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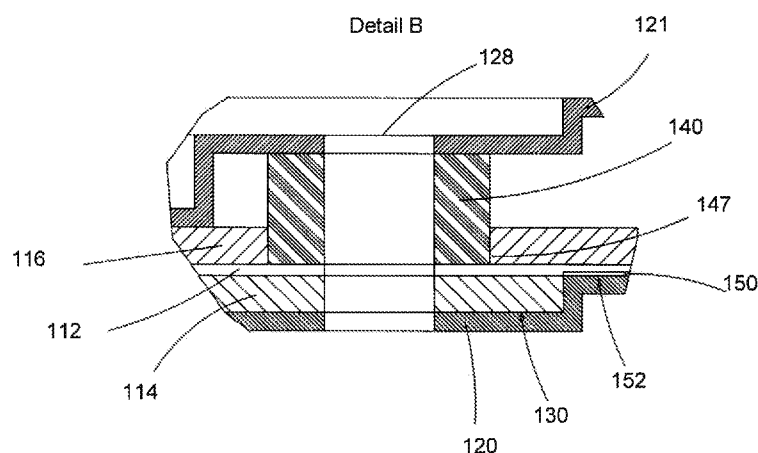


Figure 3

(57) **Abstract:** A sealing arrangement for a solid polymer electrolyte fuel cell comprising a membrane electrode assembly consists essentially of an adhesive layer (150) deposited on a landing (152) at the periphery of the separator plate (120) adjacent to the anode side of the membrane electrode assembly. The landing (152) that carries the adhesive layer (150) lies around a pocket (130) in the separator plate (120) where the anode diffusion layer (114) of the membrane electrode assembly is placed such that the adhesive layer (150) connects the polymer exchange membrane (112) of the membrane electrode assembly with the separator plate (120). The sealing arrangement can further comprise a sealing gasket (140) placed between the polymer exchange membrane (112) and the separator plate adjacent to the cathode side of the membrane electrode assembly, the sealing gasket (140) being aligned with the fuel inlet and/or the fuel outlet (128) of the separator plate.



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SEALING ARRANGEMENT FOR A SOLID POLYMER ELECTROLYTE FUEL CELL

BACKGROUND

5 Technical Field

The present invention relates to a sealing arrangement for solid polymer electrolyte fuel cells comprising an unbonded membrane electrode assembly.

Description of the Related Art

10 Fuel cells are devices in which fuel and oxidant fluids electrochemically react to generate electricity. A type of fuel cell being developed for various commercial applications is the solid polymer electrolyte fuel cell, which employs a membrane electrode assembly (MEA) comprising a proton exchange membrane (PEM) made of a suitable ionomer material (e.g.,
15 Nafion®) disposed between two electrodes. Each electrode comprises a catalyst layer located next to the proton exchange membrane. The catalyst may be, for example, a metal black, an alloy, or a supported metal catalyst such as platinum on carbon. Each of the catalyst layers can be deposited, for example, on one side of the ion exchange membrane, and such an assembly is
20 referred to as a catalyst coated membrane (CCM). A fluid diffusion layer (a porous, electrically conductive sheet material) is typically employed adjacent to the electrode for purposes of mechanical support, current collection, and/or reactant distribution. In the case of gaseous reactants, such a fluid diffusion layer is referred to as a gas diffusion layer (GDL). In some fuel cells the
25 catalyst layer is incorporated onto a gas diffusion layer instead of being deposited on the membrane and in this case the unit is referred to as a gas diffusion electrode (GDE).

During the process of making the MEA, the polymer electrolyte membrane may be disposed between the anode and the cathode gas diffusion electrodes where they are typically bonded, usually under heat and pressure, to ensure sufficient proton conduction from the catalyst layer to the membrane. In the case of an MEA using a catalyst coated membrane, an ionomer spray coat may be employed at the interface of the gas diffusion layer and the catalyst-coated membrane to improve bonding at lower temperatures and pressures.

The act of bonding the PEM to the other layers of the MEA can be however, fastidious and time consuming, particularly when bonding is conducted between heated platens. For example, bonding methods known in the art require specific heating and cooling cycles of the platens, generating a lag time between bonding of successive MEAs, to allow the platens to heat up to the desired temperature, reach equilibrium and then cool down. Furthermore, if the temperature and/or pressure are too high, and/or the bonding time is too long, then the proton exchange membrane may be damaged. However, if the temperature and/or pressure are too low, and/or the bonding time is too short, the MEA may be insufficiently bonded. Furthermore, additional care must be exercised to ensure that pressure and heat are evenly applied and distributed during bonding to ensure that the MEA components are uniformly bonded to each other. Such even pressure and heating are typically difficult to obtain for MEAs with a large surface area.

For commercial applications, a plurality of fuel cells are generally stacked in series in order to deliver a greater output voltage. Each fuel cell comprises separator plates adjacent to its gas diffusion layers to separate one cell from another in a stack. Fluid distribution features, including inlet and outlet ports, fluid distribution plenums and numerous fluid channels, are typically formed in the surface of the separator plates adjacent the electrodes in order to distribute reactant fluids to, and remove reaction by-products from, the electrodes. Separator plates also provide a path for electrical and thermal conduction, as well as mechanical support and dimensional stability to the MEA.

In an assembled fuel cell, the porous gas diffusion layers in the MEA must be adequately sealed at their periphery and to their adjacent separator plates in order to prevent reactant gases from leaking over to the wrong electrode or to prevent leaks between the reactant gases and the atmosphere surrounding the fuel cell stack. This can be challenging because the MEA is typically a relatively large, thin sheet, and thus a seal may be needed over a significant perimeter, and a fuel cell stack typically involves sealing numerous MEAs. The design of the MEA edge seal should provide for easy manufacturing techniques and for reliable, high quality leak tight seals with a simple thin design. Various ways of accomplishing this have been suggested in the art.

Prior art sealing methods generally involve the use of a sealing gasket which surrounds the MEA and which can be significantly compressed between the anode and cathode separator plates in order to effect a reliable seal between the MEA and ambient.

As an alternative to such a seal, US patent No. 8,828,617 describes a framed membrane electrode assembly having a compliant seal between the anode frame piece and the anode separator plate and a non-compliant seal between the cathode frame piece and the cathode separator plate for fluidly separating the anode from the cathode and for fluidly separating both the anode and the cathode from the surrounding environment. The non-compliant seal may include an optional thin film of an elastomer material such as silicone or a pressure sensitive adhesive.

In another example, US patent No. 6,080,503 provides a simplified stack design which allows an easier stack disassembly, testing, repair and maintenance whereby the stack comprises adhesively bonded layers. In this example, the membrane electrode assembly is adhesively bonded to both the adjacent separator plates, on the anode and on the cathode side providing a substantially gas and liquid-tight seal around the perimeter of the electrochemically active area of the membrane electrode assembly and around the fluid manifold openings. The adhesive bonding agent encapsulates in this

case the edge portion of the membrane enclosing it on three sides where it would otherwise be exposed and vulnerable to damage and it thereby also reduces the drying-out of the polymer electrolyte membrane.

Yet another example of a sealing structure for a fuel cell is disclosed in US patent No. 8,067,128 which describes a membrane electrode assembly comprising an anode diffusion layer having the same size as the adjacent catalyst coated membrane (CCM), and a cathode diffusion layer that is smaller than the CCM and the anode diffusion layer. The fuel cell further comprises an anode separator plate and a cathode separator plate which are both larger in area than the anode diffusion layer, the CCM and the cathode diffusion layer to thereby create a step shaped structure at the periphery of the assembled fuel cell. An adhesive layer is coated on the periphery of the cathode diffusion layer and another adhesive layer is coated on the periphery of the anode diffusion layer and on the periphery of the membrane, also covering the adhesive layer applied at the periphery of the cathode diffusion layer, to fill the step shaped space between the peripheries of the MEA components and the separator plates. This solution presents the disadvantage that it uses multiple adhesive layers and it needs additional fixtures to align the stack components before the adhesive layers are applied. The exterior adhesive layer also creates a messy esthetical appearance of the stack.

In these prior art embodiments, a sufficiently compressible, compliant seal or adhesive layers applied to the sides of the MEA are employed to seal both the anode and the cathode diffusion layers from the surrounding environment. However, in order to increase power density, attempts continue to be made to reduce the thickness of the individual cells making up a fuel cell stack. As fuel cell makers successfully reduce the thickness of the other components in the cells, there is a further need to reduce the thickness of the seals employed while simplifying the manufacturing method of the MEA and of the fuel cell stacks. Consequently, there remains a need in the art for improved sealing methods and designs that ensure a good sealing of the stack while minimizing the sealing area, to allow a reduction in size of the fuel cell stack

(width and height) and to preserve the required active area. The present invention fulfills this need and provides further related advantages.

BRIEF SUMMARY

5 These and other aspects of the invention will be evident in view of the attached figures and the following detailed description. A solid polymer electrolyte fuel cell is disclosed comprising a membrane electrode assembly which comprises a polymer exchange membrane disposed between an anode catalyst layer and a cathode catalyst layer, an anode gas diffusion layer
10 adjacent the anode catalyst layer, and a cathode gas diffusion layer adjacent the cathode catalyst layer. The fuel cell further comprises a first separator plate adjacent to the anode gas diffusion layer, and the first separator plate comprises fuel flow channels provided on its side facing the anode gas diffusion layer and a fuel inlet and a fuel outlet fluidly connected to the fuel flow
15 channels. The fuel cell also comprises a second separator plate adjacent to the cathode diffusion layer, the second separator plate comprising oxidant flow channels provided on its side facing the cathode gas diffusion layer.

 In the present fuel cell, the anode gas diffusion layer is placed in a pocket of the first separator plate, the pocket carrying the fuel flow channels, and the sealing arrangement for the fuel cell consists essentially of an adhesive
20 layer deposited on a landing at the periphery of the first separator plate that lies around the pocket where the anode gas diffusion layer is placed, the adhesive layer connecting the polymer exchange membrane with the side of the first separator plate facing the anode gas diffusion layer.

25 In some embodiments, the anode catalyst layer and the cathode catalyst layer are each deposited on an opposite side of the polymer exchange membrane before the fuel cell is assembled to form a catalyst coated membrane. In other embodiments, the anode catalyst layer and the cathode catalyst layer are each deposited on the anode gas fluid diffusion layer and, respectively, on the cathode gas diffusion layer before the fuel cell is
30 respectively, on the cathode gas diffusion layer before the fuel cell is

assembled to form a gas diffusion anode, and respectively a gas diffusion cathode.

The second separator plate further comprises fuel flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels. A sealing gasket is placed between the cathode catalyst layer deposited on the polymer exchange membrane and the second separator plate or between the polymer exchange membrane and the second separator plate, the sealing gasket being aligned with the fuel inlet and/or with the fuel outlet of the second separator plate and passing through a hole provided in the cathode gas diffusion layer or respectively in a hole provided in the gas diffusion cathode.

In some embodiments, the solid polymer electrolyte fuel cell further comprises a seal support, placed between the first separator plate and the anode gas diffusion layer, the seal support being aligned with and placed in the vicinity of the fuel inlet or of the fuel outlet in the second separator plate and being aligned with the sealing gasket.

In some embodiments, the second separator plate comprises fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels, and further comprises a step which surrounds the fuel inlet or the fuel outlet and is aligned therewith, and an adhesive layer deposited on a landing of the step which faces the solid polymer electrolyte, the adhesive layer being placed between the second separator plate and the cathode catalyst layer deposited on the polymer exchange membrane or between the second separator plate and the polymer exchange membrane.

In the embodiments disclosed here the adhesive layers are made of an epoxy based adhesive, a silicone based adhesive, an acrylic adhesive or a low melt temperature thermoplastic material. The adhesive layers can be in the shape of an adhesive tape.

In preferred embodiments, the first separator plate has the same construction as the second separator plate.

A method of sealing a solid polymer electrolyte fuel cell is also disclosed, the fuel cell comprising a membrane electrode assembly which comprises a polymer exchange membrane disposed between an anode catalyst layer and a cathode catalyst layer, an anode gas diffusion layer adjacent the anode catalyst layer, and a cathode gas diffusion layer adjacent the cathode catalyst layer, and also comprises a first separator plate adjacent to the anode gas diffusion layer comprising fuel flow channels provided on its side facing the anode gas diffusion layer and a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels, and a second separator plate adjacent to the cathode diffusion layer comprising oxidant flow channels provided on its side facing the cathode gas diffusion layer, wherein the anode gas diffusion layer is placed in a pocket of the first separator plate, the pocket carrying the fuel flow channels, the method comprising:

providing an adhesive layer deposited on a landing at the periphery of the first separator plate that lies around the pocket where the anode gas diffusion layer is placed, the adhesive layer connecting the polymer exchange membrane with the side of the first separator plate facing the anode gas diffusion layer.

The second separator plate further comprises fuel flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels. In preferred embodiments, the anode catalyst layer and the cathode catalyst layer are each deposited on an opposite side of the polymer exchange membrane before the fuel cell assembly to form a catalyst coated membrane, and the method further comprises providing a sealing gasket placed between the cathode catalyst layer deposited on the polymer exchange membrane and the second separator plate, the sealing gasket being aligned with the fuel inlet or, respectively with the fuel outlet in the second separator plate and with the fuel inlet or respectively with the fuel outlet in the first separator plate and passing through a hole provided in the cathode gas diffusion layer.

In the embodiments comprising a sealing gasket placed between the cathode catalyst layer deposited on the polymer exchange membrane and the second separator plate or in the embodiments comprising a sealing gasket placed between polymer exchange membrane and the second separator plate, the method further comprises providing a seal support, placed between the first separator plate and the anode gas diffusion layer, the seal support being aligned with the fuel inlet or respectively the fuel outlet in the second separator plate and with the fuel inlet or respectively the fuel outlet in the first separator plate and with the sealing gasket.

Further, in some embodiments, the second separator plate comprises fuel flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels, and further comprises a step which surrounds the fuel inlet or outlet and is aligned therewith. In the embodiments where the anode catalyst layer and the cathode catalyst layer are each deposited on an opposite side of the polymer exchange membrane before the fuel cell is assembled to form a catalyst coated membrane and the method further comprises providing an adhesive layer deposited on a landing of the step which faces the solid polymer electrolyte, the adhesive layer being placed between the second separator plate and the cathode catalyst layer deposited on the polymer exchange membrane. In the embodiments where the cathode catalyst layer is deposited on the cathode diffusion layer before the fuel cell assembly, the method further comprises providing an adhesive layer deposited on the landing of the step which faces the polymer exchange membrane, the adhesive layer being placed between the second separator plate and the polymer exchange membrane.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an exploded view of fuel cell comprising a catalyst coated membrane, two adjacent gas diffusion layers, an anode and a cathode separator plate and a sealing arrangement according to the present invention.

Figure 2A is a top view of the fuel cell illustrated in Figure 1 and Figure 2B is a schematic cross section through the fuel cell along lines A-A.

Figure 3 is a schematic cross section drawing of detail "B" showing the sealing arrangement of a preferred embodiment of the present invention.

Figure 4 is a schematic cross section drawing of detail "B1" showing another embodiment of the sealing arrangement of the present invention.

Figure 5 is a schematic cross section drawing of detail "B2" showing yet another embodiment of the sealing arrangement of the present invention.

DETAILED DESCRIPTION

In the following description, certain specific details are set forth in order to provide a thorough understanding of various embodiments of the invention. However, one skilled in the art will understand that the invention may be practiced without these details. In other instances, well-known structures associated with fuel cells, fuel cell stacks, and fuel cell systems have not been shown or described in detail to avoid unnecessarily obscuring descriptions of the embodiments of the invention.

Unless the context requires otherwise, throughout the specification and claims which follow, the word "comprise" and variations thereof, such as "comprises" and "comprising" are to be construed in an open, inclusive sense, that is, as "including but not limited to".

Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment.

Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

As used herein “unbonded” means that the major surface of the gas diffusion layer or of the gas diffusion electrode is not attached to the corresponding contacting major surface of the catalyst-coated membrane or, respectively, of the membrane.

In the present context, “sealed” should not be understood necessarily as hermetically sealed. Instead, a membrane electrode assembly is “sealed” if, in operation, intermixing of the various fluids flowing across opposing sides of the membrane electrode assembly is sufficiently restricted so that fuel cell performance, durability and safety are not unduly compromised.

Figure 1 shows an exploded view of PEM fuel cell 100 comprising an unbonded MEA 110 according to the present invention. MEA 110 comprises a catalyst coated membrane (CCM) 112 disposed between an anode gas diffusion layer (GDL) 114 and a cathode gas diffusion layer (GDL) 116. MEA 110 is disposed between a first separator plate 120 and a second separator plate 121. The first and second separator plates preferably have the same configuration comprising fuel flow channels 122, on one side of the plate, which, in the assembled fuel cell, are facing the anode side of an MEA and oxidant flow channels 124, on the opposite side of the plate, which in the assembled fuel cell, are facing the cathode side of an MEA. Fuel flow channels 122 transport the fuel (e.g. hydrogen gas) to the reaction sites on the anode catalyst layer of the CCM and oxidant flow channels 124 transport the oxidant (e.g. air) to the reaction sites on the cathode catalyst layer of the CCM.

At the anode, the fuel (e.g. hydrogen gas), reacts at the catalyst layer to form hydrogen ions, protons, and electrons. At the cathode, the oxidant reacts at the catalyst layer to form anions. The polymer electrolyte membrane isolates the fuel stream from the oxidant stream and facilitates the migration of the protons from the anode to the cathode where they react with anions formed at the cathode. The electrons pass through an external circuit, creating a flow of electricity. The net reaction product is water.

Each of the separator plates 120 and 121 further comprises a fuel inlet port 126 for allowing fuel flow into the fuel flow channels 122 and a fuel outlet port 128 through which fuel exits the fuel flow channels 122.

As illustrated in Figures 1 and 2B, the anode side of the first separator plate 120 and respectively of the second separator plate 121 is provided with a pocket 130 and, in the assembled MEA, the anode GDL 114 fits within this pocket, is exposed to the reactant flowing through the fuel flow channels 122 and allows the diffusion of the fuel to the anode catalyst layer on the side of the CCM facing the anode GDL 114.

The anode GDL 114, the CCM 112 and the cathode GDL 116 are each provided with reactant inlet holes 142, 144 and respectively 146 which, in the assembled MEA, are aligned with the fuel inlet ports 126 of the separator plates to allow fuel flow from the fuel supply to the fuel flow channels 122, and are also provided with reactant outlet holes 143, 145 and respectively 147 which, in the assembled MEA, are aligned with the fuel outlet ports 128 of the separator plates to allow the fuel return from the fuel flow channels to the stack fuel outlet. In each fuel cell in the stack, hole 142 provided in the anode GDL 114 and hole 144 provided in the CCM 112 have preferably the same size as the fuel inlet ports 126 and hole 143 provided in the anode GDL and hole 145 provided in CCM 112 have preferably the same size as the fuel outlet ports 128. Holes 146 and 147 in the cathode GDL 116 are preferably larger than holes 142 and 144 and respectively larger than holes 143 and 145 to accommodate a sealing gasket 140 for sealing the fuel inlets and respectively the fuel outlets as further described below and further illustrated in Figures 2B, 3, 4 and 5. The fuel inlet ports 126 can have the same size as the fuel outlet ports 128, or they can be of a different size, for example the fuel outlet ports can be larger than the fuel inlet ports.

The oxidant, generally air, is supplied to the oxidant flow channels from a source (it can be, for example, air from the surrounding environment) and the oxidant flows through the oxidant flow channels 124 to the reaction sites on the cathode catalyst layer of the CCM. The fuel cell illustrated in the

present figures has an open stack configuration whereby the oxidant flow channels 124 are open to the environment.

The MEAs in the stack of the present invention are unbonded, which is interpreted to mean that, when the fuel cells are being assembled, the components of the MEAs, more specifically the CCM, the anode gas diffusion layer and the cathode diffusion layer are not attached (bonded) to each other. When the fuel cells are assembled, the MEA components and the separator plates are stacked together as illustrated in Figure 1, and the stack compression system (not illustrated) enables and preserves the contact between the fuel cell components.

In the present invention, the fuel cell sealing arrangement comprises a layer of adhesive 150 which is applied on the landing 152 at the periphery of the first separator plate 120, the landing stretching along the entire perimeter of the plate. The layer of adhesive 150 provides the adhesion of the CCM 112 to the anode side of the first separator plate 120 along its landing 152. The layer of adhesive 150 seals the anode GDL 114 from the surrounding environment. The cathode GDL 116 is compressed between the second separator plate 121 and the CCM 112, compression provided by the stack compression system (not illustrated). In some embodiments, where the cathode GDL and associated structure is not sufficient to support the adhesive layer, the edge of the separator plate is configured to provide the compression of the edge of the cathode GDL between the CCM and the separator plate so that the cathode GDL is supported by the separator plate and that the adhesive layer does not go into tension. This can be done for example by extending the landings at the periphery of the separator plate on the cathode side or providing an additional element (e.g. a frame) that is placed between the cathode GDL and the separator plate. In the embodiments having an open stack configuration, illustrated in the present figures, where the oxidant flow channels do not need to be sealed from the environment, such a modification of the separator plate could be omitted. In all embodiments, the cathode GDL 116 mechanically supports the adhesive layer 150 when the adhesive layer is

compressed between the first separator plate 120 and the proton exchange membrane during the stack assembly.

The present invention provides a simple design of a sealing arrangement for each fuel cell in the stack which does not involve any sealing gaskets for sealing the anode and cathode gas diffusion layers. The layer of adhesive is preferably applied on the separator plate landing before the fuel cell is assembled. An epoxy based adhesive is generally used as the material for the layer of adhesive 150 applied on the separator plate. Other types of adhesives could also be used such as silicone based, or acrylic adhesives. Also, a low melting temperature thermoplastic can be used. For example Kynar ink is printed on the landing 152, and is then heated to the melting point of the ink so that it connects the membrane to the plate. This simplifies the manufacturing process for the fuel cell compared the previous prior art solutions using two or more adhesive layers which are applied after the stack is assembled. Furthermore, because the adhesive layer is applied to a substantially flat surface, in the present solution either an adhesive tape or an adhesive liquid can be applied to the separator plate. With the present sealing arrangement, individual fuel cells can be assembled separately and can be added to an existing stack when required. Furthermore, fuel cells can be removed from the stack and/or can be replaced without destroying the sealing of the entire stack as is the case in the solutions described in the existing prior art (for example in the United States patent no. 8,067,128). This is a more efficient and cost effective method for maintaining an operational fuel cell stack and can extend the stack life time. Also, overall the stack described in the present invention has a more esthetically pleasing appearance without any adhesive layer being exposed to the outside surface of the stack.

As illustrated in Figures 1, 2B, and 3, fuel cell 100 may preferably comprise sealing gaskets 140 which are placed between the second separator plate 121 and the CCM 112 to seal the fuel inlet port 126 and respectively the fuel outlet port 128 on the side of the cathode GDL. As further illustrated in Figure 3, sealing gasket 140 fits within hole 147 provided in the cathode GDL

116 and prevents the leakage of fuel flowing through the fuel outlet port 128 to the cathode GDL and further to the oxidant flow channels. A similar arrangement is provided for the fuel inlet port 126.

As illustrated in Figure 4, in another embodiment, the fuel cell may
5 further comprise a seal support 260 which is placed between the anode GDL 214 and the first separator plate 220, for example in a pocket 264 provided in the first separator plate 220 such that, in the assembled fuel cell, the seal support 260 is placed around the fuel outlet port 228, being substantially aligned along the vertical direction with the sealing gasket 240 to support it
10 when the fuel cell is assembled and when the stack of fuel cells is compressed. A similar arrangement can be provided at the fuel inlet. Similar to the first embodiment illustrated in Figure 3, anode GDL 214 is placed in a pocket 230 provided in the first separator plate 220 and an adhesive layer 250 is deposited on the landing 252 of the first separator plate 220 to ensure the sealing
15 between the CCM 212 and the first separator plate 220. The sealing of the fuel inlet and outlet ports relative to the oxidant flow channels is achieved in a similar way as described in relation to the first embodiment illustrated in Figure 1, more specifically through the sealing gasket 240 placed in a hole 247 in the cathode GDL 216 between the second separator plate 221 and CCM 212.

20 In yet another embodiment of the present invention illustrated in Figure 5, the sealing of the fuel inlet and outlet ports is not done by using sealing gaskets. Instead, the cathode side of the second separator plate 321 is provided with a step 340 which, in the assembled fuel cell, surrounds the fuel outlet port 328, and an adhesive layer 370 is deposited on the landing 341 of
25 the step that is facing the CCM 312. Step 340 and adhesive layer 370 fit within hole 347 provided in the cathode GDL 316 and provide an adhesive connection between the second separator plate 321 and CCM 312. A similar arrangement is provided at the fuel inlet (not illustrated). Similar to the other embodiments, anode GDL 314 is placed in a pocket 330 provided in the first separator plate
30 320 and the sealing between the CCM 312 and the first separator plate 320 is

ensured by the adhesive layer 350 which is deposited on the landing 352 of the first separator plate 320.

In all the described embodiments, instead of the CCM and gas diffusion layers arrangement, the MEAs can comprise a polymer electrolyte membrane and an anode and respectively a cathode diffusion electrode whereby the anode and the cathode catalyst layers are incorporated into the anode gas diffusion layer and, respectively, in the cathode gas diffusion layer to form a gas diffusion anode, and respectively a gas diffusion cathode.

As a person skilled in the art would know, the separator plates of the present invention can be made of a metallic, carbonaceous, graphitic or polymeric material. All of the above U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification and/or listed in the Application Data Sheet, are incorporated herein by reference, in their entirety. This application also claims the benefit of U.S. Provisional Patent Application No. 62/511,208, filed May 25, 2017, and is incorporated herein by reference in its entirety.

While particular elements, embodiments, and applications of the present invention have been shown and described, it will be understood that the invention is not limited thereto since modifications may be made by those skilled in the art without departing from the spirit and scope of the present disclosure, particularly in light of the foregoing teachings.

CLAIMS

1. A solid polymer electrolyte fuel cell comprising:

a membrane electrode assembly comprising a polymer exchange membrane disposed between an anode catalyst layer and a cathode catalyst layer, an anode gas diffusion layer adjacent the anode catalyst layer, and a cathode gas diffusion layer adjacent the cathode catalyst layer;

a first separator plate adjacent to the anode gas diffusion layer comprising fuel flow channels provided on its side facing the anode gas diffusion layer and a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels; and

a second separator plate adjacent to the cathode diffusion layer comprising oxidant flow channels provided on its side facing the cathode gas diffusion layer;

wherein the anode gas diffusion layer is placed in a pocket of the first separator plate, the pocket carrying the fuel flow channels, and the sealing arrangement for the fuel cell comprising of an adhesive layer deposited on a landing at the periphery of the first separator plate that lies around the pocket where the anode gas diffusion layer is placed, the adhesive layer connecting the polymer exchange membrane with the side of the first separator plate facing the anode gas diffusion layer.

2. The solid polymer electrolyte fuel cell of claim 1, wherein the anode catalyst layer and the cathode catalyst layer are each deposited on an opposite side of the polymer exchange membrane before the fuel cell assembly to form a catalyst coated membrane.

3. The solid polymer electrolyte fuel cell of claim 1, wherein the anode catalyst layer and the cathode catalyst layer are each deposited on the anode gas fluid diffusion layer and, respectively, on the cathode gas diffusion layer

before the fuel cell assembly to form a gas diffusion anode, and respectively a gas diffusion cathode.

4. The solid polymer electrolyte fuel cell of claim 2 wherein the second separator plate further comprises fuel flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels, and wherein the solid polymer electrolyte fuel cell further comprises a sealing gasket placed between the cathode catalyst layer deposited on the polymer exchange membrane and the second separator plate, the sealing gasket being aligned with the fuel inlet in the second separator plate and passing through a hole provided in the cathode gas diffusion layer.

5. The solid polymer electrolyte fuel cell of claim 3 wherein the second separator plate further comprises fuel flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels, and wherein the solid polymer electrolyte fuel cell further comprises a sealing gasket placed between the polymer exchange membrane and the second separator plate, the sealing gasket being aligned with the fuel inlet in the second separator plate and passing through a hole provided in the cathode gas diffusion layer.

6. The solid polymer electrolyte fuel cell of claim 2 wherein the second separator plate further comprises fuel flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels, and wherein the solid polymer electrolyte fuel cell further comprises a sealing gasket placed between the cathode catalyst layer deposited on the polymer exchange membrane and the second separator plate, the sealing gasket being aligned with the fuel outlet in the second separator plate and passing through a hole provided in the cathode gas diffusion layer.

7. The solid polymer electrolyte fuel cell of claim 3 wherein the second separator plate further comprises fuel flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels, and wherein the solid polymer electrolyte fuel cell further comprises a sealing gasket placed between the polymer exchange membrane and the second separator plate, the sealing gasket being aligned with the fuel outlet in the second separator plate and passing through a hole provided in the cathode gas diffusion layer.
8. The solid polymer electrolyte fuel cell of claim 4 or 6 further comprising a seal support, placed between the first separator plate and the anode gas diffusion layer, the seal support being aligned with and placed in the vicinity of the fuel inlet or the fuel outlet in the second separator plate and being aligned with the sealing gasket.
9. The solid polymer electrolyte fuel cell of claim 5 or 7 further comprising a seal support, placed between the first separator plate and the anode gas diffusion anode, the seal support being aligned with and placed in the vicinity of the fuel inlet of the fuel outlet in the second separator plate and being aligned with the sealing gasket.
10. The solid polymer electrolyte fuel cell of claim 2 wherein the second separator plate comprises fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels, and further comprises a step which surrounds the fuel inlet or the fuel outlet and is aligned therewith, and an adhesive layer deposited on a landing of the step which faces the solid polymer electrolyte, the adhesive layer being placed between the second separator plate and the cathode catalyst layer deposited on the polymer exchange membrane.

11. The solid polymer electrolyte fuel cell of claim 3 wherein the second separator plate comprises fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels, and further comprises a step which surrounds the fuel inlet or the fuel outlet and is aligned therewith, and an adhesive layer deposited on a landing of the step which faces the solid polymer electrolyte, the adhesive layer being placed between the second separator plate and the polymer exchange membrane.

12. The solid polymer electrolyte fuel cell of claim 1 wherein the adhesive layer is made of an epoxy based adhesive, a silicone based adhesive, an acrylic adhesive or a low melt temperature thermoplastic material.

13. The solid polymer electrolyte fuel cell of claim 1 wherein the adhesive layer is an adhesive tape.

14. The solid polymer electrolyte fuel cell of claim 1 wherein the first separator plate has the same construction as the second separator plate.

15. A method of sealing a solid polymer electrolyte fuel cell, the fuel cell comprising a membrane electrode assembly which comprises a polymer exchange membrane disposed between an anode catalyst layer and a cathode catalyst layer, an anode gas diffusion layer adjacent the anode catalyst layer, and a cathode gas diffusion layer adjacent the cathode catalyst layer; a first separator plate adjacent to the anode gas diffusion layer comprising fuel flow channels provided on its side facing the anode gas diffusion layer and a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels; and a second separator plate adjacent to the cathode diffusion layer comprising oxidant flow channels provided on its side facing the cathode gas diffusion layer; wherein

the anode gas diffusion layer is placed in a pocket of the first separator plate, the pocket carrying the fuel flow channels, the method comprising:

providing an adhesive layer deposited on a landing at the periphery of the first separator plate that lies around the pocket where the anode gas diffusion layer is placed, the adhesive layer connecting the polymer exchange membrane with the side of the first separator plate facing the anode gas diffusion layer.

16. The method of claim 15 wherein the second separator plate further comprises fuel flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels, and wherein the anode catalyst layer and the cathode catalyst layer are each deposited on an opposite side of the polymer exchange membrane to form a catalyst coated membrane, the method further comprising providing a sealing gasket placed between the cathode catalyst layer deposited on the polymer exchange membrane and the second separator plate, the sealing gasket being aligned with the fuel inlet or, respectively, with the fuel outlet in the second separator plate and passing through a hole provided in the cathode gas diffusion layer.

17. The method of claim 16 further comprising providing a seal support, placed between the first separator plate and the anode gas diffusion layer, the seal support being aligned with the sealing gasket.

18. The method of claim 15 wherein the second separator plate further comprises fuel flow channels, a fuel inlet and a fuel outlet fluidly connected to the fuel flow channels on its side that is opposite to the side comprising the oxidant flow channels, and a step which surrounds the fuel inlet or the fuel outlet and is aligned therewith and wherein the anode catalyst layer and the cathode catalyst layer are each deposited on an opposite side of the polymer exchange membrane before the fuel cell assembly to form a catalyst coated

membrane, the method further comprising providing an adhesive layer deposited on a landing of the step which faces the solid polymer electrolyte, the adhesive layer being placed between the second separator plate and the cathode catalyst layer deposited on the polymer exchange membrane.

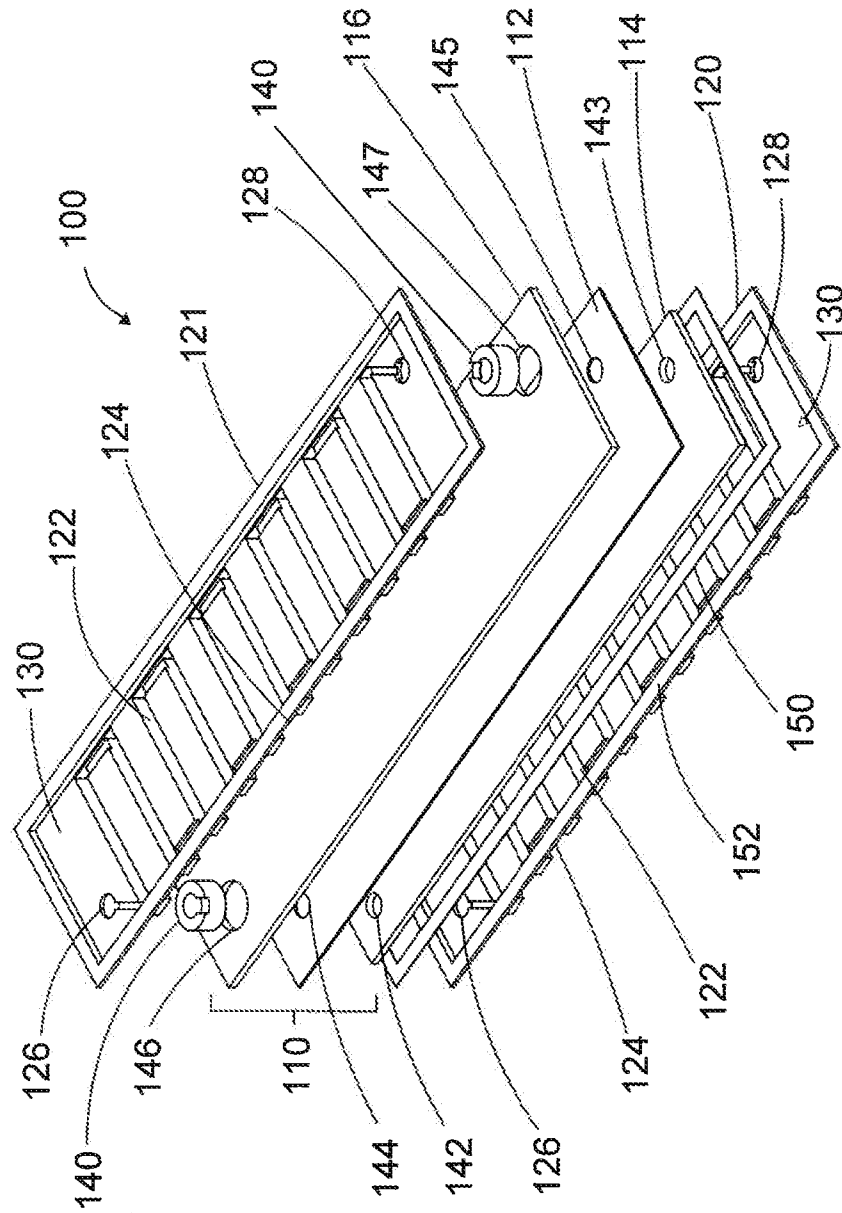


Figure 1

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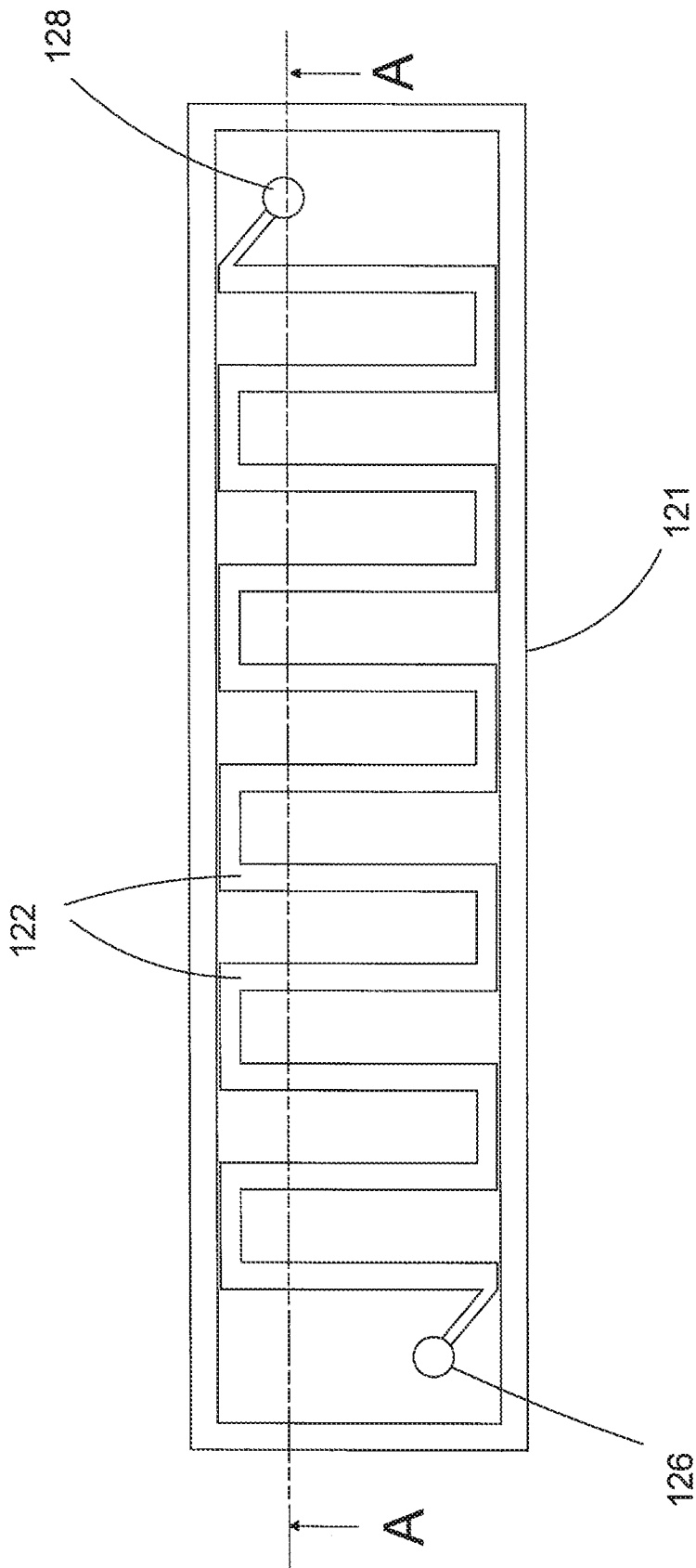


Figure 2A

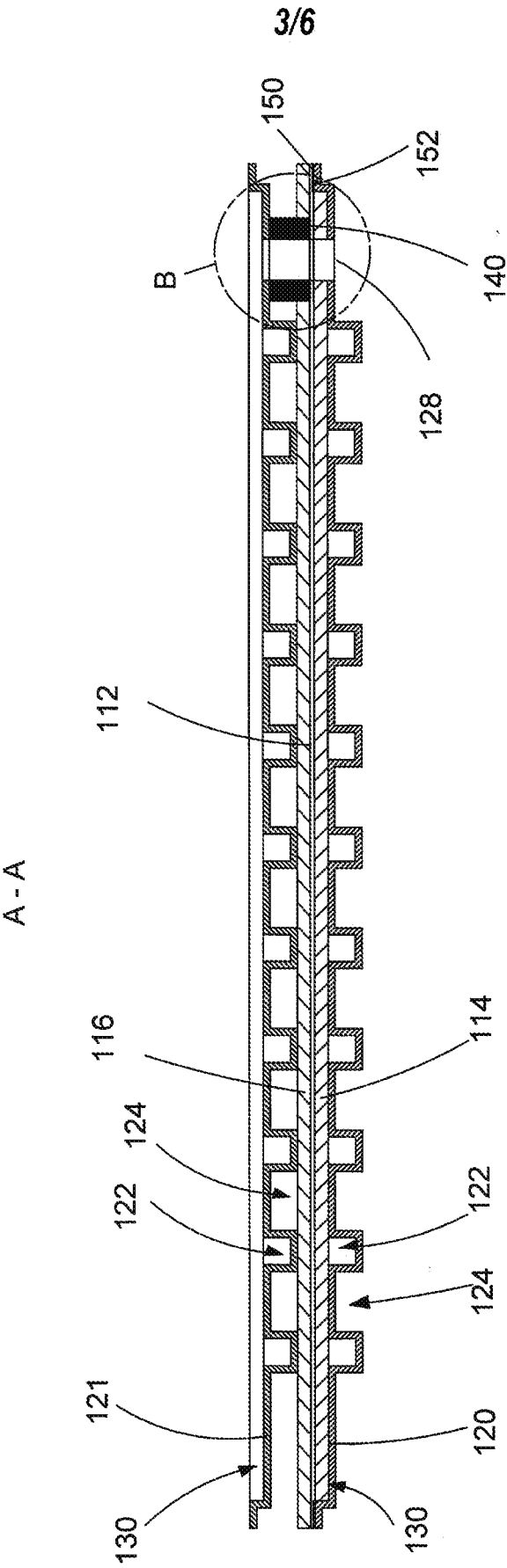


Figure 2B

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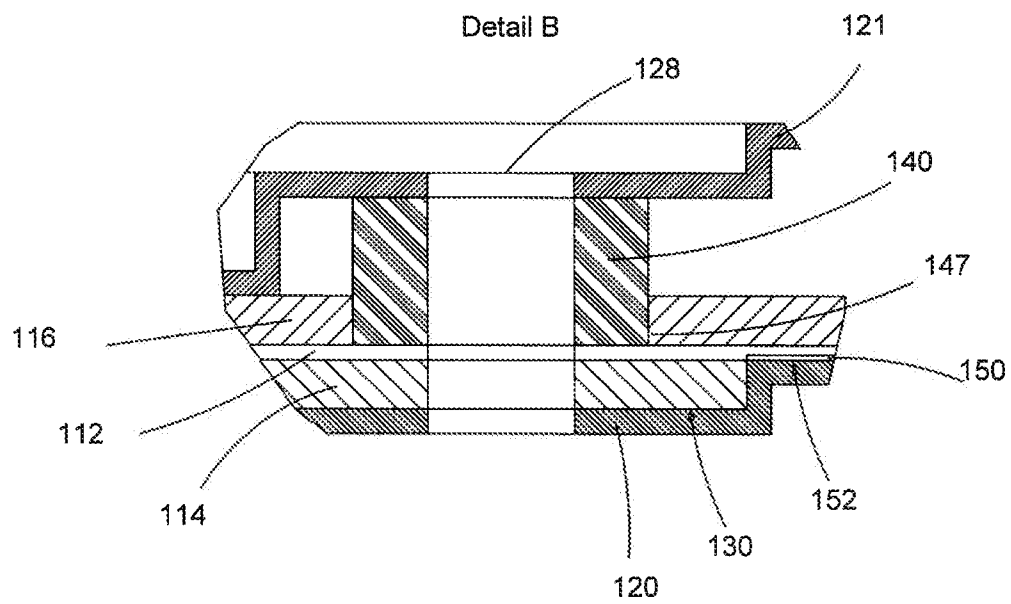


Figure 3

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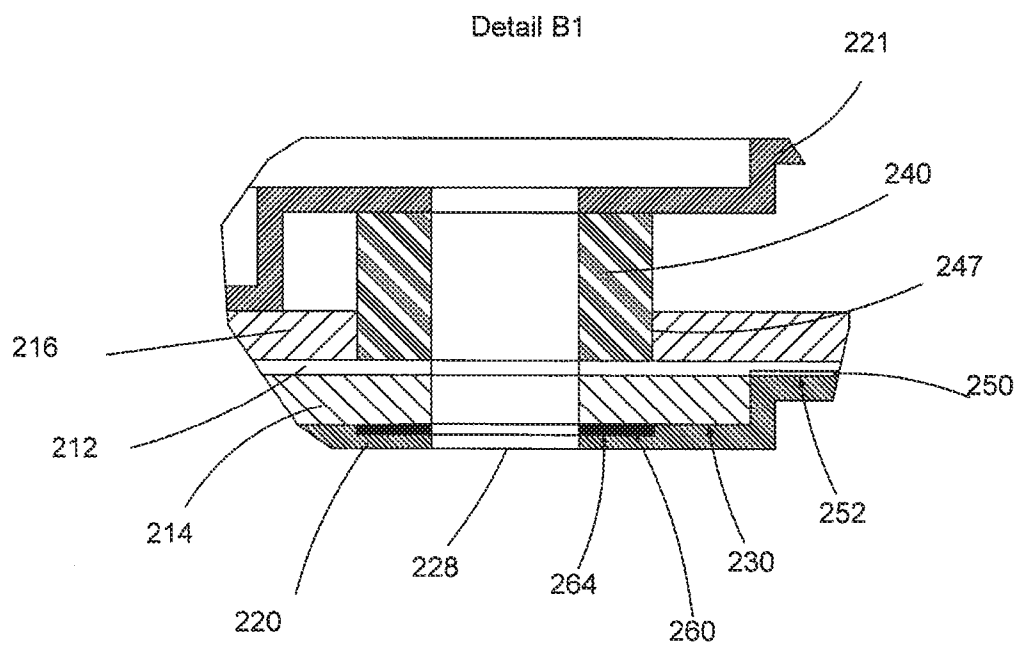


Figure 4

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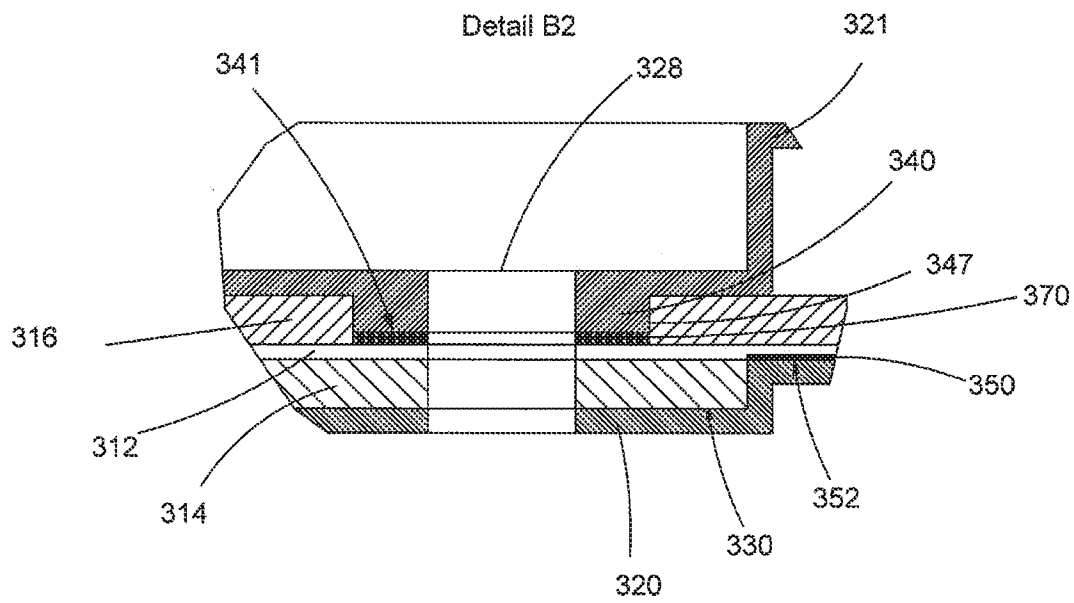


Figure 5

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2018/033537

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01M8/241 H01M8/0271 H01M8/0297 H01M8/0247 H01M8/2483
 ADD. H01M8/1018 H01M8/0284

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	EP 1 624 515 A1 (DU PONT CANADA [CA]) 8 February 2006 (2006-02-08) figures 3,4,6 claim 4 paragraphs [0043] - [0051] -----	1-3, 12-15 4-11, 16-18
X	US 2004/028983 A1 (HAYASHI TOMOKAZU [JP] ET AL) 12 February 2004 (2004-02-12) figure 10 paragraphs [0045], [0049] - [0053] -----	1,2,15
X	GB 2 348 047 A (BALLARD POWER SYSTEMS [CA]) 20 September 2000 (2000-09-20) figure 3b page 1 page 10, lines 6-10 page 14, lines 16-20 -----	1,3,12, 15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

27 June 2018

Date of mailing of the international search report

10/07/2018

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2018/033537

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