



(51) International Patent Classification:

H01M 8/023 (2016.01) *H01M 8/04119* (2016.01)
H01M 8/0241 (2016.01) *H01M 8/1018* (2016.01)

(21) International Application Number:

PCT/GB2016/051603

(22) International Filing Date:

1 June 2016 (01.06.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1509516.9 2 June 2015 (02.06.2015) GB

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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: WATER MANAGEMENT IN AN AIR-BREATHING FUEL CELL

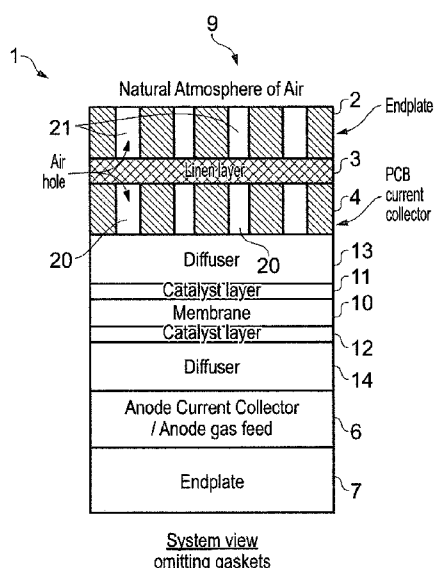


FIG. 2

(57) Abstract: A fuel cell apparatus comprises a membrane-electrode assembly and a gas diffusion layer disposed over the membrane-electrode assembly and a perforated ventilation plate. A textile layer is positioned adjacent to the perforated ventilation plate and is configured to allow passage of air through the textile layer and to allow wicking of water within the layer. The textile layer is formed from fibres woven or otherwise overlaid relative to one another in a manner which leaves open spaces for air transport through the layer but each fibre is formed of strands of material that wick water through the material, both transverse to the plane of the layer and along / in the plane of the layer.

WATER MANAGEMENT IN AN AIR-BREATHING FUEL CELL

The present invention relates to electrochemical fuel cells, and in particular to air-breathing / air-powered fuel cells.

5

Such fuel cells comprise a proton exchange membrane (PEM) sandwiched between two porous electrodes, together comprising a membrane-electrode assembly (MEA). The MEA itself is conventionally sandwiched between: (i) a cathode diffusion structure having a first face adjacent to the cathode face of the MEA and (ii) an anode diffusion structure
10 having a first face adjacent the anode face of the MEA. The diffusion structures can contain carbon microporous layers. The second face of the anode diffusion structure contacts an anode fluid flow field plate for current collection and for distributing hydrogen to the second face of the anode diffusion structure. The second face of the cathode diffusion structure contacts a cathode plate for current collection and for distributing
15 oxygen to the second face of the cathode diffusion structure, and for extracting water reaction product from the MEA.

An important consideration in the operation of such fuel cells is the management of oxygen flows to the cathode and water flows from the cathode. In a passive air-breathing proton
20 exchange membrane fuel cell (PEMFC), air must pass in to the cathode diffusion structure and water must pass out of the cathode diffusion structure.

Some conventional fuel cells use cathode flow paths extending past the cathode current collector or along channels therein, and past and through the gas diffusion layer. Air is
25 driven along these cathode flow paths, driven by a fan or an air compressor, in a direction parallel to the plane of the MEA and gas diffusion layer, and this air flow provides sufficient transport to exhaust water from the cathode.

Where the fuel cell is not force ventilated, and / or where the air and water transport to and
30 from the gas diffusion layer is transverse to the plane of the MEA, it can be more difficult to ensure sufficient air transport to the cathode of the MEA at the same time as ensuring sufficient water transport away from the MEA.

It is an object of the invention to provide an alternative water management structure and method for delivery of gas to an MEA at the same time as assisting water transport away from the MEA.

- 5 According to one aspect, the present invention provides a fuel cell apparatus comprising:
a membrane-electrode assembly;
a gas diffusion layer disposed over the membrane-electrode assembly;
a perforated ventilation plate; and
a textile layer adjacent to the perforated ventilation plate configured to allow
10 passage of air through the textile layer and to allow wicking of water within the layer.

The textile layer may be a woven or knitted fabric. The textile layer may be formed from spun threads. The textile layer may be linen. The textile layer may have a warp thread count in the range 17 to 22 threads per centimetre and a weft thread count in the range
15 20 to 26 threads per centimetre. The textile layer may comprise threads of diameter between 180 and 600 microns. The textile layer may comprise weft threads of diameter in the range 180 to 500 microns, and warp threads of diameter in the range 200 to 600 microns. The textile layer may comprise pores defined between individual threads, the pores having a size between 120 and 350 microns. The pores may have a size of 120 to
20 400 microns between weft threads and a size of 200 to 350 microns between warp threads. The textile layer may comprise a basket weave.

The perforated ventilation plate may comprise a current collector plate electrically coupled to the membrane-electrode assembly via the gas diffusion layer. The textile layer may
25 extend between the perforated ventilation plate and a perforated end plate disposed over the ventilation plate. The perforated ventilation plate may have an outer face and an inner face and a plurality of perforations extending between the outer face and the inner face to allow transport of fluid from the outer face through the perforations to the gas diffusion layer.

30 The textile layer may extend over an outer surface of the current collector plate. The textile layer may extend over an outer surface of a perforated end plate which is in compressive, overlaying relationship with the current collector plate. The textile layer may comprise a plurality of fibres, each fibre being formed of strands of material such that the
35 fibres are each capable of wicking water through the material. The textile layer may

comprise an electrically conductive textile layer disposed between the perforated plate and the gas diffusion layer and configured as a current collector plate. The electrically conductive textile layer may be formed from spun threads or yarn. The textile layer may be linen incorporating electrically conductive threads interwoven therewith. The textile layer may comprise a current collector layer and is coupled to an electrical current connector. The electrical current connector may be provided at a peripheral edge of the textile layer.

According to another aspect, the invention provides a method of operating a fuel cell apparatus comprising:

passing oxidant to a membrane-electrode assembly via a gas diffusion layer disposed over the membrane-electrode assembly, and via a perforated ventilation plate disposed over the gas diffusion layer;

passing water from the membrane-electrode assembly to the perforated ventilation plate via the gas diffusion layer;

using a textile layer adjacent to the perforated ventilation plate to absorb and transport water by wicking of water within the layer, while allowing oxidant transport through interstices in the textile layer.

The method may further comprise using at least a part of the ventilation plate as a current collector plate to extract current from the fuel cell apparatus. The method may further comprise using the textile layer as a current collector layer to extract current from the fuel cell apparatus.

Embodiments of the present invention will now be described by way of example and with reference to the accompanying drawings in which:

Figure 1 shows a perspective schematic view of a fuel cell deploying an air breathing face to transport air to the surface of an MEA and to transport water away from the surface of the MEA;

Figure 2 shows a schematic partial cross-sectional view through a portion of the fuel cell of figure 1;

Figure 3 shows a schematic partial cross-sectional view through an enlarged portion of the fuel cell shown in figure 2;

Figure 4 shows a schematic partial cross-sectional view through a portion of an alternative fuel cell similar to figure 1;

Figure 5 shows a schematic partial cross-sectional view through a portion of another alternative fuel cell similar to figure 1;

Figure 6 shows a schematic partial cross-sectional view through a portion of another alternative fuel cell similar to figure 1

5 Figure 7 shows a schematic partial cross-sectional view through a portion of another alternative fuel cell similar to figure 1.

Figure 1 shows a perspective view of a planar fuel cell apparatus 1 comprising a cathode endplate 2, a textile layer 3, a cathode current collector plate 4, a gasket assembly 5, an anode current collector plate 6 and an anode endplate 7. The gasket assembly 5 surrounds a cathode gas diffusion layer and an anode gas diffusion layer and provides sealing engagement with a membrane-electrode assembly disposed between the anode and cathode gas diffusion layers, none of which is visible in figure 1, but are shown in figure 2. The anode current collector plate 6 may provide anode fluid flow channels (not shown) for distribution of anode fluid to the membrane-electrode assembly.

The cathode endplate 2 and cathode current collector plate 4 are perforated by a plurality of apertures 8 which generally provide an air-breathing face 9 of the fuel cell apparatus 1, to allow ingress of air and egress of water and water vapour from the fuel cell apparatus. The cathode end plate 2 and cathode current collector plates thereby serve as ventilation plates. The apertures 8 preferably form an array, and more preferably a regular array, of apertures 8 each of dimension sufficient to allow gas and fluid transport therethrough, while being small enough to retain structural integrity of the fuel cell assembly and, in the case of the current collector plate 4, to provide adequate electrical contact across the surface area of the gas diffusion layer.

With reference now to figure 2, the individual layers of the fuel cell apparatus 1 can now be seen. The membrane-electrode assembly comprises a membrane 10 and catalyst layers 11 and 12 as well known in the art. On the cathode side of the MEA is a cathode gas diffusion layer 13 and on the anode side of the MEA is an anode gas diffusion layer 14. The gas diffusion layers 13, 14 ensure good distribution of fluid flows to and from the membrane electrode assembly. The cross-section seen in figure 2 represents a small portion of the whole assembly seen in figure 1.

A particular feature of the arrangement of figures 1 and 2 is the provision of a textile layer 3 disposed between the current collector plate 4 and the end plate 2. The textile layer 3 is generally provided to assist in water transport away from the gas diffusion layer 13. The textile layer 3 is generally characterized as a layer of material which is manufactured from
5 fibres which are woven or otherwise overlaid relative to one another in a manner which leaves open spaces (which may be referred to as interstitial spaces, or pores) between fibres. The interstitial spaces allow air transport through the layer 3 (i.e. transverse to the plane of the layer), but each fibre is formed of strands of material that are capable of wicking water through the material, both transverse to the plane of the layer and along /
10 in the plane of the layer.

A preferred textile layer 3 is a cloth, or woven or knitted fabric. One preferred textile is linen, e.g. a textile woven from flax. Other options more generally include any textile formed from cellulosic fibres such as cotton or hemp. The fibres used to make the textile
15 are preferably spun threads (e.g. yarn) as this provides an ideal substrate which lowers or breaks the surface tension of water thereby enabling the wicking of water through and along the fibres, and thereby through and along the textile layer. The formation of the textile by fibres woven or otherwise overlaid relative to one another provides pores or interstitial spaces allowing good transport of air or other gaseous medium through the
20 textile layer from one face to the other. The fibres are preferably hydrophilic in nature.

Preferably, the textile layer 3 is formed from natural fibres, but synthetic fibres or blended yarns may also be considered.

25 In some exemplary arrangements, the textile layer 3 has a warp thread count in the range 17 to 22 threads per centimetre and a weft thread count in the range 20 to 26 threads per centimetre.

The textile layer 3 may be comprised of threads having diameters between 180 and 600
30 microns. More particularly, the textile layer may comprise weft threads of diameter in the range 180 to 500 microns, and warp threads of diameter in the range 200 to 600 microns.

The textile layer may comprise pores defined between the individual threads having a pore size (e.g. a pore diameter measured in the plane of the textile) of between 120 and 350
35 microns. More particularly, the pores may be generally rectangular or square and have a

pore size of 120 to 400 microns between weft threads and a pore size of 200 to 350 microns between warp threads.

5 If a woven textile is used, the textile layer 3 may comprise any suitable weave pattern, which can include a basket style weave.

10 In the arrangement of figure 2, the textile layer 3 is disposed between the current collector plate 4 and the end plate 2, both of which have axially aligned apertures 8, respectively shown by reference numerals 20 and 21. With reference to figure 3, it can be seen that water droplets 30 forming in the apertures 20 without the presence of the textile layer 3 may tend to accrete and block or substantially occlude the apertures 20 which would have a detrimental effect on transport of oxygen to the cathode diffusion layer 13. However, the textile layer 3, being formed of many fibres each of which has a wicking property, tends to break the surface tension of water droplets forming in the apertures 20, 21 and absorb the water, thereby transporting the water both through the plane of the textile layer 3 as indicated by arrow 32 and along the plane of the textile layer, as indicated by the arrow 31. The upper surface 33 of the textile layer 3 (i.e. the surface distal from the gas diffusion layer 13) provides an evaporation surface for egress of water vapour via aperture 21.

20 At the same time, the separation of the individual fibres in the textile layer ensures that the layer remains breathable for air to pass through it.

The water that is soaked up by the textile layer may also be transported laterally (in the plane of the layer) to the peripheral edges of the textile layer 3 as visible in figure 1 and can also be evaporated from there. To assist this, the textile layer 3 could be oversized compared to the plates 2 and 4 to emerge therefrom and allow a larger surface area for evaporation.

30 The textile layer 3 need not be sandwiched between a current collector plate 4 and a separate end plate 2. A unitary plate 40 could be formed, with the textile layer 3 being disposed on the outer face (i.e. the face distal from the diffusion layer 13), as shown in figure 4. The unitary plate 40 similarly serves as a ventilation plate. If the current collector plate 4 has sufficient structural integrity, the end plate 2 may be superfluous and may be dispensed with, its function essentially having been integrated into the current collector plate 4 e.g. as a unitary plate 40 as seen in figure 4.

In another arrangement, the textile layer 3 could be disposed over the outer surface of the end plate 2.

- 5 The textile layer 3 could also be formed with flaps (not shown) that could descend to the diffuser layer 13 from the endplate 2, via the apertures 20, whilst maintaining the main layer above the current collector plate 4. If the textile layer were disposed on the endplate, the flaps could descend to the diffuser layer 13 via the apertures 20 and 21. This would allow the water at the surface of the diffusion layer 13 to be soaked up and distributed
10 throughout the textile layer 3 on top of the endplate or current collector plate, which would benefit from a greater evaporation surface area compared to the design shown in figures 2 and 3.

- The textile layer 3 could be made from electrically conductive fibres, or have electrically
15 conductive fibres woven through the textile, to allow electrical conduction through the layer. This can eliminate the need for a current collector plate 4, as discussed later.

- A hydrophobic layer may be provided on the surface of the gas diffusion layer 13 to enhance repulsion of water droplets into the apertures 20 where the droplets will be wicked
20 away from the apertures 20.

- Multiple textile layers may be used to achieve optimal wicking and evaporation surfaces, while maintaining adequate gas transport through the layers. If multiple textile layers 3 are used, they may be arranged with different weave patterns, different weave densities and
25 different fibre sizes in any combination desired to optimise air transport across the layers (from one face to the other face), when also optimising wicking of water within and through the layers.

- The cathode collector plate 4 could be fabricated as a printed circuit board (e.g. FR-4) with
30 a conductive layer (e.g. metal layer) on its lower surface as viewed in figures 2 and 3. The apertures 8 in the printed circuit board, collector plate 4, and/or end plate 2 may be of any suitable shape and aspect ratio to optimise fluid transport (i.e. air and water) such that large water droplet formation is discouraged by wicking into the textile layer 3, while air transport is enabled. The shape and aspect ratio may also be configured to optimise hole
35 density versus strength of the plate(s) 2, 4. The shape of the apertures may, for example,

be circular or elliptical, triangular elongate, hexagonal or rectangular, with or without rounded ends or corners.

5 The design of fuel cell apparatus 1 may be applied to single units or to larger planar arrays of fuel cells.

The endplates 2, 7 may be fabricated from thermally conductive material to assist in heat dissipation from the fuel cell.

10 A benefit of the textile layer 3 is to enhance water transport from the gas diffuser layer 13 and reduce the risk of cathode flooding. The textile layer 3 could also be used with force ventilated fuel cell apparatus if required. Although most benefit is realised by deploying a textile layer at the cathode side of the fuel cell apparatus, in principle it would be possible to install such a textile layer in the anode side, if water build up is a problem where limited
15 quantities of water can pass through the MEA.

In a general aspect, operation of the fuel cell apparatus includes passing oxidant to the membrane-electrode assembly via the gas diffusion layer disposed over the membrane-electrode assembly, and via the apertures in the perforated current collector plate (and
20 separate end plate, if one is present). Water is passed from the membrane-electrode assembly to the perforated current collector plate via the gas diffusion layer. The textile layer adjacent to the perforated current collector layer absorbs the water from the gas diffusion layer and transports the water at least partially by wicking the water within the layer, while allowing oxidant to be transported through interstices in the textile layer.

25 In another arrangement, the textile layer itself may be used as the current collection layer. An example of a suitable arrangement is shown in figure 5. In figure 5, a fuel cell apparatus 50 has a perforated ventilation plate 52 (e.g. an end plate) which need not be electrically conductive, since it does not need to serve as a current collector plate. The fuel cell
30 apparatus further includes a textile layer 53, a cathode gas diffusion layer 54, a membrane-electrode assembly 55, an anode gas diffusion layer 56, an anode current collector plate 57 and an anode endplate 58.

35 In this arrangement, the textile layer 53 includes an electrically conductive material. Other aspects of the textile layer are as described above in connection with figures 2 and 3. For

example, the textile layer 53 is generally provided to assist in water transport away from the gas diffusion layer 54. The textile layer 53 is generally characterized as a layer of material which is manufactured from fibres which are woven or otherwise overlaid relative to one another in a manner which leaves open spaces (which may be referred to as
5 interstitial spaces, or pores) between fibres. The interstitial spaces allow air transport through the layer 53 (i.e. transverse to the plane of the layer), but each fibre is formed of strands of material that are capable of wicking water through the material, both transverse to the plane of the layer and along / in the plane of the layer. A preferred textile is formed from spun threads (e.g. yarn) such that wicking of water by the threads is encouraged.

10 The choice of materials for the textile layer 53, e.g. a cloth, or woven or knitted fabric, linen, etc are as previously described in connection with figures 2 and 3. However, in this instance, the textile layer includes electrically conductive fibres incorporated therein, e.g. woven into the structure. Provided that the textile layer is made sufficiently electrically
15 conductive, it can serve as a current collector plate, e.g. replacing plate 4 of figure 2.

As shown in figure 5, the textile layer in this instance may include a suitable electrical connection thereto to conduct fuel cell current from the assembly. Preferably, this electrical connection may be located at a peripheral edge of the textile layer 53, and may
20 comprise an electrically conductive track or element 51 which extends from a contact area 60 with the textile layer 53, past a peripheral gasket 61 (e.g. gasket assembly 5 as seen in figure 1) and to a connector tab 62 which extends from the peripheral edge of the fuel cell apparatus 50. The electrically conductive element 51 could form part of the end plate 52, e.g. it could be an electrically conductive track bonded thereto. The electrically
25 conductive element 51 could extend along one or more sides of the fuel cell apparatus. Multiple conductive elements 51 could be disposed at intervals around the periphery of the fuel cell apparatus. Anode current collector plate 57 and anode endplate 58 could be combined.

30 Although shown only on the cathode side in figure 5, a corresponding electrically conductive textile layer arrangement could also be used on the anode side.

In an alternative arrangement, the conductive track or element 51 of figure 5 could be integrated into the perforated ventilation plate 52, as indicated schematically in a fuel cell
35 apparatus 64 of figure 6. In figure 6, the conductive track or element 65 is provided on the

perforated ventilation plate 52 and includes an exposed portion 66 suitable for making electrical contact. Alternative arrangements can be envisaged, e.g. in which the conductive track or element passes through, or around the edge of, the ventilation plate 52 to a top surface 67 thereof, to create an exposed contact area.

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In another alternative arrangement, the electrically conductive textile layer 53 could extend beyond the peripheral gasket 61 and beyond the perimeter 68 of the perforated ventilation end plate 52 as shown by extension 70 to directly provide an electrical connection tab 71, as shown in the fuel cell apparatus 74 in figure 7.

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In a general aspect, operation of this fuel cell apparatus relies on passing oxidant to the membrane-electrode assembly 55 via the gas diffusion layer 54 disposed over the membrane-electrode assembly, and via the perforated ventilation plate 52 disposed over the gas diffusion layer 54. Water is passed from the membrane-electrode assembly 55 to the perforated ventilation plate 52 via the gas diffusion layer 54. The electrically conductive textile layer 53 is disposed between the perforated ventilation plate 52 and the gas diffusion layer 54 to absorb and transport the water by wicking of water within the layer 54, while allowing oxidant transport through interstices in the textile layer.

15

20 Other embodiments are intentionally within the scope of the accompanying claims.

CLAIMS

1. A fuel cell apparatus comprising:
a membrane-electrode assembly;
5 a gas diffusion layer disposed over the membrane-electrode assembly;
a perforated ventilation plate; and
a textile layer adjacent to the perforated ventilation plate configured to allow
passage of air through the textile layer and to allow wicking of water within the layer.
- 10 2. The fuel cell apparatus of claim 1 in which the textile layer is a woven or knitted fabric.
3. The fuel cell apparatus of claim 1 in which the textile layer is formed from spun threads.
- 15 4. The fuel cell apparatus of claim 2 in which the textile layer is linen.
5. The fuel cell apparatus of claim 2 in which the textile layer has a warp thread count in the range 17 to 22 threads per centimetre and a weft thread count in the range 20 to 26
20 threads per centimetre.
6. The fuel cell apparatus of claim 2 in which the textile layer comprises threads of diameter between 180 and 600 microns.
- 25 7. The fuel cell apparatus of claim 6 in which the textile layer comprises weft threads of diameter in the range 180 to 500 microns, and warp threads of diameter in the range 200 to 600 microns.
8. The fuel cell apparatus of claim 2 in which the textile layer comprises pores defined
30 between individual threads, the pores having a size between 120 and 350 microns.
9. The fuel cell apparatus of claim 8 in which the pores have a size of 120 to 400 microns between weft threads and a size of 200 to 350 microns between warp threads.

10. The fuel cell apparatus of claim 2 in which the textile layer comprises a basket weave.

5 11. The fuel cell apparatus of claim 1 in which the perforated ventilation plate comprises a current collector plate electrically coupled to the membrane-electrode assembly via the gas diffusion layer.

10 12. The fuel cell apparatus of claim 11 in which the textile layer extends between the perforated ventilation plate and a perforated end plate disposed over the ventilation plate.

13. The fuel cell apparatus of claim 1 in which the perforated ventilation plate has an outer face and an inner face and a plurality of perforations extending between the outer face and the inner face to allow transport of fluid from the outer face through the perforations to the gas diffusion layer.

15 14. The fuel cell apparatus of claim 11 in which the textile layer extends over an outer surface of the current collector plate.

20 15. The fuel cell apparatus of claim 11 in which the textile layer extends over an outer surface of a perforated end plate which is in compressive, overlaying relationship with the current collector plate.

25 16. The fuel cell apparatus of claim 1 in which the textile layer comprises a plurality of fibres, each fibre being formed of strands of material such that the fibres are each capable of wicking water through the material.

30 17. The fuel cell apparatus of claim 1 in which the textile layer comprises an electrically conductive textile layer disposed between the perforated plate and the gas diffusion layer and configured as a current collector plate.

18. The fuel cell apparatus of claim 17 in which the electrically conductive textile layer is formed from spun threads or yarn.

35 19. The fuel cell apparatus of claim 17 in which the textile layer is linen incorporating electrically conductive threads interwoven therewith.

20. The fuel cell apparatus of claim 17 in which the textile layer comprises a current collector layer and is coupled to an electrical current connector.

5 21. The fuel cell apparatus of claim 20 in which the electrical current connector is provided at a peripheral edge of the textile layer.

22. A method of operating a fuel cell apparatus comprising:

10 passing oxidant to a membrane-electrode assembly via a gas diffusion layer disposed over the membrane-electrode assembly, and via a perforated ventilation plate disposed over the gas diffusion layer;

passing water from the membrane-electrode assembly to the perforated ventilation plate via the gas diffusion layer;

15 using a textile layer adjacent to the perforated ventilation plate to absorb and transport water by wicking of water within the layer, while allowing oxidant transport through interstices in the textile layer.

23. The method of claim 22 further comprising:

20 using at least a part of the ventilation plate as a current collector plate to extract current from the fuel cell apparatus.

24. The method of claim 22 further comprising using the textile layer as a current collector layer to extract current from the fuel cell apparatus.

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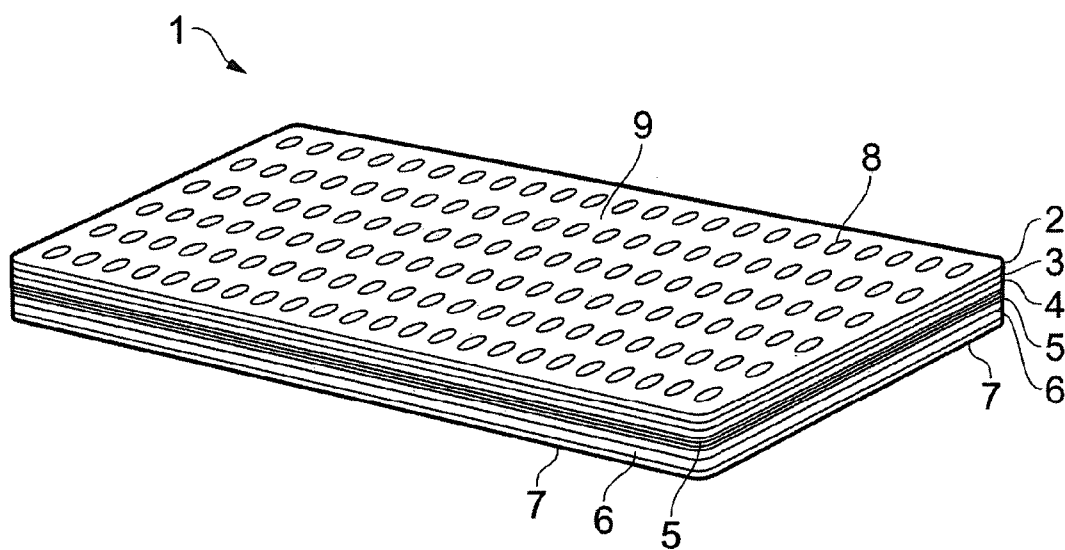
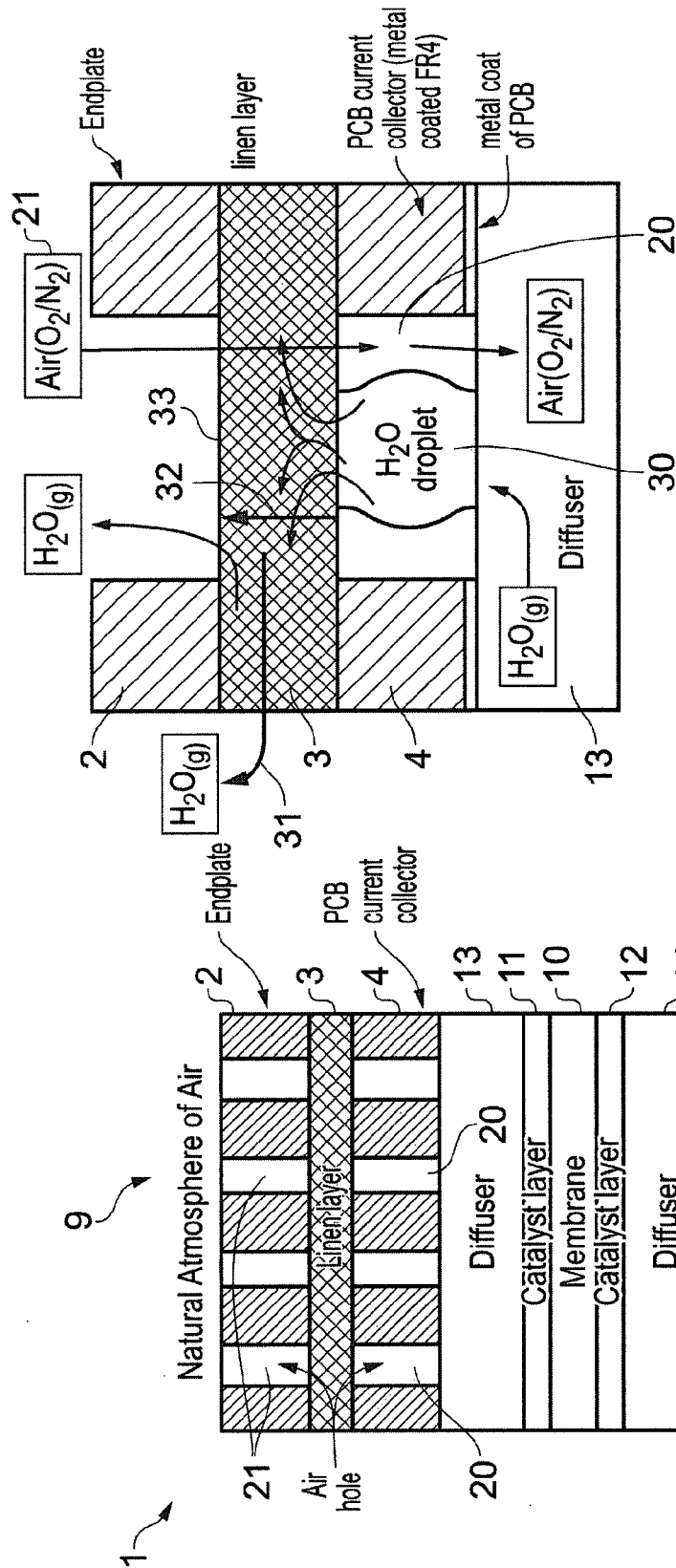


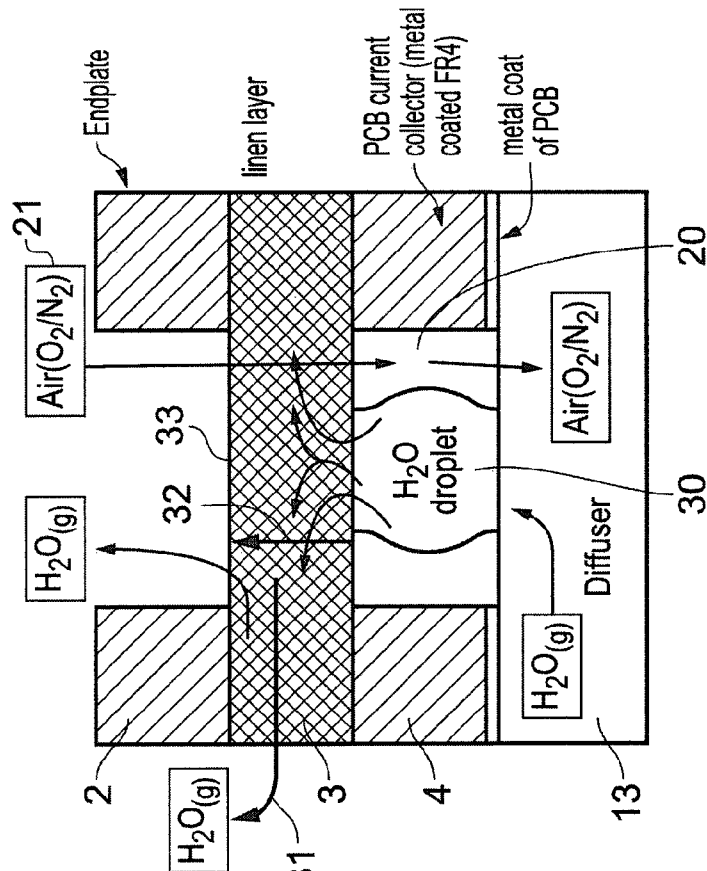
FIG. 1

2/4



System view
omitting gaskets

FIG. 2



Enlarged view
Details the water retention and evaporation
process whilst still able to pass air through
to the diffuser

FIG. 3

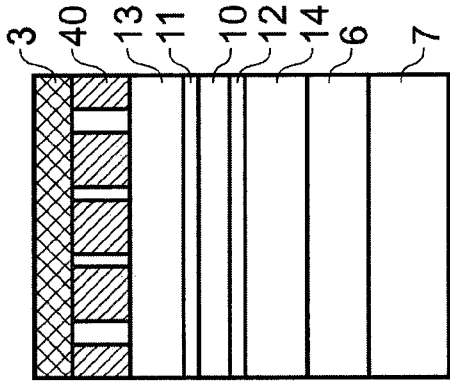


FIG. 4

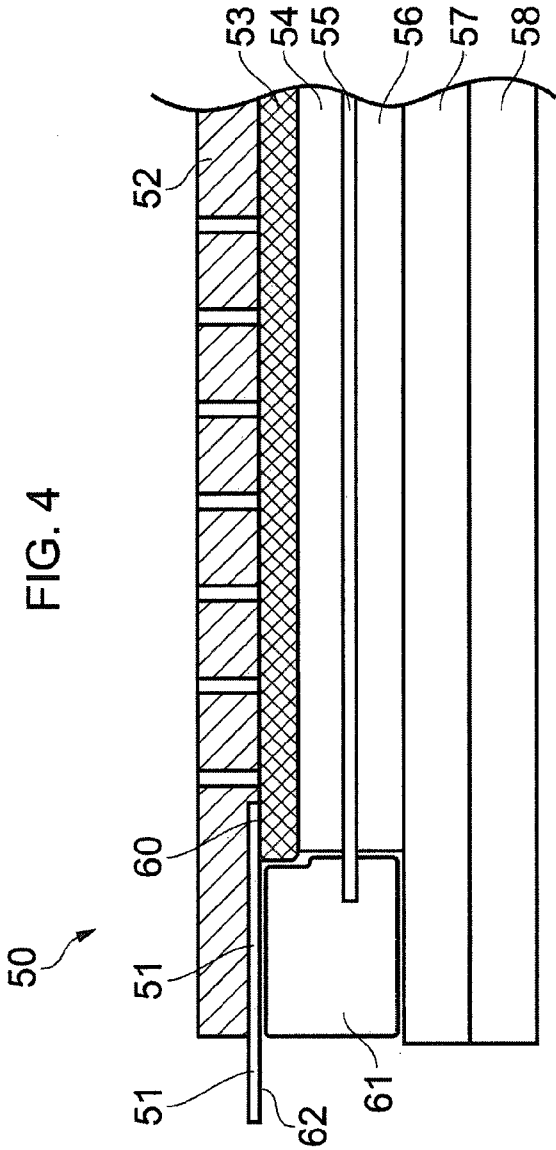


FIG. 5

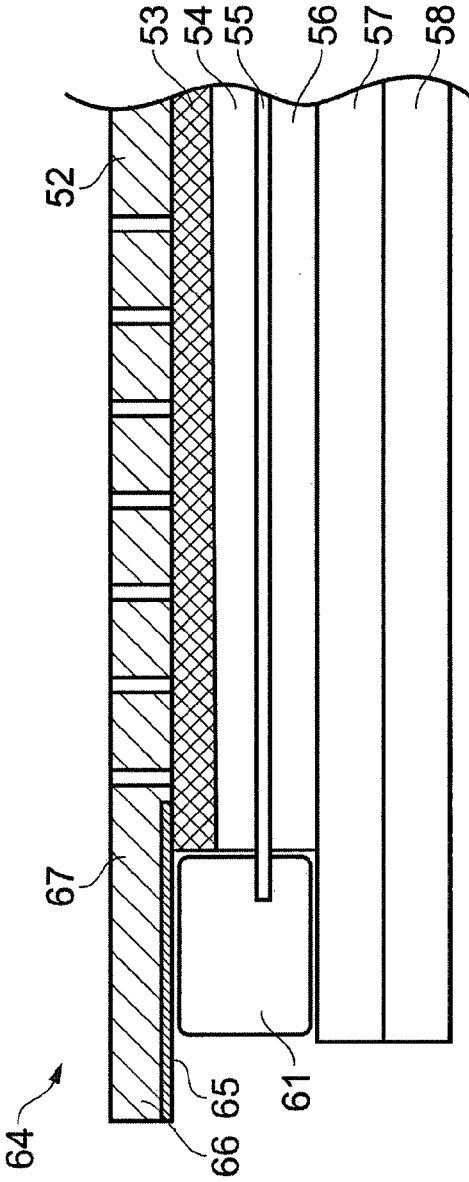


FIG. 6

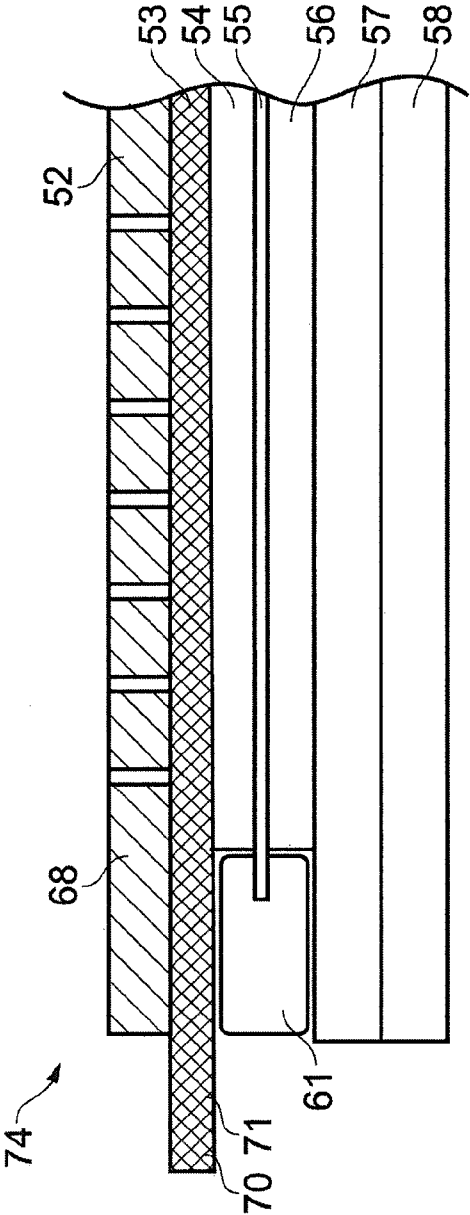


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2016/051603

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01M8/023 H01M8/0241 H01M8/04119
ADD. H01M8/1018

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	US 2008/280188 A1 (EUN YEONG-CHAN [KR] ET AL) 13 November 2008 (2008-11-13) paragraph [0022] - paragraph [0030]; figures 2,3 -----	1-16,22, 23 17-21,24
X	US 2008/176128 A1 (LEE CHING-PO [TW] ET AL) 24 July 2008 (2008-07-24) paragraph [0022] - paragraph [0023]; figures 1,2 -----	1-14,16, 22,23
X	WO 2007/139940 A2 (UNIV LELAND STANFORD JUNIOR [US]; HONDA MOTOR CO LTD [JP]; KUBOTA TADA) 6 December 2007 (2007-12-06) page 9, line 5 - page 13, line 19; figures 1,5 -----	1-3,22, 23



Further documents are listed in the continuation of Box C.



See patent family annex.

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12 September 2016

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20/09/2016

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2016/051603

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008280188 A1	13-11-2008	KR 20080098847 A	12-11-2008
		US 2008280188 A1	13-11-2008

US 2008176128 A1	24-07-2008	TW 200832800 A	01-08-2008
		US 2008176128 A1	24-07-2008

WO 2007139940 A2	06-12-2007	CA 2652891 A1	06-12-2007
		EP 2030274 A2	04-03-2009
		JP 5189085 B2	24-04-2013
		JP 2009538509 A	05-11-2009
		KR 20090017624 A	18-02-2009
		US 2008032169 A1	07-02-2008
		WO 2007139940 A2	06-12-2007
