasses the active area of the fuel cells of the stack. This flow path over the reservoirs but bypassing the active area of the fuel cell is advantageous when very hot fluid is passed through the stack for biological control.

There now follows, by way of example only, a detailed description of embodiments of the invention with reference to the following figures, in which:

Figure 1 shows a flow plate with liquid storage reservoir associated therewith;

Figure 2 shows a detailed view of the liquid storage reservoir and its connection with the flow plate (not shown), on a cathode side of the flow plate;

Figure 3 shows a detailed view of the delivery conduit on the cathode side of the flow plate;

Figure 4 shows a detailed view of the liquid storage reservoir and its connection with the flow plate, on an anode side of the flow plate;

Figure 5 shows a plurality of flow plates arranged together with a plurality of active areas to form a plurality of fuel cells in a fuel cell stack;

Figure 6 shows a moulding that encapsulates the liquid storage reservoir;

Figure 7 shows a detailed view of the reservoir with a projection that forms part of the valve; and

Figure 8 shows an air box defining an inlet manifold around the liquid storage reservoirs.

Figure 1 shows a fuel cell flow plate 1. The flow plate 1 is configured to be arranged on one side of an active area of a fuel cell for delivering a reactant to the active area. The active area has an anode side and a cathode side and typically comprises a membrane and a catalyst layer. A further flow plate is configured to be arranged on the other side of the active area for delivering a further reactant. The reactants comprise a fuel and an

oxidant and thus one flow plate delivers the fuel to an anode side, for example, and the other flow plate delivers the oxidant to the cathode side.

5 The flow plates include a delivery channel or a plurality of delivery channels to convey reactant over one of the sides of the active area of the fuel cell. In this embodiment the flow plates are bipolar in that they provide delivery channels for an anode side of a first fuel cell on one side and delivery channels for a cathode side of an adjacent fuel cell in the stack on their other side. Thus, the flow plates can be considered to have an anode side and a cathode side, designating the side of the fuel cell the delivery channels
10 therein deliver reactant to.

Figure 1 shows a cathode side of the flow plate 1 comprising a plurality of delivery channels 2 that extend from an inlet end 3 to an outlet end 4. A liquid storage reservoir 5 is provided at the inlet end 3 for supplying the fuel cell with water for cooling and/or
15 hydration via the delivery channels 2. It will be appreciated that other liquids may be used. The flow plate 1 and liquid storage reservoir 5 are configured and arranged such that an oxidant can be supplied to the delivery channels 2 from an oxidant inlet manifold 80 (shown in Figure 8) that surrounds the reservoir 5. The oxidant inlet manifold 80 may be common to a plurality of flow plates 1 when they are arranged in a
20 stack. The oxidant therefore flows over the liquid storage reservoir 5 from the inlet manifold 80 on its way to the delivery channels 2. The inlet end 3 includes a cathode gallery 8 that is configured to receive oxidant from the oxidant inlet manifold 80 and distribute the oxidant into the delivery channels 2.

25 The flow plate 1 defines part of a further oxidant manifold 6, which may provide an exhaust path for oxidant that enters via the oxidant inlet manifold and passes over the reservoir 5. The oxidant inlet manifold 80 and further oxidant manifold 6 can be used to thaw any frozen liquid in the reservoir 5 as will be described in more detail below.

30 The flow plate 1 also defines a fuel inlet manifold 7. The fuel inlet manifold comprises two spaced apertures in the flow plate, which, when the flow plate is arranged in a stack, form a pair of channels through the stack.

The liquid storage reservoir 5, which in this example comprises a water storage
35 reservoir, is shown in more detail in Figure 2. The reservoir 5 includes a delivery conduit 10 (shown in more detail in figure 3) to transfer liquid from the reservoir 5 to the delivery channels 2. In this example, the liquid is delivered to the delivery channels 2 via

flow paths (subterranean and therefore not visible) extending from an outlet 11 of the delivery conduit 10. Liquid leaving the reservoir for the delivery channels 2 enters the delivery conduit 10 by an inlet 12. The inlet 12 extends to a valve 13, formed by a projection of the reservoir 5, which opens into an inter conduit space 14. Figure 7 shows the reservoir 5 of the flow plate 1 with the projection 70 that is configured to project into an inlet aperture in the delivery conduit 10. The projection 70 can move by flexure within the inlet aperture to form the valve 13. The inter conduit space 14 may provide communication with other delivery conduits in other flow plates. The inter conduit space 14 connects to the outlet 11 where the liquid is delivered to the delivery channels 2 by the flow paths (not visible) that extend within the plate.

The reservoir 5 is defined by the surface 15, which forms an internal surface of the reservoir, in combination with an adjacent flow plate. The surface includes a plurality of projections 16 that act to space the adjacent flow plate from the surface 15 to define the volume of the reservoir 5. The reservoir 5 is filled via a reservoir inlet 17 which is in communication with the reservoir via a flow path within the frame 18. The reservoir 5 further includes a reservoir outlet 19. The provision of the reservoir inlet 17 and reservoir outlet 19 allows liquid to be circulated through the reservoir 5. The flow plate 1 may be configured to be orientated such that the reservoir 5 is located at the top. Accordingly, the reservoir inlet 17 and/or reservoir outlet 19 may be positioned such that the reservoir can only be filled to a predetermined level, which defines an air gap within the reservoir 5. In the event of freezing conditions in which the liquid in the reservoir freezes, the air gap provides an expansion region for the frozen liquid to expand into to maintain the integrity of the reservoir 5.

The gallery 8 comprises a plurality of manifold guide channels 20. The guide channels 20 comprise a plurality of parallel channels extending perpendicular to the further oxidant manifold 6. The manifold guide channels 20 are configured to provide a laminar flow into the gallery 8. The gallery 8 further includes gallery exit guide channels 21, which transfer the oxidant into the delivery channels 2. The manifold guide channels 20 and gallery exit guide channels 21 are separated by a distribution region 22 comprising a volume in the gallery 8 for the oxidant from the oxidant inlet manifold (not shown) that surrounds the reservoirs to diffuse, expand and present a more uniform pressure distribution at the gallery exit guide channels 21. Thus, the gallery 8 assists in ensuring that a substantially equal amount of oxidant is provided to each of the delivery channels 2 over the width of the flow plate 1. The subterranean flow paths from the delivery conduit 10 and, in particular, the outlet 11, open into the delivery channels 2

through openings (not visible) in the flow plate 1 adjacent the exit guide channels 21. Thus, the oxidant, which is typically air, mixes with the liquid, which is typically water, from the reservoir 5 at an upstream end of the delivery channels 2. The water therefore enters the delivery channels 2 entrained in the oxidant flow for use in hydrating and evaporatively cooling the active area of the fuel cell.

At the outlet end 4, the delivery channels 2 open into an outlet manifold 23 for conveying the unused oxidant gases, liquid and any reaction products away from the fuel cell.

Figure 4 shows the opposite side of the flow plate 2, which is the anode side. Thus, the delivery channels 2 on this side deliver fuel to an anode side of an active area of an adjacent fuel cell, when the flow plate is arranged in a stack. The flow plate delivery channels 2 have been omitted in Figure 4 leaving the manifolds 6, 7 and reservoir 5 and an anode gallery 40. The anode gallery 40 is formed on the opposite side to the cathode gallery 8. It will be appreciated that the delivery channels (not shown) of the anode side are supplied with fuel from the gallery 40, as will be described below.

The oxidant inlet manifold (not shown) and further manifold 6 does not have access to the anode side of the flow plate, while the fuel inlet manifold 7 includes an opening into the anode gallery 40. The opening comprises a plurality of channels 41 that fan from the manifold 7 to guide fuel into the gallery 40. The delivery conduit 10 does not have access to the gallery 40. The channels 41 open into a distribution region 42. The distribution region 42 and channels 41 are shaped to guide the fuel such that it diffuses/is distributed evenly over the delivery channels. Accordingly, the gallery 40 is shaped around each fuel inlet manifold 7 to present a widening funnel 43 towards the delivery channels. The outer channels of the fanning channels 41 are arranged to direct fuel along the boundary of the funnel 43, while the more central channels of the fanning channels 41 direct fuel more directly towards the delivery channels of the flow plate (not shown).

As shown in Figure 5, the flow plates 1 with their associated liquid storage reservoirs 5 are configured to be arranged side by side and interleaved by an active area to form a plurality of fuel cells arranged in a fuel cell stack 50. The galleries 8, 40 are separated from one another by a gasket such that the cathode gallery 8 may supply a cathode side of the active area and the anode gallery 40 may supply an anode side of the active area. Each of the inlet manifold 80, further manifold 6, fuel inlet manifold 7 and outlet manifold 23 of each flow plate 2 align such that the manifolds extend continuously through the

stack 50. The oxidant inlet manifold 80, which may be defined by an air box 81 (shown in Figure 8), surrounds the reservoirs 5 of the plurality of flow plates 2 and introduces oxidant to the stack delivery channels through gaps between the reservoirs 5. Thus, oxidant and fuel can be fed into a common manifold and can reach each of the flow plates 2. As shown in figure 8, the air box comprises a moulding that sealingly connects by clips 82 and seals 83 to the flow plate stack on a side of the reservoirs 5 opposite the delivery channels. The air box 81 is thus common to the flow plates that form the stack.

In use, oxidant is introduced under pressure into the oxidant inlet manifold 80 and fuel is introduced into the fuel inlet manifold 7. The liquid storage reservoirs 5 hold a quantity of coolant, such as water, sufficient for adequately cooling and/or hydrating its associated active area. In this example, the reservoirs each hold 4-5cc. The water in the reservoirs 5 may be circulated therethrough by way of inlet 17 and outlet 19. The pressure at the inlet 17 relative to the outlet 19 (or just at the inlet if an outlet is not provided) may be used to control the flow of liquid from each of the reservoirs 5 into their associated delivery channels 2. Further, the valve 13 may be configured to hold a head of liquid in the reservoir.

In order to control the accumulation of liquid within the delivery channels or active area, a "blow down" operation may be performed. A blow down may also be performed at shut down of the fuel cell stack to remove any liquid, such as water for cooling and/or hydration, from the stack. This is advantageous in the event of the stack 50 experiencing freezing conditions, which could lead to blockages caused by the frozen liquid. The blow down operation may be performed by applying oxidant, at an elevated pressure, to the oxidant inlet manifold 80 to drive water through the stack and out through the appropriate outlet manifold 23. Such an elevated pressure would thus be present in the delivery channels 2, which is in communication with the liquid storage reservoirs 5. However, the valve 13 acts as a check valve to isolate the reservoirs 5 thereby retaining the liquid within the reservoirs 5. The valve 13 may be a check valve only allowing flow out of the reservoirs 5.

In the event of the fuel cell stack 50 experiencing freezing conditions, water in the reservoirs 5 may freeze. However, the expansion region within each reservoir 5 provides space for any expansion of the liquid in each of the reservoirs 5. Further, the reservoirs 5 are sized such that there is a gap in between each reservoir of successive flow plates in the stack. Therefore, should there be any swelling of the reservoirs 5 due to frozen liquid, the inter-reservoir gap will provide space for said swelling.

Providing a liquid storage reservoir 5 associated with each flow plate is advantageous as the need for an external water tank and associated conduits is obviated. Further, the solution is scalable as each fuel cell in the stack 50 has a stored quantity of liquid that is sized to provide its cooling and/or hydration requirement.

When it is desired to restart the fuel cell stack, the liquid in the reservoirs 5 may be frozen. Thus, the fuel cell stack may be operated at a lower power than normal operating power as no or limited cooling may be available. Given that each reservoir 5 is closely associated with each fuel cell in the stack, the heat generated by operation of the stack at lower power will be conducted to the reservoir to assist in thawing the liquid. As liquid melts and becomes available for cooling and/or hydration, the fuel cell stack may be operated at a higher power, which may be normal operating power, or until further liquid is available from the reservoirs 5.

Alternatively or in addition, the oxidant flow through each of the plates 1 may be reversed such that oxidant is supplied to each flow plate 1 from the outlet manifold 23. The oxidant would then be heated as it passes through the active area and then leaves each flow plate and therefore the stack by flowing by each reservoir 5 and out through the oxidant inlet manifold 80. The oxidant would be heated by the operation of the stack, which may be in a lower power mode as mentioned above, and would subsequently impart this heat to the reservoirs 5 to melt any frozen liquid therein.

Alternatively or in addition, compressors that supply oxidant to the oxidant inlet manifold may be operated in a mode that imparts heat to the oxidant. This heated oxidant, when supplied to the stack 50, may act to heat the reservoirs 5 and therefore melt any frozen liquid therein. The outlet manifold 23 may be closed during the process and an outlet associated with the further manifold 6 may be opened. Thus, the warm/hot oxidant applied by the compressor will, from the oxidant inlet manifold 80, flow over the reservoirs 5 and then leave the stack via the further manifold 6. This configuration is also useful when performing a biological eradication procedure in which biological matter is controlled by application of hot air through the oxidant inlet manifold 80. Thus, the further manifold 6 provides a route for hot air, which may be used thawing frozen liquid in the reservoirs or biological matter eradication, to heat the reservoirs 5 without passing through the active area. This is advantageous as the temperature of the air used for biological eradication may be damaging to the active area.

Further, the reservoirs 5 may be electrically conductive and may be electrically connected together in series when arranged in a fuel cell stack 50. Ohmic heating of the reservoirs 5 may be provided by applying a current across the serially linked reservoirs 5. The current may be generated by the stack or may be from a battery or other external power source.

Further, the fuel cell stack 50 may include an accumulator (not shown) which may be used to pressurize the reservoirs 5 at least during the thawing process. This is advantageous as a pump which may normally apply pressure to the reservoirs to control the flow of liquid into the stack 50 may be frozen. The accumulator provides a convenient means for pressurizing the reservoirs 5 as it can do so without moving parts (which could be liable to freezing) to generate the pressure.

It will be appreciated that while the above embodiment provides the reservoir 5 associated with the cathode delivery channels 2, it may equally be applied to supply the anode delivery channels with hydration liquid or coolant or both.

Figure 6 shows the reservoir 5 encapsulated by the moulding of the flow plate 1. The reservoir 5 includes guide channels 60 and 61 arranged on opposite sides of the reservoir 5. The guide channels 60 are configured and arranged to guide the oxidant received from the oxidant inlet manifold 80 (not shown in figure 6) over the surface of the reservoir 5. The guide channels 61 further guides the oxidant from the surface of reservoirs 5 into the further manifold 6. The guide channels thus distribute the oxidant supply such that it flows evenly over the reservoir 5.

CLAIMS

1. A fuel cell flow plate for forming a fuel cell stack comprising a plurality of fuel cells, the flow plate configured to receive a reactant at a first end and provide an exhaust at a second end, the flow plate having a delivery channel between the first and second ends configured to deliver a reactant to an active area of an associated fuel cell, the flow plate having a liquid storage reservoir configured to store a quantity of liquid for supply to the fuel cell and including a delivery conduit configured to direct liquid stored in the liquid storage reservoir into the delivery channel.
2. A fuel cell flow plate according to claim 1, in which the conduit and/or reservoir includes a valve configured to control flow between the delivery channel and the liquid storage reservoir.
3. A fuel cell flow plate according to claim 2, in which the valve comprises a check valve arranged to prevent flow from the delivery channel to the liquid storage reservoir.
4. A fuel cell flow plate according to claim 2 or claim 3, in which the valve is configured to prevent flow from the reservoir into the delivery channel when the pressure in the reservoir is below a threshold pressure.
5. A fuel cell flow plate according to any preceding claim, in which the conduit is configured to direct the liquid from the reservoir into the delivery channel of a cathode side of the associated fuel cell.
6. A fuel cell flow plate according to any preceding claim, in which the flow plate includes an inlet manifold configured to receive reactant and direct it to the first end of the delivery channel.
7. A fuel cell flow plate according to claim 6, in which the flow plate is configured to provide a flow path for reactant received via the inlet manifold that passes over the reservoir prior to its connection with the first end of the delivery channel.
8. A fuel cell flow plate according to any preceding claim, in which the flow plate includes a further manifold arranged such that it extends between the delivery channel and the reservoir.

9. A fuel cell flow plate according to claim 8, in which the delivery conduit spans the further manifold.

10. A fuel cell flow plate according to claim 8 or claim 9, in which the further manifold
5 is configured to provide an exit path for reactant received via the reactant inlet manifold that bypasses the active area.

11. A fuel cell flow plate according to any preceding claim, in which the liquid storage reservoir includes a liquid inlet for filling the liquid reservoir.

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12. A fuel cell flow plate according to any preceding claim, in which the liquid storage reservoir includes a liquid outlet separate from the delivery conduit.

13. A fuel cell flow plate according to any preceding claim, in which the liquid storage
15 reservoir is configured such that when filled with liquid in use, an air gap is provided within the reservoir for compensating for expansion of the liquid in the event of freezing.

14. A fuel cell flow plate according to claim 13, in which the liquid inlet and liquid outlet are arranged to provide the air gap.

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15. A fuel cell stack including a plurality of fuel cell flow plates as defined in any one of claims 1 to 14, the fuel cell flow plates interleaved with a plurality of fuel cell active areas to form a plurality of fuel cells, the fuel cell stack thereby comprising a plurality of liquid storage reservoirs each associated with a flow plate in the stack.

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16. A fuel cell stack according to claim 15, in which the liquid storage reservoirs are arranged adjacent one another and include an expansion gap therebetween.

17. A fuel cell stack according to claim 15 when dependent on claim 11, in which the
30 liquid inlet extends from a liquid inlet manifold, the liquid inlet manifold common to the plurality of liquid reservoirs for delivering liquid to the respective liquid inlets.

18. A fuel cell stack according to claim 15 when dependent on claim 12, in which the liquid outlet extends from a liquid outlet manifold, the manifold common to the plurality of
35 liquid reservoirs for receiving liquid from the respective liquid outlets.

19. A fuel cell stack according to any one of claims 15 to 18, in which the stack is configured to reverse a reactant flow direction during a thawing operation such that reactant heated by operation of the fuel cell stack is flowed over the reservoirs for thawing any frozen liquid therein.

5

20. A fuel cell stack according to any one of claims 15 to 19, in which the fuel cell stack includes a reactant inlet manifold on a first side of the reservoirs and a further manifold on an opposite side of the reservoirs, the further manifold located between the reservoirs and the delivery channel, the inlet manifold and further manifold providing a
10 flow path over the reservoirs that bypasses the active area of the fuel cells of the stack.

21. A fuel flow plate as described herein and as illustrated in Figures 1 to 4 and 6 and 7 of the accompanying drawings.

15 22. A fuel cell stack as described herein and as illustrated in Figure 5 of the accompanying drawings.

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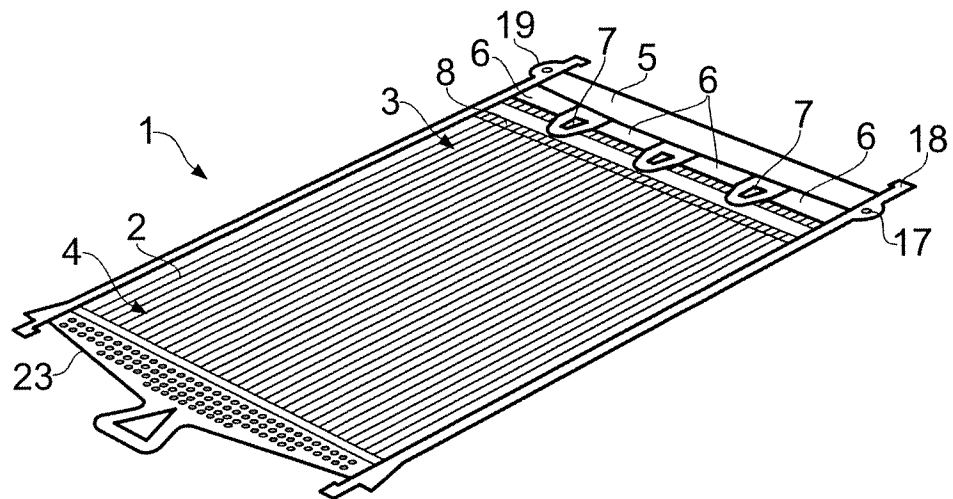


FIG. 1

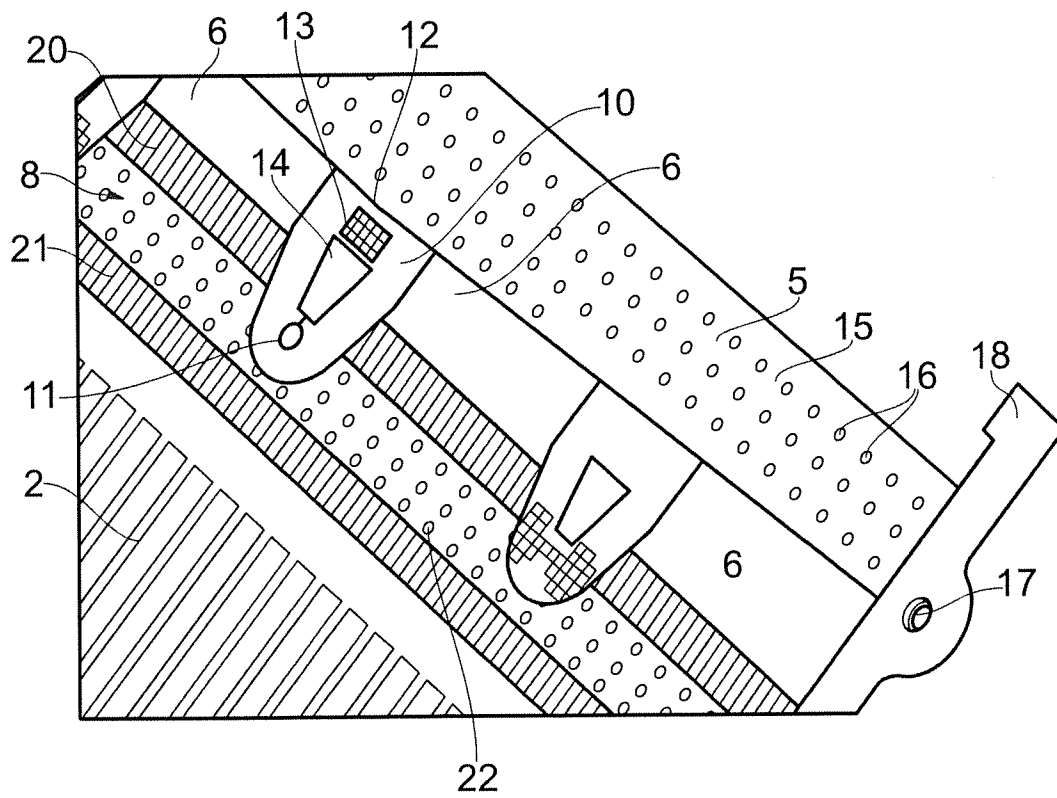


FIG. 2

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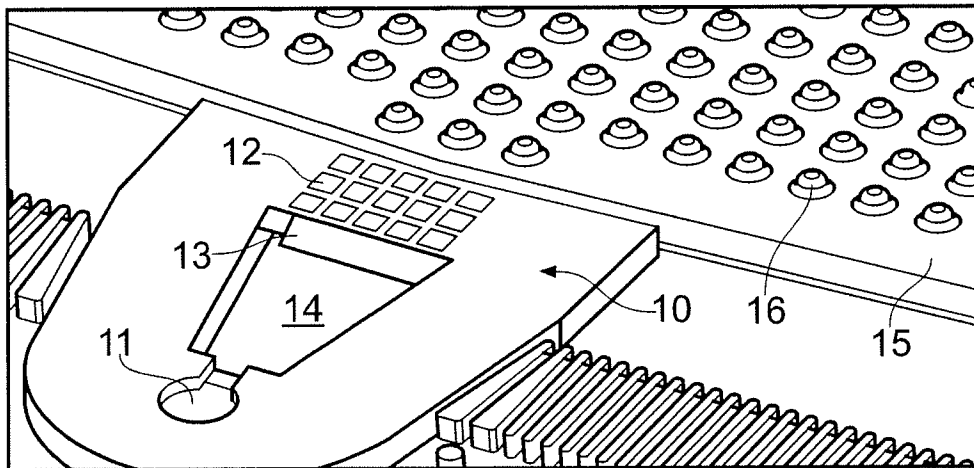


FIG. 3

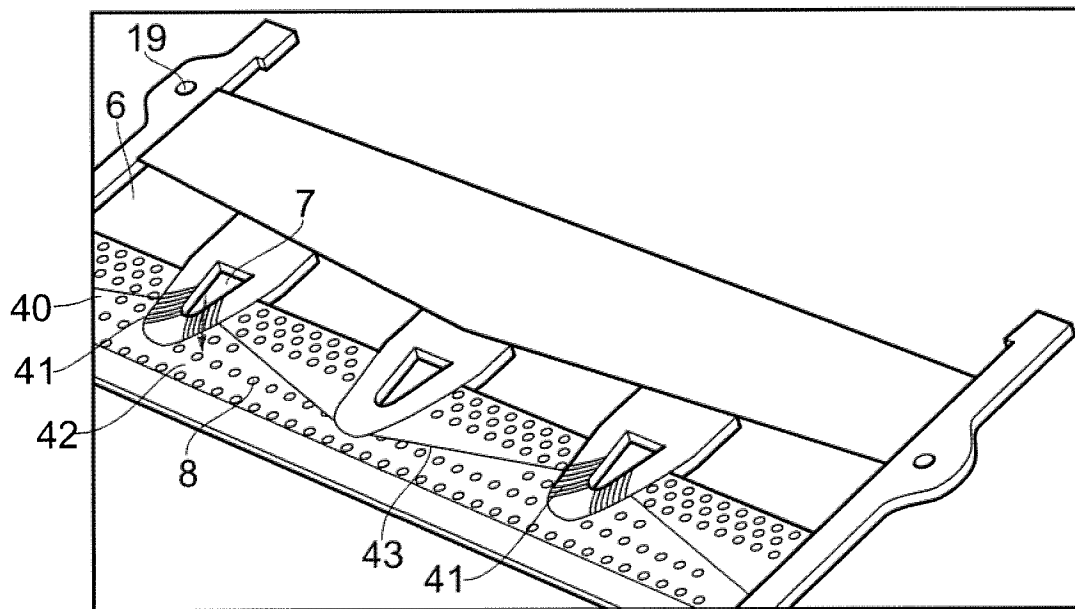


FIG. 4

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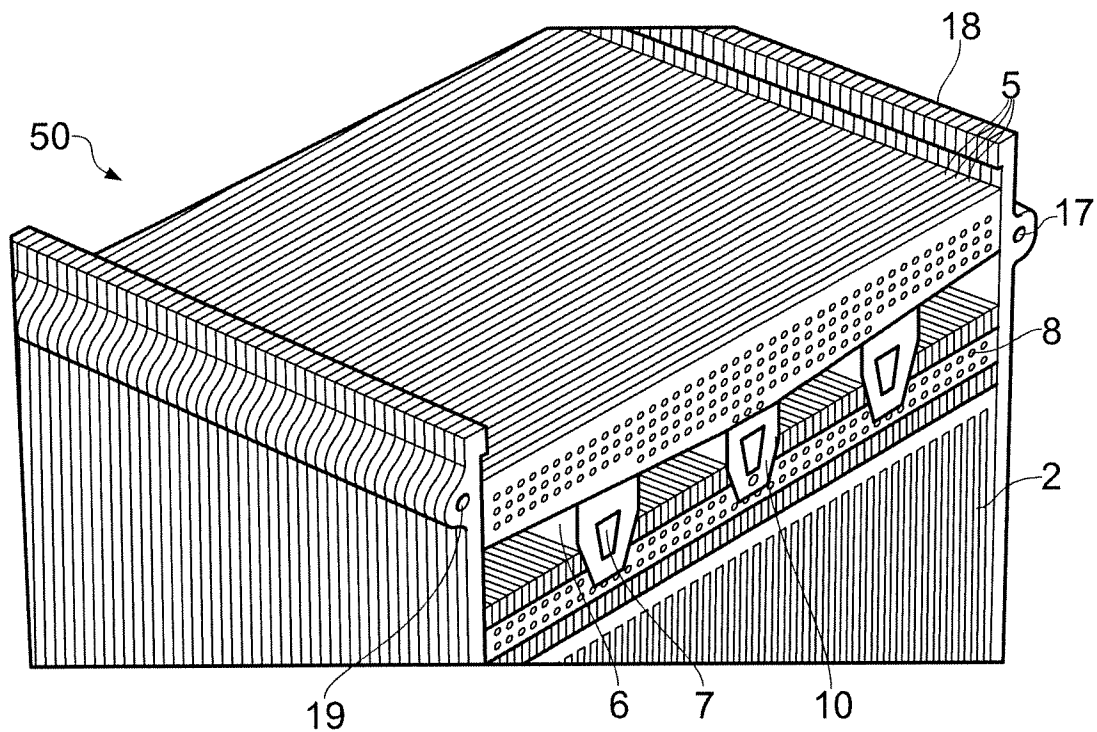


FIG. 5

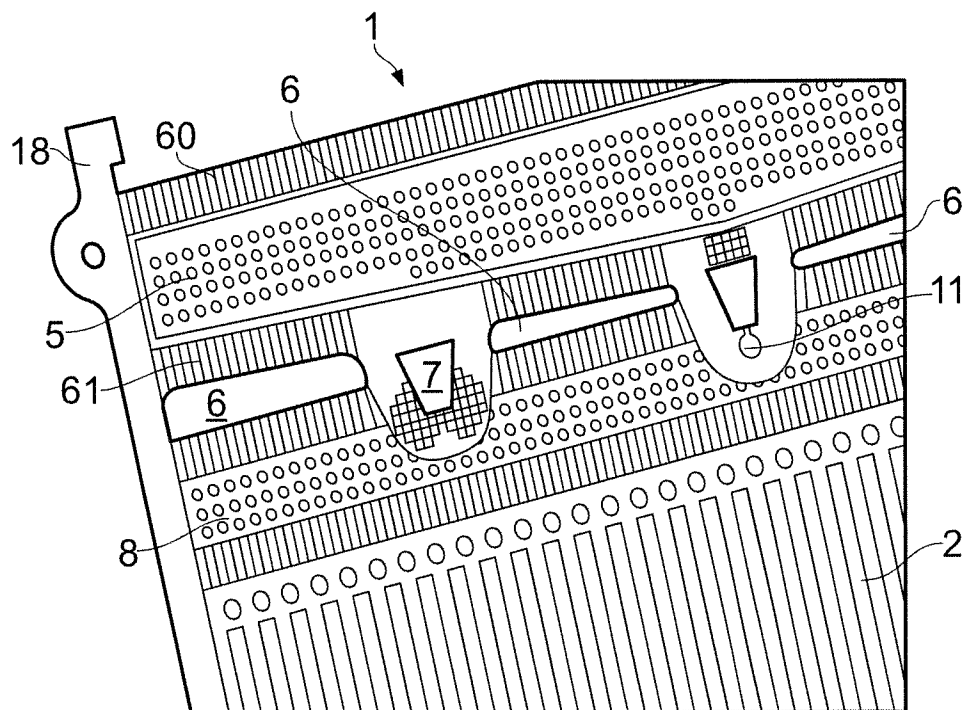


FIG. 6

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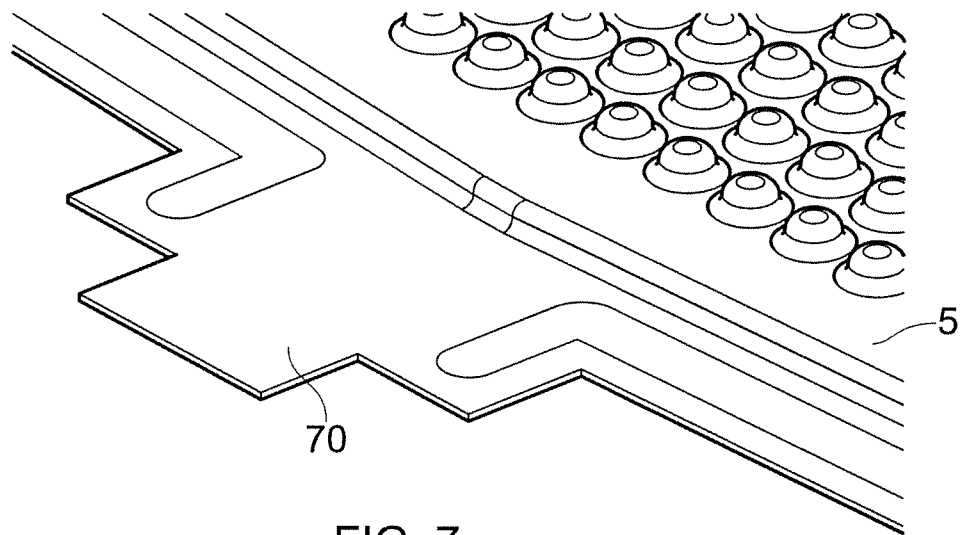


FIG. 7

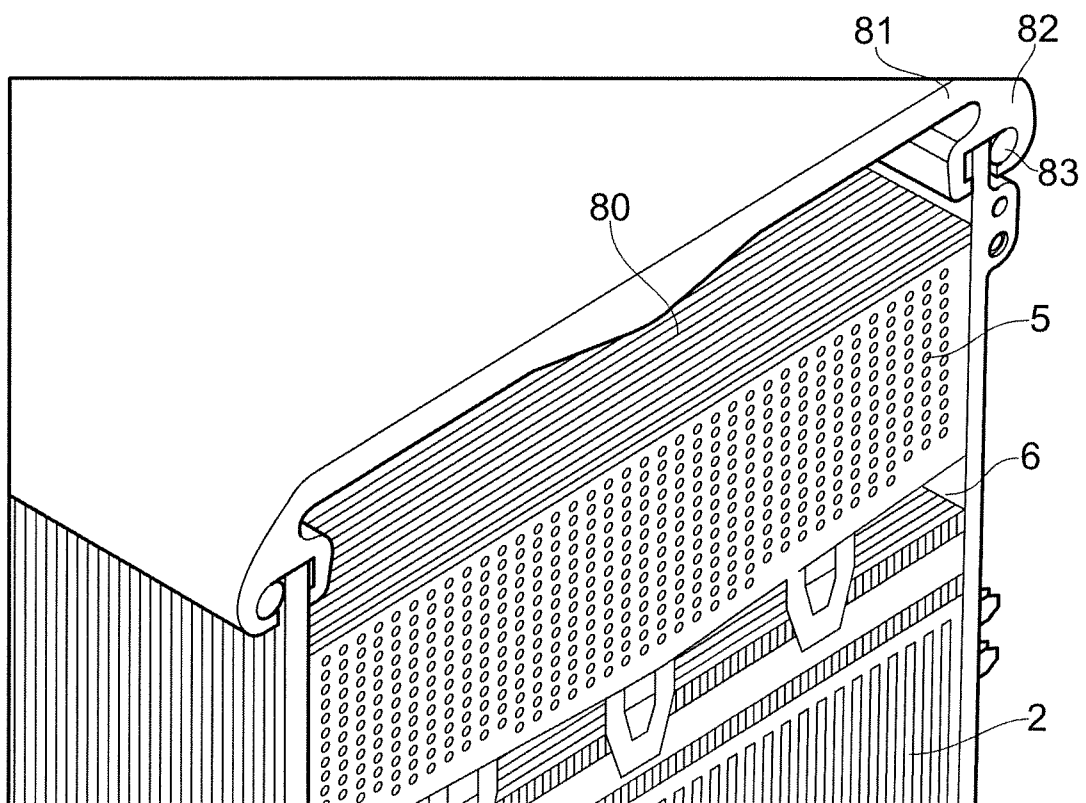


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2015/051875

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01M8/02 H01M8/04
ADD. H01M8/24

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01M

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	GB 2 437 767 A (INTELLIGENT ENERGY LTD [GB]) 7 November 2007 (2007-11-07) page 8, line 17 - page 11, line 3 figures 6-9	1-9, 11-22 10
A	----- US 2010/119897 A1 (LIN CHIH-YEN [TW] ET AL) 13 May 2010 (2010-05-13) figure 2 page 2, paragraph 0036-0042	1-22
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A	----- GB 2 390 738 A (INTELLIGENT ENERGY LTD [GB]) 14 January 2004 (2004-01-14) figures 2, 4 page 2, lines 21-22 ----- -/-	1-22



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

18 September 2015

Date of mailing of the international search report

28/09/2015

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Authorized officer

Kelly, Michael

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2015/051875

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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