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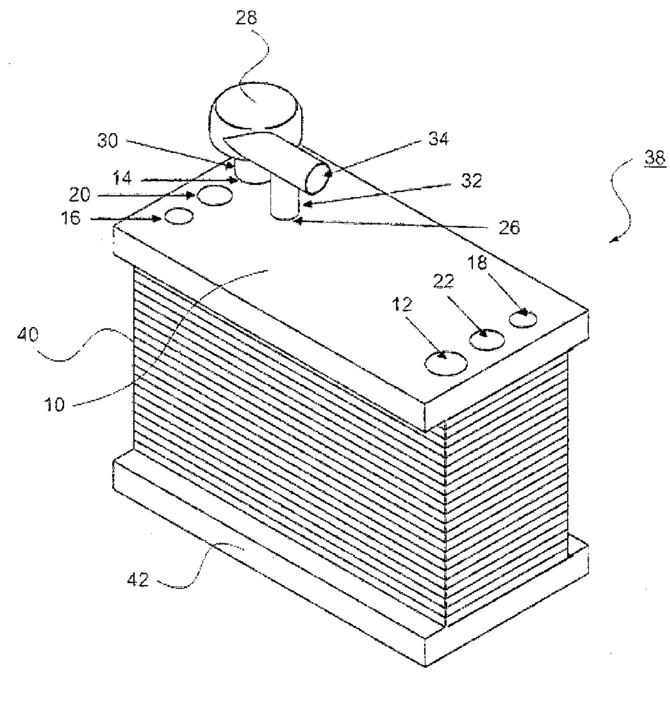
(54) **Title**: END PLATE ASSEMBLY FOR PROTON EXCHANGE MEMBRANE FUEL CELL AND FUEL CELL ASSEMBLY EMPLOYING SAME



(57) **Abstract**: An end plate assembly for a proton exchange membrane (PEM) fuel cell and a fuel cell assembly (38) are provided. The end plate assembly includes a planar member (10) having an inlet port (12) and an outlet port (14), and a pump (28). The pump (28) includes a suction inlet (30) connected to the outlet port (14) of the planar member (10), a first discharge outlet (32) in fluid communication with the inlet port (12) of the planar member (10) and a second discharge outlet (34). The pump (28) is arranged to suck exhaust from a cathode side of the proton exchange membrane fuel cell via the outlet port (14) of the planar member (10) to create a negative pressure environment in the cathode side of the proton exchange membrane fuel cell and to re-circulate a portion of the exhaust via the inlet port (12) of the planar member (10) to hydrate a membrane of the proton exchange membrane fuel cell.

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END PLATE ASSEMBLY FOR PROTON EXCHANGE MEMBRANE FUEL CELL AND FUEL CELL ASSEMBLY EMPLOYING SAME

Field of the Invention

The present invention relates to fuel cell technology and more particularly to an end plate assembly for a proton exchange membrane (PEM) fuel cell and a fuel cell assembly employing the same.

Background of the Invention

In solid polymer fuel cells that use a proton exchange membrane as the electrolyte, the water content of the membrane greatly influences the performance of the fuel cell. In general, the proton conductivity of a membrane increases with increases in its water content. It is therefore desirable to maintain a sufficiently high level of hydration in the membrane during fuel cell operation.

Summary of the Invention

Accordingly, in a first aspect, the present invention provides an end plate assembly for a proton exchange membrane fuel cell. The end plate assembly includes a planar member having an inlet port and an outlet port, and a pump. The pump includes a suction inlet connected to the outlet port of the planar member, a first discharge outlet in fluid communication with the inlet port of the planar member and a second discharge outlet. The pump is arranged to suck exhaust from a cathode side of the proton exchange membrane fuel cell via the outlet port of the planar member to create a negative pressure environment in the cathode side of the proton exchange membrane fuel cell and to re-circulate a portion of the exhaust via the inlet port of the planar member to hydrate a membrane of the proton exchange membrane fuel cell.

In a second aspect, the present invention provides a fuel cell assembly. The fuel cell assembly includes a first end plate having an inlet port and an outlet port, a second end plate, a fuel cell stack coupled between the first and second end plates, and a pump. The pump includes a suction inlet connected to the outlet port of the first end plate, a first discharge outlet in fluid communication with the inlet port of the first end plate and a second discharge outlet. The pump is arranged to suck exhaust from cathode sides of the fuel cell stack via the outlet port of the first end plate to create a negative pressure environment in the cathode sides of the fuel cell stack and to re-circulate a portion of the exhaust via the inlet port of the first end plate to hydrate membranes of the fuel cell stack.

Other aspects and advantages of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

Brief Description of the Drawings

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a bottom perspective view of a planar member of an end plate assembly in accordance with one embodiment of the present invention;

FIG. 2 is a top plan view of the planar member of FIG. 1;

FIG. 3 is a perspective view of a pump of an end plate assembly in accordance with one embodiment of the present invention;

FIG. 4 is a perspective view of a fuel cell assembly in accordance with one embodiment of the present invention;

FIG. 5 is a graph showing a stack voltage of a fuel cell assembly in accordance with one embodiment of the present invention over a range of operation currents compared to that of a fuel cell assembly employing a conventional end plate; and

FIG. 6 is a graph showing a power output of a fuel cell assembly in accordance with one embodiment of the present invention over time compared to that of a fuel cell assembly employing a conventional end plate.

Detailed Description of An Exemplary Embodiment

The detailed description set forth below in connection with the appended drawings is intended as a description of a presently preferred embodiment of the invention, and is not intended to represent the only form in which the present invention may be practiced. It is to be understood that the same or equivalent functions may be accomplished by different embodiments that are intended to be encompassed within the scope of the invention.

Referring now to FIG. 1, a bottom perspective view of a planar member 10 of an end plate assembly for a proton exchange membrane (PEM) fuel cell is shown. The planar member or end plate10 includes a first inlet port 12 for receiving a supply of a reactant gas, a first outlet port 14 for exhausting the reactant gas. In the present embodiment, the planar member 10 also includes a second inlet port 16 for receiving a supply of fuel, a second outlet port 18 for exhausting the fuel, a third inlet port 20 for receiving a flow of cooling water and a third outlet port 22 for discharging the cooling water. In the embodiment shown, a channel 24 is formed in the planar member 10. The channel 24 in the present embodiment fluidly connects a first discharge outlet of a pump (not shown) to the first inlet port 12 of the planar member 10.

The planar member or end plate 10 may be made of metal, reinforced epoxy or other composite material and may be fabricated by machining, casting or moulding. The ports 12, 14, 16, 18, 20 and 22 and the channel 24 may be formed in the planar member 10 by drilling, casting or moulding.

Referring now to FIG. 2, a top plan view of the planar member 10 of FIG. 1 is shown. As can be seen from FIGS. 1 and 2, the reactant gas supply inlet 12, the reactant gas exhaust outlet 14, the fuel supply inlet 16, the fuel exhaust outlet 18, the cooling water inlet 20 and the cooling water outlet 22 extend through the end plate 10. An inlet 26 of the channel 24 is visible on the top surface of the end plate 10, but not the channel 24 as the channel 24 is formed on an underside of the end plate 10 in the present embodiment. The inlet 26 is fluidly connected to the reactant gas supply inlet 12 via the conduct channel 24 in the present embodiment.

Although the end plate 10 is shown in FIGS. 1 and 2 as having three through holes at each end, it should be understood by those of ordinary skill in the art that the present invention is not limited by the number of through holes or the location of the through holes. Fewer or more through holes in alternative layouts may be provided in alternative embodiments.

Referring now to FIG. 3, a perspective view of a pump 28 of an end plate assembly for a proton exchange membrane (PEM) fuel cell is shown. The pump 28 includes a suction inlet 30, a first discharge outlet 32 and a second discharge outlet 34. The suction inlet 30 is to be connected to the first outlet port or reactant gas exhaust outlet 14 of the planar member or end plate 10 of FIGS. 1 and 2 to suck exhaust reactant gas stream from a fuel cell stack. The first discharge outlet 32 is to be connected to the inlet 26 of the channel 24 shown in FIG. 2 such that the first discharge outlet 32 is in fluid communication with the first inlet port or reactant gas supply inlet 12 of the planar member or end plate 10 via the channel 24. The second discharge outlet 34 of the pump 28 is open to an ambient environment. A valve regulator 36 is provided at a bifurcation between the first discharge outlet 32 and the second discharge outlet 34 of the pump 28.

The pump 28 is arranged to suck exhaust from a cathode side of the proton exchange membrane fuel cell via the first outlet port or reactant gas exhaust outlet 14 of the planar member or end plate 10 to create a negative pressure environment in the cathode side of the proton exchange membrane fuel cell and to recirculate a portion of the exhaust via the first inlet port or reactant gas supply inlet 12 of the planar member or end plate 10 to hydrate a membrane of the proton exchange membrane fuel cell. In one embodiment, the pump 28 is arranged to suck the exhaust from the cathode side of the proton exchange membrane fuel cell to create a negative pressure environment of between about 0.1 metre of water column (m WC) and about 3 m WC, and more preferably, about 0.5 m WC, in the cathode side of the proton exchange membrane fuel cell. In the embodiment shown, the pump 28 is a blower having a bifurcated outlet to partially re-circulate the exhaust reactant gas stream by allocating a fraction of the exhaust reactant gas stream into a mixing chamber via the conduct channel 24.

In one embodiment, the valve regulator 36 is arranged to direct between about 10 percent (%) and about 60 % of the exhaust to the first discharge outlet 32 for recirculation.

Referring now to FIG. 4, a fuel cell assembly 38 incorporating the planar member 10 and the pump 28 of an end plate assembly of a proton exchange membrane (PEM) fuel cell described above with reference to FIGS. 1 to 3 is shown. The fuel cell assembly 38 includes a fuel cell stack 40 coupled between a first end plate 10 and a second end plate 42.

The first end plate 10 includes a first inlet port or reactant gas supply inlet 12, a first outlet port or reactant gas exhaust outlet 14, a second inlet port or fuel supply inlet 16, a second outlet port or fuel exhaust outlet 18, a third inlet port or cooling water inlet 20 and a third outlet port or cooling water outlet 22. In the present embodiment, the first end plate 10 is located at the top of the fuel cell stack 40.

The pump 28 includes a suction inlet 30, a first discharge outlet 32 and a second discharge outlet 34. The suction inlet 30 is connected to the first outlet port or reactant gas exhaust outlet 14 of the first end plate 10 to suck exhaust reactant gas from the fuel cell stack 40. The first discharge outlet 32 is connected to a recirculation inlet 26 at an opening of a channel (channel 24 shown in FIG. 1) such that the first discharge outlet 32 is in fluid communication with the first inlet port or reactant gas supply inlet 12 of the first end plate 10 via the channel 24. The channel 24 fluidly connects the first discharge outlet 32 of the pump 28 to the first inlet port or reactant gas supply inlet 12 of the first end plate 10. The second discharge outlet 34 of the pump 28 is open to an ambient environment.

The channel 24 in the present embodiment is integrally formed inside the first end plate 10. Advantageously, this makes the fuel cell system more compact and elegant and improves the reliability and energy density of the fuel cell system. Nevertheless, although the conduct channel 24 is illustrated and described in the present embodiment as being an internal channel integrated inside the first end plate 10, it should be understood by those of ordinary skill in the art that the present invention is not limited by the layout or arrangement of the conduct channel. For example, in an alternative embodiment, the conduct channel may be an external channel attached outside the first end plate 10.

The fuel cell stack 40 includes a series of similar fuel cells. As fuel cell stacks are well known to those of ordinary skill in the art, a detailed description of the fuel stack 40 is not required for a complete understanding of the present invention.

Fuel supplied into the fuel cell stack 40 through the fuel supply inlet 16 enters an anode side of each fuel cell in the fuel cell stack 40 where the fuel is split into protons and electrons by catalysts. The fuel supply stream may be a pure hydrogen stream or a mixed hydrogen stream.

Concurrently, a reactant gas stream is introduced through the reactant gas supply inlet 12 into a cathode side of each fuel cell where the reactant gas combines with the protons passing though solid proton exchange membranes of the fuel cells and the electrons received via an outer circuit (not shown) to form water and generate heat. The reactant gas supply stream may be an oxidant supply stream and in such an embodiment, the reactant gas exhaust stream is an oxidant exhaust stream.

Water distribution in the fuel cell stack 40 is managed through an end plate assembly including the first end plate 10 and the pump 28.

The pump 28 is connected to the exhaust port 14 to suck out the exhaust reactant gas. More particularly, the pump 28 is arranged to suck exhaust from cathode sides of the fuel cell stack 40 via the first outlet port or reactant gas exhaust outlet 14 of the first end plate 10 to create a negative pressure environment in the cathode sides of the fuel cell stack. In one embodiment, the pump 28 is arranged to suck the exhaust from the cathode sides of the fuel cell stack 40 to create a negative pressure environment of between about 0.1 metre of water column (m WC) and about 3 m WC, and more preferably about 0.5 m WC, in the cathode sides of the fuel cell stack 40. Therefore, the cathode sides of all the fuel cells in the fuel cell stack 40 are at negative pressure, instead of positive pressure. Evaporation of water is promoted in a negative pressure environment and this induces three benefits. Firstly, more water is exhausted in vapour form and this helps prevent the undesirable flooding phenomenon. Secondly, more heat is carried out and thus removed from the fuel cell stack 40 with higher vaporisation levels and this reduces the complexity of the stack cooling requirements. Lastly, corrosion at the exhaust port area due to liquid water accumulation is reduced or eliminated.

The pump 28 is also arranged to recirculate a portion of the exhaust via the first inlet port or reactant gas supply inlet 12 of the first end plate 10 to hydrate the membranes of the fuel cell stack 40. The vapour-rich exhaust gas stream that is sucked into the pump 28 is allocated through the bifurcated outlet. A portion of the vapour-rich exhaust gas stream is recirculated into the fuel cell stack 40 through the first discharge outlet 32 which is fluidly connected to the reactant gas supply inlet 12 of the first end plate 10 via the recirculation inlet 26 and the conduct channel 24, and the other portion is exhausted into the ambient environment via the second discharge outlet 34. The fraction of exhaust stream to be recirculated may be allocated by a valve regulator (valve regulator 36 in FIG. 3) provided at a bifurcation between the first discharge outlet 32 and the second discharge outlet 34.

Due to the negative pressure inside the fuel cell stack 40, fresh reactant gas stream is automatically sucked into the reactant gas supply inlet 12. The reactant gas supply inlet 12 is connected to a mixing chamber (not shown) beneath the reactant gas supply inlet 12. In the present embodiment, the mixing chamber is a cylindrical channel formed at an end of the bipolar plate of each fuel cell in the fuel cell stack 40. Mixing of a fraction of the exhaust reactant gas stream with the fresh intake reactant gas supply stream takes place in the reactant gas-mixing chamber. The fresh reactant gas is humidified and heated when mixed with the vapour-rich re-circulated exhaust gas. The humidified and heated reactant gas is then distributed to the cathode side of each fuel cell in the fuel cell stack 40. The moisture in the humidified reactant gas diffuses through the solid polymer membranes of the fuel cells to the anode sides. The humidity of the solid polymer membranes is thus kept in a favourable condition both at the cathode side and at the anode side.

The performance of the end plate assembly of the present invention was investigated by experiments performed using fuel cell stacks incorporating the end plate assembly of the present invention and comparing the results obtained from these with that obtained from identical fuel cell stacks employing conventional end plates.

Experiment 1

In a first experiment, a fuel cell stack was assembled. The rated power of the stack having an average unit cell voltage of 0.7 volt (V) is 1 kilowatt (kW). The endplate was formed to a dimension of 200 millimetres (mm) in length, 80 mm in width and 12 mm in height. The reactant gas supply inlet, the exhaust port and the recirculation inlet are formed to a diameter of 12 mm. The fuel supply inlet and the fuel exhaust port are formed to a diameter of 8 mm. A conduct channel linking the recirculation inlet and the reactant gas supply inlet is integrated inside the endplate. The channel is formed to a width of 12mm and a depth of 8 mm. The fuel cell stack contains a total of 64 cells. A 25 micron (μm) thick catalyst coated proton exchange Nafion membrane having 0.4 milligram per square centimetre (mg/cm^2) platinum catalyst loading on both the anode and the cathode was selected. The stack was designed with a liquid cooling structure and was operated at a dead-end mode at the anode.

The electrical performance and stability of the stack was tested in both a self-humidification mode with an end plate assembly of the present invention installed and a non-humidification mode employing a conventional end plate.

Referring now to FIG. 5, a graph showing a stack voltage of a fuel cell assembly in accordance with one embodiment of the present invention over a range of operation currents compared to that of a fuel cell assembly employing a conventional end plate is shown. The data for the current-voltage (I-V) curves shown in FIG. 5 are obtained from the assembled fuel cell stack operating in the self-humidifying mode and the non-humidifying mode. As can be seen from FIG. 5, the performance of the stack in the self-humidification mode employing the end plate assembly of the present invention is significantly better than that of the stack in the non-humidification mode employing the conventional end plate, and particularly so at high current densities. The improved performance of the self-humidifying stack is attributed to use of the end plate assembly of the present invention which provides the self-humidification function and helps keep the fuel cell stack in a favourable operating condition.

In the non-humidification mode, water loss at the anode resulting from the electro-osmotic drag causes drying of the anode and significantly increases the membrane resistance in the stack. In contrast, in the self-humidification mode, a portion of the water produced at the cathode is sucked out and fed back into an upstream portion of the stack through the mixing chamber. Advantageously, this enhances the reactant gas humidity at the cathode. The water moisture at the cathode side then diffuses through the membrane to the anode side. The ohmic polarization of the stack is decreased significantly due to hydration of the membrane. Consequently, the stack in the self-humidification mode displays higher current density.

Referring now to FIG. 6, a graph showing a power output of a fuel cell assembly in accordance with one embodiment of the present invention over time compared to that of a fuel cell assembly employing a conventional end plate is shown. FIG. 6 shows the results of stability testing of the stack in both the self-humidification and non-humidification modes. It was found that the power output of the stack in the non-humidification mode decreases rapidly from about 0.9 kW to about 0.3 kW within 5 hours (hr) at an average unit cell voltage of 0.7 V. The power output of the stack in the self-humidification mode however remains stable for over 20 hr at a power output of about 1 kW.

It is evident therefore that the stack employing the end plate assembly of the present invention exhibits excellent properties compared to that using the conventional end plate.

Experiment 2

A second experiment was performed with a second fuel cell stack having a rated power of 250 watt (W) and an average unit cell voltage of 0.7 V. The second fuel cell stack contains a total of 16 cells. The second fuel cell stack is largely similar to that used in the first experiment, the main difference being the absence of a cooling water inlet and a cooling water outlet in the second fuel cell stack. The second fuel cell stack was tested without water-cooling.

Stability testing was again performed on the stack in both the self-humidification mode with an end plate assembly of the present invention installed and the non-humidification mode employing a conventional end plate.

Through the stability testing, it was found that the power output of the stack in the non-humidification mode decreases rapidly from about 240 W to about 70 W within 5 hr at an average unit cell voltage of 0.7 V. In contrast, no noticeable drop in the power output of the stack was observed in the self-humidification mode within the same period.

As is evident from the foregoing discussion, the present invention provides a fuel cell assembly that uses water produced at a cathode to humidify a proton exchange membrane (PEM) fuel cell by recycling the discharged reactant gas stream and water vapour. The end plate assembly of the present invention enables a fraction of the vapour-rich discharged reactant gas to be mixed with and used to humidify fresh intake reactant gas, thereby providing a continuous supply of reactant gas and humidity to the fuel cell system. Additionally, recycling of the discharged reactant gas enhances the heat-exchange and this helps with the heat management and increases temperature uniformity in the fuel cell system. Further advantageously, the requirements of the fuel cell system are simplified with the present invention as use of the end plate assembly of the present invention eliminates the need for an external humidification system typically including a reservoir, a heater and piping. The end plate assembly of the present invention thus provides cost and space savings, whilst improving the efficiency of the whole fuel cell system.

Moreover, because exhaust reactant gas is sucked out with the end plate assembly of the present invention, the cathode sides of all the fuel cells are at negative pressure and evaporation of water is promoted at negative pressure. Consequently, more water is exhausted in vapour form and thus more heat is carried out from the fuel cell stack due to the high evaporation heat of water. This helps with the heat management and improves the stability of the fuel cell stack. Furthermore, due to the negative pressure in the fuel cell, the fresh reactant gas is automatically sucked into a mixing chamber where it is humidified and heated by the vapour-rich re-circulated exhaust gas before being distributed into the cathode side of each fuel cell. The water moisture then diffuses through the solid polymer membrane to the anode side. Thus, the humidity of the solid polymer membrane is kept in a favourable condition both at the cathode side and at the anode side.

The present invention is suitable for air-cooled and water-cooled fuel cell systems, and particularly, systems that employ near ambient pressure air as the oxidant gas supply.

While a preferred embodiment of the invention has been illustrated and described, it will be clear that the invention is not limited to this embodiment only.

Numerous modifications, changes, variations, substitutions and equivalents will be apparent to those skilled in the art without departing from the scope of the invention as described in the claims.

Further, unless the context dearly requires otherwise, throughout the description and the claims, the words "comprise", "comprising" and the like are to be construed in an inclusive as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

CLAIMS

1. An end plate assembly for a proton exchange membrane fuel cell, comprising:

a planar member having an inlet port and an outlet port; and

a pump having a suction inlet connected to the outlet port of the planar member, a first discharge outlet in fluid communication with the inlet port of the planar member and a second discharge outlet, wherein the pump is arranged to suck exhaust from a cathode side of the proton exchange membrane fuel cell via the outlet port of the planar member to create a negative pressure environment in the cathode side of the proton exchange membrane fuel cell and to recirculate a portion of the exhaust via the inlet port of the planar member to hydrate a membrane of the proton exchange membrane fuel cell.

2. The end plate assembly for a proton exchange membrane fuel cell of claim 1, wherein the pump is arranged to suck the exhaust from the cathode side of the proton exchange membrane fuel cell to create a negative pressure environment of between about 0.1 metre of water column (m WC) and about 3 m WC in the cathode side of the proton exchange membrane fuel cell.

3. The end plate assembly for a proton exchange membrane fuel cell of claim 2, wherein the pump is arranged to suck the exhaust from the cathode side of the proton exchange membrane fuel cell to create a negative pressure environment of about 0.5 m WC in the cathode side of the proton exchange membrane fuel cell.

4. The end plate assembly for a proton exchange membrane fuel cell of claim 1, further comprising a valve regulator at a bifurcation between the first discharge outlet and the second discharge outlet of the pump.

5. The end plate assembly for a proton exchange membrane fuel cell of claim 4, wherein the valve regulator is arranged to direct between about 10 percent (%) and about 60 % of the exhaust to the first discharge outlet for recirculation.

6. The end plate assembly for a proton exchange membrane fuel cell of claim 1, wherein the second discharge outlet of the pump is open to an ambient environment.

7. The end plate assembly for a proton exchange membrane fuel cell of claim 1, wherein the pump is a blower having a bifurcated outlet.

8. The end plate assembly for a proton exchange membrane fuel cell of claim 1, further comprising a channel fluidly connecting the first discharge outlet of the pump to the inlet port of the planar member.

9. The end plate assembly for a proton exchange membrane fuel cell of claim 8, wherein the channel is formed in the planar member.

10. A fuel cell assembly, comprising:

a first end plate having an inlet port and an outlet port;

a second end plate;

a fuel cell stack coupled between the first and second end plates; and

a pump having a suction inlet connected to the outlet port of the first end plate, a first discharge outlet in fluid communication with the inlet port of the first end plate and a second discharge outlet, wherein the pump is arranged to suck exhaust from cathode sides of the fuel cell stack via the outlet port of the first end plate to create a negative pressure environment in the cathode sides of the fuel cell stack and to recirculate a portion of the exhaust via the inlet port of the first end plate to hydrate proton exchange membranes of the fuel cell stack.

11. The fuel cell assembly of claim 10, wherein the pump is arranged to suck the exhaust from the cathode sides of the fuel cell stack to create a negative pressure environment of between about 0.1 metre of water column (m WC) and about 3 m WC in the cathode sides of the fuel cell stack.

12. The fuel cell assembly of claim 11, wherein the pump is arranged to suck the exhaust from the cathode sides of the fuel cell stack to create a negative pressure environment of about 0.5 m WC in the cathode sides of the fuel cell stack.

13. The fuel cell assembly of claim 10, further comprising a valve regulator at a bifurcation between the first discharge outlet and the second discharge outlet of the pump.

14. The fuel cell assembly of claim 13, wherein the valve regulator is arranged to direct between about 10 percent (%) and about 60 % of the exhaust to the first discharge outlet for recirculation.

15. The fuel cell assembly of claim 10, wherein the second discharge outlet of the pump is open to an ambient environment.

16. The fuel cell assembly of claim 10, wherein the pump is a blower having a bifurcated outlet.

17. The fuel cell assembly of claim 10, further comprising a channel fluidly connecting the first discharge outlet of the pump to the inlet port of the first end plate.

18. The fuel cell assembly of claim 17, wherein the channel is formed in the first end plate.

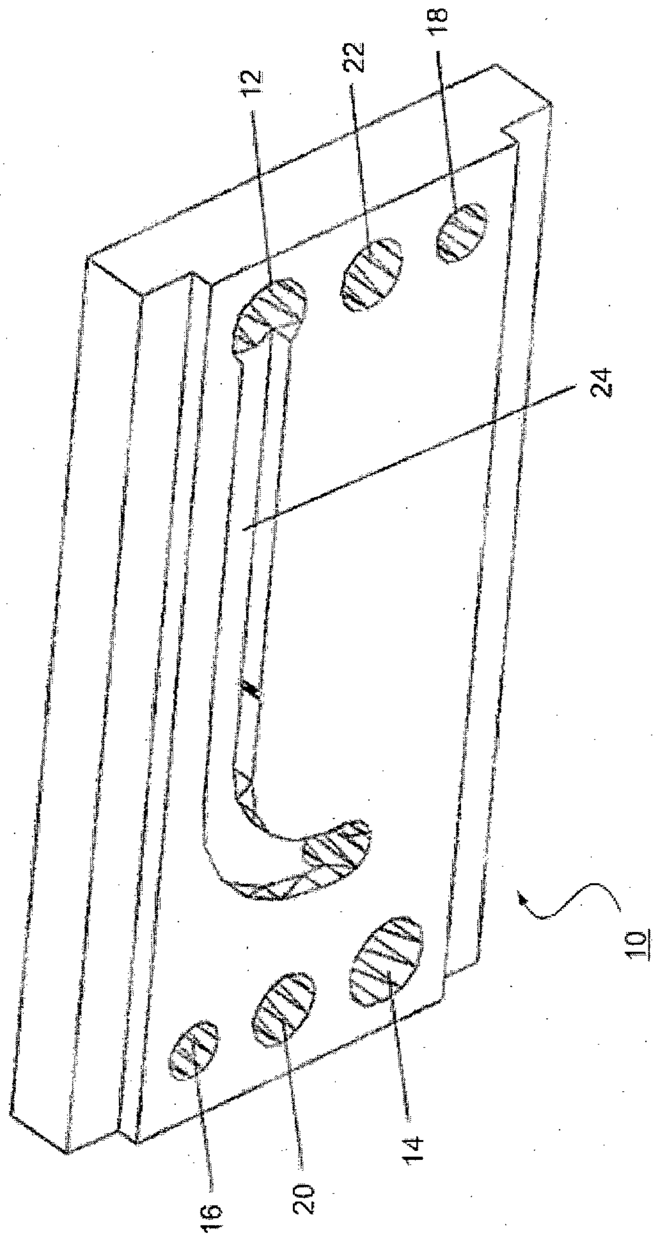


FIG. 1

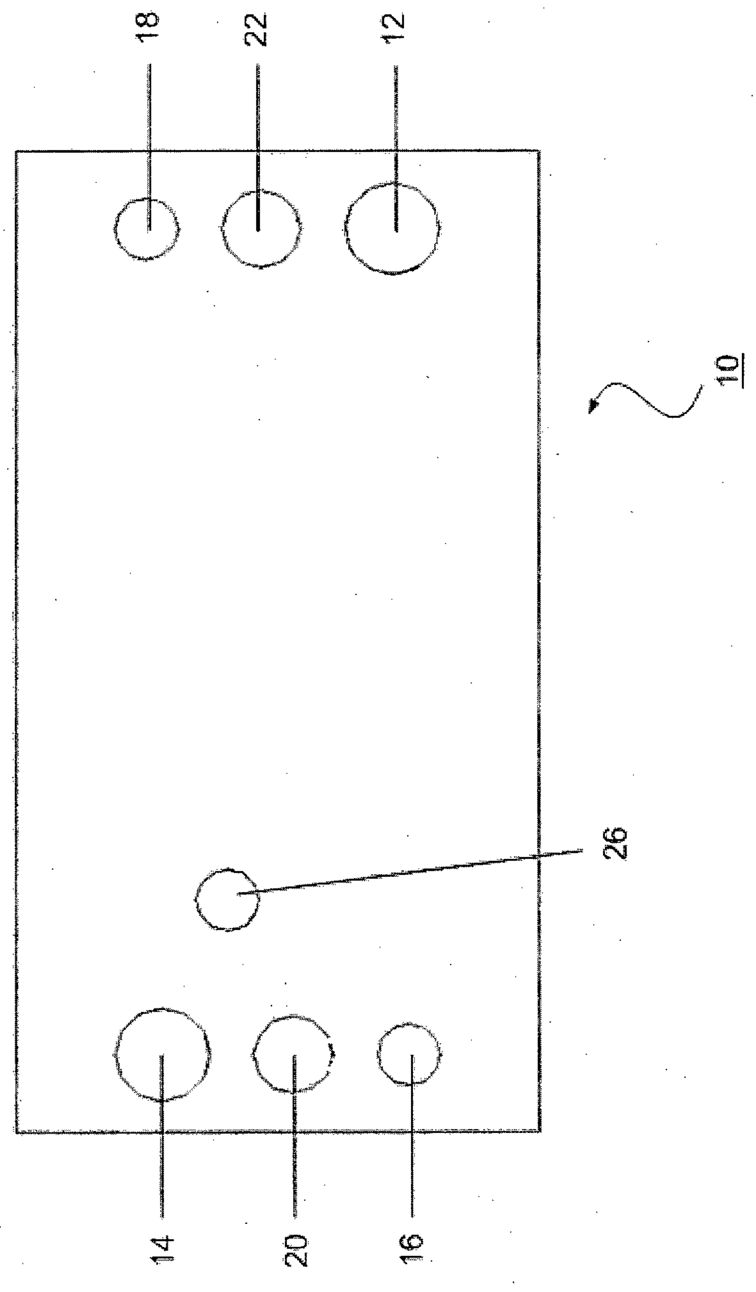


FIG. 2

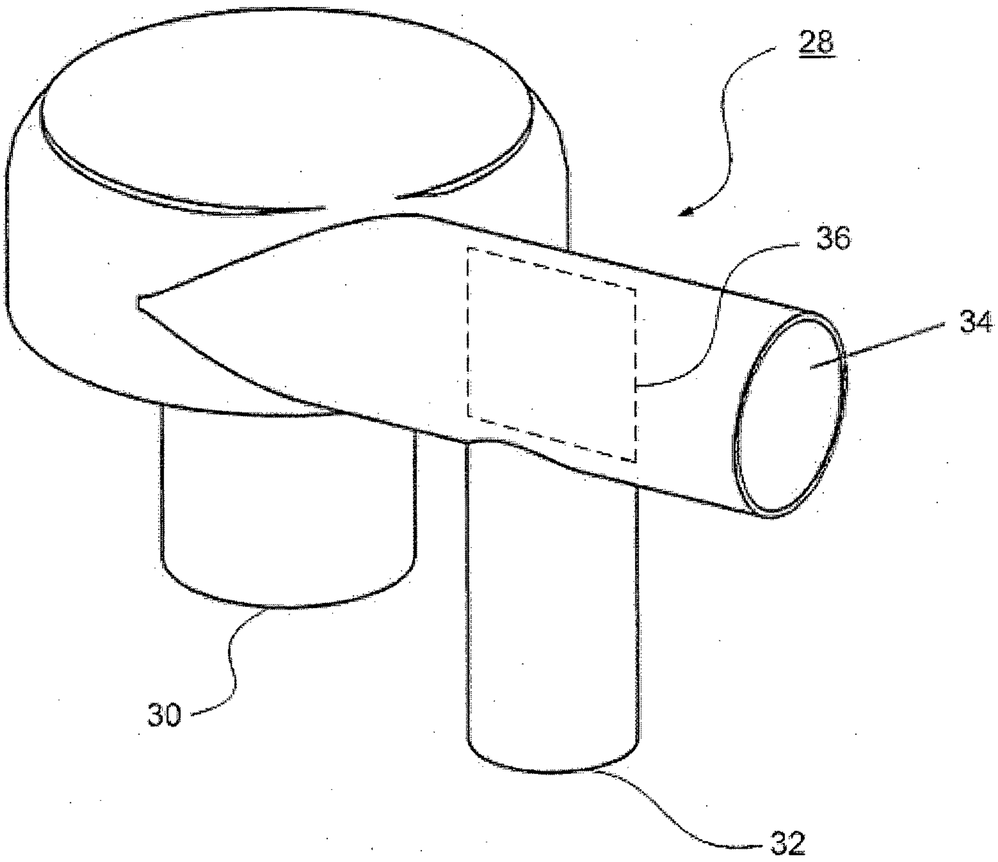


FIG. 3

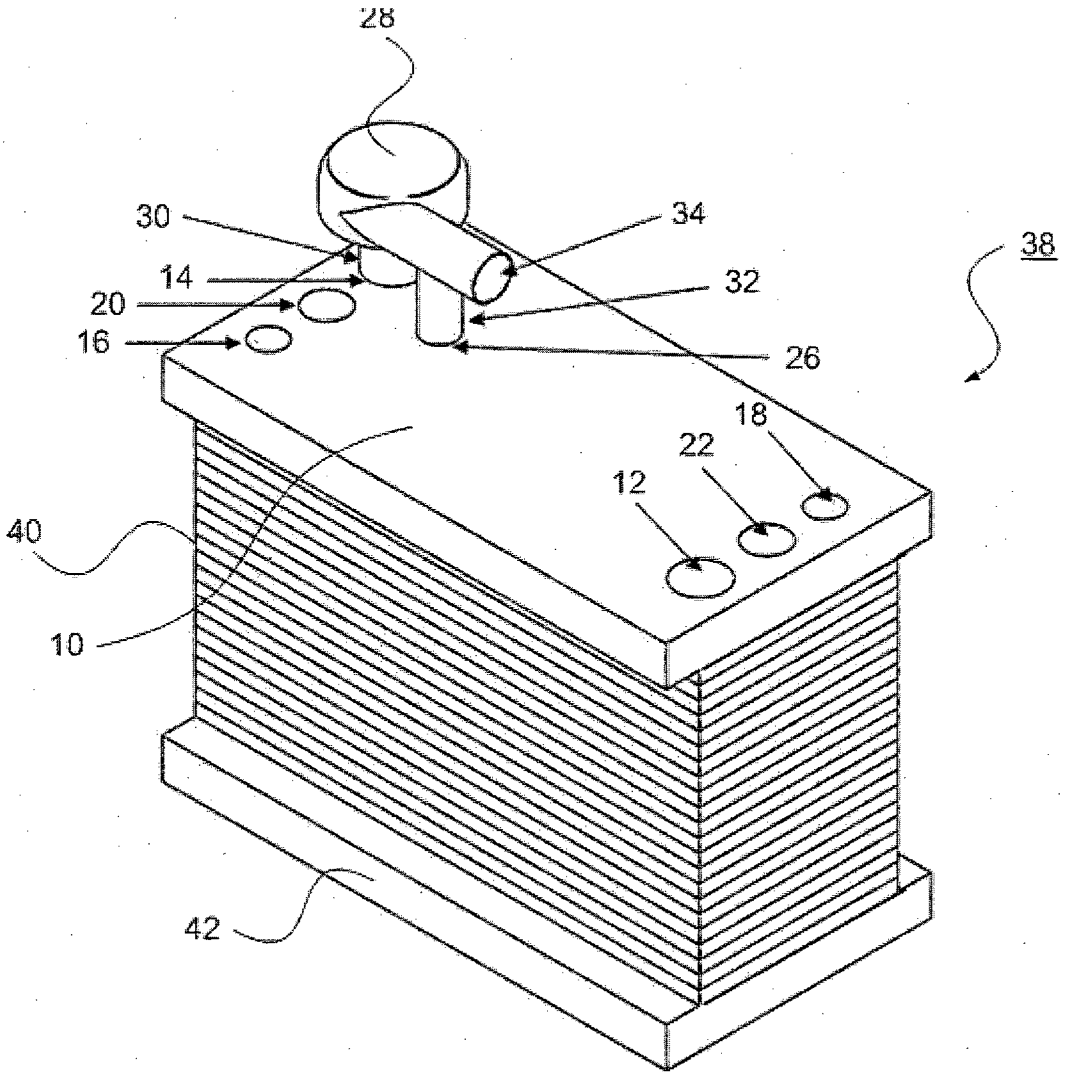
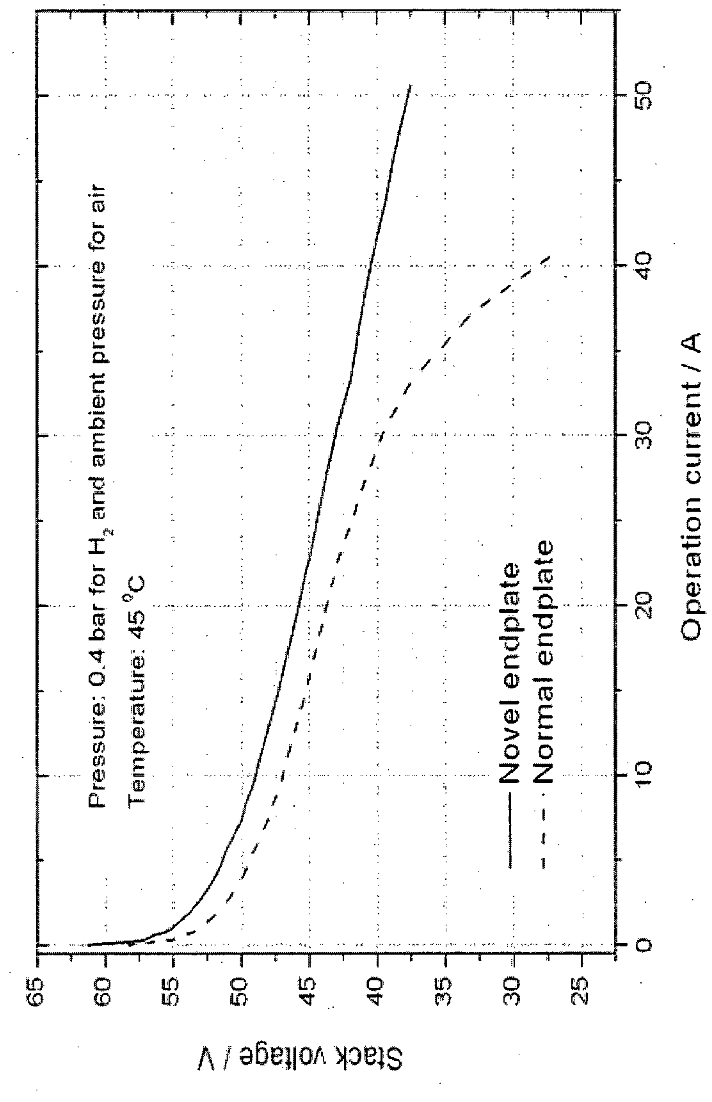


FIG. 4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Temperature: 45 °C
Novel endplate
Normal endplate
Operation current / A
Stack voltage / V
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10
20
30
40
50
65
60
55
50
45
40
35
30
25

FIG. 5

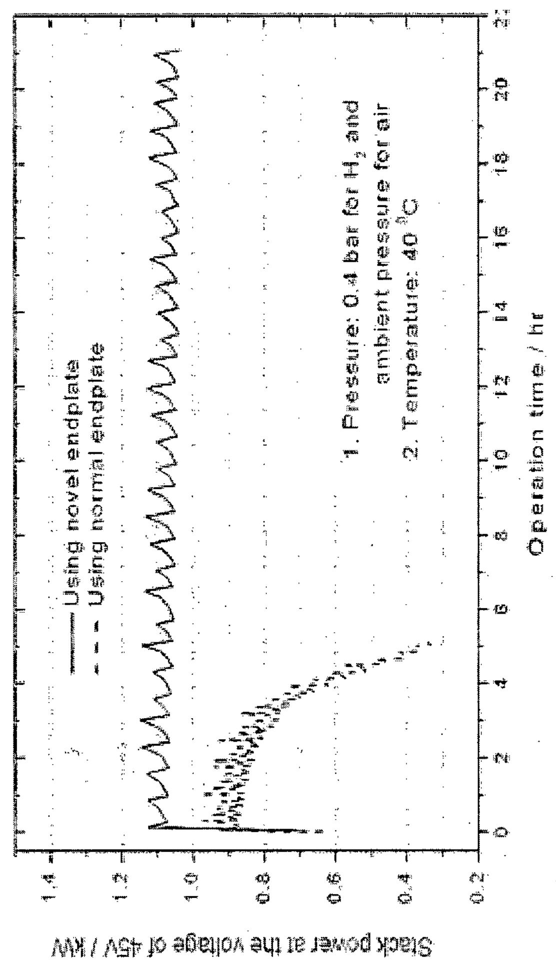
Using novel endplate
Using normal endplate
1. Pressure: 0.4 bar for H_2 and ambient pressure for air
2. Temperature: 40 °C
Stack power at the voltage of 45V / kW
Operation time / hr
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
16
18
20
22

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2012/000048

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

H01M 8/04 (2006.01) ***H01M 2/00*** (2006.01)

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)

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)
EPODOC, WPI, NPL, INSPEC, Google Patents, Google Scholar; IPC MARKS - H01M2/-, H01M8/-; KEY WORDS - HYDRAT+, MOISTURI[S,Z]+, WET+, RE_CIRCULAT+, RECYCL+, CIRCULAT+, RE_USE?, COVER+, PLAT?, BLOCK, FRAM+, PUMP, SUCK+, SUCTION, DRAW+, BLOWER+, EXHAUST+, PROTON, EXCHANG+, MEMBRAN+, PEM, PEMFC, FUEL, CELL.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/0001313 A1 (ZHANG et al.) 03 January 2008 See whole document	
A	WO 2000/017952 A1 (ENERGY PARTNERS, L.C.) 30 March 2000 See whole document	
A	WO 2007/020819 A1 (TOYOTA JIDOSHA KABUSHIKI KAISHA) 22 February 2007 See Abstract	
A	WO 2007/003745 A1 (PEUGEOT CITROEN AUTOMOBILES SA) 11 January 2007 See Abstract	

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:

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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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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
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 April 2012	26 April 2012

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This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	2008001313	CN	101098021	DE	102007029596	JP	2008021645
		US	7875396	US	2011039167	US	8137853
WO	0017952	AU	59265/99	CA	2344377	CN	1332891
		EP	1116297	JP	2002525824	US	6207312
WO	2007020819	CA	2614450	CN	101243572	EP	1916731
		JP	2007052948	KR	20080034512	US	2009280371
WO	2007003745	CN	101233647	EP	1900053	FR	2887691
		JP	2008544471	US	2010098982	US	8142951

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX