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KIM et al.(10) **Pub. No.: US 2013/0336826 A1**(43) **Pub. Date: Dec. 19, 2013**(54) **FLUID PUMPING DEVICE, FUEL CELL
DEVICE AND FUEL GAS RECIRCULATION
METHOD USING THE SAME**(30) **Foreign Application Priority Data**

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AND TECHNOLOGY, SEOUL (KR)**(21) Appl. No.: **13/832,601**(22) Filed: **Mar. 15, 2013**(57) **ABSTRACT**

Provided is a fluid pumping device, and more particularly, a fluid pumping device capable of being used in fuel cell systems and the like and spatially separating a fluid temporary storage unit through which a fluid at high temperature passes from a pump, thereby maintaining the durability of the pump, facilitating replacement and management, and achieving a reduction in weight.

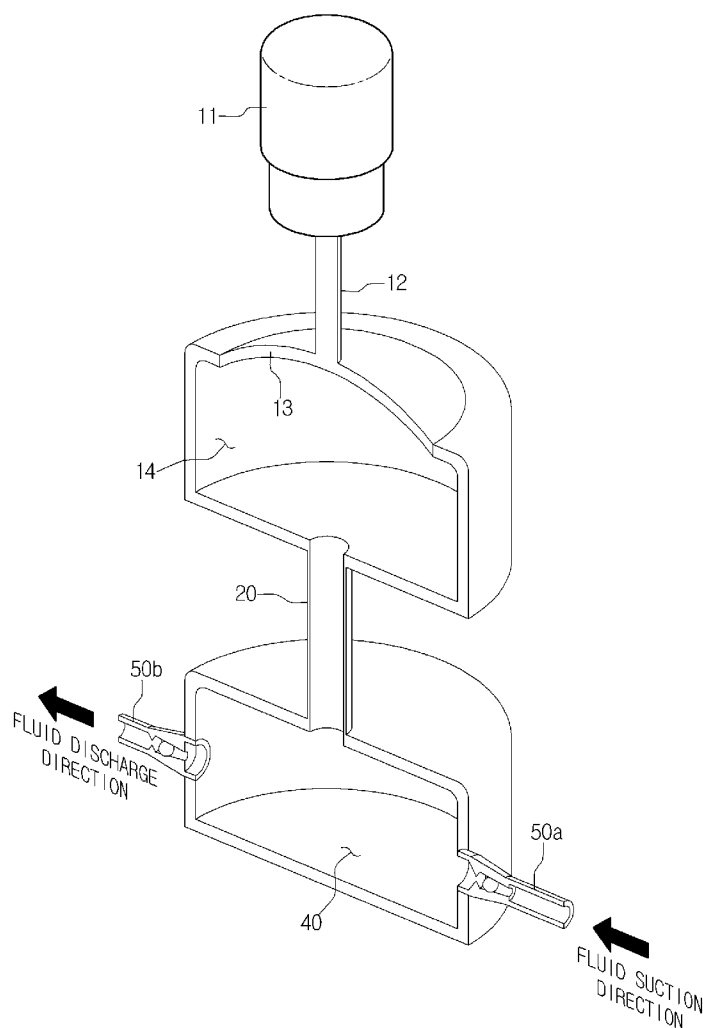


FIG. 1

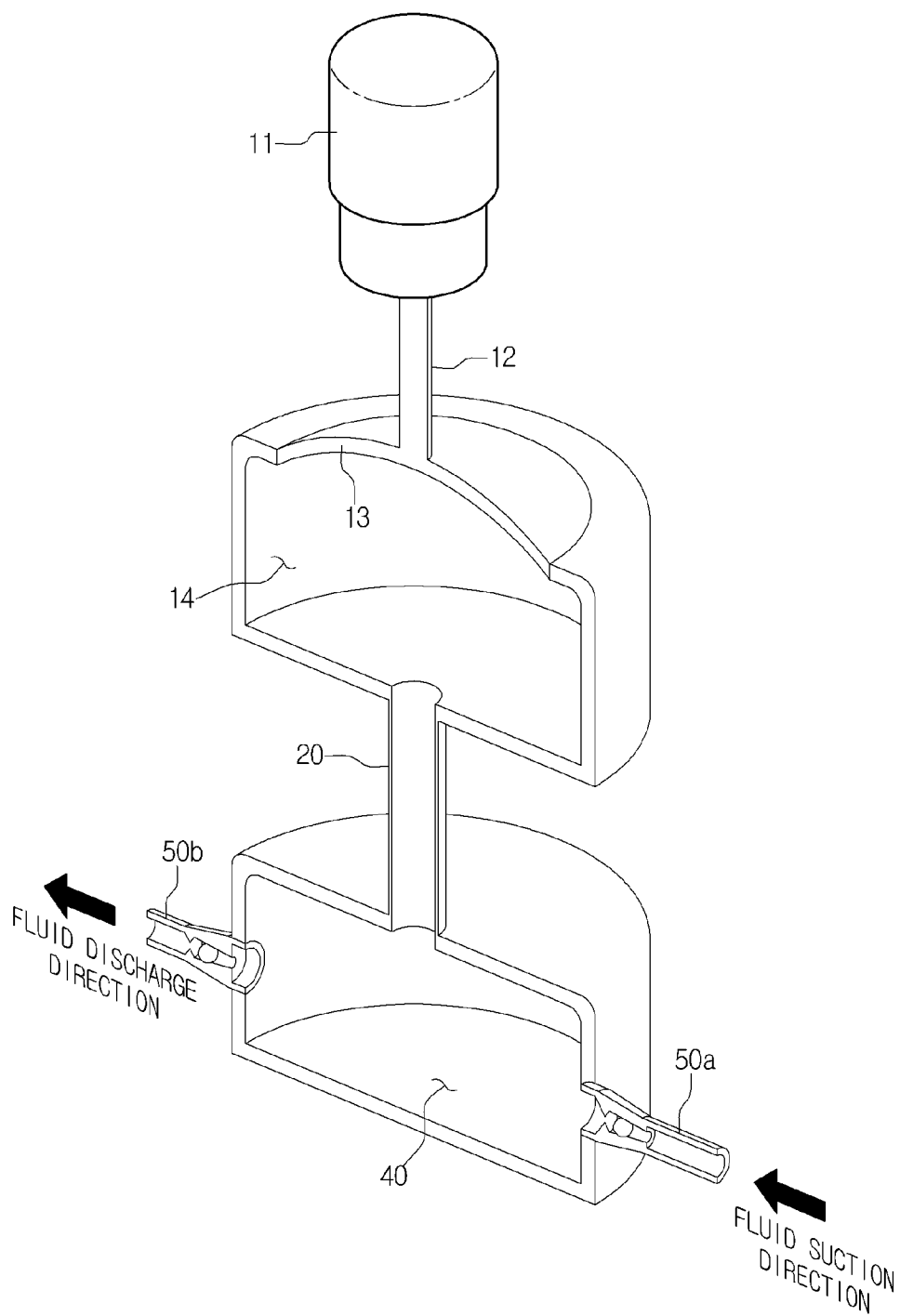


FIG.2

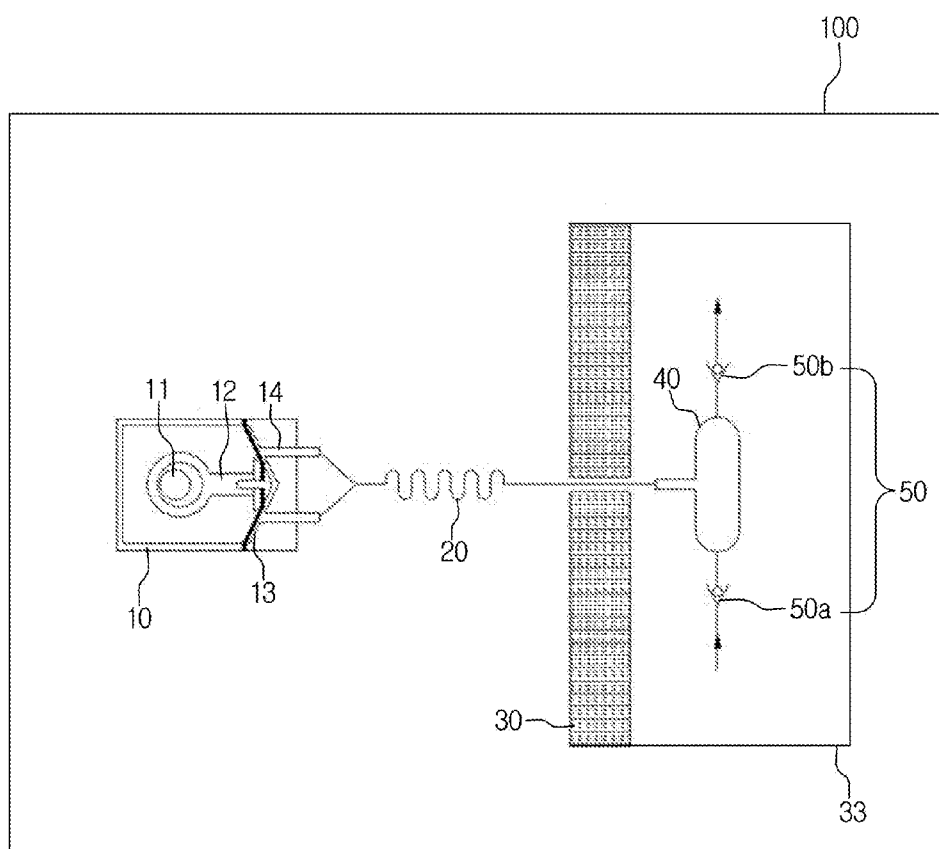


FIG. 3

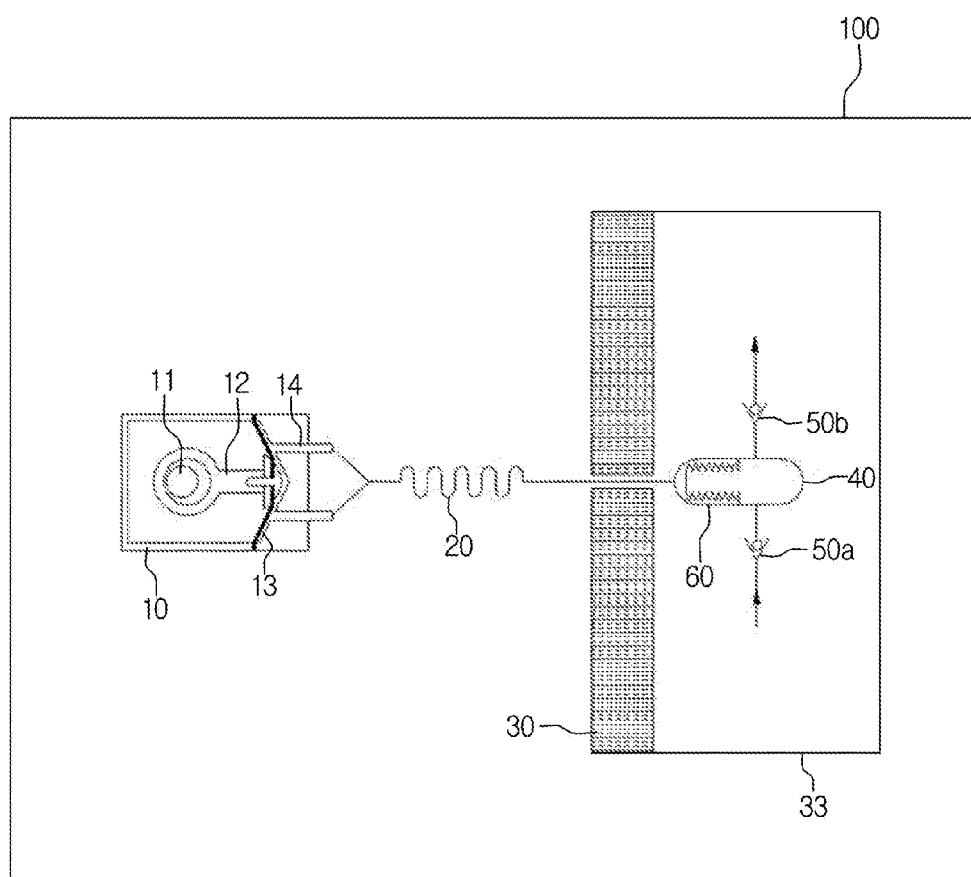


FIG. 4

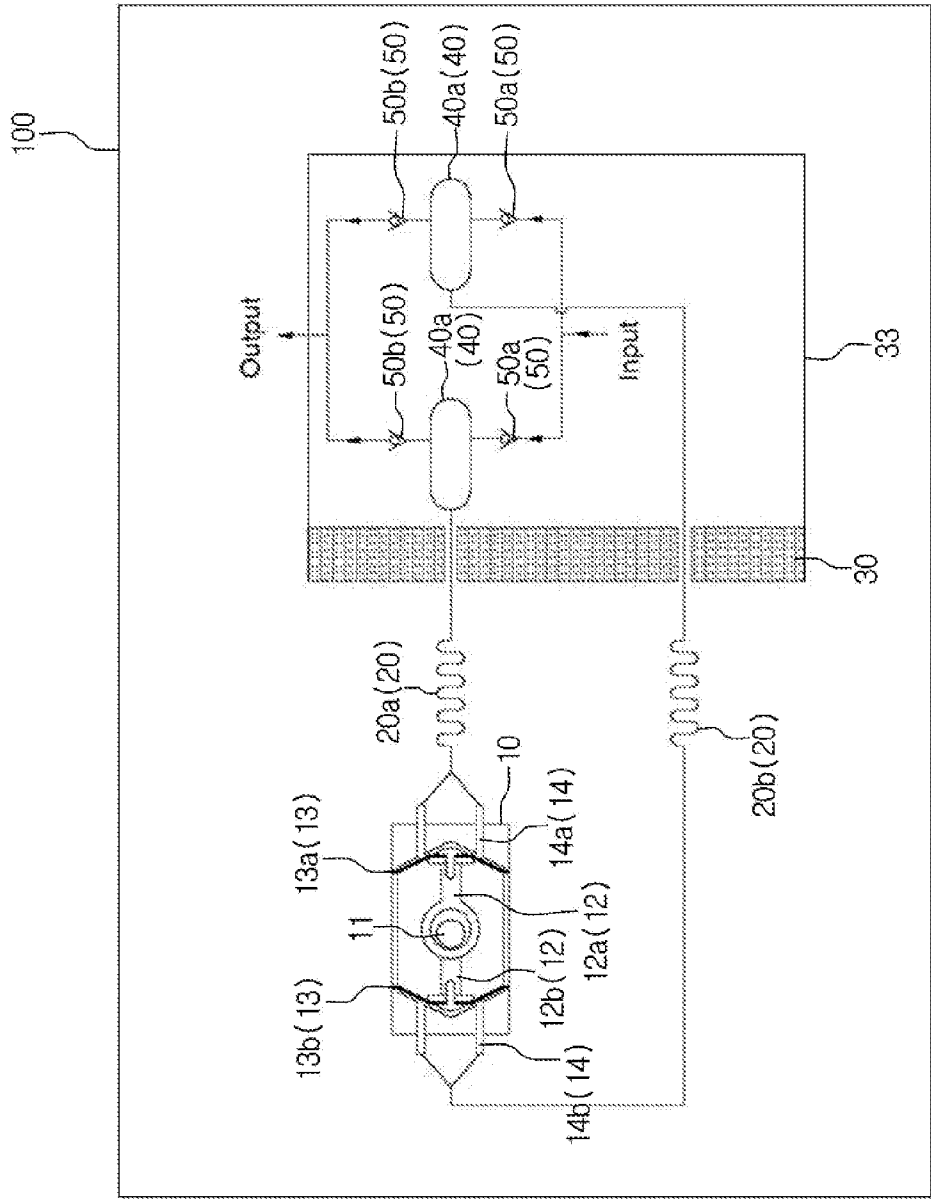


FIG. 5

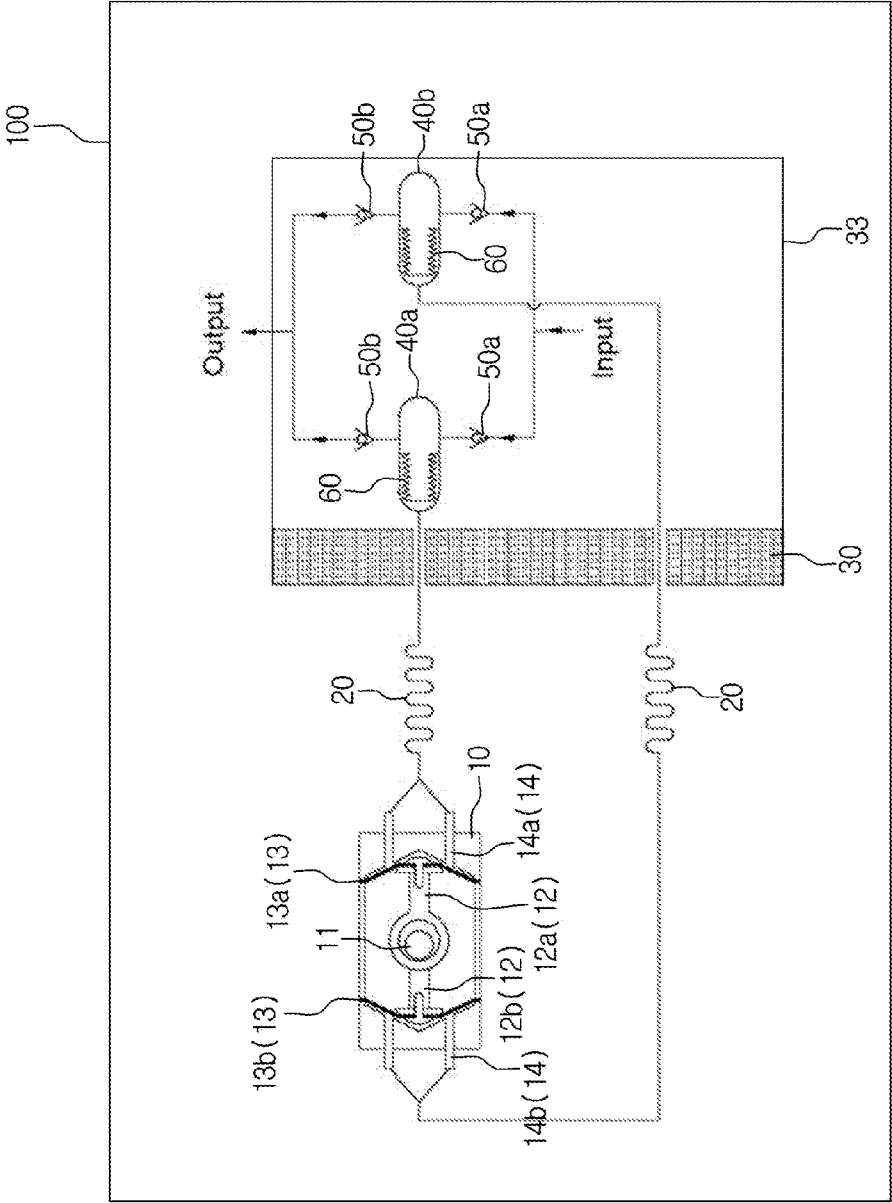


FIG. 6

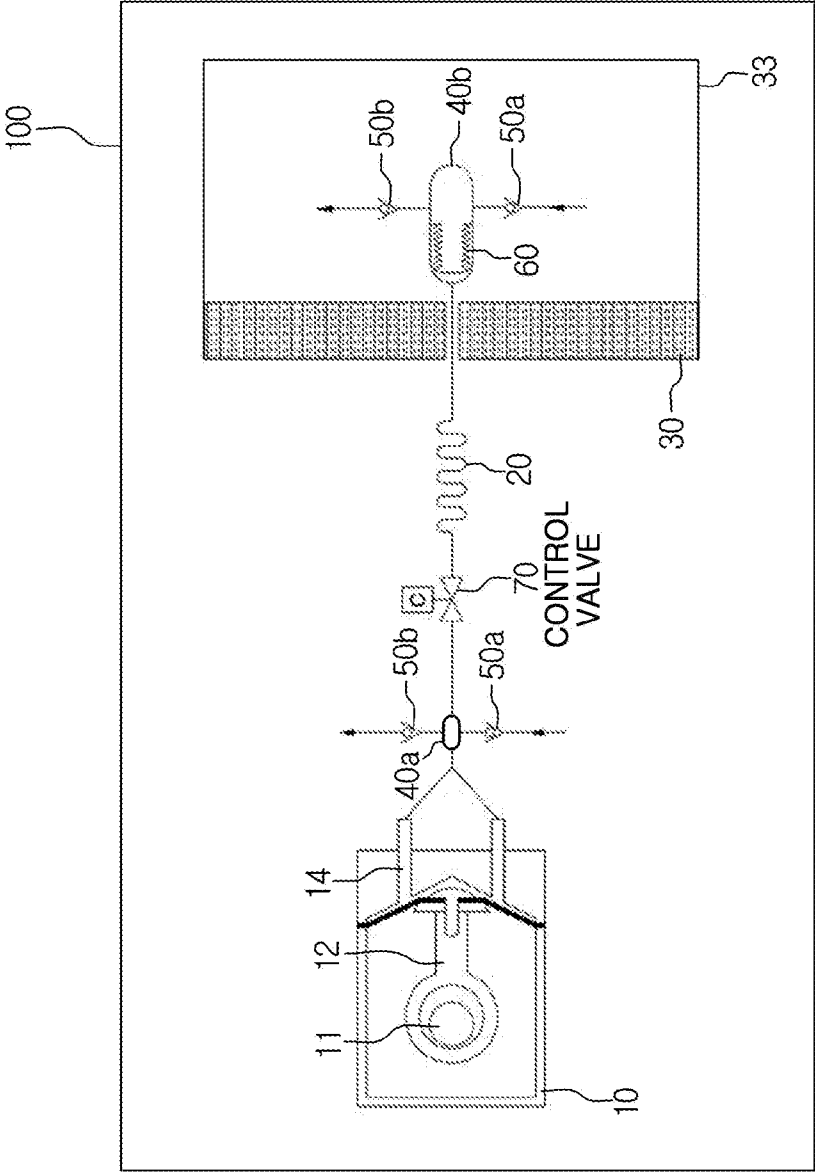


FIG. 7

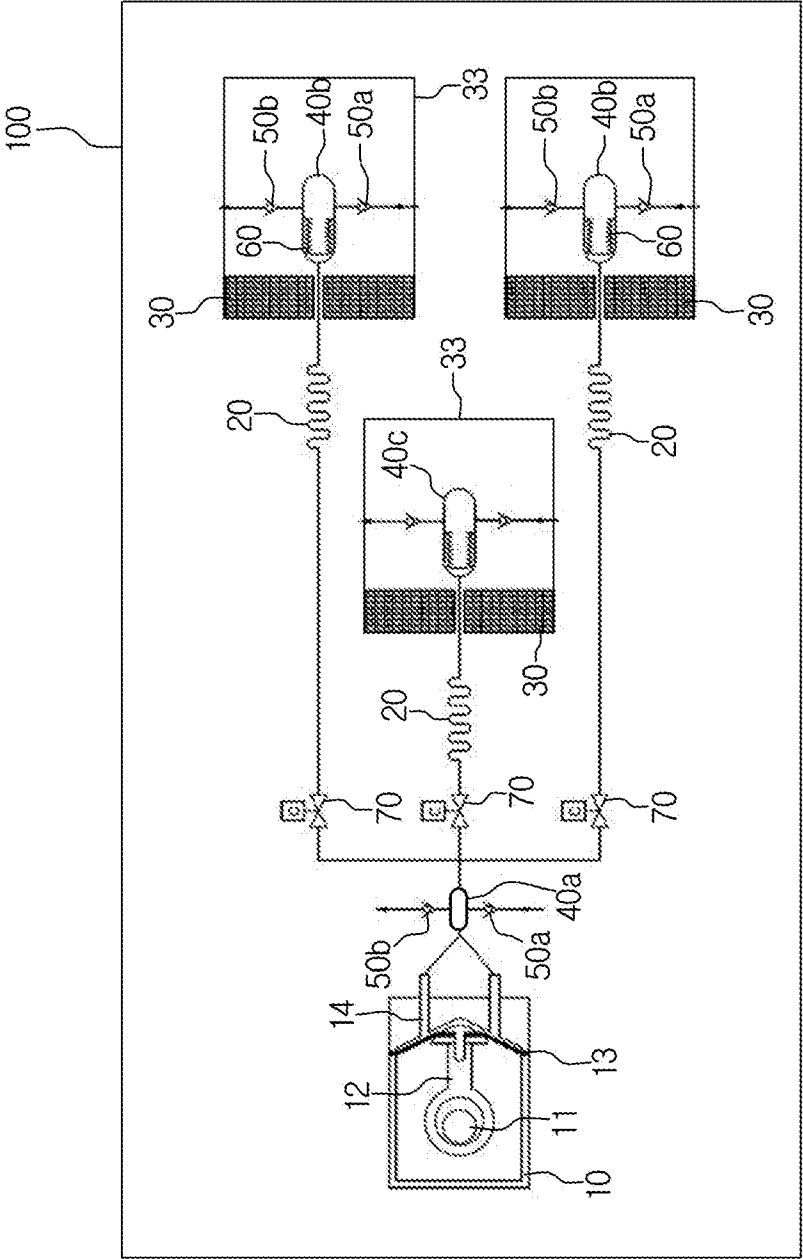


FIG. 8

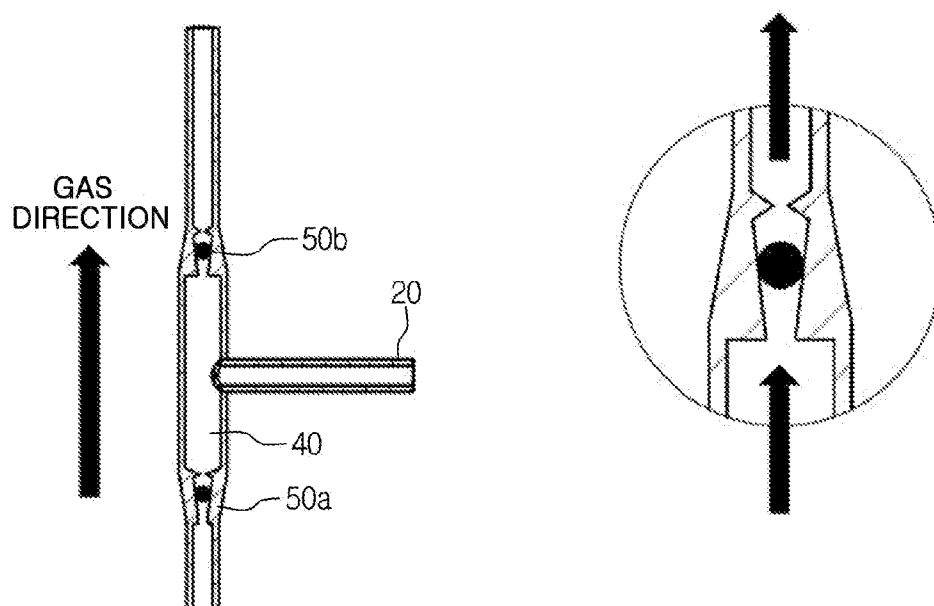
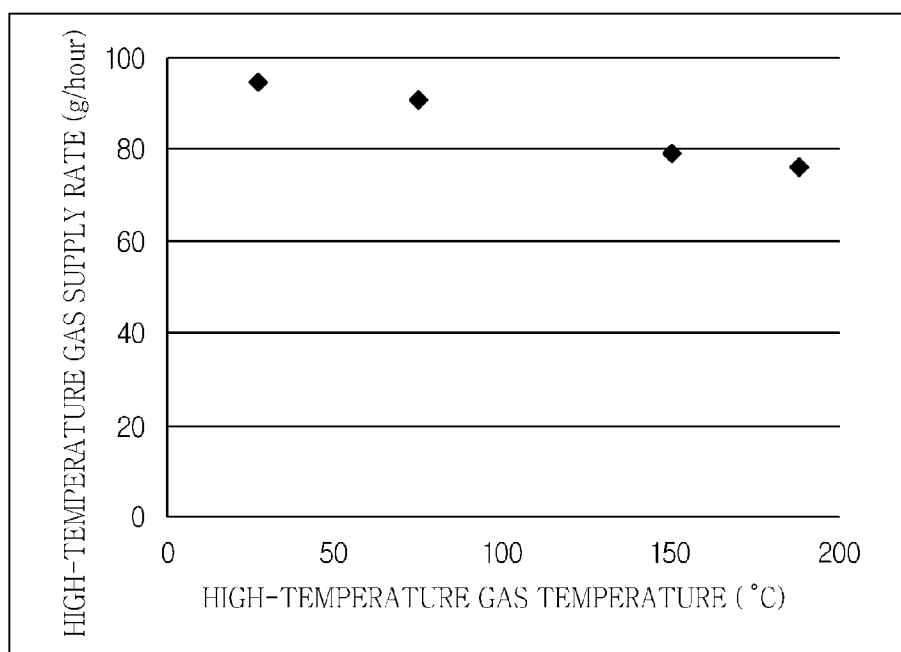


FIG. 9



FLUID PUMPING DEVICE, FUEL CELL DEVICE AND FUEL GAS RECIRCULATION METHOD USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Korean Patent Application No. 10-2012-0063636, filed on Jun. 14, 2012, and all the benefits accruing therefrom under 35 U.S.C. §119, the contents of which in its entirety are herein incorporated by reference.

BACKGROUND

[0002] 1. Field

[0003] The present disclosure relates to a fluid pumping device, and a fuel cell device and a fuel gas recirculation method using the same, and more particularly, to a fluid pumping device capable of being applied to a fuel cell device, particularly, a high-temperature fuel cell and to a fluid mixing process under high-temperature conditions, a cooling process, a reaction process, a process of reaction between a solid and a fluid and extraction under high-temperature conditions, a nuclear reactor, and the like, and a fuel cell device and a fuel gas recirculation method using the same.

[0004] 2. Description of the Related Art

[0005] There is an urgent request for energy efficiency due to fossil energy depletion and environmental pollution.

[0006] Regarding this, in cases of high-temperature fuel cell systems such as solid oxide fuel cells (SOFC) or molten carbonate fuel cells, thermodynamic efficiency of power generation is high, and waste heat at a high temperature has a wide range of applications. Therefore, the systems have been actively studied.

[0007] Particularly, such fuel cells are high-temperature fuel cells that operate at a temperature of higher than or equal to 500° C. and thus may use various hydrocarbons other than hydrogen as fuels and may use inexpensive non-metallic electrodes.

[0008] In the high-temperature fuel cell energy systems such as solid oxide fuel cells and molten carbonate fuel cells, researches for increasing energy efficiency have been carried out.

[0009] In detail, the fuel utilization (used fuel/supplied fuel) in the fuel cell system is generally less than 100%. Therefore, the unused fuel remains in gas discharged from the anode outlet. When the fuel is recirculated by a pump and is supplied to the anode inlet, the fuel utilization may be enhanced and thus the efficiency of the fuel cell systems may be enhanced.

[0010] In addition, when the space velocity of the gas in the anode is increased due to the recirculation of the gas discharged from the anode outlet, the temperature distribution in the fuel cell may become uniform, and mass transfer inside of the anode may be improved, thereby simultaneously enhancing the performance and the stability of the fuel cell stacks.

[0011] However, the temperature of the gas discharged from the outlet of the high-temperature fuel cell is generally higher than or equal to 500° C. and such high-temperature gas has too high temperature to be used in the recirculation pump. Therefore, the temperature of the gas discharged from the outlet has to be reduced to a temperature level that is able to be used in the recirculation pump for fuel recirculation, and the temperature has to be increased again to be supplied to the

inlet of the fuel cell. Therefore, there is a problem in that additional power for cooling and heating is needed.

[0012] In the fluid pumping device for recirculation of the outlet gas of the existing high-temperature fuel cell, a pump in a low-temperature side and a fluid storage unit in a high-temperature side are directly connected to each other to directly supply a fluid at high temperature to the pump. Accordingly, in cases where the fluid at high temperature is combustible and fluidic, a sealant should be employed in the pump in order to maintain high sealability of the pump, and a cooling device is installed on the pump shaft for protecting the pump from being overheated by the high-temperature fluid.

[0013] However, according to the research results of the inventors, in cases where the temperature of a high-temperature unit in the existing pumping device is increased, the length of the pump shaft is increased. As a result, thermal deformation and vibration become severe and this may result in degradation of the durability of the pump. In addition, when the pump shaft is increased, there is a problem in that the size of the pumping device itself is increased.

REFERENCES OF THE RELATED ART

Patent Document

[0014] (Patent Document 1) Apparatus for cooling hydrogen recirculation blower for fuel cell vehicle (US 2009/001419 A1)

[0015] (Patent Document 2) Foil gas bearing supported high temperature centrifugal blower and method for cooling thereof (US 2009/0087299)

[0016] (Patent Document 3) Circulating pump (U.S. Pat. No. 3,478,689)

[0017] (Patent Document 4) High-temperature fan (U.S. Pat. No. 2,428,765)

[0018] (Patent Document 5) Pumping a high or low temperature fluid (U.S. Pat. No. 3,666,375)

SUMMARY

[0019] The present disclosure is directed to providing a fluid pumping device capable of being applied to a fuel cell device, particularly, a high-temperature fuel cell and to a fluid mixing process under high-temperature conditions, a cooling process, a reaction process, a process of reaction between a solid and a fluid and extraction under high-temperature conditions, a nuclear reactor, and the like for recirculation of a fuel gas, thereby maintaining the durability of a pump, facilitating replacement and management, and achieving a reduction in weight and size, and a fuel cell device and a fuel gas recirculation method using the same.

[0020] In one aspect, there is provided a fluid pumping device including: a fluid temporary storage unit which temporarily stores and discharges a flow of a fluid; a pump which is positioned to be separated from the fluid temporary storage unit and repeats suction and discharge of a fluid pressure; a connection tube which connects the fluid temporary storage unit and the pump to each other to transmit the fluid pressure by the pump; and first and second check valves which are respectively positioned at both inlet and outlet of the fluid temporary storage unit and are repeatedly opened and closed in response to the suction and the discharge of the fluid pressure by the pump, wherein, when the first check valve is

closed, the second check valve is opened. Consequently, when the first check valve is opened, the second check valve is closed.

[0021] According to an embodiment, the fluid temporary storage unit may be positioned inside a high-temperature unit, and the pump may be positioned outside the high-temperature unit.

[0022] According to an embodiment, the high-temperature unit may include a heat insulation material on a wall surface.

[0023] According to an embodiment, the connection tube may be a flexible tube.

[0024] According to an embodiment, the connection tube may further include a cooling device.

[0025] According to an embodiment, the pump may be a diaphragm pump including: a motor; a connecting rod which performs a reciprocating motion according to a rotating motion of the motor; a diaphragm which is attached to one side of the connecting rod and performs a vertical motion according to the reciprocating motion of the connecting rod; and a compartment which repeats contraction and expansion according to the vertical motion of the diaphragm, and the discharge and the suction of the fluid pressure may be induced by the contraction and the expansion of the compartment.

[0026] According to an embodiment, the fluid temporary storage unit may further include a thin partition installed at a connection portion connected to the connection tube.

[0027] According to an embodiment, a plurality of the fluid temporary storage units may be arranged, and the plurality of the fluid temporary storage units may be connected to the pump by a plurality of the connection tubes.

[0028] According to an embodiment, the plurality of the fluid temporary storage units may be provided, at least one of the fluid temporary storage units may be positioned inside the high-temperature unit, and at least one of the fluid temporary storage units may be positioned outside the high-temperature unit.

[0029] According to an embodiment, the connection tube may further include a control valve which controls a flow rate of the fluid pumped to the fluid temporary storage unit.

[0030] According to an embodiment, the check valves may be ball type check valves or plate type check valves.

[0031] According to an embodiment, the fluid may be a high-temperature outlet gas at higher than or equal to 100° C. discharged from an anode of a fuel cell.

[0032] According to an embodiment, the fluid pumping device may include first and second fluid temporary storage units and first and second connection tubes. The diaphragm pump may include: first and second connecting rods connected to a motor; a first diaphragm which is attached to one side of the first connecting rod and performs a vertical motion according to a reciprocating motion of the connecting rod; a second diaphragm which is attached to one side of the second connecting rod and performs a vertical motion according to a reciprocating motion of the connecting rod; the first compartment which repeats contraction and expansion according to the vertical motion of the first diaphragm; and the second compartment which repeats contraction and expansion according to the vertical motion of the second diaphragm. When the first compartment contracts, the second compartment may expand, and when the first compartment expands, the second compartment may contract. The first compartment may be connected to the first fluid temporary storage unit by

the first connection tube. The second compartment may be connected to the second fluid temporary storage unit by the second connection tube.

[0033] According to an embodiment, a thin partition may further be installed at a connection portion between the first fluid temporary storage unit and the first connection tube, and a thin partition may further be installed at a connection portion between the second fluid temporary storage unit and the second connection tube.

[0034] According to an embodiment, the fluid pumping device may include a first fluid temporary storage unit and a second fluid temporary storage unit, the first fluid temporary storage unit may be positioned outside a high-temperature unit, and the second fluid temporary storage unit is positioned inside the high-temperature unit, and the connection tube may connect the pump to the first fluid temporary storage unit and may be drawn therefrom to be connected to the second fluid temporary storage unit.

[0035] According to an embodiment, a control valve which controls the fluid pressure supplied from the first fluid temporary storage unit to the second fluid temporary storage unit may further be installed in the connection tube between the first fluid temporary storage unit and the second fluid temporary storage unit.

[0036] According to an embodiment, the fluid pumping device may include a first fluid temporary storage unit and second to fourth fluid temporary storage units, the first fluid temporary storage unit may be positioned outside a high-temperature unit and the second to fourth fluid temporary storage units may be positioned inside the high-temperature unit, and the connection tube may connect the pump to the first fluid temporary storage unit and may be drawn therefrom to branch off to three tubes so as to be respectively connected to the second to fourth fluid temporary storage units.

[0037] According to an embodiment, a control valve which controls the fluid pressure supplied from the first fluid temporary storage unit to the second to fourth fluid temporary storage units may be installed in each of the connection tubes between the first fluid temporary storage unit and the second to fourth fluid temporary storage units.

[0038] In another aspect, there is provided a fuel cell device including: a fuel cell; and the fluid pumping device, wherein an outlet gas discharged from an anode of the fuel cell is supplied to the fluid temporary storage unit.

[0039] In still another aspect, there is provided a fuel gas recirculation method including: supplying an outlet gas discharged from an anode of a fuel cell to the fluid temporary storage unit of the fluid pumping device.

[0040] According to the aspects of the disclosure, compared to the existing fluid pumping device, a high-temperature gas, for example, the outlet gas at high temperature discharged from the anode of a fuel cell may be used for pumping for recirculation without an additional cooling process. In addition, the pump durability is easily maintained, and factors of breakdown are reduced and thus replacement and maintenance are easy, and a reduction in weight and size is possible. Therefore, the device is simplified and there is no limitation to installation locations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] The above and other aspects, features and advantages of the disclosed exemplary embodiments will be more apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0042] FIG. 1 is a conceptual diagram of a fluid pumping device according to the disclosure;

[0043] FIG. 2 is a schematic diagram of a fluid pumping device according to first embodiment of the disclosure;

[0044] FIG. 3 is a schematic diagram of a fluid pumping device (an additional thin partition installed) according to second embodiment of the disclosure;

[0045] FIG. 4 is a schematic diagram of a fluid pumping device (double-acting type) according to third embodiment of the disclosure;

[0046] FIG. 5 is a schematic diagram of a fluid pumping device (double-acting type and an additional thin partition installed) according to fourth embodiment of the disclosure;

[0047] FIG. 6 is a schematic diagram of a thin partition type fluid pumping device including a control valve for a fuel cell according to an embodiment of the disclosure;

[0048] FIG. 7 is a schematic diagram of a thin partition type multiple fluid pumping device for a fuel cell according to an embodiment of the disclosure;

[0049] FIG. 8 is a schematic diagram of a ball type check valve according to an embodiment of the disclosure; and

[0050] FIG. 9 is a graph showing a result of pumping a high-temperature gas using the fluid pumping device according to an embodiment of the disclosure.

[Detailed Description of Main Elements]

10: diaphragm pump
 11: motor
 12: connecting rod (12a: first connecting rod, 12b: second connecting rod)
 13: diaphragm (13a: first diaphragm, 13b: second diaphragm)
 14: compartment (14a: first compartment, 14b: second compartment)
 50: check valve (50a: first check valve, 50b: second check valve)
 20: connection tube (20a: first connection tube, 20b: second connection tube)
 30: heat insulation material 33: high-temperature unit
 40: fluid temporary storage unit
 40a: first fluid temporary storage unit
 40b: second fluid temporary storage unit
 40c: third fluid temporary storage unit
 40d: fourth fluid temporary storage unit
 60: thin partition
 70: control valve
 100: fluid pumping device

DETAILED DESCRIPTION

[0051] The present disclosure now will be described more fully hereinafter with reference to the accompanying drawings. The accompanying drawings show exemplary embodiments of the disclosure and are provided only to facilitate understanding of the disclosure. Therefore, the technical scope of the disclosure is not limited by the drawings.

[0052] First, referring to FIG. 2, a fluid pumping device according to an embodiment of the disclosure includes: a fluid temporary storage unit which temporarily stores and discharges the flow of a fluid; a pump which is positioned to be separated from the fluid temporary storage unit and repeats suction and discharge of a fluid pressure; a connection tube which connects the fluid temporary storage unit and the pump to each other to transmit the fluid pressure by the pump; and first and second check valves which are respectively positioned at a fluid inlet and a fluid outlet of the fluid temporary storage unit and are repeatedly opened and closed in response to the suction and the discharge of the fluid pressure by the

pump. When the first check valve is closed, the second check valve is opened, and when the first check valve is opened, the second check valve is closed.

[0053] The fluid temporary storage unit is a unit which temporarily stores and discharges the flow of the fluid, and although not particularly limited, may have a form that minimizes an effect on the flow of the fluid and has a volume at which an appropriate fluid pressure is generated to cause a fluid flow according to a use flow rate and a pressure. The material of the container is not particularly limited as long as the material ensures a property of being stable at high temperature (for example, mechanical properties, thermal properties, and corrosion resistance). When the material is a metal, a material may be selected from the group consisting of stainless steel (Fe—Cr alloy), Inconel (Ni—Cr—Fe alloy), and FeCrAlloy (Fe—Cr—Al alloy), and when the material is a ceramic, a material may be selected from the group consisting of zirconia, alumina, mulite, quartz (silica), and glass.

[0054] The fluid temporary storage unit is positioned to be separated from the pump unlike the techniques according to the related art. According to an embodiment, the container of the fluid temporary storage unit is a part which temporarily stores and discharges the fluid at high temperature and may be positioned inside a high-temperature unit, and the pump may be positioned outside the high-temperature unit.

[0055] The fluid temporary storage unit may further include a thin partition at a connection portion connected to the connection tube. Referring to FIG. 3, the fluid at high temperature may pass through the fluid temporary storage unit, and when the fluid at high temperature passing through the fluid temporary storage unit is liquefied, there is a concern of the liquid escaping from the fluid temporary storage unit and flowing into the connection tube. In the case where the fluid at high temperature flows into the connection tube, the fluid may flow into the pump through the connection tube, resulting in damage in the durability of the pump. Therefore, by positioning the thin partition between the fluid temporary storage unit and the connection tube, the inflow of the fluid at high temperature into the pump through a connection pipe may be prevented beforehand. The thin partition is not limited as long as the thin partition does not impede the fluid pressure transmitted from the pump through the connection tube and blocks the inflow of the fluid into the connection pipe.

[0056] In addition, in a case when the thin partition impedes the transmission of the fluid pressure generated by the pump to the fluid temporary storage unit, pumping of the fluid is not uniformly performed, and there is a concern of a pumping efficiency being reduced. Therefore, the thin partition may be detachable.

[0057] The check valves are connected to the fluid inlet and the fluid outlet of the fluid temporary storage unit. The check valves are not limited as long as the check valves are positioned at the fluid inlet and the fluid outlet of the fluid temporary storage unit and cause the fluid to flow only in one direction. The check valves may be ball type check valves or plate type check valves. In the case of the ball type check valves, the material of a ball may be selected from the group consisting of ceramic (zirconia or silica), glass, and a plastic that is stable at high temperature (for example, Teflon).

[0058] An embodiment of the ball type check valve is illustrated in FIG. 8. Referring to FIG. 8, a pipe in which the ball is positioned widens in diameter in a direction in which the fluid flows, and in a case where the fluid flows in the arrow direction, the ball in the check valve moves upward and the

interval between the pipe and the ball is increased, thereby allowing the fluid to flow. In a case where the fluid flows in an opposite direction (reverse direction) to the arrow, the ball moves downward and narrows the interval between the pipe and the ball, thereby causing the fluid not to flow. Accordingly, the check valves have functions of causing the fluid to flow only in one direction and preventing the backflow of the fluid.

[0059] The diameter of the ball type check valve may vary depending on the flow rate and the use pressure. In addition, the size of the ball used in the ball type check valve may be changed according to the diameter of the check valve, and has an appropriate weight in order to have a role of opening and closing gas at a particular use flow rate. The weight of the ball is set to sufficiently open and close gas at a particular use flow rate and has an appropriate Kv value (Kv is a flow rate of water at 5 to 30° C. that passes when the differential pressure of a valve is 1 bar) so as not to apply an excessive pressure on the valve and not to cause a high energy loss due to the excessive pressure.

[0060] In addition, the check valve may be of a metal plate type. In the case of the metal plate type check valve, the material thereof may be at least one selected from the group consisting of stainless steel (Fe—Cr alloy), Inconel (Ni—Cr—Fe alloy), and FeCrAlloy (Fe—Cr—Al alloy). Here, in the case of the metal plate type check valve, the pump operates at temperatures at which the elasticity of a metal plate is maintained. The operation temperature of the metal plate type check valve is desirable to be appropriately below 200° C., and during operation at a higher temperature, there is a possibility of the metal plate deviating from its elastic limit and being subjected to plastic deformation.

[0061] The pump is not limited as long as the pump generates the fluid pressure and a diaphragm pump is desirable. Unlike the configuration of a diaphragm according to the related art in which check valves are formed at inlet and outlet portions in a compartment in the diaphragm pump and a fluid is transmitted through the compartment, the diaphragm pump of this disclosure has a configuration including: a motor that generates power; a connecting rod that performs a reciprocating motion according to a rotating motion of the motor; a diaphragm (thin partition) that performs a vertical motion according to the reciprocating motion of the connecting rod; and a compartment that repeats contraction and expansion according to the vertical motion of the diaphragm. Therefore, unlike the diaphragm according to the related art, the fluid does not directly pass through the compartment of the diaphragm. The diaphragm is a kind of thin partition, and a plurality of diaphragms connected to a single diaphragm pump may be provided. Therefore, a plurality of compartments may be provided (see FIGS. 4 and 5). In a diaphragm pump that includes the plurality of compartments divided by the plurality of diaphragms, a motor generates force, the force is transmitted to a connecting rod, and the connecting rod performs a reciprocating motion to cause the first diaphragm and the second diaphragm to perform vertical motions. Accordingly, when the first compartment expands, the second compartment contracts, and when the first thin partition plate contracts, the second compartment expands. The contraction and the expansion of the compartments are alternately repeated at predetermined time intervals. The fluid pressures generated in the first compartment and the second compartment are transmitted to a first fluid temporary storage unit and a second fluid temporary storage unit through a first connec-

tion tube and a second connection tube connected to the first compartment and the second compartment, respectively. Accordingly, pumping of the fluid into the first and second fluid temporary storage units may be alternately performed, and in a case where the fluid pumping device is applied to a fuel cell, the fluid may be continuously supplied to the fuel cell and may also be supplied at a constant amount.

[0062] The connection tube is not limited as long as the connection tube connects the pump and the fluid temporary storage unit to each other and transmits the fluid pressure generated by the pump to the fluid temporary storage unit, and may be a flexible tube. The flexible tube may be a long and thin bellows made of stainless steel, phosphor bronze, or aluminum, or a tube that has rubber, nylon, polyvinyl chloride resin, or the like as a main material, and may be reinforced by a surrounding copper mesh having sufficient elasticity on the outer side for reinforcement. The volume and the diameter of the connection tube may vary depending on the flow rate and the pressure of the fluid that passes through the fluid temporary storage unit.

[0063] A cooling device may further be included on the outer surface of the connection tube. The cooling device is not limited as long as the cooling device cools the fluid to reduce the temperature thereof in a case where the fluid at high temperature is liquefied by the fluid temporary storage unit that stores and discharges the fluid at high temperature and flows out to the connection pipe side. The cooling device may be an air cooling type or a water cooling type. In addition, the cooling device may surround the entire connection tube and include a temperature measuring and detecting sensor to sufficiently cool the fluid. When the cooling device is not provided, some of the high-temperature gas could be liquefied at the vicinity of the pump, resulting in corrosion of the diaphragm and reducing the durability of the pump.

[0064] A control valve may be disposed on the connection pipe (FIGS. 6 and 7). The control valve is not limited as long as the control valve controls the fluid amount pumped to the fluid temporary storage unit by controlling the fluid pressure generated by the pump and transmitted to the fluid temporary storage unit through the connection pipe. When a fluid pump device including the control valve is employed in fuel cell systems, the flow rate of high-temperature outlet gas supplied to the anode inlet of the fuel cell may be arbitrarily controlled.

[0065] The fluid is not limited and may be an outlet gas discharged from the outlet of the anode of a fuel cell. The gas may be in the temperature range of 100° C. to 1000° C. A fuel (mainly hydrogen or carbon monoxide) that is not fully utilized in the fuel cell may remain in the gas discharged from the anode outlet and the fuel utilization may be increased in a case where the fuel is recirculated and supplied to the fuel cell again. Therefore, in a case where the anode outlet gas of the fuel cell is recirculated into the anode inlet of the fuel cell again through the fluid temporary storage unit of the disclosure, the overall efficiency of a fuel cell system may be improved.

[0066] According to an embodiment, the fluid pumping device may include a plurality of fluid temporary storage units. Here, at least one of the fluid temporary storage units may be positioned inside the high-temperature unit, and at least one of the fluid temporary storage units may be positioned outside the high-temperature unit (see FIG. 6). Particularly, the connection tube may connect the pump to the first fluid temporary storage unit and may be drawn therefrom to be connected to the second fluid temporary storage unit. The

connection tube between the first fluid temporary storage unit and the second fluid temporary storage unit may further include a control valve that controls the fluid pressure supplied from the first fluid temporary storage unit to the second fluid temporary storage unit. The fluid at room temperature is pumped to the first fluid temporary storage unit, and the fluid at high temperature is pumped to the second fluid temporary storage unit.

[0067] According to an embodiment, the fluid pumping device of the disclosure transmits the fluid pressure to the first fluid temporary storage unit, and the transmitted fluid pressure is transmitted to the second to fourth fluid temporary storage units. Particularly, the first fluid temporary storage unit may be positioned outside the high-temperature unit, the connection tube connects the pump to the first fluid temporary storage unit and is drawn therefrom to branch off to three connection tubes, and the three branched connection tubes are respectively connected to the second to fourth fluid temporary storage units to transmit the fluid pressures to the second to fourth fluid temporary storage units. The second to fourth fluid temporary storage units are respectively positioned in the high-temperature units. Particularly, a control valve is employed on each of the three connection tubes, and the amount of the fluid pumped to each of the fluid temporary storage units may be controlled depending on the fluid temporary storage units (see FIG. 7).

[0068] Hereinafter, Experimental Example in which a fluid at high temperature is pumped using the fluid pumping device according to the disclosure are proposed. This is only an example of the disclosure, and the range of the disclosure is not limited to the following Experimental Example.

EXPERIMENTAL EXAMPLE

[0069] An experiment is performed as follows to measure the performance of the fluid pumping device.

[0070] The diaphragm pump and the fluid temporary storage unit are positioned separately, and the diaphragm pump and the fluid temporary storage unit are connected with the flexible tube. In addition, the check valves are positioned at both inlet and outlet of the fluid temporary storage unit.

[0071] As the diaphragm pump, a product manufactured by KAMOER (Model No. KVP8DUDC24) is used. As the diaphragm of the pump, polyphenylsulfide (PPS) diaphragms are used.

[0072] As the check valve, 1/4-inch check valves manufactured by Parker are used. A check magnitude is 1/3 psi, and the check valves are of a plate type and include springs and O-rings therein.

[0073] As the fluid temporary storage unit, a 1/4-inch Tee union manufactured by Hylok is used. The Tee union is configured to have an internal volume of 2.5 cm³ and SUS 316 as its material.

[0074] The material of the flexible tube that connects the diaphragm pump and the fluid temporary storage unit is Teflon and has a tube diameter of 1/8 inches and a length of 40 cm.

[0075] The check valve and the fluid temporary storage unit are connected to the anode outlet of the fuel cell to allow the outlet gas at the anode to flow into the check valve connected to the inlet of the fluid temporary storage unit, and the check valve connected to the outlet of the fluid temporary storage unit positioned on the opposite side to the check valve is connected to the anode inlet of the fuel cell. In addition, a heat insulation material is employed between the diaphragm pump

and the fluid temporary storage unit to spatially separate the pump and the fluid temporary storage unit from each other. Further, the control valve is connected to the flexible tube to control the amount of the fluid pressure generated by the pump when the fluid pressure is transmitted to the fluid temporary storage unit. In the fluid pumping device configured as described above, the pump is operated for 100 hours and the outlet gas at high temperature discharged from the anode outlet of the fuel cell is re-supplied to the anode inlet of the fuel cell.

[0076] According to the experiment result, the supply rate of the high-temperature gas is maintained at a constant level (see FIG. 9). In the Experimental Example, the gas at around 200° C. is supplied. However, in the cases where the types and materials of the fluid temporary storage unit and the check valves are changed to be applicable for high temperature gas, a high-temperature gas at higher than or equal to 500° C. may yield the same results. Therefore, it is confirmed that the fuel cell is able to re-supply the anode outlet gas at high temperature through the fluid pumping device according to the disclosure without requiring an additional cooling process and reducing the durability of the pump.

What is claimed is:

1. A fluid pumping device comprising:

a fluid temporary storage unit which temporarily stores and discharges a flow of a fluid;

a pump which is positioned to be separated from the fluid temporary storage unit and repeats suction and discharge of a fluid pressure;

a connection tube which connects the fluid temporary storage unit and the pump to each other to transmit the fluid pressure by the pump; and

first and second check valves which are respectively positioned at a fluid inlet and a fluid outlet of the fluid temporary storage unit and are repeatedly opened and closed in response to the suction and the discharge of the fluid pressure by the pump,

wherein, when the first check valve is closed, the second check valve is opened, and when the first check valve is opened, the second check valve is closed.

2. The fluid pumping device according to claim 1, wherein the fluid temporary storage unit is positioned inside a high-temperature unit, and the pump is positioned outside the high-temperature unit.

3. The fluid pumping device according to claim 1, wherein the high-temperature unit includes a heat insulation material on a wall surface.

4. The fluid pumping device according to claim 1, wherein the connection tube is a flexible tube.

5. The fluid pumping device according to claim 1, wherein the connection tube further includes a cooling device on the outer surface of the connection tube.

6. The fluid pumping device according to claim 1, wherein the pump is a diaphragm pump including:

a motor;

a connecting rod which performs a reciprocating motion according to a rotating motion of the motor;

a diaphragm which performs a vertical motion according to the reciprocating motion of the connecting rod; and

a compartment which repeats contraction and expansion according to the vertical motion of the diaphragm, and wherein the discharge and the suction of the fluid pressure are achieved by the contraction and the expansion of the compartment.

7. The fluid pumping device according to claim 1, wherein the fluid temporary storage unit further includes a thin partition at a connection portion connected to the connection tube.
8. The fluid pumping device according to claim 1, wherein a plurality of the fluid temporary storage units are arranged, and the plurality of the fluid temporary storage units are connected to the pump by a plurality of the connection tubes.
9. The fluid pumping device according to claim 8, wherein at least one of the fluid temporary storage units among the plurality of the fluid temporary storage units is positioned inside the high-temperature unit, and at least one of the fluid temporary storage units among the plurality of the fluid temporary storage units is positioned outside the high-temperature unit.
10. The fluid pumping device according to claim 1, wherein the connection tube further includes a control valve which controls an amount of the fluid pumped to the fluid temporary storage unit by controlling the fluid pressure transmitted to the fluid temporary storage unit.
11. The fluid pumping device according to claim 1, wherein the check valves are ball type check valves or plate type check valves.
12. The fluid pumping device according to claim 1, wherein the fluid is a high-temperature outlet gas at higher than or equal to 100° C. discharged from an anode of a fuel cell.
13. The fluid pumping device according to claim 8, wherein the fluid pumping device includes first and second fluid temporary storage units and first and second connection tubes, wherein a diaphragm pump includes:
 - first and second connecting rods connected to a motor;
 - a first diaphragm which is attached to one side of the first connecting rod and performs a vertical motion according to a reciprocating motion of the connecting rod;
 - a second diaphragm which is attached to one side of the second connecting rod and performs a vertical motion according to a reciprocating motion of the connecting rod;
 - a first compartment which repeats contraction and expansion according to the vertical motion of the first diaphragm; and
 - a second compartment which repeats contraction and expansion according to the vertical motion of the second diaphragm,
 wherein, when the first compartment contracts, the second compartment expands, and when the first compartment expands, the second compartment contracts, wherein the first compartment is connected to the first fluid temporary storage unit by the first connection tube, and

wherein the second compartment is connected to the second fluid temporary storage unit by the second connection tube.

14. The fluid pumping device according to claim 13, wherein the first and second fluid temporary storage units further include thin partitions at connection portions connected to the first and second connection tubes, respectively.

15. The fluid pumping device according to claim 1, wherein the fluid pumping device includes a first fluid temporary storage unit and a second fluid temporary storage unit,

wherein the first fluid temporary storage unit is positioned outside a high-temperature unit, and the second fluid temporary storage unit is positioned inside the high-temperature unit, and

wherein the connection tube connects the pump to the first fluid temporary storage unit and is drawn therefrom to be connected to the second fluid temporary storage unit.

16. The fluid pumping device according to claim 15, wherein the connection tube between the first fluid temporary storage unit and the second fluid temporary storage unit further includes a control valve which controls the fluid pressure supplied from the first fluid temporary storage unit to the second fluid temporary storage unit.

17. The fluid pumping device according to claim 8, wherein the fluid pumping device includes a first fluid temporary storage unit and second to fourth fluid temporary storage units,

wherein the first fluid temporary storage unit is positioned outside a high-temperature unit, and the second to fourth fluid temporary storage units are positioned inside the high-temperature unit, and

wherein the connection tube connects the pump to the first fluid temporary storage unit and is drawn therefrom to branch off to three tubes so as to be connected to the second to fourth fluid temporary storage units.

18. The fluid pumping device according to claim 17, wherein each of the connection tubes between the first fluid temporary storage unit and the second to fourth fluid temporary storage units further includes a control valve which controls the fluid pressure supplied from the first fluid temporary storage unit to the second to fourth fluid temporary storage units.

19. A fuel cell device comprising:

a fuel cell; and

the fluid pumping device according to claim 1, wherein an outlet gas discharged from an anode of the fuel cell is supplied to the fluid temporary storage unit.

20. A fuel gas recirculation method comprising:

supplying an outlet gas discharged from an anode of a fuel cell to the fluid temporary storage unit of the fluid pumping device according to claim 1.

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