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(54) **PORTABLE REFRIGERATOR WITH FUEL CELL SYSTEM AND OPERATING METHOD THEREOF**

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(57) **ABSTRACT**

Disclosed are a portable refrigerator with a fuel cell system and an operating method thereof. The portable refrigerator with a fuel cell system comprises a case having a storage space, a fuel cell stack disposed in the case, a gas tank configured to store gas necessary to operate the fuel cell stack, a fan configured to cool the fuel cell stack and supply air to the fuel stack, a thermoelectric cooling means disposed in the case, and configured to cool the storage space, a battery charged by the fuel cell stack, and configured to supply power to the thermoelectric cooling means, and a controller configured to control the fuel cell stack and the thermoelectric cooling means.

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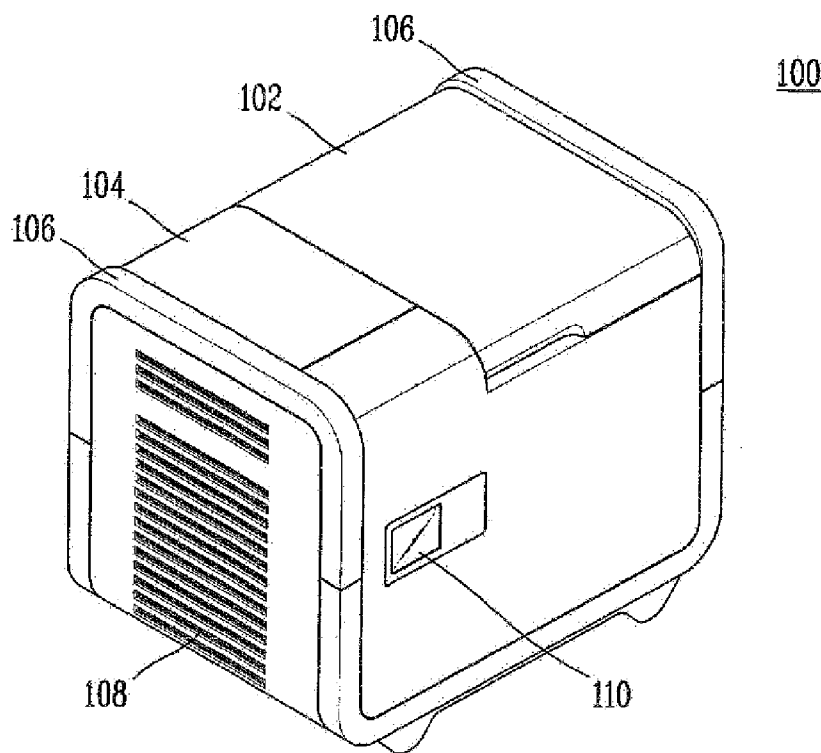


FIG. 1

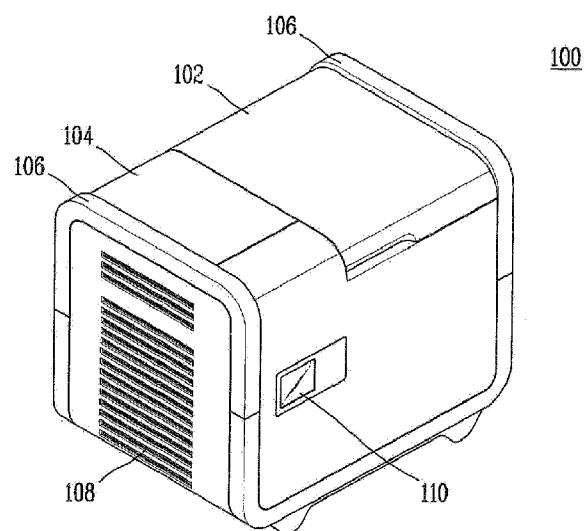


FIG. 2

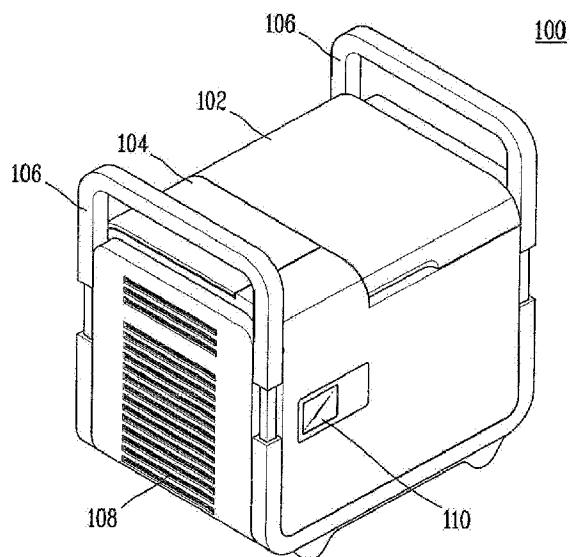


FIG. 3

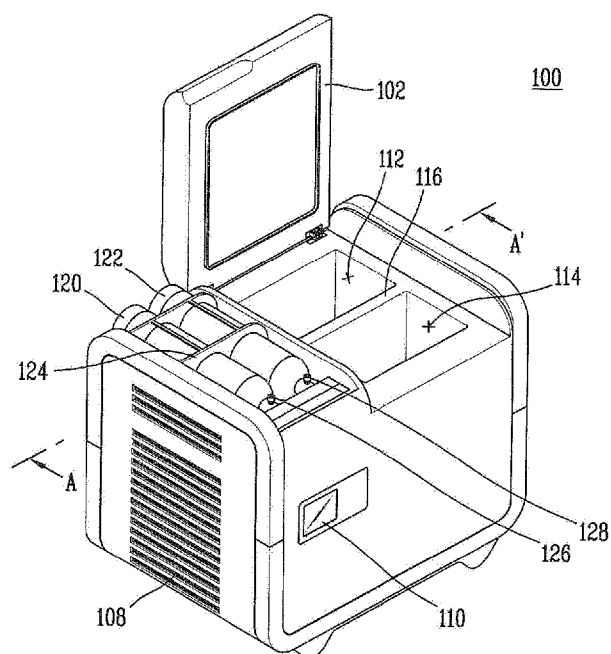


FIG. 4

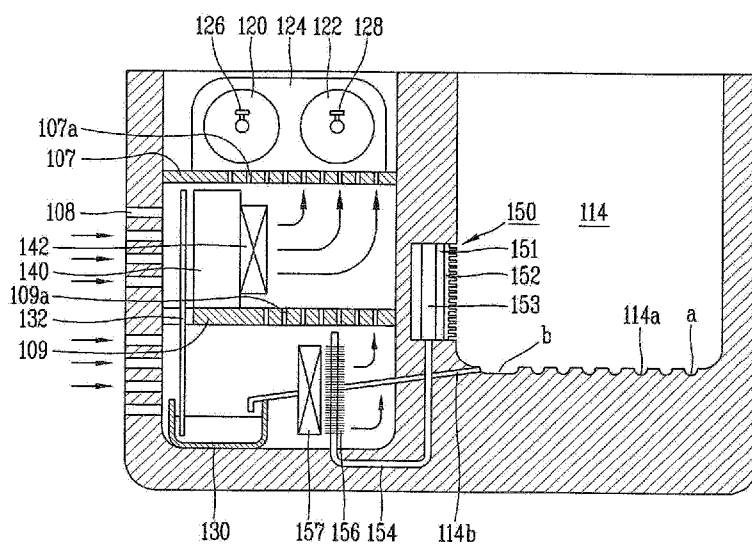


FIG. 5

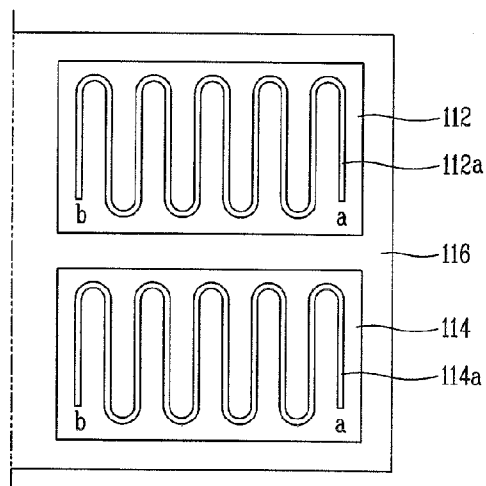


FIG. 6

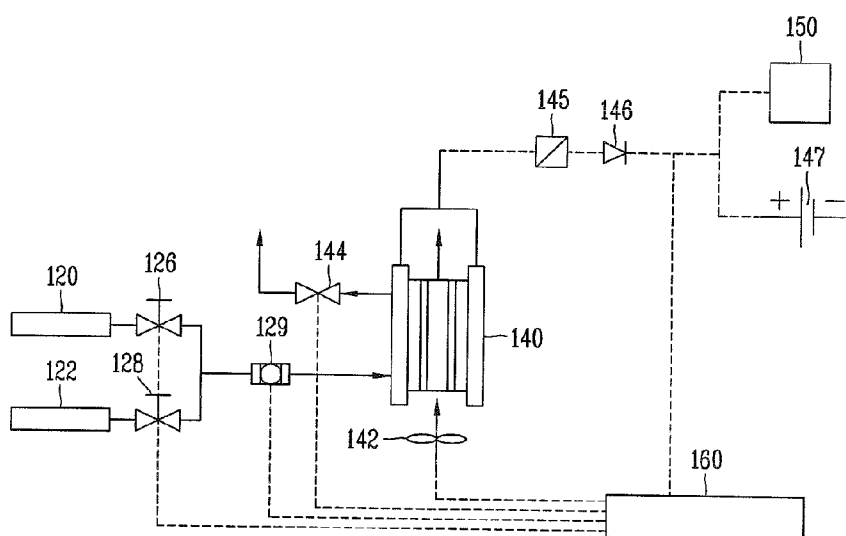


FIG. 7A

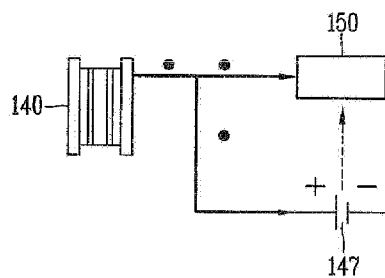


FIG. 7B

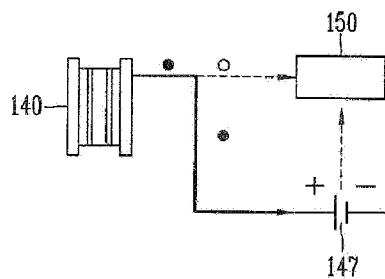


FIG. 7C

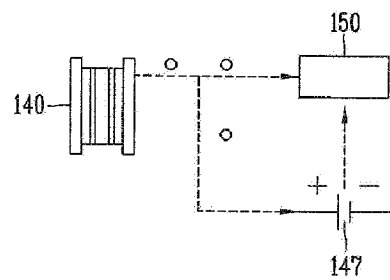
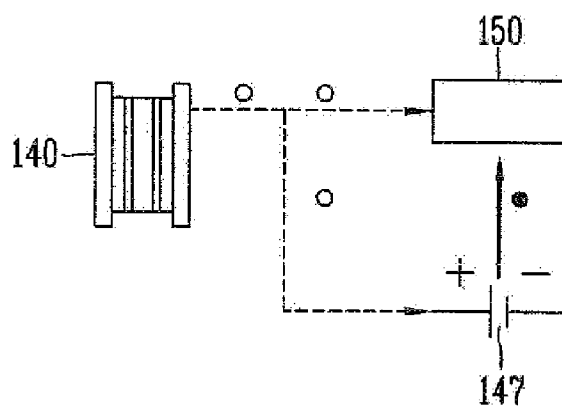


FIG. 7D



**PORTABLE REFRIGERATOR WITH FUEL
CELL SYSTEM AND OPERATING METHOD
THEREOF**

**CROSS-REFERENCE TO A RELATED
APPLICATION**

[0001] Pursuant to 35 U.S.C. §119(a), this application claims the benefit of earlier filing date and right of priority to Korean Application 10-2010-0079005, filed on Aug. 16, 2010, the content of which is incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a portable refrigerator with a fuel cell system and an operating method thereof, and particularly, to a portable refrigerator using a fuel cell as an energy source.

[0004] 2. Background of the Invention

[0005] A portable refrigerator is configured to be easily carried with a smaller volume than a general refrigerator for home or commercial uses. This portable refrigerator is being used as a refrigerator for leisure or medical uses.

[0006] The portable refrigerator may be classified according to a cooling method. The cooling method may include a method using a vapor compression type cooling cycle, and a method using a thermoelectric element. The method using a vapor compression type cooling cycle has an advantage of high energy efficiency. However, the method has disadvantages such as a complicated structure and a large volume. Accordingly, the method using a thermoelectric element is being widely adopted.

[0007] The method using a thermoelectric element adopts the Peltier effect that heat absorption and heat release (dissipation) simultaneously occur from contact points between two conductors when a current flows. Here, a heat absorption phenomenon is applied to a cooling operation. The method using a thermoelectric element has a lower energy efficiency than the method using a vapor compression type cooling cycle. However, the method using a thermoelectric element implements a simplified structure and a small size due to no additional components, and can precisely control a cooling capacity.

[0008] Furthermore, the method using a thermoelectric element is not influenced by a gravitational direction when a cooling system is applied. Besides, the method using a thermoelectric element has an eco-friendly characteristic due to no refrigerant. Accordingly, the method using a thermoelectric element is suitable for medical uses, especially.

[0009] In order to operate a portable refrigerator using a thermoelectric element, a battery is generally used as a power source. However, the conventional portable refrigerator using a battery has the following problems. Firstly, when a battery of a large capacity is used to supply high power for operating the thermoelectric element, the entire system has a large volume to degrade a portable characteristic. Secondly, when the battery is consumed up, it takes a lot of time to charge the battery.

SUMMARY OF THE INVENTION

[0010] Therefore, an object of the present invention is to provide a portable refrigerator capable of supplying a sufficient amount of power and capable of being easily carried.

[0011] Another object of the present invention is to provide an operating method of a portable refrigerator.

[0012] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is provided a portable refrigerator with a fuel cell system, comprising: a case having a storage space; a fuel cell stack disposed in the case; a gas tank configured to store gas necessary to operate the fuel cell stack; a fan configured to cool the fuel cell stack and supply air to the fuel stack; a thermoelectric cooling means disposed in the case, and configured to cool the storage space; a battery charged by the fuel cell stack, and configured to supply power to the thermoelectric cooling means; and a controller configured to control the fuel cell stack and the thermoelectric cooling means.

[0013] As a power source of the portable refrigerator, a fuel cell may be used. Inside of the case may be divided into two spaces. One space may be utilized as a storage space, and another space may be utilized as a space for each component necessary to drive the fuel cell and cooling means for cooling the storage space. This may allow the portable refrigerator to have a compact and portable structure.

[0014] The fuel cell may include PAFC (Phosphoric Acid FC), MCFC (Molten Carbonate FC), SOFC (Solid Oxide FC), DMFC (Direct Methanol FC) and PEMFC (Proton Exchange Membrane FC) according to a type of an electrolyte and a fuel. In the present invention, the PEMFC may be used as a driving source.

[0015] The PEMFC may be operated by a principle that electricity is generated by a catalytic reaction between hydrogen of an anode side and oxygen of a cathode side, and water and heat are generated by a chemical reaction between the hydrogen and the oxygen. This PEMFC may have a high output density, a low operation temperature less than 100° C., less restrictions on an installation place, and a small size due to a simplified configuration. The PEMFC may be a fuel cell system that can be applied for the purposes of carrying, living and transferring, due to high endurance, a short initial-driving time, an operation at a room temperature and under an atmospheric pressure, a rapid response speed, etc. Especially, the PEMFC having a flexible configuration due to an energy conversion function and a storage function separate from each other, a long lifespan due to high durability, and a relatively low cost may be suitable for a driving source of the portable refrigerator.

[0016] Heat generated while the stack is operated may be removed by the cooling fan. Air having passed the stack by the cooling fan may have temperature increment due to heat transfer, and may be exhausted from the stack in the high-temperature state. The exhausted air may be blown to the gas tank. Here, the gas tank may store hydrogen therein. The air blown to the gas tank may heat the gas tank to exhaust the hydrogen stored in the gas tank to outside.

[0017] The fuel cell stack may be arranged below the gas tank, and a plurality of through holes may be formed at a gas tank fixing plate disposed between the gas tank and the fuel cell stack. This may allow air having temperature increment to be transferred to the gas tank via the through holes.

[0018] The thermoelectric cooling means may be operated by power of the battery. However, when the voltage of the battery is not sufficient, the thermoelectric cooling means may be operated by directly receiving power from the fuel cell

stack. For selective power supply to the thermoelectric cooling means, the fuel cell stack and the battery may be controlled by the controller.

[0019] The thermoelectric cooling means may include a thermoelectric device disposed such that a low temperature side is towards the storage space, a radiating means connected to a high temperature side of the thermoelectric device, and a fan provided at the radiating means. The air having temperature increment may be blown to the gas tank by the fan for cooling the radiating means.

[0020] A flow path for collecting condensed water may be formed on a bottom surface of the storage space, and a condensed water reservoir for storing the condensed water collected in the flow path may be provided. Condensed water generated in the storage space during the operation of the refrigerator may be collected to the bottom surface of the storage space. Here, the condensed water may be collected in one spot due to the flow path, and then may be moved to the condensed water reservoir. This may minimize collection of condensed water in the storage space.

[0021] Here, the condensed water stored in the condensed water reservoir may be supplied to the stack. For this, a moisture supplying means may be further provided.

[0022] The moisture supplying means may include a non-woven fabric covering one side surface of the stack, and having one end extending to inside of the condensed water reservoir. Air introduced by the cooling fan may be blown to the stack via the non-woven fabric. Once air passes through the non-woven fabric by the cooling fan, moisture contained in the non-woven fabric may be evaporated to be supplied into the stack. The moisture supplied to the stack may allow the stack to be smoothly operated.

[0023] The condensed water reservoir may be disposed at a position lower than the bottom surface of the storage space.

[0024] The portable refrigerator with a fuel cell system according to the present invention may further comprise a pump configured to transfer condensed water collected in the storage space to the condensed water reservoir.

[0025] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is also provided an operating method of a portable refrigerator comprising a fuel cell stack, a battery configured to store power generated from the fuel cell stack, and a thermoelectric cooling means operated by receiving power from the battery or the fuel cell stack, the method comprising: checking an output voltage of the battery; when the output voltage is less than a predetermined value, charging the battery by operating the fuel cell stack; and when the thermoelectric cooling means needs to be operated in the process of charging the battery, directly is supplying power to the thermoelectric cooling means from the fuel cell stack.

[0026] When the thermoelectric cooling means needs to be operated in a state that the output voltage of the battery is not sufficient, power may be directly supplied to the battery and the thermoelectric cooling means from the fuel cell stack, respectively. This may always provide a cooling function, thereby enhancing a user's convenience.

[0027] Since a fuel cell may be used as a power source of the portable refrigerator, the portable refrigerator according to the present invention may have a more compact structure and an enhanced portable characteristic.

[0028] The foregoing and other objects, features, aspects and advantages of the present invention will become more

apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

[0030] In the drawings:

[0031] FIG. 1 is a perspective view of a portable refrigerator according to a first embodiment of the present invention;

[0032] FIG. 2 is a perspective view of the portable refrigerator of FIG. 1, which shows a state that handgrips have been lifted up;

[0033] FIG. 3 is a perspective view of the portable refrigerator of FIG. 1, which shows a state that first and second covers have opened;

[0034] FIG. 4 is a longitudinal section view taken along line A-A' in FIG. 3;

[0035] FIG. 5 is a planar view of a bottom surface of a storage space in the portable refrigerator of FIG. 1; and

[0036] FIG. 6 is a view schematically showing each component of the portable refrigerator of FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

[0037] Description will now be given in detail of the present invention, with reference to the accompanying drawings.

[0038] For the sake of brief description with reference to the drawings, the same or equivalent components will be provided with the same reference numbers, and description thereof will not be repeated.

[0039] Hereinafter, a portable refrigerator according to the present invention will be explained in more detail with reference to the attached drawings.

[0040] FIG. 1 is a perspective view of a portable refrigerator according to a first embodiment of the present invention, FIG. 2 is a perspective view of the portable refrigerator of FIG. 1, which shows a state that handgrips have been lifted up, and FIG. 3 is a perspective view of the portable refrigerator of FIG. 1, which shows a state that first and second covers have opened.

[0041] Referring to FIGS. 1 to 3, the portable refrigerator 100 is provided with a first cover 102 and a second cover 104 mounted at an upper part thereof so as to be open and closed. The first cover 102 is configured to cover a refrigerating chamber, and the second cover 104 is configured to cover a mechanical chamber having a fuel cell stack, etc. to be later explained.

[0042] Handgrips 106 are slidably installed at both side surfaces of the portable refrigerator so as to enhance a portable characteristic. As shown in FIG. 2, the handgrips 106 are configured to be usable after being upwardly slid. When not used, the handgrips 106 are downwardly slid to be in an accommodated state as shown in FIG. 1.

[0043] A plurality of slits 108 are formed on the side surface adjacent to the mechanical chamber, through which external air can be easily introduced into the mechanical chamber. The slits 108 may be provided on a front surface or a rear surface of the portable refrigerator 100. An LCD 110 is

provided on the front surface of the portable refrigerator **100**, through which an operation state of the portable refrigerator **100** is informed to a user.

[0044] Referring to FIG. 3, the refrigerating chamber open and closed by the first cover **102** is divided into a first space **112** and a second space **114** by a partition wall **116**. Here, the number of partitioned spaces of the refrigerating chamber may be arbitrary. Furthermore, the partition wall **116** may not be fixed, but may be configured to vary an area of each space by being slid.

[0045] At an upper part of the mechanical chamber open and closed by the second cover **104**, installed are two canisters **120** and **122** configured to store gas required to operate a fuel cell stack. The canisters **120** and **122** are charged with hydrogen, and are stably fixed to an upper side of the mechanical chamber by a canister fixing plate **124**. Solenoid valves **126** and **128** are respectively installed at outlets of the canisters **120** and **122** for control of gas supply.

[0046] FIG. 4 is a longitudinal section view taken along line A-A' in FIG. 3, and FIG. 5 is a planar view of a bottom surface of a storage space in the portable refrigerator of FIG. 1.

[0047] Referring to FIGS. 4 and 5, condensed water channels **112a** and **114a** are formed on bottom surfaces of the first and second spaces **112** and **114**. Each of the condensed water channels **112a** and **114a** is formed in a zigzag form, and is configured to have a height gradually lowered toward 'b' from 'a' in FIG. 5. Accordingly, condensed water generated from each storage space is collected in the condensed water channels by gravity, and then is finally collected in the region of 'b'.

[0048] Here, the condensed water channel may not be limited to the illustrated form, but may have any form to collect condensed water to one spot. For instance, the condensed water channel may have a lattice form.

[0049] Referring to FIG. 4 back, the mechanical chamber is divided into three spaces by an upper plate **107** and a lower plate **109**. As aforementioned, the condensed water collected in the region of 'b' moves to outside the space along a transfer pipe **114b**. Then, the condensed water is stored in a condensed water reservoir **130** installed at a lowermost part of the mechanical chamber. The condensed water reservoir **130** is installed at a position lower than the bottom surface of each storage space, so that collected condensed water can be introduced into the condensed water reservoir without an additional pump. Here, an additional pump may be installed.

[0050] A lower end of the non-woven fabric **132** extending in upper and lower directions is immersed in the condensed water reservoir **130**. The non-woven fabric **132** is installed on one side surface of the portable refrigerator **100** so as to cover the slits **108** on an inner side surface. Under this configuration, condensed is water stored in the condensed water reservoir **130** is absorbed to the non-woven fabric **132**.

[0051] The canister fixing plate **124** is fixed to the upper plate **107**, and the upper plate **107** is provided with a plurality of through holes **107a**. The lower plate **109** is also provided with a plurality of through holes **109a**, and a fuel cell stack **140** is mounted above the lower plate **109**.

[0052] The fuel cell stack **140** generates power by using hydrogen stored in the canisters, and oxygen provided through the cooling fan **142** arranged to be adjacent thereto. The cooling fan **142** for removing heat generated during the operation of the fuel cell stack **140** is provided on one side surface of the fuel cell stack **140**. Here, air introduced by the cooling fan **142** passes through the non-woven fabric **132**.

Accordingly, condensed water soaked into the non-woven fabric **132** is evaporated by flow of the air thus to be supplied to the fuel cell stack **140**. The air exhausted to outside via the fuel cell stack **140** has temperature increment due to heat from the fuel cell stack **140**. The high-temperature air is supplied to the canisters **120** and **122** through the through holes **107a**.

[0053] Accordingly, the canisters **120** and **122** are heated by relatively-high temperature air. This may allow hydrogen stored in the canisters **120** and **122** to be in a state suitable for operating the fuel cell stack **140**. Furthermore, air is exhausted to outside of the portable refrigerator **100** after transferring heat to the canisters **120** and **122** to some degrees. This may minimize increase of an indoor temperature due to exhausted air when the portable refrigerator **100** is used for a long time.

[0054] A thermoelectric cooling means **150** is installed at one side of the storage space. More concretely, the thermoelectric cooling means **150** includes a thermoelectric device **151** arranged so that a low temperature side thereof can be toward the storage space. A heat sink **152** having a plurality of radiating fins on the surface thereof is attached to the low temperature side of the thermoelectric device **151**. Referring to FIG. 4, the heat sink **152** is configured to cool the storage space by natural convection. However, the present invention is not limited to this. That is, an additional fan may be provided to heat-exchange air inside the storage space with the heat sink **152**.

[0055] A heat sink **153** is also provided at a high temperature side of the thermoelectric device **151**. The heat sink **153** is thermally connected to a radiating plate **156** provided below the mechanical chamber by a heat pipe **154**. The radiating plate **156** is provided with a cooling fan **157**. Accordingly, heat generated from the high temperature side of the thermoelectric device **151** is transferred to the heat sink **153**, the heat pipe **154** and the radiating plate **156**, and then is transferred to indoor air by the cooling fan **157**.

[0056] The exhausted high-temperature air sequentially passes through the through holes **109a** of the lower plate **109** and the through holes **107a** of the upper plate **107**, thereby heating the canisters **120** and **122**.

[0057] Hereinafter, the operation of the portable refrigerator **100** will be explained with reference to FIG. 6.

[0058] FIG. 6 is a view schematically showing each component of the portable refrigerator of FIG. 1.

[0059] Referring to FIG. 6, hydrogen stored in the two canisters **120** and **122** is supplied to the fuel cell stack **140** according to an open or closed state of the solenoid valves **126** and **128**. Here, the solenoid valves **126** and **128** are controlled so that the hydrogen can be supplied to the fuel cell stack **140** only when the fuel cell stack **140** is operated by the controller **160**.

[0060] Here, the hydrogen can be supplied to the fuel cell stack **140** by directly supplying reformed hydrogen, or by reforming a hydrocarbon-based material by including a reformer in the system. The method using a reformer has an advantage that many types of hydrocarbon-based fuels being used as an energy source can be directly used. However, the method using a reformer has a problem that a reformer has to be included in the entire system. Therefore, hydrogen is stored in the canisters **120** and **122** thus to be directly supplied to the fuel cell stack **140**.

[0061] The hydrogen from the canisters is reacted via the fuel cell stack, and then is operated by a dead end method without being exhausted to the outside. A purging valve **144**

is mounted to a rear end of the fuel cell stack 140. The purging valve 144 is operated in a predetermined period, thereby removing water or impurities remaining in the fuel cell stack 140. Here, the purging valve 144 is operated for about 0.5 seconds in a period of 10 seconds.

[0062] The hydrogen exhausted from the canisters cannot be directly supplied to the fuel cell stack due to instability and high pressure. Accordingly, the hydrogen needs to be uniformly depressurized into a pressure suitable for the fuel cell stack 140. For this, a regulator 129 is disposed between the solenoid valves and the fuel cell stack.

[0063] The thermoelectric cooling means 150 is operated by power supplied from a battery 147. The battery 147 is charged by power generated by the fuel cell stack 140, and an output voltage thereof is periodically checked by the controller. If the battery has a voltage less than a lower limit value, the fuel cell stack 140 is operated to charge the battery. On the other hand, if the battery has a voltage more than a higher limit value, the fuel cell stack 140 is stopped to maintain a suitable voltage range of the battery.

[0064] A DC-DC converter 145 is disposed between the fuel cell stack 140 and the battery 147. The controller 160 real time checks a voltage of the DC-DC converter 145, thereby checking an output voltage from the fuel cell stack 140. If the hydrogen remaining in the canisters is deficient, the DC-DC converter 145 has a lowered voltage. Accordingly, upon detection of a lowered voltage, the controller informs, through the LCD 110, a time point when the canisters are to be replaced.

[0065] Driving conditions of the fuel cell stack 140 according to a charged state of the battery and a load will be explained with reference to FIGS. 7A to 7D. In FIGS. 7A to 7D, the solid line indicates an electrically-connected state, whereas the dotted line indicates an electrically-disconnected state.

[0066] Once the portable refrigerator is operated, the controller real time checks a voltage of the battery. If the voltage of the battery is less than a predetermined value, the controller charges the battery by driving the fuel cell stack 140 as shown in FIG. 7A. FIG. 7A shows a state that a load is applied even from the thermoelectric cooling means, i.e., cooling power is supplied even to the thermoelectric device. Electricity generated from the fuel cell stack is supplied to the thermoelectric cooling means via the DC-DC converter 145 and a diode 146 as well as the battery.

[0067] If cooling power is not required any more, the current state of the system is converted into a state of FIG. 7B. Under the state of FIG. 7B, power is not supplied to the thermoelectric cooling means, but electricity generated from the fuel cell stack is used only to charge the battery until the output voltage of the battery reaches the higher limit value. FIGS. 7C and 7D show that the fuel cell stack is not operated. More concretely, FIG. 7C shows that a load is not applied to the battery and the thermoelectric cooling means, and FIG. 7D shows that a load is applied only to the thermoelectric cooling means. That is, when the battery has a sufficient capacity, the thermoelectric cooling means is driven just by power of the battery in a state that the fuel cell stack is not driven.

[0068] On the contrary, when the voltage of the battery is lowered to a voltage less than the lower limit value, the current state of the system is re-converted into the state of FIG. 7A.

[0069] The foregoing embodiments and advantages are merely exemplary and are not to be construed as limiting the present disclosure. The present teachings can be readily applied to other types of apparatuses. This description is intended to be illustrative, and not to limit the scope of the claims. Many alternatives, modifications, and variations will be apparent to those skilled in the art. The features, structures, methods, and other characteristics of the exemplary embodiments described herein may be combined in various ways to obtain additional and/or alternative exemplary embodiments.

[0070] As the present features may be embodied in several forms without departing from the characteristics thereof, it should also be understood that the above-described embodiments are not limited by any of the details of the foregoing description, unless otherwise specified, but rather should be construed broadly within its scope as defined in the appended claims, and therefore all changes and modifications that fall within the metes and bounds of the claims, or equivalents of such metes and bounds are therefore intended to be embraced by the appended claims.

What is claimed is:

1. A portable refrigerator with a fuel cell system, comprising:

- a case having a storage space;
- a fuel cell stack disposed in the case;
- a gas tank configured to store gas necessary to operate the fuel cell stack;
- a fan configured to cool the fuel cell stack and supply air to the fuel stack;
- a thermoelectric cooling means disposed in the case, and configured to cool the storage space;
- a battery charged by the fuel cell stack, and configured to supply power to the thermoelectric cooling means; and
- a controller configured to control the fuel cell stack and the thermoelectric cooling means.

2. The portable refrigerator with a fuel cell system of claim 1, wherein air having passed through the fuel cell stack is blown to the gas tank.

3. The portable refrigerator with a fuel cell system of claim 2, wherein the fuel cell stack is arranged below the gas tank, and a plurality of through holes are formed at a gas tank fixing plate disposed between the gas tank and the fuel cell stack.

4. The portable refrigerator with a fuel cell system of claim 1, wherein the thermoelectric cooling means is controlled by the controller so as to selectively receive power from the fuel cell stack and the battery.

5. The portable refrigerator with a fuel cell system of claim 4, wherein when the battery has a voltage less than a predetermined level, the controller controls power to be directly supplied to the thermoelectric cooling means from the fuel cell stack.

6. The portable refrigerator with a fuel cell system of claim 1, wherein the thermoelectric cooling means comprises:

- a thermoelectric device disposed such that a low temperature side is towards the storage space;
- to a radiating means connected to a high temperature side of the thermoelectric device; and
- a fan provided at the radiating means.

7. The portable refrigerator with a fuel cell system of claim 6, wherein air having passed through the radiating means is blown to the gas tank by the fan.

8. The portable refrigerator with a fuel cell system of claim 1, wherein a flow path for collecting condensed water is formed on a bottom surface of the storage space, and a con-

condensed water reservoir for storing the condensed water collected in the flow path is provided.

9. The portable refrigerator with a fuel cell system of claim 8, further comprising a moisture supplying means configured to supply the condensed water stored in the condensed water reservoir to the fuel cell stack.

10. The portable refrigerator with a fuel cell system of claim 9, wherein the moisture supplying means comprises:

a non-woven fabric covering one side surface of the fuel cell stack, and having one end extending to inside of the condensed water reservoir,

wherein air introduced by the cooling fan is blown to the fuel cell stack via the non-woven fabric.

11. The portable refrigerator with a fuel cell system of claim 8, wherein the condensed water reservoir is disposed at a position lower than the bottom surface of the storage space.

12. The portable refrigerator with a fuel cell system of claim 8, further comprising a pump configured to transfer condensed water collected in the storage space to the condensed water reservoir.

13. An operating method of a portable refrigerator comprising a fuel cell stack, a battery configured to store power generated from the fuel cell stack, and a thermoelectric cooling means operated by receiving power from the battery or the fuel cell stack, the method comprising:

checking an output voltage of the battery;

when the output voltage is less than a predetermined value,

charging the battery by operating the fuel cell stack; and

when the thermoelectric cooling means needs to be operated in the process of charging the battery, directly supplying power to the thermoelectric cooling means from the fuel cell stack.

* * * * *