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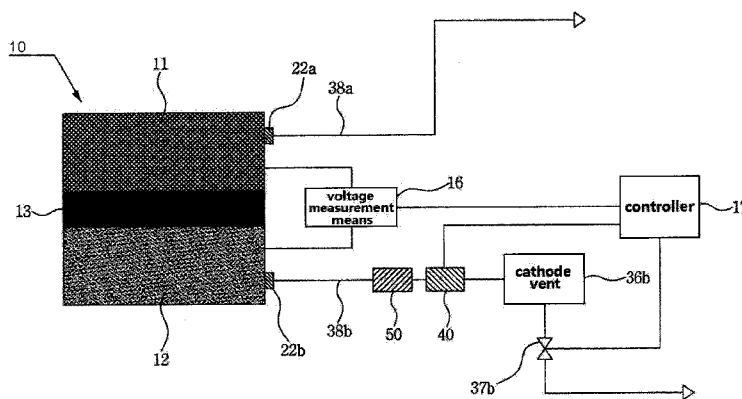
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(54) Title: SYSTEM TO MANAGE WATER AND FUEL FOR DEAD-END MODE PEM FUEL CELL

FIG. 6



(57) Abstract: Disclosed herein is a system for managing water and fuel in a polymer electrolyte membrane fuel cell operated in dead-end mode. In the system for managing water and fuel in a polymer electrolyte membrane fuel cell operated in dead-end mode, a fuel cell system operated in dead-end mode in which an anode to which fuel is supplied and a cathode to which oxidizer is supplied are formed, and a polymer electrolyte membrane is formed between the anode and the cathode, and which is operated in a state in which an exhaust flow path of the cathode is interrupted, the system comprises a pulsator means connected to an exhaust flow path of the cathode for generating pulsation having predetermined amplitude and period at the cathode; a voltage measurement means for measuring voltage generated at the fuel cell; and a controller for controlling the amplitude and period of the pulsator means. According to the present invention, there are advantages in that water accumulated in the interior of the fuel cell is exhausted thereby preventing loss in fuel and oxidizer and enhancing the efficiency of the fuel cell.

SYSTEM TO MANAGE WATER AND FUEL FOR DEAD-END MODE PEM FUEL
CELL

BACKGROUND OF THE INVENTION

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1. Field of the Invention

The present invention relates to a system for managing the water and fuel of a polymer electrolyte membrane fuel cell operating in dead-end mode and, more particularly to polymer
10 electrolyte membrane fuel cell system which utilizes a pulsator and a permselective membrane in a polymer electrolyte membrane fuel cell in order to exhaust water generated within the polymer electrolyte membrane fuel cell operating in dead-end mode.

15

2. Description of the Related Art

The energy of oil, production of which is considerably decreased compared to quantity demanded thereof causes considerable environmental problems, and oil reserves is
20 limited, so that at recently studies for substitute energy are performed actively. Among those, a fuel cell system using hydrogen energy has a higher heat efficiency than an internal combustion engine and the product thereof is clean, so that a fuel cell system using hydrogen energy has been focused as an
25 excellent energy substitute with familiarity to an

environment.

A fuel cell generates power by performing electrochemical reaction. Conventional reactant for the fuel cell is fuel, such as hydrogen or hydrocarbon, and air as an oxidizer. 5 Particularly, the fuel cell conventionally comprises anode, cathode and electrolyte as basis components. The anode and cathode are porous and generally include electrocatalyst, and fuel moves through the porous anode and oxidizer moves through the porous cathode. The fuel moving through the porous anode 10 is hydrogen or hydrocarbon stored in a high-pressure fuel tank.

Among those, Polymer Electrolyte Membrane Fuel Cell (PEMFC) employs open mode or dead-end mode according to a system operation method, and most studies focus on a fuel cell operated in the open mode.

15 The fuel cell system operating in the open mode has less than 100% fuel usage rate, so that the amount of fuel supplied should be higher than the amount of fuel for generating required current. Furthermore, non-react fuel which is not absorbed in a gas diffusion layer is exhausted to the outside 20 of the system together water, so that a separate recirculation system exists.

On the other hand, the fuel cell operated in the dead-end mode supplies fuel only using pressure without a separate blower, thereby maximizing the usage rate of fuel. 25 Furthermore, moisture generated after reaction always exists

inside channels, so that there are advantages in that a separate fuel supply device and a separate recirculation device are not required, and a humidifier device is also minimized. Furthermore, loss in pressure is small, so that
5 pressure is uniformly applied onto the interior of the channel of the fuel cell, thereby power being always higher than that of the open mode.

The fuel cell system operated in the dead-end mode is classified into three types. First, the fuel cell is operated
10 such that the anode is operated in the dead-end mode, and the cathode is operated in the open mode. Secondary, the fuel cell is operated such that the cathode is operated in the dead-end mode and, the cathode is operated in the open mode. Thirdly, the fuel cell is operated such that both of the anode
15 and cathode are operated in the dead-end mode.

In the fuel cell system operated in such dead-end mode, the fuel cell is operated in the state in which the flow path of the fuel exhausted from the anode of the fuel cell and/or the flow path of the oxidizer exhausted from the cathode of
20 the fuel cell are closed, so that, as time elapses, the amount of water collected in the flow paths of the fuel and oxidizers increases.

For example, when the fuel and the oxidizer are reacted, electrons are generated in the anode, and the electrons can
25 not pass through the electrolyte and forms current towards an

external circuit. Here, the cathode receives the electrons from the external circuit, and electrons are recombined with oxide thereby generating an amount of water in the cathode. Furthermore, the amount of water formed in the cathode passes
5 through the electrolyte due to osmosis, and supplied to the anode so that water may be generated in the anode.

The fuel cell system operated in the dead-end mode has a closed ends, so that the initial efflux of the fuel does not occur. On the other hand, the early stage of the reaction,
10 the partial pressure of hydrogen is high and the partial pressure of hydrogen is low, but, as the operation time of the fuel cell increases, the partial pressure of hydrogen becomes higher and the partial pressure of water becomes lower. As a result, flooding phenomenon occurs because of the generated
15 water, so that the part to be reacted is covered with water and reaction area decreases, thereby a problem in which the performance of the fuel cell is degraded occurring.

That is, when the water is choked or the partial pressure of hydrogen is low due to flooding, and thus, it is
20 difficult to generate reaction, the generated water is combined with carbon according to an inverse reaction to regenerate hydrogen, and loss in the carbon is generated due to reaction such as the following [reaction formula 1], thereby generating a problem in which irreversible loss is
25 generated.

[reaction formula 1]



5 Therefore, in a conventional fuel cell operated in the dead-end mode, in order to resolve the above-described problem, a method for exhaust water through a purging to the exterior of the fuel cell.

FIG 1 is a diagram schematically illustrating a
10 conventional fuel cell system operated in dead-end mode. FIG. 1 illustrates the case in which anode and cathode are both operated in dead-end mode, and any one of the anode and cathode may be operated in open mode.

15 As illustrated in FIG.1, fuel moves from a fuel tank 14 through a mass flow controller 31a, a pressure control valve 32a, a membrane humidifier 33a to which water is supplied from a water tank 34, and a mass flow meter (MFM) 35a, and enters the input end 21a of the anode 11 of the fuel cell.

20 Oxidizer moves through a mass flow controller 31b, a pressure control valve 32b, a membrane humidifier 33b to which water is supplied from the water tank 34, and a mass flow meter (MFM) 35b, and enters the input end 21b of the cathode 12 of the fuel cell.

25

The mass flow controllers 31a and 31b, the mass flow meters 35a and 35b, the membrane humidifiers 33a and 33b, and the water tank 34 for supplying moisture to the membrane humidifiers 33a and 33b are not essential components in the fuel cell operated in the conventional dead-end mode, so that they may not be employed according to the selection of a designer.

The fuel and oxidizer input to the fuel cell 10 are reacted to each other. Water generated by reaction is mostly generated in the cathode and an amount of water is supplied to the anode 11 through an electrolyte 13 due to osmosis.

The water generated in the cathode 12 is exhausted to the output end 22b of the cathode 12, and passes through an exhaustion flow path 38b and a cathode vent 36b to a purge valve 37b.

Furthermore, the water supplied to the anode 11 is exhausted to the output end 22a of the anode 11 and passes through an exhaustion flow path 38a and an anode vent 36a to a purge valve 37a.

On the other side, a voltage measurement means measures the voltage of the fuel cell 10, and a controller 17 opens the purge valves 37a and 37b to exhausts the water when the voltage is lower than a predetermined value, and then recovers the voltage. The above-description is disclosed in the following patents 1 and 2.

[Patent 1] Japan patent application 2004-536436

[Patent 2] International patent application
PCT/JP2007/072916

5 FIG. 2 is a graph illustrating the voltage of the fuel cell with respect to purging time in the conventional fuel cell system operated in dead-end mode, and FIG. 3 is a graph illustrating voltage and pressure with respect to time.

In FIG. 2, it is known that when the current output from
10 the fuel cell is 40A, the more the fuel cell is operated, the voltage value output from the fuel cell decreases. That is, as the operation time increases, the more water is generated within the interior of the fuel cell, thereby degrading the performance of the fuel cell, and the output voltage value
15 decreases. Therefore, the purge valve is periodically opened and the water is exhausted to recover an original voltage value.

FIG. 3 is a graph illustrating change in pressure and voltage according to time within one period when operation is
20 performed under current density 1.8 A/cm^2 .

When the purge valves 37a and 37b are opened (purging time is 0), the voltage is rapidly recovered, and after the purge valves 37a and 37b have been closed, water is generated and then voltage is decreased at a constant gradient.
25 However, the speed at which the voltage is decreased becomes

small, and then at some point, the voltage is rapidly decreased again. It is for this reason that the water initially generated within a channel is exhausted and then the voltage is rapidly recovered, but, when the purge valves are
5 closed, water is generated and then the voltage is again decreased.

However, when the purge valves 37a and 37b are opened and the speed of dynamic pressure with respect to the speed of flowing fluid is 0, the static pressure becomes 1.5 bar, and
10 the reaction pressure of the fuel becomes higher, thereby the voltage being recovered. Therefore, since pressure, which had been dropped, increases to cause voltage to be increased, gradient at which voltage is decreased becomes small, However, after voltage has been recovered, affection due to water is
15 worked and the voltage again is dropped rapidly.

FIG. 4 is a graph illustrating purging time with respect to current in a conventional fuel cell system operated in dead-end mode, and FIG. 5 is a graph illustrating an average purging time with respect to current density according to
20 pressure.

As known in FIG. 4, as the current value output from the fuel cell increases, the purging time is shorter. For example, when it is desired to obtain current of 40A, purging is performed every forty 45 minutes, when it is desired to
25 current of 45A, purging is performed every 10 minutes.

Under one pressure condition, the more current density increases, the amount of moisture interrupting a gas diffusion layer increases, so that it is known that a period at which the moisture is exhausted is decreased.

5 As known in FIG. 5, under one current density, the more operating pressure is high, the output value is increased, but the period is shorter. This means that when pressure is higher and then an output value increases, the water generated increases and therefore moisture to be exhausted increases,
10 purging is performed many times.

On the other hand, when water is exhausted by purging in a fuel cell operated in dead-end mode, fuel is exhausted together the water, so that there is a problem in that fuel is consumed unnecessarily, voltage stability degrades because a
15 voltage value changes greatly. As a result, in the fuel cell operated in dead-end mode, there is a problem in that the efficiency of the fuel cell is decreased due to purging.

SUMMARY OF THE INVENTION

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Accordingly, the present invention has been made keeping in mind the aforementioned problems occurring in the prior art, and an object of the present invention is to add a pulsator and a permselective membrane to a fuel cell operated
25 in dead-end mode to lengthen a purging period and exhaust

water accumulated in the interior of the fuel cell thereby preventing loss in fuel and oxidizer and enhancing the efficiency of the fuel cell.

In order to complete the object of the present invention,
5 an embodiment of the present invention provides a fuel cell system operated in dead-end mode in which an anode to which fuel is supplied and a cathode to which oxidizer is supplied are formed, and a polymer electrolyte membrane is formed between the anode and the cathode, and which is operated in a
10 state in which a exhaustion flow path of the cathode is interrupted, the system comprising a pulsator means connected to an exhaustion flow path of the cathode for generating pulsation having predetermined amplitude and period at the cathode; a voltage measurement means for measuring voltage
15 generated at the fuel cell; and a controller for controlling the amplitude and period of the pulsator means.

Preferably, the system further comprises a permselective membrane disposed between the exhaustion flow path of the cathode and the pulsator means for passing water and
20 interrupting passage of the oxidizer thereby exhausting only the water to exterior of the fuel cell.

Preferably, the permselective membrane further comprises a pin attached to a surface thereof for promoting evaporation of the water.

25 Preferably, the system further comprises a purge valve

controlled by the controller for opening the exhaustion flow path of the cathode when the voltage measured by the voltage measurement means is lower than a predetermined value.

Another embodiment of the present invention provides a
5 fuel cell system operated in dead-end mode in which an anode to which fuel is supplied and a cathode to which oxidizer is supplied are formed, and a polymer electrolyte membrane is formed between the anode and the cathode, and which is operated in a state in which a exhaustion flow path of the
10 anode is interrupted, the system comprising: a pulsator means connected to the exhaustion flow path of the anode for generating pulsation having predetermined amplitude and period at the anode; a voltage measurement means for measuring voltage generated at the fuel cell; and a controller for
15 controlling the amplitude and period of the pulsator means.

Preferably, the system further comprises a permselective membrane disposed between the exhaustion flow path of the anode and the pulsator means for passing water and interrupting passage of the oxidizer thereby exhausting only
20 the water to exterior of the fuel cell.

Preferably, the permselective membrane further comprises a pin attached to a surface thereof for promoting evaporation of the water.

Preferably, the system further comprises a purge valve
25 controlled by the controller for opening the exhaustion flow

path of the anode when the voltage measured by the voltage measurement means is lower than a predetermined value.

Still embodiment of the present invention provides a fuel cell system operated in dead-end mode in which an anode to which fuel is supplied and a cathode to which oxidizer is supplied are formed, and a polymer electrolyte membrane is formed between the anode and the cathode, and which is operated in a state in which a exhaustion flow path of the anode and a exhaustion flow path of the cathode are interrupted, the system comprising: a pulsator means connected to the exhaustion flow path of the anode and the exhaustion flow path of the cathode for generating pulsation having predetermined amplitude and period at the anode and the cathode; a voltage measurement means for measuring voltage generated at the fuel cell; and a controller for controlling the amplitude and period of the pulsator means.

Preferably, the system further comprises permselective membranes respectively disposed between the exhaustion flow path of the anode and the pulsator means and between the exhaustion flow path of the cathode and the pulsator means, for passing water and interrupting passage of the oxidizer thereby exhausting only the water to exterior of the fuel cell.

Preferably, the permselective membrane further comprises a pin attached to a surface thereof for promoting evaporation

of the water.

Preferably, the system further comprises a purge valve controlled by the controller for opening the exhaustion flow path of the anode and the exhaustion flow path of the cathode
5 when the voltage measured by the voltage measurement means is lower than a predetermined value.

The present invention add a pulsator and a permselective membrane to a fuel cell operated in dead-end mode to lengthen a purging period and exhaust water accumulated in the interior
10 of the fuel cell thereby preventing loss in fuel and oxidizer and enhancing the efficiency of the fuel cell.

BRIEF DESCRIPTION OF THE DRAWINGS

15 The above and other objects, features and advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG 1 is a diagram schematically illustrating a
20 conventional fuel cell system operated in dead-end mode.

FIG. 2 is a graph illustrating the voltage of the fuel cell with respect to purging time in the conventional fuel cell system operated in dead-end mode.

FIG. 3 is a graph illustrating voltage and pressure with
25 respect to time.

FIG. 4 is a graph illustrating purging time with respect to current in a conventional fuel cell system operated in dead-end mode.

FIG. 5 is a graph illustrating an average purging time
5 with respect to current density according to pressure.

FIG. 6 is a schematic diagram illustrating a system for managing water and fuel in a polymer electrolyte membrane fuel cell operating in dead-end mode according to an embodiment of the present invention in which a pulsator and a permselective
10 membrane are added to a cathode.

FIG. 7 is a schematic diagram illustrating a system for managing water and fuel in a polymer electrolyte membrane fuel cell operating in dead-end mode according to the present invention in which a pulsator and a permselective membrane are
15 added to an anode.

FIG. 8 is a schematic diagram illustrating a system for managing water and fuel in a polymer electrolyte membrane fuel cell operating in dead-end mode according to the present invention in which a pulsator and a permselective membrane are
20 added to both an anode and a cathode.

FIG. 9 is a diagram schematically illustrating the pulsator.

FIG. 10 is a diagram schematically illustrating the permselective membrane.

25 FIG. 11 is a graph illustrating voltage values with

respect to purging time in a fuel cell system which does not employ a pulsator.

FIG. 12 is a graph illustrating voltage values with respect to purging time in a system for managing water and fuel in a polymer electrolyte membrane fuel cell operated in dead-end mode using a pulsator according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The above-described characteristics and advantages are apparent from the following description with reference to the attached drawings. It is noted that, like reference numerals refer to like parts throughout the various figures in the drawings. The preferred embodiments are described below with reference to accompanied drawings.

FIG. 6 is a schematic diagram illustrating a system for managing water and fuel in a polymer electrolyte membrane fuel cell operating in dead-end mode according to an embodiment of the present invention in which a pulsator and a permselective membrane are added to a cathode.

According to an embodiment of the present invention, in a polymer electrolyte membrane fuel cell system 1 in which the cathode 12 of the polymer electrolyte membrane fuel cell is operated in dead-end mode and the anode 11 is operated in open mode, a pulsator 40 and a permselective membrane 50 are added

to the cathode 12.

FIG. 7 is a schematic diagram illustrating a system for managing water and fuel in a polymer electrolyte membrane fuel cell operating in dead-end mode according to the present invention in which a pulsator and a permselective membrane are added to an anode.

According to an embodiment of the present invention, in a polymer electrolyte membrane fuel cell system 1 in which the anode 11 of the polymer electrolyte membrane fuel cell is operated in dead-end mode and the cathode 12 is operated in open mode, a pulsator 40 and a permselective membrane 50 are added to the anode 11.

FIG. 8 is a schematic diagram illustrating a system for managing water and fuel in a polymer electrolyte membrane fuel cell operating in dead-end mode according to the present invention in which a pulsator and a permselective membrane are added to both an anode and a cathode.

According to an embodiment of the present invention, in a polymer electrolyte membrane fuel cell system 1 in which the anode 11 and cathode 12 of the polymer electrolyte membrane fuel cell are both operated in dead-end mode, a pulsator 40 and a permselective membrane 50 are added to the anode 11 and the cathode 12 respectively.

The pulsator 40 and the permselective membrane 50 are described in detail below.

FIG. 9 is a diagram schematically illustrating the pulsator, and FIG. 10 is a diagram schematically illustrating the permselective membrane.

The pulsator used in the present invention may be implemented using any device for generating vibration, and includes a reversible pump, a control valve or a sound vibrator, such as a speaker or another shock wave generator, but is not limited to those.

The pulsator 40 illustrated in FIG. 9 is a device for enhancing diffusion depending on a period and a distance of reciprocating movement. Using the pulsator 40, the diffusion of the fuel and oxidizer within the polymer electrolyte membrane fuel cell 10 is enhanced, thereby making concentration distribution uniform.

The diffusion of fuel and oxidizer within the polymer electrolyte membrane fuel cell is enhanced using the pulsator 40, thereby making the distribution thereof uniform.

The distribution of the water, fuel and oxidizer, which exist within the polymer electrolyte membrane fuel cell 10, becomes uniform by the operation of the pulsator 40, thereby increasing a purging period.

The pulsator 40 includes an oscillatory flow unit 41 which is coupled to exhaustion flow paths 38a and 38b, a motor 45 which supplies power to the pulsator 40, a disk 44 which is rotated by the motor 45, a crank 43 which connects the disk 44

and a piston, and the piston 42 which transforms the vertical movement of the crank into the horizontal movement of the oscillatory flow unit 41.

The pulsator illustrated in FIG. 9 is only one embodiment
5 of a pulsator which can be used in the present invention, the pulsator is not limited to the type illustrated in FIG. 9.

In the meanwhile, another embodiment of the present invention, the polymer electrolyte membrane fuel cell system 1 according to the present invention further includes a
10 permselective membrane 50 which is disposed between the exhaustion flow path 38a of the anode and/or the exhaustion flow path 38b of the cathode and the pulsator and passes water and interrupts fuel and oxidizer, thereby exhausting only the water to the exterior of the fuel cell.

15 The permselective membrane 50 illustrated in FIG. 10 passes water, and does not pass gas and may be implemented using any material which may be used as nafion or heat exchangers.

The permselective membrane 50 is employed in the polymer
20 electrolyte membrane fuel cell system 1 to continuously exhaust water, so that it is prevented that the partial pressure of the water within the polymer electrolyte membrane fuel cell 10 becomes lower and the partial pressure of fuel becomes lower.

25 That is, since the temperature within the polymer

electrolyte membrane fuel cell 10 is high, and the temperature of the permselective membrane 50 is low, so that condensation occurs in the permselective membrane 50. The condensed water passes through the permselective membrane 50 and is exhausted
5 to the exterior of the polymer electrolyte membrane fuel cell 10.

As illustrated in drawings, the permselective membrane 50 may further include a pin 51 for prompting the evaporation of the water on the surface of the permselective membrane 50 in
10 order to exhaust an amount of water.

The controller 17 of FIG. 6 to FIG. 8 is connected to the voltage measurement means 16. The voltage measurement means 16 means the voltage generated at the polymer electrolyte membrane fuel cell 10 to transmit it to the controller 17, and
15 then the controller 17 controls the activation and operation method of the pulsator 40.

The controller 17 may operate the pulsator 40 continuously from the initial stage of the operation of the fuel cell to time at which the operation of the fuel cell is
20 stopped, and may selectively operate the pulsator 40 only during the voltage measured in the polymer electrolyte membrane fuel cell 10 is low.

The controller 17 performs control to operate the pulsator 40 when the partial pressure of the water within the
25 fuel cell increases and the voltage measured by the voltage

measurement means 16 is low as the polymer electrolyte membrane fuel cell 10 is operated.

Furthermore, in the case in which the pulsator 40 continuously operates, the amplitude and frequency are
5 modified by pulsation and the partial pressure of the water is dropped, and the partial pressures of the fuel and oxidizer become higher.

Accordingly, according to the present invention, the pulsator 40 and the permselective membrane 50 are added to a
10 conventional polymer electrolyte membrane fuel cell, thereby exhausting water without the purge valves 37a and 37b. As a result, a problem in which, when the purge valves 37a and 37b are opened, water as well as fuel and oxidizer are exhausted, thereby degrading the efficiency of the fuel cell, can be
15 resolved.

Meanwhile, according to still another embodiment of the present invention, the polymer electrolyte membrane fuel cell system 1 includes not only the pulsator 40 and the permselective membrane 50 but also the purge valves 37a and
20 37b, and the controller 17 determines whether the purge valves 37a and 27b are opened.

That is, when water is not completely exhausted through permselective membrane 50, and therefore residue water still exists, the residue water can be exhausted by opening the
25 purge valves 37a and 37b. When water is exhausted

simultaneously utilizing the permselective membrane 50 and the purge valves 37a and 37b, a purging period becomes much shorter than a conventional case. As a result, the water is firstly exhausted through the permselective membrane 50 and then the residue water is secondary exhausted through the purge valves 37a and 37b, so that the time (purging period) during which the purge valves 37a and 37b are opened becomes longer thereby efficiently operating the fuel cell.

FIG. 11 is a grape illustrating voltage values with respect to purging time in a fuel cell system which does not employ a pulsator, and FIG. 12 a grape illustrating voltage values with respect to purging time in a system for managing water and fuel in a polymer electrolyte membrane fuel cell operated in dead-end mode using a pulsator according to the present invention.

According to an embodiment of the system for managing water and fuel in a polymer electrolyte membrane fuel cell operated in dead-end mode using a pulsator according to the present invention, as illustrated in FIG. 6, the grape shows voltage measured when the density of operation current is $1.8\text{A}/\text{cm}^2$ in the case in which the cathode 12 is operated in dead-end mode and the anode 11 is operated in open mode.

The values resulting from integration of the grape represents the amount of power. Under same experiment conditions, the average of voltage values measured when the

fuel cell is operated in open mode is about 0.54V. Meanwhile, as illustrated in FIG. 11, it can be known that voltage values measured in a conventional fuel cell operated in dead end mode are 0.550 V to 0.615 V. That is, fuel is wasted due to
5 purging in dead-end mode, but the amount of power obtained as time elapses is higher than the amount of the wasted fuel.

The reason for this is that the pressure of oxidizer is uniformly applied to the interior of the fuel cell in the fuel cell in which the cathode 12 is operated in dead-end mode and
10 the anode 11 is operated in open mode, so that loss in pressure is less than that in open mode and the usage rate of fuel is considerably higher than that in open mode.

In a conventional polymer electrolyte membrane fuel cell system, because fuel is applied with a predetermined pressure,
15 the above-result means that more higher output is obtained without a separate power source for supplying fuel in dead-end mode than that in open mode.

FIG. 12 is a graph illustrating a period at which pulsation flux is applied to the cathode 12 when current
20 density is 1.8 A/cm^2 . The pulsation is applied at amplitude of 10mm and frequency of 2 Hz. In the result of experiment, it is known that the average period of purging is 900 seconds and is lengthened 4 times more than the average period of purging represented in FIG. 11 experimented under same
25 conditions as conditional case.

It is shown that the speed at which voltage is dropped decreases due to pulsation during one period, and therefore, a period is lengthened. The reason for this is that water accumulated at the rear end of the fuel cell 10 is uniformly distributed to the interior of the channel through pulsation, so that the moisture interrupting the gas diffusion layer is exhausted.

Therefore, in the fuel cell system 1 operated in dead-end mode, the pulsator 40 is employed at the rear end of the fuel cell, output and power amount are increased compared to open mode, and the period of purging is lengthened compared to the case in which the pulsator 40 is not employed, thereby decreasing fuel wasted unnecessarily.

It is apparent to those skilled in the art that, when the pulsator 40 is applied to the anode 11 as shown in FIG. 7 or the pulsator 40 is applied to both the anode 11 and the cathode 12 as shown in FIG. 40, purging time is lengthened and therefore, the efficiency of the fuel cell.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

WHAT IS CLAIMED IS:

1. A fuel cell system operated in dead-end mode in which an anode to which fuel is supplied and a cathode to which
5 oxidizer is supplied are formed, and a polymer electrolyte membrane is formed between the anode and the cathode, and which is operated in a state in which a exhaustion flow path of the cathode is interrupted, the system comprising:

a pulsator means connected to an exhaustion flow path of
10 the cathode for generating pulsation having predetermined amplitude and period at the cathode;

a voltage measurement means for measuring voltage generated at the fuel cell;

a controller for controlling the amplitude and period of
15 the pulsator means.

2. The system as set forth in claim 1, further comprising a permselective membrane disposed between the exhaustion flow path of the cathode and the pulsator means for passing water
20 and interrupting passage of the oxidizer thereby exhausting only the water to exterior of the fuel cell.

3. The system as set forth in claim 2, wherein the permselective membrane further comprises pins attached to a
25 surface thereof for promoting evaporation of the water.

4. The system as set forth in claim 1 or 2, further comprising a purge valve controlled by the controller for opening the exhaustion flow path of the cathode when the
5 voltage measured by the voltage measurement means is lower than a predetermined value.

5. A fuel cell system operated in dead-end mode in which an anode to which fuel is supplied and a cathode to which
10 oxidizer is supplied are formed, and a polymer electrolyte membrane is formed between the anode and the cathode, and which is operated in a state in which a exhaustion flow path of the anode is interrupted, the system comprising:

a pulsator means connected to the exhaustion flow path of
15 the anode for generating pulsation having predetermined amplitude and period at the anode;

a voltage measurement means for measuring voltage generated at the fuel cell;

a controller for controlling the amplitude and period of
20 the pulsator means.

6. The system as set forth in claim 5, further comprising a permselective membrane disposed between the exhaustion flow path of the anode and the pulsator means for passing water and
25 interrupting passage of the oxidizer thereby exhausting only

the water to exterior of the fuel cell.

7. The system as set forth in claim 6, wherein the permselective membrane further comprises pins attached to a
5 surface thereof for promoting evaporation of the water.

8. The system as set forth in claim 5 or 6, further comprising a purge valve controlled by the controller for opening the exhaustion flow path of the anode when the voltage
10 measured by the voltage measurement means is lower than a predetermined value.

9. A fuel cell system operated in dead-end mode in which an anode to which fuel is supplied and a cathode to which
15 oxidizer is supplied are formed, and a polymer electrolyte membrane is formed between the anode and the cathode, and which is operated in a state in which a exhaustion flow path of the anode and a exhaustion flow path of the cathode are interrupted, the system comprising:

20 a pulsator means connected to the exhaustion flow path of the anode and the exhaustion flow path of the cathode for generating pulsation having predetermined amplitude and period at the anode and the cathode;

a voltage measurement means for measuring voltage
25 generated at the fuel cell;

a controller for controlling the amplitude and period of the pulsator means.

10. The system as set forth in claim 9, further
5 comprising permselective membranes respectively disposed between the exhaustion flow path of the anode and the pulsator means and between the exhaustion flow path of the cathode and the pulsator means, for passing water and interrupting passage of the oxidizer thereby exhausting only the water to exterior
10 of the fuel cell.

11. The system as set forth in claim 10, wherein the permselective membrane further comprises pins attached to a surface thereof for promoting evaporation of the water.

15

12. The system as set forth in claim 9 or 10, further comprising a purge valve controlled by the controller for opening the exhaustion flow path of the anode and the exhaustion flow path of the cathode when the voltage measured
20 by the voltage measurement means is lower than a predetermined value.

FIG. 1

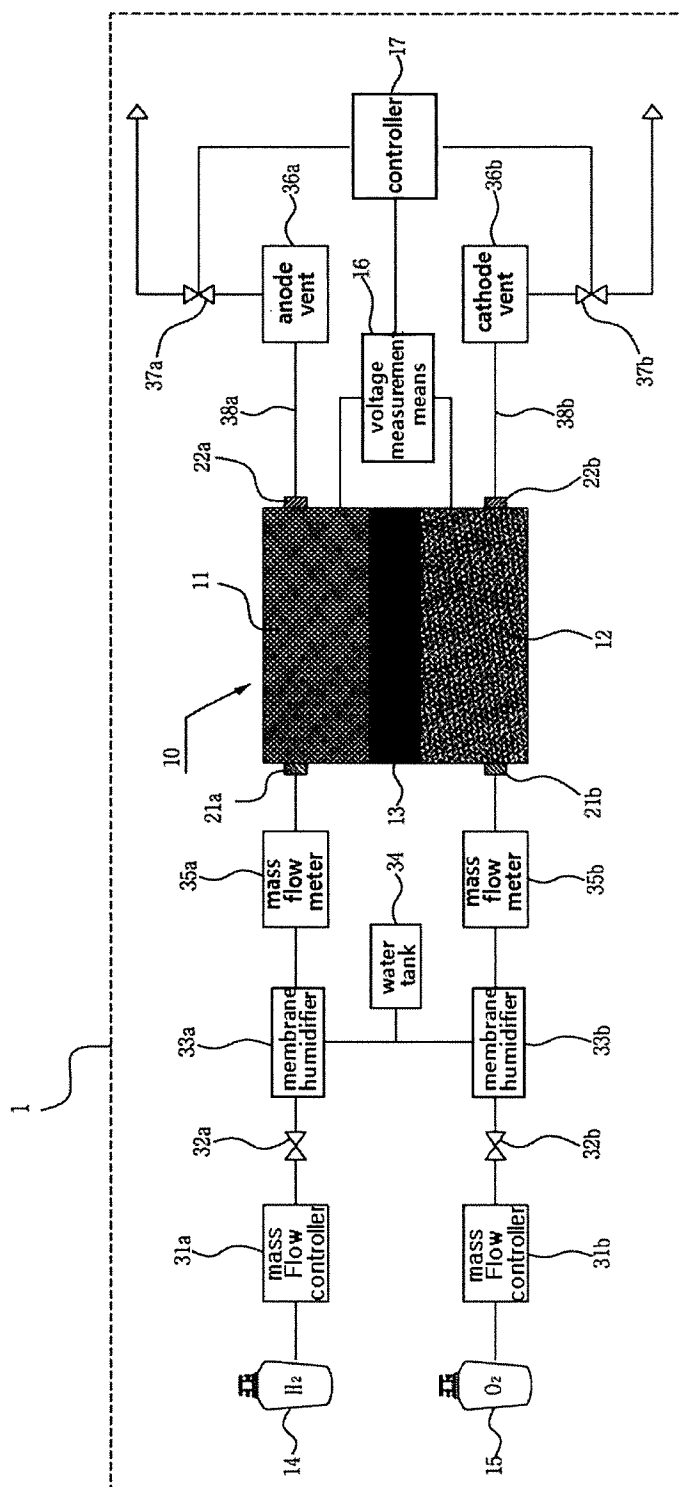


FIG. 2

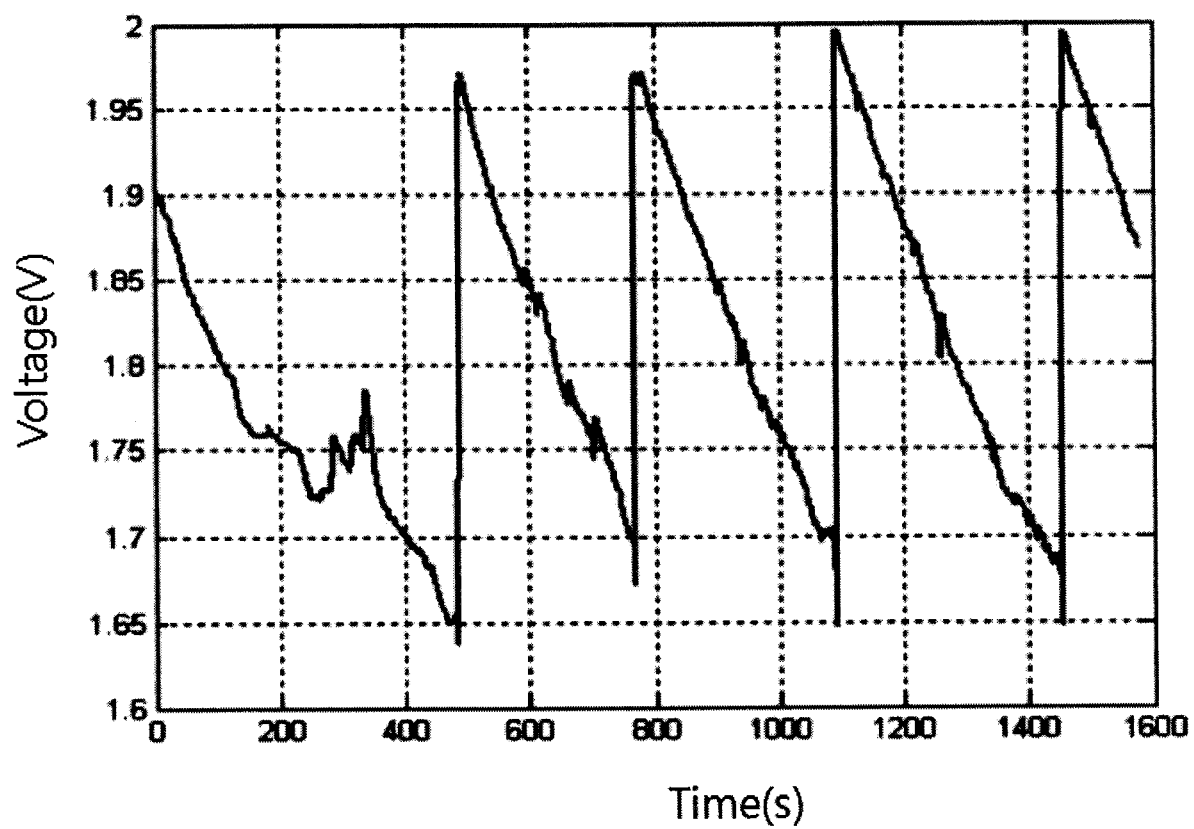


FIG. 3

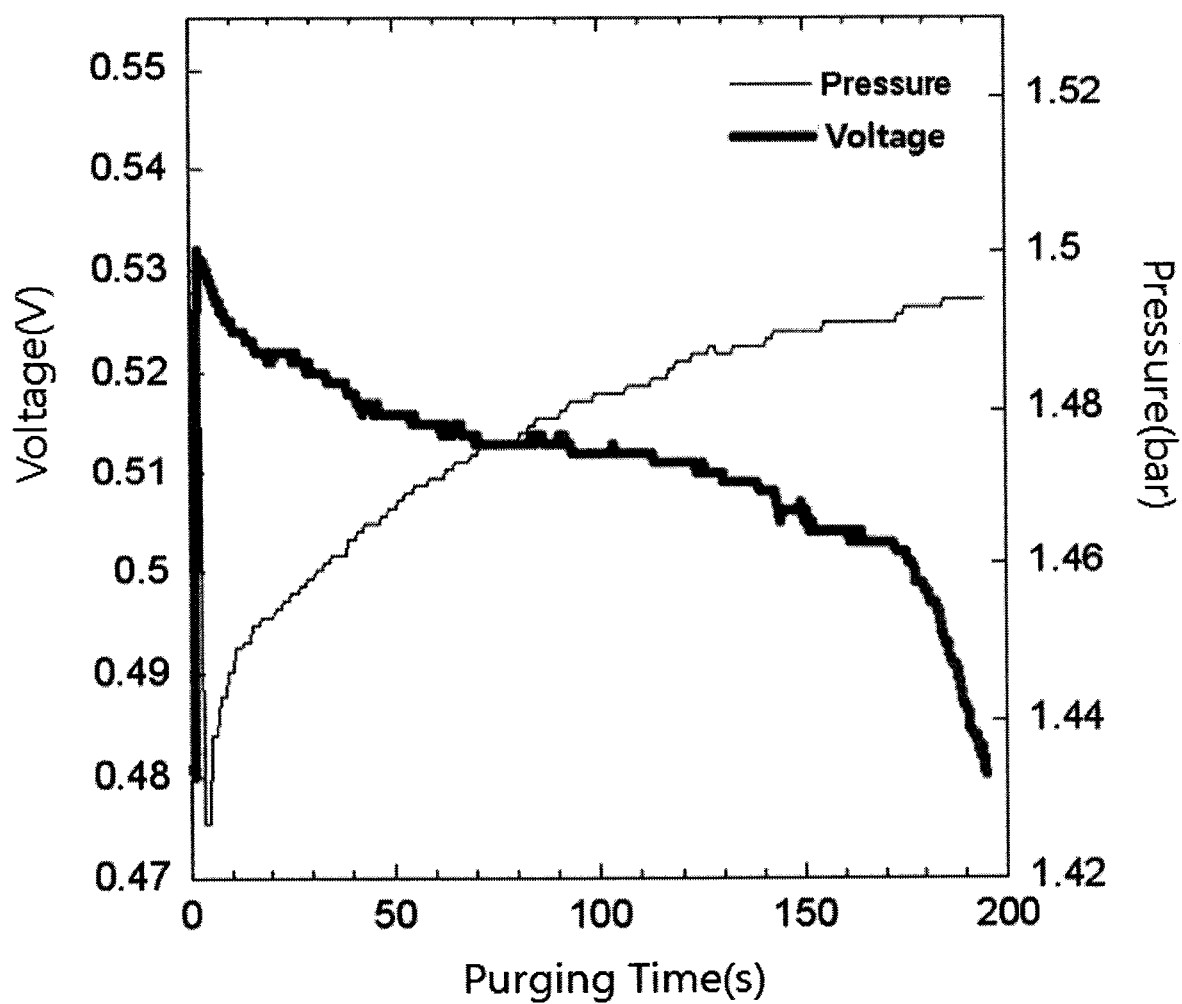


FIG. 4

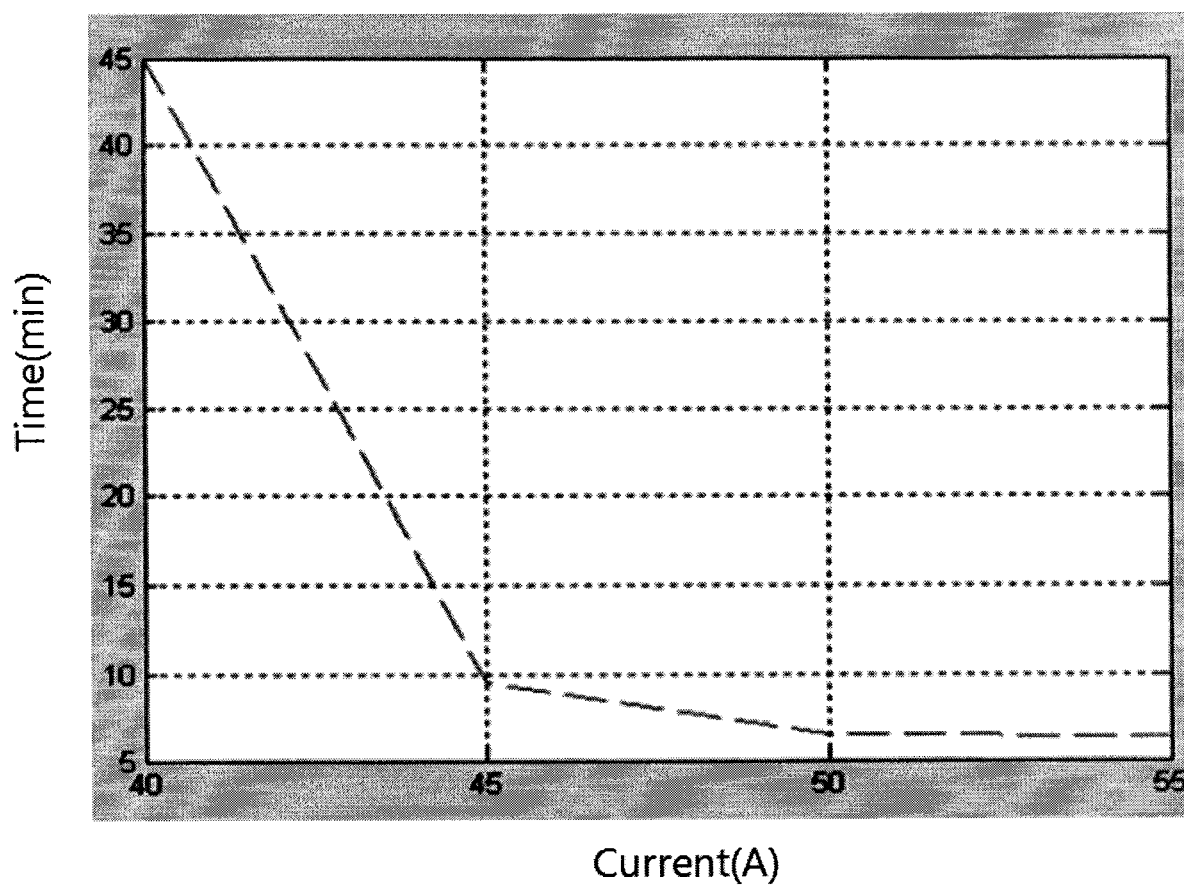


FIG. 5

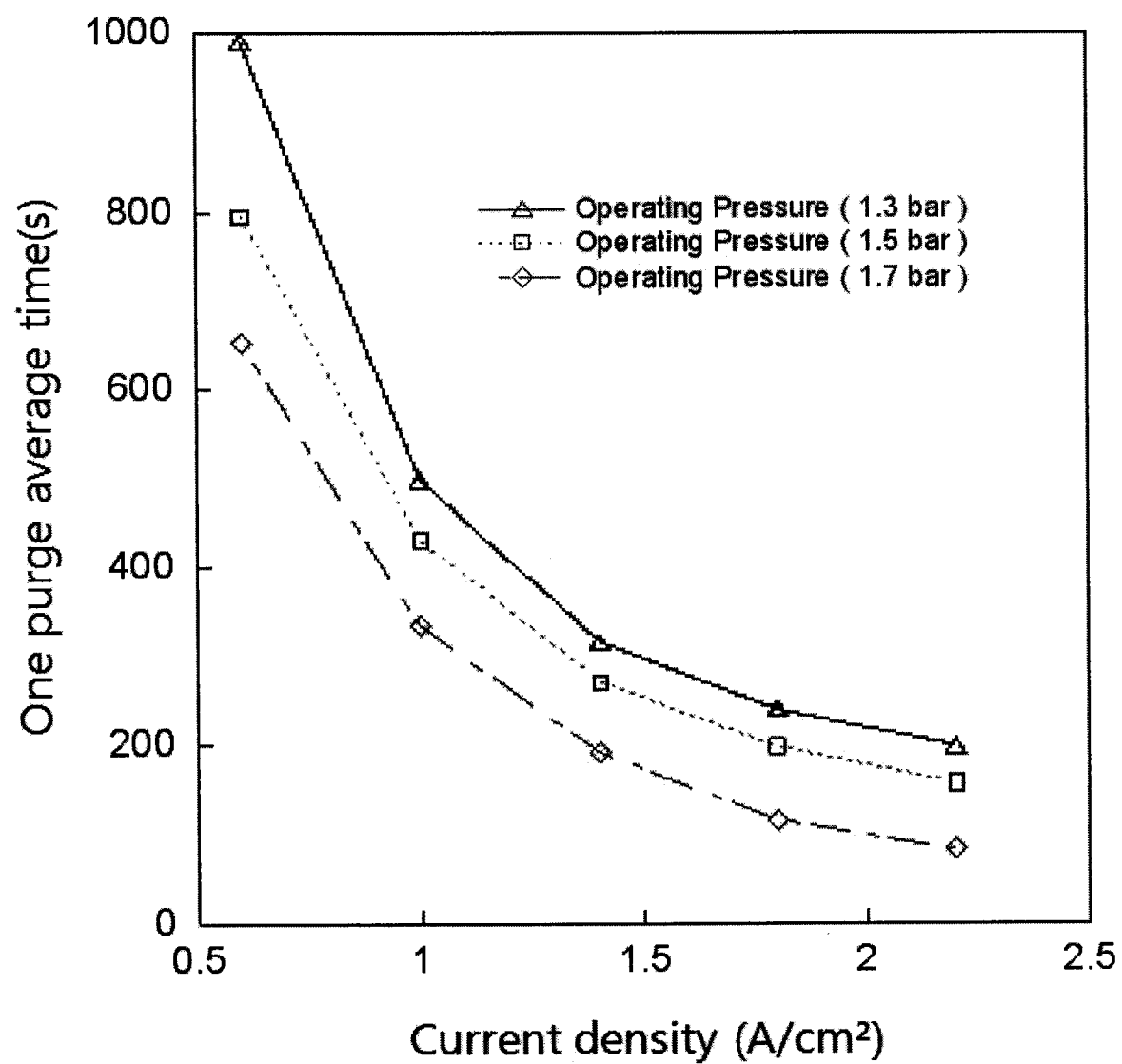


FIG. 6

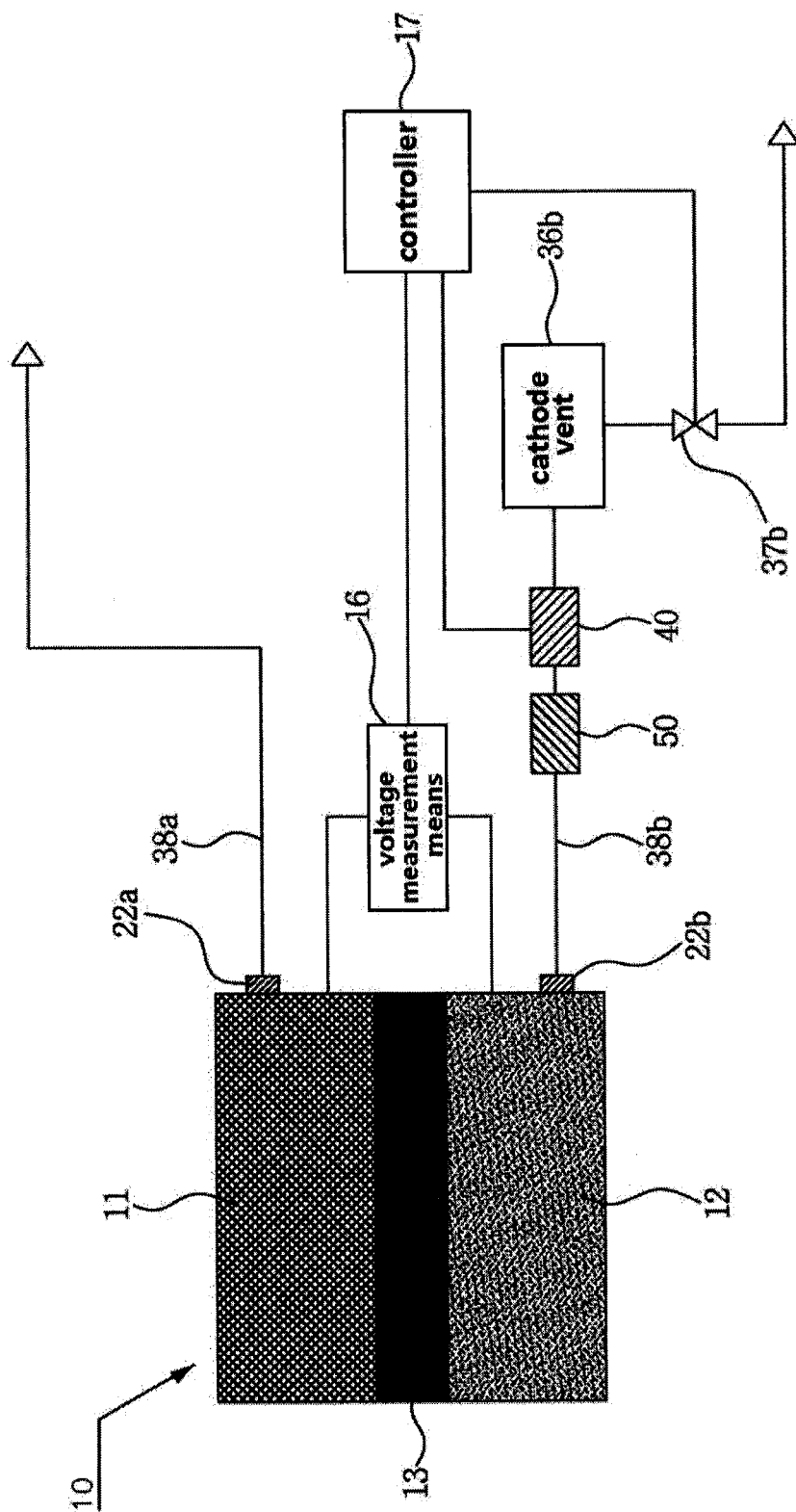


FIG. 7

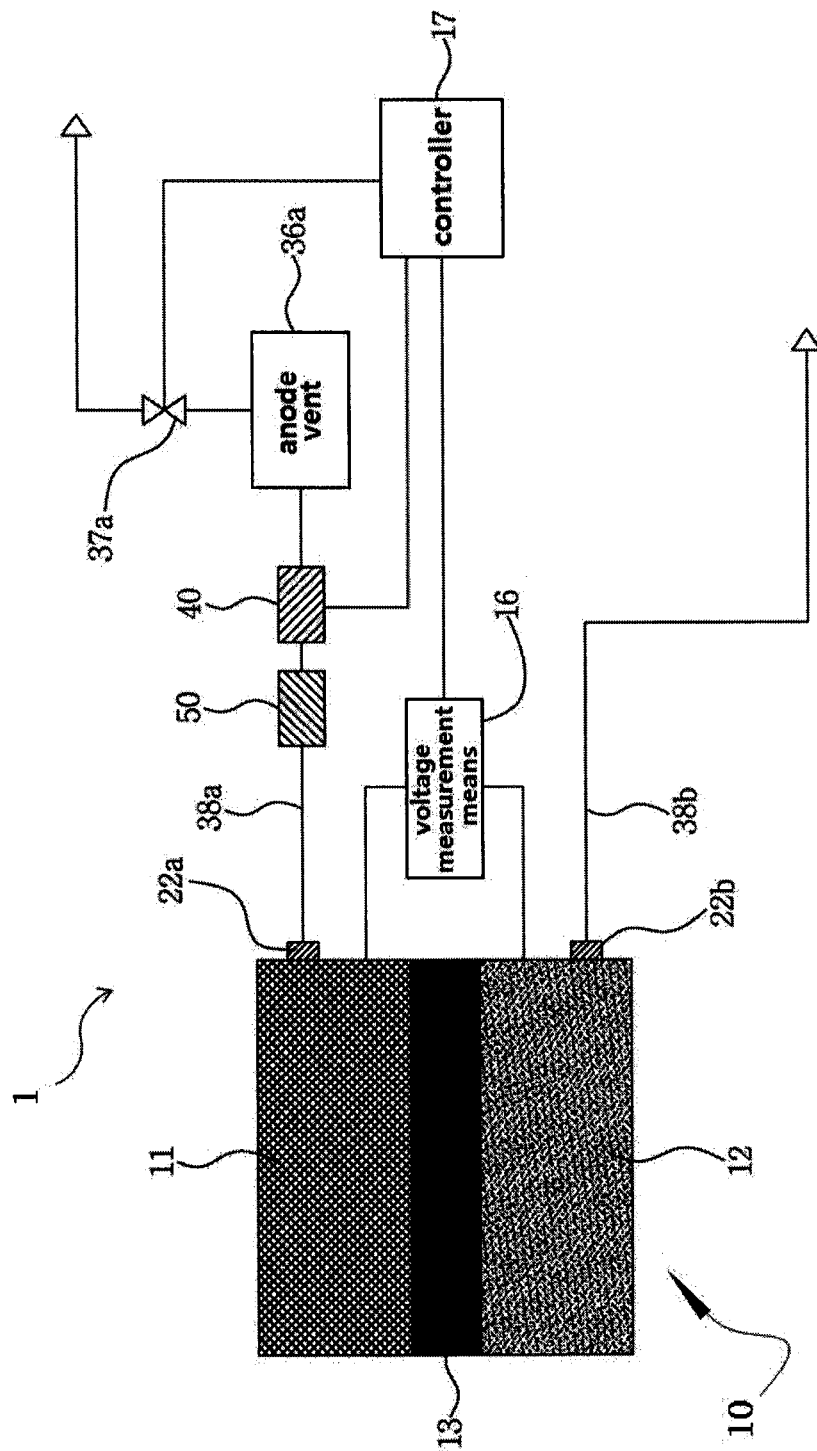


FIG. 8

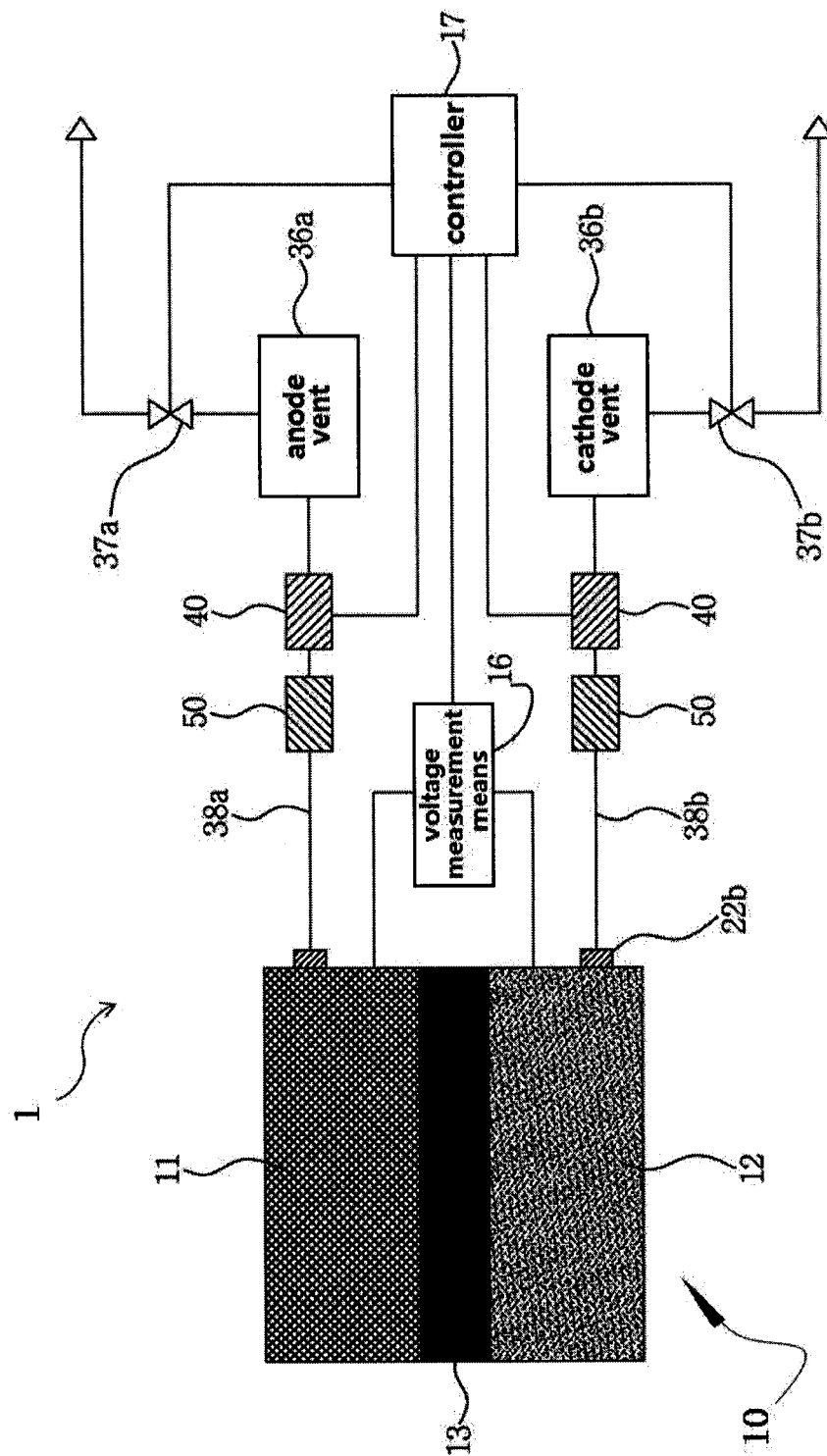


FIG. 9

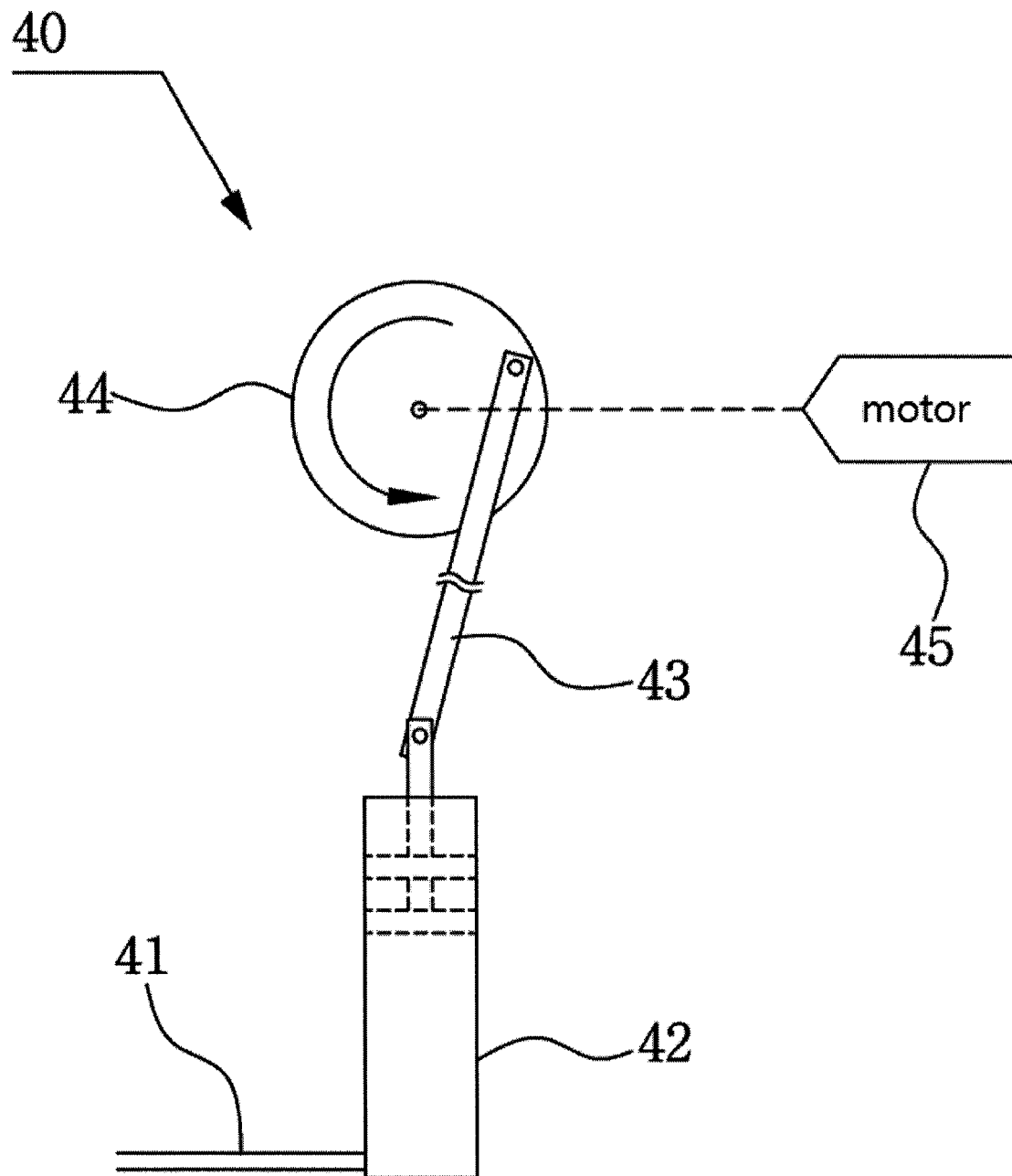


FIG. 10

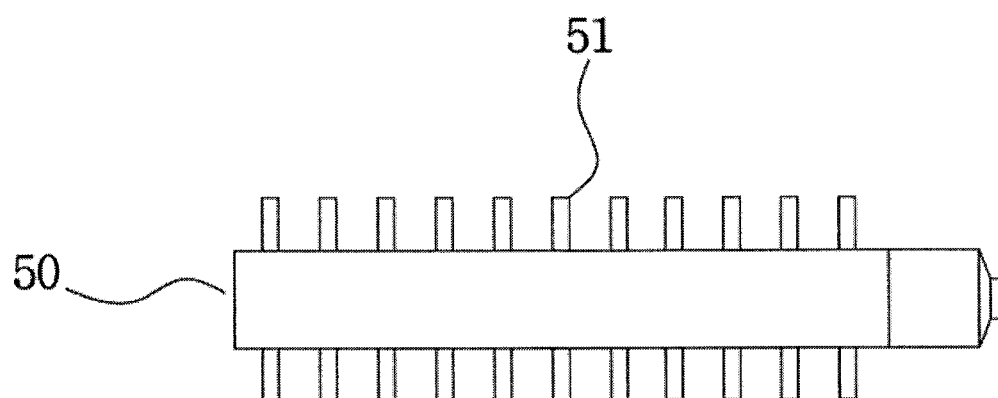


FIG. 11

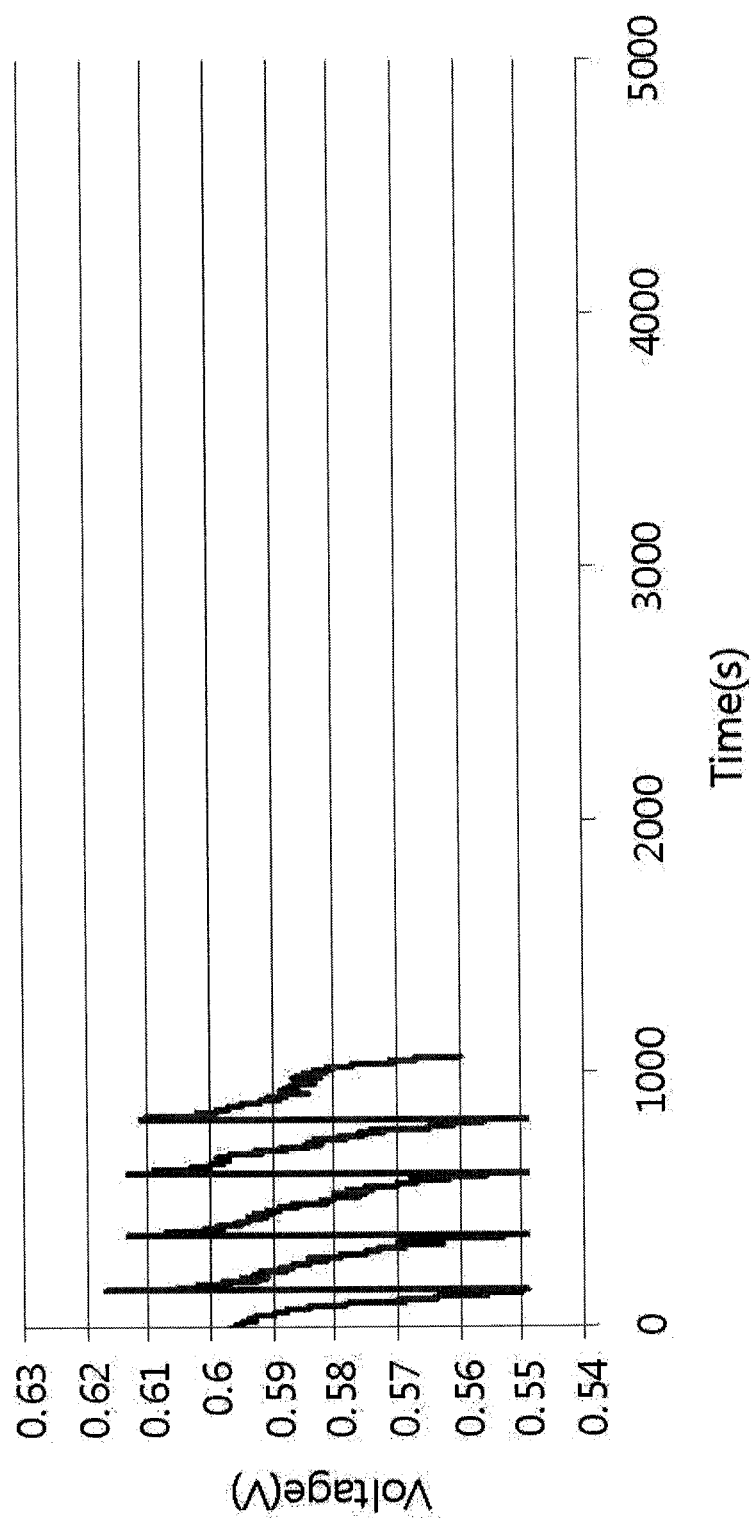
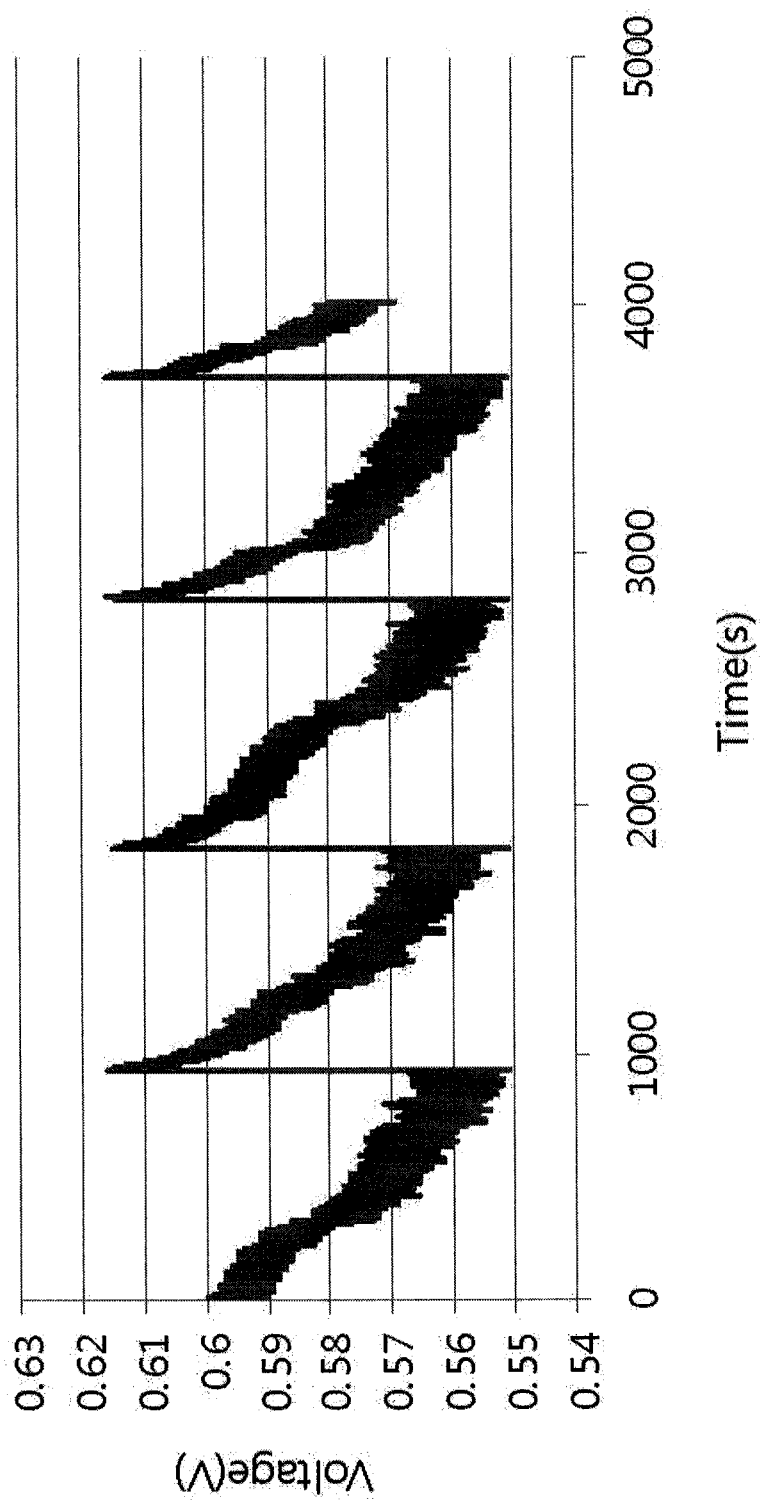


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2008/007416**A. CLASSIFICATION OF SUBJECT MATTER****H01M 8/04(2006.01)i**

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)

IPC 9: 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)
eKOMPASS (KIPO internal) and keywords "dead-end mode, pulsator, voltage measurement, amplitude, period, controller, water separator, pin, water evaporation, fuel cell, and similar terms"**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Choi et al., "An Experimental Study on The Performance Improvement of Dead-End Type PEMFC with Pulsating Effect", Korean Journal of Air-Conditioning and Refrigeration Engineering, 2008(November), pp.567-571	1-12
A	Rodatz et al., "Efficiency Improvements by Pulsed Hydrogen Supply in PEM Fuel Cell Systems", 15th Triennial World Congress, Barcelona, Spain, 2002	1-12
A	JP 19-280892 A (TOYOTA MOTOR CORP.) 15 October 2007 See abstract, Figure 1, p. 3-5, and claim 1	1-12
A	JP 17-353569 A (MATSUSHITA ELECTRIC IND CO. LTD.) 22 December 2005 See abstract, Figure 1, p. 5-6, and claims 1-3	1-12

☐ 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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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

20 AUGUST 2009 (20.08.2009)

Date of mailing of the international search report

20 AUGUST 2009 (20.08.2009)

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Telephone No. 82-42-481-8173



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2008/007416

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2007-280892 A	25. 10. 2007	NONE	
JP 2005-353569 A	22. 12. 2005	EP 1756898 A2 KR 10-0792724 B1 US 2007-0231644 A1 WO 2005-112167 A2	28.02.2007 11.01.2008 04. 10. 2007 24. 11. 2005