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(54) **GAS SUPPLY MODULE AND GAS SUPPLY SYSTEM**

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(57) **ABSTRACT**

A gas supply module includes: a plurality of tanks; a solenoid valve; an intermediate flow path; a merging portion; a gas discharge flow path; a pressure measuring device; and a control unit. The control section controls the solenoid valve of any one of the solenoid valves to the open state at the start of the gas discharge, controls the solenoid valve to the closed state at the end of the gas discharge, and records the pressure measured by the pressure measuring device as the pressure of the tank provided with the solenoid valve controlled to the closed state.

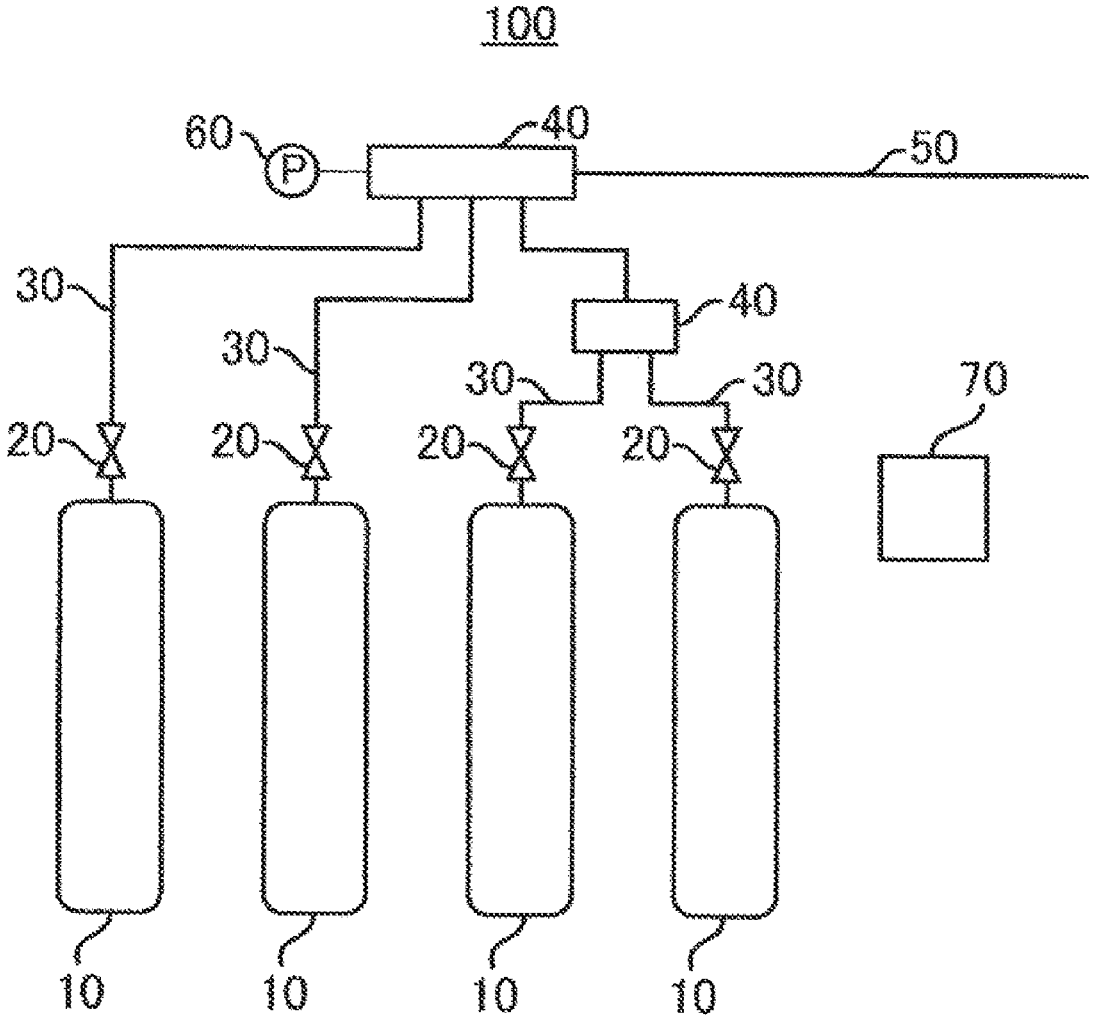


FIG. 1

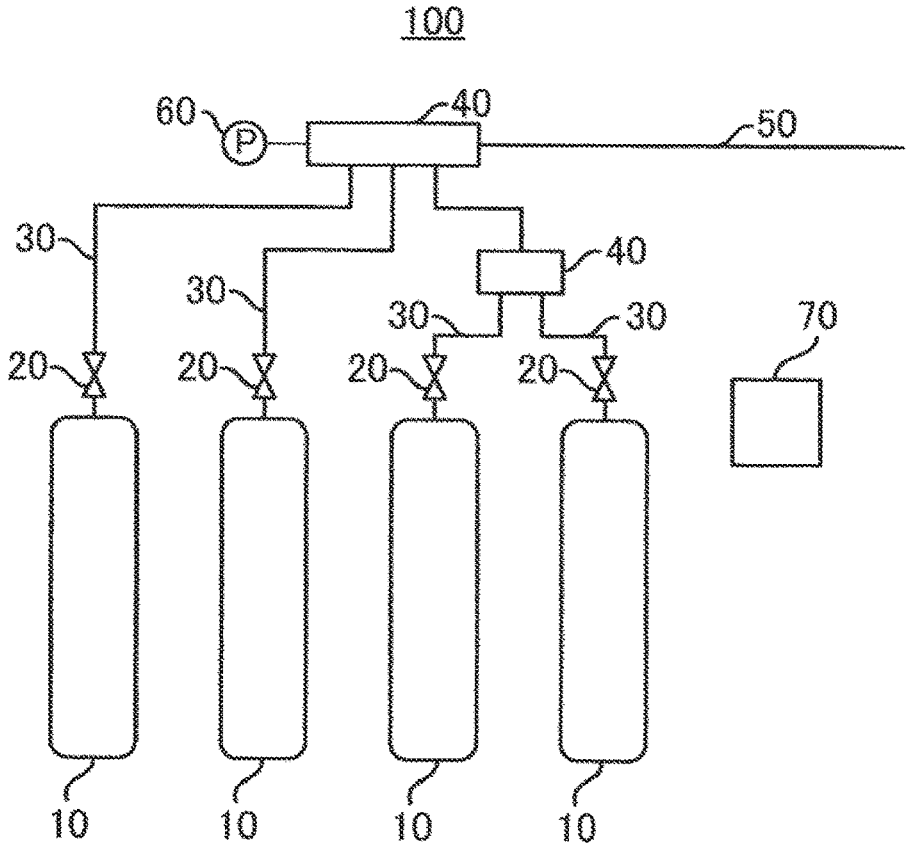

100
60
P
40
50
30
40
30
30
30
70
20
20
20
20
10
10
10
10

FIG. 2

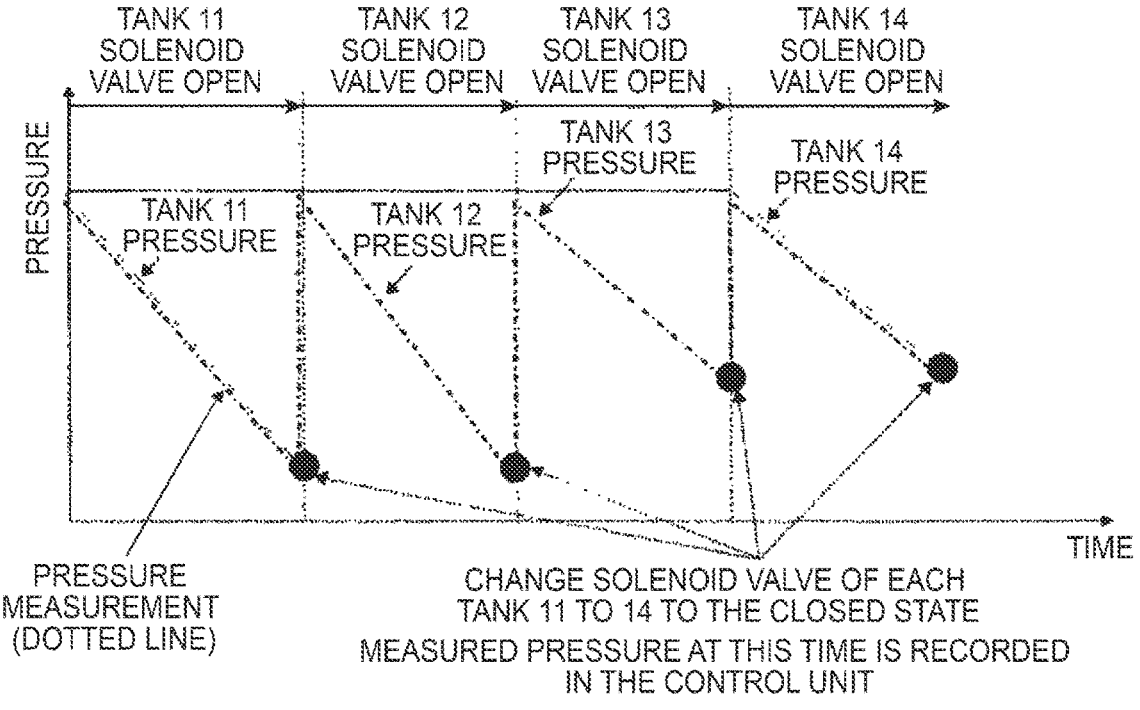

TANK 11 SOLENOID VALVE OPEN
TANK 12 SOLENOID VALVE OPEN
TANK 13 SOLENOID VALVE OPEN
TANK 14 SOLENOID VALVE OPEN
PRESSURE
TANK 13 PRESSURE
TANK 14 PRESSURE
TANK 11 PRESSURE
TANK 12 PRESSURE
TIME
PRESSURE MEASUREMENT (DOTTED LINE)
CHANGE SOLENOID VALVE OF EACH TANK 11 TO 14 TO THE CLOSED STATE
MEASURED PRESSURE AT THIS TIME IS RECORDED IN THE CONTROL UNIT

FIG. 3

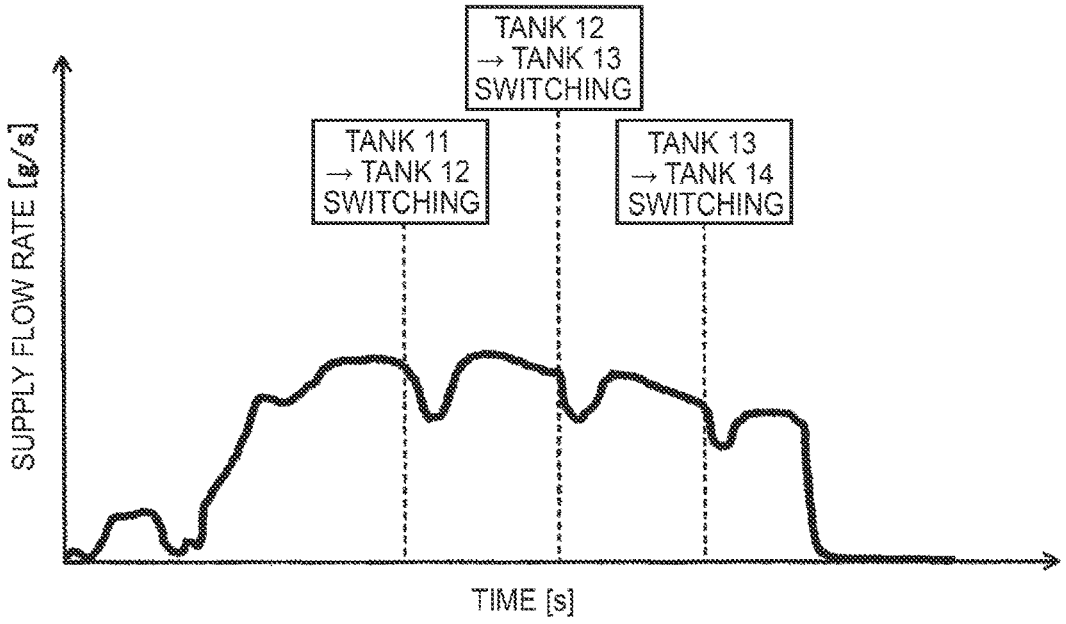

TANK 12
→ TANK 13
SWITCHING
TANK 11
→ TANK 12
SWITCHING
TANK 13
→ TANK 14
SWITCHING
SUPPLY FLOW RATE [g/s]
TIME [s]

FIG. 4

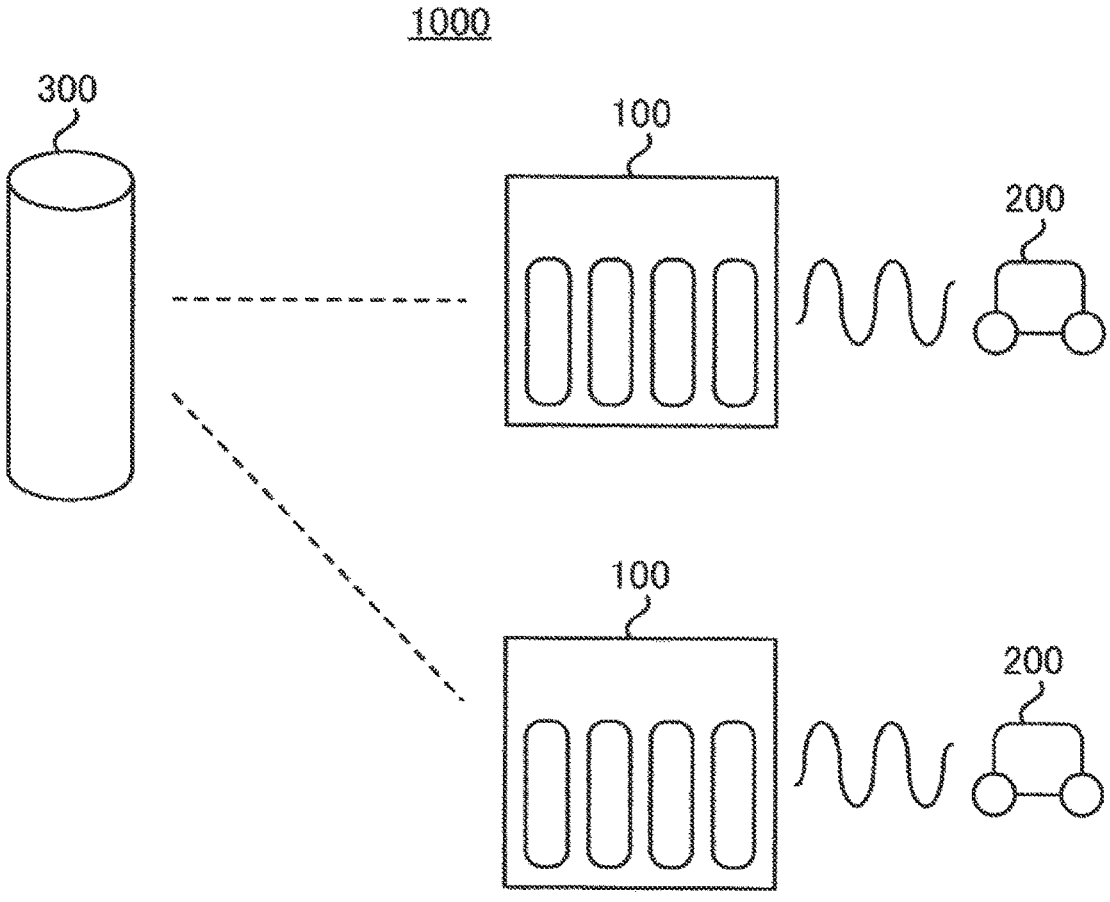
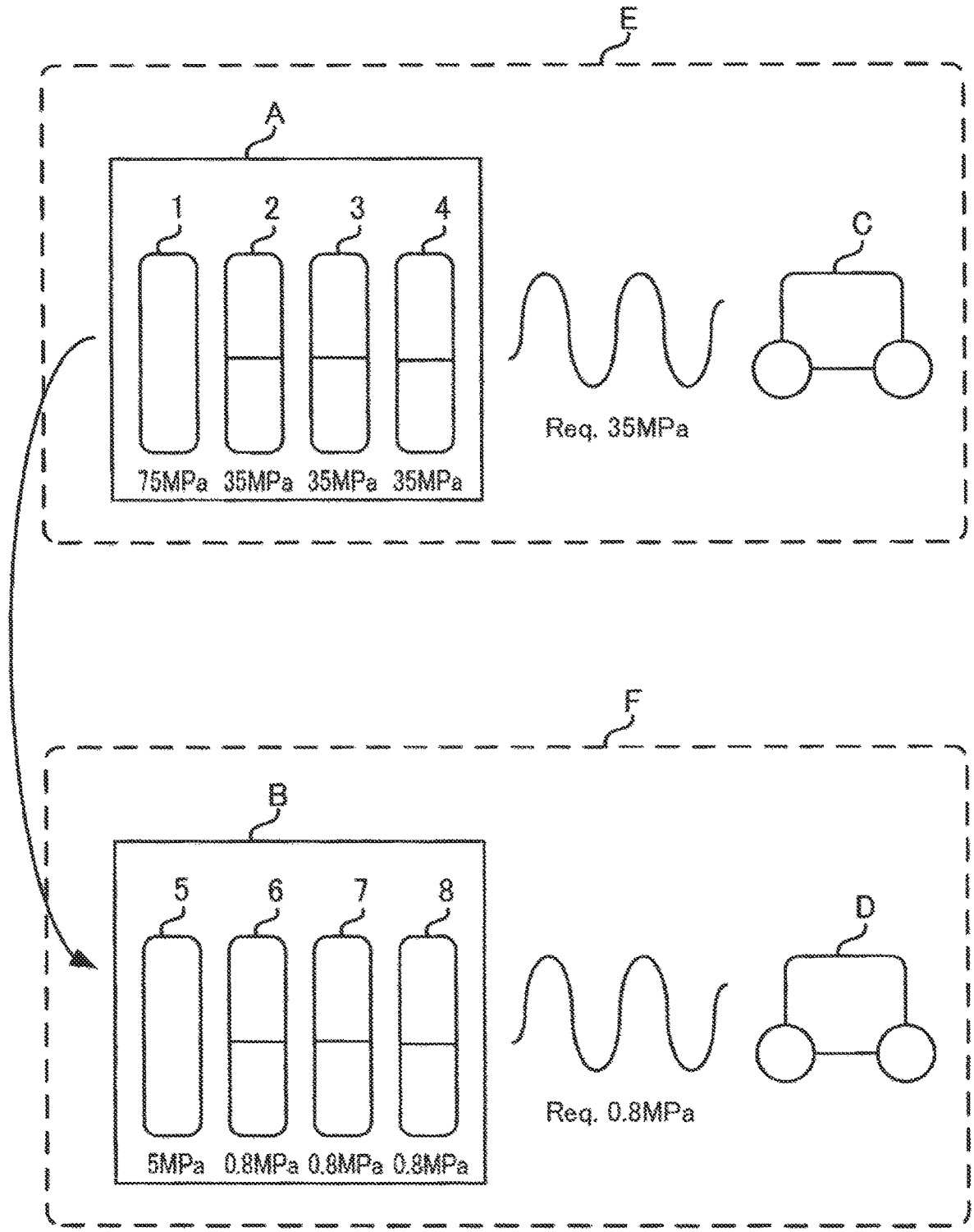

1000
300
100
200
100
200

FIG. 5


E
A
1
2
3
4
75MPa
35MPa
35MPa
35MPa
C
Req. 35MPa
F
B
5
6
7
8
5MPa
0.8MPa
0.8MPa
0.8MPa
D
Req. 0.8MPa

GAS SUPPLY MODULE AND GAS SUPPLY SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2022-205357 filed on Dec. 22, 2022, incorporated herein by reference in its entirety.

BACKGROUND

1. Technical Field

[0002] The present application relates to a gas supply module and a gas supply system.

2. Description of Related Art

[0003] A fuel cell is a device that generates electricity by using hydrogen and oxygen. Hydrogen used for power generation is usually stored in a hydrogen tank, and is supplied to a fuel cell at the time of power generation.

[0004] Japanese Unexamined Patent Application Publication No. 2022-68652 (JP 2022-68652 A) discloses a hydrogen supply device that supplies hydrogen gas to a fuel cell in a fuel cell system. The hydrogen supply device of JP 2022-68652 A has a plurality of hydrogen tanks, an on-off valve provided to each of the hydrogen tanks, and a control unit that controls the on-off valve. In operation of the fuel cell, the control unit selects hydrogen tanks in order from the hydrogen tanks that are not the hydrogen tank having the largest capacity, and controls the respective on-off valves so that the hydrogen gas is supplied from the selected hydrogen tanks to the fuel cell.

[0005] JP 2022-68652 A describes that using such a hydrogen supply device makes it possible to prolong the life of the hydrogen supply device.

SUMMARY

[0006] In some cases, a gas supply module including a plurality of hydrogen tanks is used for filling hydrogen into a hydrogen tank provided in a fuel cell system. In such a gas supply module, the pressure in the hydrogen tank is monitored. The pressure of each hydrogen tank is measured by a pressure sensor provided in each hydrogen tank. However, if a pressure sensor is provided to each hydrogen tank, there is a problem that the configuration of the device becomes complicated.

[0007] In view of the above circumstances, it is an object of the present disclosure to provide a gas supply module and a gas supply system capable of reducing the number of pressure measuring devices.

[0008] The present disclosure provides, as one aspect for solving the above problem, a gas supply module that includes: a plurality of tanks filled with gas; a solenoid valve that is provided in each of the tanks and controls release of the gas filled in the tank; and an intermediate flow path extending toward a downstream side from each of the tanks via the solenoid valve; a merging portion connected to a plurality of the intermediate flow paths; a gas discharge flow path extending toward the downstream side from the merging portion; a pressure measuring device provided on the merging portion or on the downstream side of the merging portion; and a control unit that controls opening and closing of the solenoid valve.

The control unit controls, at a start of gas discharge, any one of the solenoid valves to be in an opened state, and, controls, at an end of the gas discharge, the solenoid valve to be in a closed state and records a pressure measured by the pressure measuring device as a pressure of the tank including the solenoid valve that is controlled to be in the closed state.

[0009] The present disclosure provides, as one aspect for solving the above problem, a gas supply system including: a plurality of the gas supply modules; a plurality of devices including a fuel cell system; and a server connected to the gas supply modules via a network.

The gas supply modules are paired with the respective devices, and the server stores device requirement information including a gas quantity and a minimum pressure required for an operation of each of the devices.

The server obtains gas supply module information including a gas quantity and a pressure of each of the tanks included in each of the gas supply modules.

The server compares the gas supply module information with the device requirement information in each of the pairs, and determines a pair having the gas supply module not satisfying a requirement of the device.

In a group of the pairs having the gas supply module not satisfying the requirement of the device, the server compares the gas supply module information of the gas supply module of one of the pairs with the device requirement information of another pair of the pairs, and searches for the gas supply module that satisfies the requirement of the device of the other pair.

[0010] According to the gas supply module of the present disclosure, the number of pressure measuring devices can be reduced. Further, according to the gas supply system of the present disclosure, the gas supply module can be operated efficiently.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which like signs denote like elements, and wherein:

[0012] FIG. **1** is a block diagram of a gas supply module;

[0013] FIG. **2** is a diagram showing a change with time in the pressure of each tank **10** when four tanks **10** (tanks **11** to **14**) are used in this order;

[0014] FIG. **3** is a diagram showing a change with time in flow rate when four tanks **10** (tanks **11** to **14**) are used in order;

[0015] FIG. **4** is a schematic diagram of a gas supply system **1000**; and

[0016] FIG. **5** is a schematic diagram illustrating an embodiment of a gas supply system **1000**.

DETAILED DESCRIPTION OF EMBODIMENTS

Gas Supply Module

[0017] The gas supply module of the present disclosure will be described with reference to the gas supply module **100** which is an embodiment. FIG. **1** shows a block diagram of a gas supply module **100**.

[0018] The gas supply module **100** includes a plurality of tanks **10**, a solenoid valve **20** provided in each of the plurality of tanks **10**, an intermediate flow path **30** extending

downstream from each of the plurality of tanks **10** via the solenoid valve **20**, a merging portion **40** connected to the plurality of intermediate flow paths **30**, a gas discharge flow path **50** extending downstream from the merging portion **40**, a pressure measuring device **60**, and a control unit **70** for controlling opening and closing of the solenoid valve.

Tank **10**

[0019] The tank **10** is filled with gas. The type of the gas is not particularly limited, but is, for example, a fuel gas used in a fuel cell. Examples of the fuel gas include hydrogen and a reformed gas. The capacity and the number of the tanks **10** are not particularly limited, and may be appropriately set according to the purpose.

Solenoid Valve **20**

[0020] The solenoid valve **20** is provided in each of the plurality of tanks **10**, and is an on-off valve that controls the release of the gas filled in the tank **10**. The opening and closing of the solenoid valve **20** is performed by the control unit **70**. The type of the solenoid valve **20** is not particularly limited, and examples thereof include a solenoid valve.

Intermediate Flow Path **30**

[0021] The intermediate flow path **30** is a flow path extending downstream from each of the plurality of tanks **10** via the solenoid valve **20**. As shown in FIG. **1**, the intermediate flow path **30** connects the respective tanks **10** and the merging portion **40**.

Merging Portion **40**

[0022] The merging portion **40** is a member connected to the plurality of intermediate flow paths **30**. The number of the merging portion **40** is not particularly limited, and may be one or two or more. If there is one merging portion **40**, all intermediate flow path **30** are connected to one merging portion **40**. In the case where two or more merging portions **40** are provided, at least one intermediate flow path **30** is connected to one merging portion **40**, and the merging portions **40** are connected to each other. However, the number of merging portions connected to the gas discharge flow path **50** is one. FIG. **1** shows an embodiment with two merging portions **40**. As shown in FIG. **1**, the merging portions **40** are connected to each other, and the gas discharge flow path **50** is connected to one merging portion **40**.

Gas Discharge Flow Path **50**

[0023] The gas discharge flow path **50** is a flow path extending from the merging portion **40** to the downstream side. The other end of the gas discharge flow path **50** may be connected to the outside.

Pressure Measuring Device **60**

[0024] The pressure measuring device **60** is a device that measures the pressure of the gas discharged from the tank **10**. The pressure measuring device **60** is provided downstream of the merging portion **40** or the merging portion **40**. Accordingly, the number of pressure measuring devices **60** provided in the gas supply module **100** can be reduced.

[0025] The reason for this will be described later.

Control Unit **70**

[0026] The control unit **70** is a device that controls opening and closing of the solenoid valve **20**. The control unit **70** is a computer such as an Electronic Control Unit (ECU).

[0027] The control unit **70** is characterized in that, at the start of gas discharge, one solenoid valve **20** of the solenoid valves **20** is controlled to be in an open state, and at the end of gas discharge, the solenoid valve **20** is controlled to be in a closed state, and the pressure measured by the pressure measuring device **60** is recorded as the pressure of the tank **10** including the solenoid valve **20** controlled to be in a closed state.

[0028] As described above, the control unit **70** controls one solenoid valve **20** of the solenoid valves **20** to be in the open state and the other solenoid valve **20** to be in the closed state at the start of gas discharge. That is, the gas supply module **100** is always controlled to release gas from one tank **10**. Therefore, when the tank **10** for discharging the gas is changed from one tank **10** to another tank **10**, the solenoid valve **20** of one tank **10** is changed to the closed state, and then the solenoid valve of the other tank **10** is changed to the open state. With such control, the pressure of the merging portion **40** and the gas flowing downstream thereof becomes equal to the pressure of the tank **10** provided with the solenoid valve **20** in the open state at all times. Therefore, at the end of the gas discharge, the solenoid valve **20** is controlled to be in the closed state, and the pressure measured by the pressure measuring device **60** is recorded, whereby the pressure of the tank **10** including the solenoid valve **20** controlled to be in the closed state can be specified. As described above, the control unit **70** can always monitor the pressure of each tank **10** by controlling the gas supply module **100** as described above.

[0029] Conventionally, in a gas supply module, a technique for monitoring the pressure of each tank is known, and a pressure measuring device is provided in each tank. That is, conventionally, the number of tanks and the number of pressure measuring devices are the same. On the other hand, in the gas supply module **100**, the number of the pressure measuring devices **60** can be reduced to at least one by performing the above-described control. This simplifies the device configuration and reduces the installation cost.

[0030] FIG. **2** shows changes with time in the pressure of each tank **10** when four tanks **10** (tanks **11** to **14**) are used in this order. In FIG. **2**, for the sake of clarity, the dotted line indicating the pressure measurement value and the solid line indicating the pressure of each tank **10** are described apart from each other, but these lines actually overlap each other. As shown in FIG. **2**, when the solenoid valve **20** of one tank **10** is in the open state, the solenoid valve **20** of another tank **10** is controlled to be in the closed state. In the case where the four tanks **10** are used in this manner in order, the pressure measurement value when the solenoid valve **20** of each tank **10** is changed to the closed state indicates the pressure of each tank **10**. Therefore, it can be seen from FIG. **2** that the gas supply module **100** can monitor the pressure of each tank **10** even if the number of pressure measuring devices **60** is reduced.

[0031] FIG. **3** shows the flow rate over time when four tanks **10** (tanks **11** to **14**) are used in this order. The flow rate was measured in the gas discharge flow path **50**. As shown in FIG. **3**, it can be seen that the gas supply module **100** can maintain an appropriate flow rate even when the four tanks **10** are used in sequence.

Use

[0032] The gas supply module **100** may generally be used as a pressure accumulator of a simple filling device that supplies gas to a tank provided in a fuel cell system. Accordingly, the gas supply module **100** may be in a transportable form.

[0033] The gas supply module of the present disclosure has been described with reference to one embodiment. According to the gas supply module of the present disclosure, the number of pressure measuring devices can be reduced.

Gas Supply System

[0034] The gas supply system of the present disclosure will be described with reference to the gas supply system **1000** which is an embodiment. FIG. **4** shows a schematic diagram of the gas supply system **1000**.

[0035] The gas supply system **1000** includes a plurality of gas supply modules **100**, a plurality of devices **200** including a fuel cell system, and a server **300** connected to the plurality of gas supply modules **100** via a network.

Gas Supply Module **100**

[0036] As described above, in the gas supply module **100**, the pressure of each tank **10** is monitored. Therefore, the pressure of each tank **10** provided in the gas supply module **100** is recorded by the control unit **70**. Thus, the pressure of each tank **10** of the gas supply module **100** used in the gas supply system **1000** is known.

[0037] The gas supply system **1000** uses a gas supply module **100**. However, the gas supply module used in the gas supply system of the present disclosure is not limited thereto. For example, a gas supply module in which the pressure of each tank is known may be used. For example, a conventional gas supply module may be used.

[0038] The conventional gas supply module is, for example, as follows. That is, the gas supply module includes: a plurality of tanks filled with gas; a solenoid valve provided in each of the plurality of tanks for controlling the discharge of the gas filled in the tanks; an intermediate flow path extending from each of the plurality of tanks to the downstream side via the solenoid valve; a merging portion connected to the plurality of intermediate flow paths; a gas discharge flow path extending from the merging portion to the downstream side; a pressure measuring device provided in each of the plurality of tanks; and a control unit for controlling the opening and closing of the solenoid valve.

Device **200**

[0039] The device **200** comprises a fuel cell system. The fuel cell system includes at least a fuel cell and a fuel gas tank (hydrogen tank). Since the fuel cell system is well known in the art, a description thereof will be omitted here. The device **200** may be, for example, a fuel cell electric vehicle.

[0040] In the gas supply system **1000**, one gas supply module **100** and one device **200** form a pair. By "pair" is meant the relationship that the gas supply module **100** is intended to supply gas (e.g., hydrogen) to a particular device **200**.

Server **300**

[0041] The server **300** is connected to the plurality of gas supply modules **100** via a network. The connection method of the network is not particularly limited. It may be a wired network or a wireless network. Also, the type of the network is not particularly limited.

Examples Include the Internet and WI-FI

[0042] The server **300** is a computer that optimizes the combination of the gas supply module **100** and the device **200**. Accordingly, the server **300** has device request information including the amount of gas and the minimum pressure required for the operation of each device **200**.

[0043] Optimization of the combination of the gas supply module **100** and the device **200** by the server **300** is performed as follows. (1) First, the server **300** obtains gas supply module information including the gas amount and pressure of each tank **10** included in each gas supply module **100**. The amount of gas in the tank **10** can be calculated from, for example, the capacity and pressure of the tank **10**. (2)Next, in each pair, the gas supply module information and the device requirement information are compared to determine a pair having a gas supply module that does not satisfy the device request. (3) Subsequently, in the set of pairs having gas supply modules that do not satisfy the requirements of the device **200**, the gas supply module information of one pair of gas supply modules **100** is compared with the device requirement information of the other pair of device **200**, and the gas supply module **100** that satisfies the requirements of the other pair of devices is searched. The search results may be displayed to be visible to the user.

[0044] By performing the steps (1) to (3), even if the gas supply module **100** does not satisfy the requirements of the device **200** in one pair, the other pair of device **200** to which the gas supply module **100** can be applied can be searched. Then, the user can efficiently operate the gas supply module **100** by appropriately replacing the gas supply module **100** based on the search result.

[0045] FIG. **5** shows a specific example of the gas supply system **1000**. FIG. **5** shows an example in which the gas supply modules A and B of the two pairs E and F and the devices C and D are used.

[0046] First, the pair E formed from the gas supply module A and the device C will be described. As shown in FIG. **5**, the gas supply module A is in use, and the pressures of the respective tanks **1** to **4** are 70 MPa, 35 MPa, 35 MPa, 35 MPa. Here, the minimum pressure required for the operation of the device C is 35 MPa. Thus, the tank **1** meets this requirement. However, the amount of gas required for the operation of the device C is not satisfied only by the tank **1**. Accordingly, the server determines that the pair E is a pair having the gas supply module A that does not satisfy the requirements of the device C.

[0047] Next, a pair F formed from the gas supply module B and the device D will be described. As shown in FIG. **5**, the gas supply module B is in use and the pressure of the respective tanks **5** to **8** is 5 MPa, 0.8 MPa, 0.8 MPa, 0.8 MPa. Here, the minimum pressure required for the operation of the device D is 0.8 MPa. Thus, the tank **5** meets this requirement. However, the amount of gas required for the operation of the device D is not satisfied only by the tank **5**. Accordingly, the server determines that the pair F is a pair

having the gas supply module B that does not satisfy the requirements of the device D.

[0048] Next, the server compares the gas supply module information of the gas supply module A of the pair E and the device requirement information of the device D of the other pair F in the set of pairs E and F. Then, the gas supply module A of the pair E satisfies the requirements of the device D of the other pair F. Thus, the server can provide the user with this search result. The user can replace the gas supply module B with the gas supply module A based on the search result. Therefore, the gas supply module can be operated efficiently.

[0049] The gas supply system of the present disclosure has been described with reference to one embodiment. According to the gas supply system of the present disclosure, the gas supply module can be operated efficiently.

What is claimed is:

1. A gas supply module comprising:

a plurality of tanks filled with gas;

a solenoid valve that is provided in each of the tanks and controls release of the gas filled in the tank; and

an intermediate flow path extending toward a downstream side from each of the tanks via the solenoid valve;

a merging portion connected to a plurality of the intermediate flow paths;

a gas discharge flow path extending toward the downstream side from the merging portion;

a pressure measuring device provided on the merging portion or on the downstream side of the merging portion; and

a control unit that controls opening and closing of the solenoid valve, wherein the control unit controls, at a start of gas discharge, any one of the solenoid valves to be in an opened state, and, controls, at an end of the gas discharge, the solenoid valve to be in a closed state and records a pressure measured by the pressure measuring device as a pressure of the tank including the solenoid valve that is controlled to be in the closed state.

2. A gas supply system comprising:

a plurality of the gas supply modules according to claim **1**;

a plurality of devices including a fuel cell system; and

a server connected to the gas supply modules via a network,

wherein the gas supply modules are paired with the respective devices,

wherein the server stores device requirement information including a gas quantity and a minimum pressure required for an operation of each of the devices,

wherein the server obtains gas supply module information including a gas quantity and a pressure of each of the tanks included in each of the gas supply modules,

wherein the server compares the gas supply module information with the device requirement information in each of the pairs, and determines a pair having the gas supply module not satisfying a requirement of the device, and

wherein, in a group of the pairs having the gas supply module not satisfying the requirement of the device, the server compares the gas supply module information of the gas supply module of one of the pairs with the device requirement information of another pair of the pairs, and searches for the gas supply module that satisfies the requirement of the device of the other pair.

* * * * *