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Fuel cell ship

Abstract

A fuel cell ship includes a fuel cell that generates electric power by an electrochemical reaction of fuel, a propulsion device that generates propulsive force on a hull by electric power supplied from the fuel cell, a fuel supply pipe through which the fuel is supplied from a fuel tank housing the fuel to the fuel cell, a duct compartment that houses a part of the fuel supply pipe, a vent pipe that communicates with the duct compartment, and a fuel filling port that serves as an inlet for filling the fuel tank with the fuel. The fuel filling port is provided in the duct compartment.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS
(1) This application is claims priority under 35 U.S.C. § 119 to JP Application No. 2021-092712 filed Jun. 2, 2021, the entire contents of which are hereby incorporated by reference.
TECHNICAL FIELD
(2) The present invention relates to a fuel cell ship.
BACKGROUND ART
(3) In the related art, a fuel cell ship in which a fuel gas (for example, hydrogen gas) is supplied from a fuel tank to a fuel cell and a propulsion device is driven by electric power generated by the fuel cell has been proposed (see, for example, Patent Document 1).
PRIOR ART DOCUMENT
Patent Document
(4) Patent Document 1: Japanese Unexamined Patent Application Publication No. 2018-92815
SUMMARY OF INVENTION
Technical Problem
(5) In a fuel cell ship, it may be required not to arrange electrical equipment (such as ventilation fans) around a portion through which a flammable fuel gas passes, for example, around a fuel gas filling port. This is because the arranged electrical equipment can ignite the fuel gas. Hereinafter, a portion through which the fuel gas passes may be referred to as a hazardous site, and a location around the hazardous site where electrical equipment cannot be arranged may be referred to as a hazardous location. In a fuel cell ship, if hazardous sites are scattered, which results in expansion of the hazardous location, the area in which electrical equipment can be arranged becomes narrow. As a result, the degree of freedom of arranging electrical equipment is reduced.
(6) The present invention has been made to solve the above-described problem, and an object the present invention is to provide a fuel cell ship by which the hazardous location where electrical equipment cannot be arranged is narrowed, and the degree of freedom of arranging the electrical equipment can be increased.
Solution to Problem
(7) A fuel cell ship according to an aspect of the present invention is a fuel cell ship including a fuel cell that generates electric power by an electrochemical reaction of fuel, and a propulsion device that generates propulsive force on a hull by electric power supplied from the fuel cell. The fuel cell ship further includes a fuel supply pipe through which the fuel is supplied from a fuel tank housing the fuel to the fuel cell, a duct compartment that houses a part of the fuel supply pipe, a vent pipe that communicates with the duct compartment, and a fuel filling port that serves as an inlet for filling the fuel tank with the fuel. The fuel filling port is provided in the duct compartment.
Advantageous Effects of Invention
(8) According to the above configuration, it is possible to narrow the hazardous location in which electrical equipment cannot be arranged, and increase the degree of freedom of arranging the electric equipment.

Description

BRIEF DESCRIPTION OF DRAWINGS

(1) FIG. **1** is a rear perspective view illustrating an appearance of a fuel cell ship according to an embodiment of the present invention.

(2) FIG. **2** is an explanatory diagram illustrating a schematic configuration of the fuel cell ship.

(3) FIG. **3** is an explanatory diagram schematically illustrating an internal structure of the fuel cell ship.

(4) FIG. **4** is an enlarged perspective view illustrating a portion A in FIG. **1**.

(5) FIG. **5** is a perspective view of the portion A in FIG. **1** in which a fuel gas filling port lid portion and an inert gas filling port lid portion are not illustrated.

(6) FIG. **6** is a flowchart of processing based on detection of a fuel gas in a duct compartment of the fuel cell ship.

DESCRIPTION OF EMBODIMENTS

(7) An embodiment of the present invention will be described below based on the drawings. In this description, direction is defined as follows. First, a direction from a stern to a bow of a fuel cell ship is “front”, and a direction from the bow to the stern is “rear”. A horizontal direction perpendicular to a front-rear direction is defined as a left-right direction. At this time, when the fuel cell ship is moving forward, the left side is defined as “left” and the right side is defined as “right” when viewed from the operator. The upstream side in the gravity direction perpendicular to the front-back direction and the left-right direction is referred to as “up”, and the downstream side is referred to as “down”.

(8) [1. Schematic Configuration of Fuel Cell Ship]

(9) Firstly, a fuel cell ship SH according to the present embodiment will be described with reference to FIGS. **1** and **2**. FIG. **1** is a rear perspective view illustrating an appearance of the fuel cell ship SH. FIG. **2** is an explanatory diagram illustrating a schematic configuration of the fuel cell ship SH. The fuel cell ship SH includes a hull **1** and a cabin **2**. The cabin **2** is arranged on top of the hull **1**.

(10) The fuel cell ship SH further includes a fuel cell system **3**, a fuel gas storage unit **4**, a storage battery system **5**, a propulsion device **6**, a plurality of pieces of peripheral equipment **11**, and a control device **12**. In FIG. **2**, a control signal or a high voltage power supply line is indicated by a solid line, and a control signal or a low voltage power supply line is indicated by a dashed line.

(11) The fuel cell system **3** functions as a main power supply. The fuel cell system **3** consumes a fuel gas to generate electric power (specifically, DC electric power). The fuel gas is an example of a fuel, for example, a combustible gas. Typically, the fuel gas is hydrogen gas. The fuel cell system **3** supplies generated electric power to the propulsion device **6** and the peripheral equipment **11**. The fuel cell system **3** can also supply electric power to the storage battery system **5** to charge the storage battery system **5**.

(12) The fuel gas storage unit **4** stores the fuel gas to be supplied to the fuel cell system **3**. The supply of fuel gas from the fuel gas storage unit **4** to the fuel cell system **3** is performed via a fuel gas supply pipe **32** described later (see FIG. **3**).

(13) The storage battery system **5** includes a storage battery. The storage battery is, for example, a lithium secondary battery, but may also be a nickel-cadmium storage battery, a nickel-hydrogen storage battery, or the like. The storage battery system **5** functions as an auxiliary power source for supplying the stored electric power (specifically, DC electric power) to the propulsion device **6** and the peripheral equipment **11**. By the storage battery system **5** functioning as an auxiliary power source, it is possible to compensate for a shortage of electric power supplied from the fuel cell system **3** to the propulsion device **6** or the like. The storage battery system **5** may supply electric power to the control device **12**.

(14) The propulsion device **6** is driven by electric power supplied from a fuel cell **31** (described later) (see FIG. **3**) of the fuel cell system **3**, and generates a propulsive force on the hull **1**. That is,

the fuel cell ship SH includes the propulsion device **6** that generates a propulsive force on the hull **1** by the electric power supplied from the fuel cell **31**.

(15) The propulsion device **6** may be driven only by the electric power supplied from the storage battery included in the storage battery system **5**, or may be driven by the electric power supplied from both the fuel cell **31** and the storage battery. That is, the propulsion device **6** may be driven by the electric power supplied from at least one of the fuel cell and the storage battery to generate the propulsive force on the hull **1**.

(16) The propulsion device **6** includes an electric power conversion device **6***a*, a propulsion motor **6***b*, and a propeller **6***c*. The electric power conversion device **6***a* converts the electric power supplied from the fuel cell system **3** into electric power according to the specifications of the propulsion motor **6***b*. For example, the electric power conversion device **6***a* converts DC electric power into AC electric power. In this case, the electric power conversion device **6***a* has, for example, an inverter. The propulsion motor **6***b* is driven by electric power (for example, AC electric power) supplied from the electric power conversion device **6***a*. When the propulsion motor **6***b* is driven, the rotational force of the propulsion motor **6***b* is transmitted to the propeller **6***c*. As a result, the propeller **6***c* rotates, and a propulsive force is generated on the hull **1**. A configuration is also possible in which a marine gear is provided between the propulsion motor **6***b* and the propeller **6***c*.

(17) Examples of the peripheral equipment **11** include a compressor, a solenoid valve, and a pump. Examples of the peripheral equipment **11** also include electrical equipment such as lighting equipment and air conditioning equipment, but the types of peripheral equipment **11** are not particularly limited.

(18) The control device **12** controls the fuel cell system **3**, the fuel gas storage unit **4**, the storage battery system **5**, the propulsion device **6**, and the plurality of pieces of peripheral equipment **11**. The control device **12** is composed of, for example, one or two or more computers. The computer is, for example, a Programmable Logic Controller (PLC), but may also be an Electronic Control Unit (ECU). The control device **12** is supplied with electric power from a battery (for example, a lead battery) (not illustrated) or the storage battery of the storage battery system **5**.

(19) The control device **12** has a control unit **12***a* and a storage unit **12***b*. The control unit **12***a* includes a processor such as a Central Processing Unit (CPU). The storage unit **12***b* includes a storage device and stores data and computer programs. Specifically, the storage unit **12***b* includes a main storage device such as a semiconductor memory and an auxiliary storage device such as a semiconductor memory, a solid state drive, and/or a hard disk drive. The storage unit **12***b* may also include removable media. The storage unit **12***b* corresponds to an example of a non-transitory computer-readable storage medium.

(20) The processor of the control unit **12***a* executes a computer program stored in the storage device of the storage unit **12***b*, to control the fuel cell system **3**, the fuel gas storage unit **4**, the storage battery system **5**, the propulsion device **6**, and the plurality of pieces of peripheral equipment **11**.

(21) [2. Internal Structure of Fuel Cell Ship]

(22) Next, an internal structure of the fuel cell ship SH will be described with reference to FIG. **3**. FIG. **3** is an explanatory diagram schematically illustrating the internal structure of the fuel cell ship SH. In FIG. **3**, the air flow is indicated by a dashed line arrow. Each member is illustrated in FIG. **3** in which the right side of the drawing is the bow side and the left side of the drawing is the stern side. However, the position of each member is not limited to the position illustrated in FIG. **3** as long as the connection relationship between each member is maintained.

(23) The fuel cell ship SH includes an engine room **13** and a fuel room **14**. The engine room **13** and the fuel room **14** are arranged below a deck **1***a* of the hull **1**. The engine room **13** is located on the bow side with respect to the fuel room **14**. Below the deck **1***a*, partition walls W1, W2 and W3 are located in order from the bow side to the stern side. The engine room **13** is separated from other spaces by the partition walls W1 and W2. The fuel room **14** is separated from other spaces by the

partition walls W2 and W3. The partition walls W1 to W3 are made of, for example, fiber reinforced plastics (FRP), but may be iron plates.

(24) (2-1. Configuration of Fuel Cell System)

(25) The fuel cell system **3** of the fuel cell ship SH is located in the engine room **13**. The fuel cell system **3** includes the fuel cell **31**, the fuel gas supply pipe **32**, and a fuel cell side shutoff valve **33**. The fuel cell side shutoff valve **33** is an example of the peripheral equipment **11** (see FIG. **2**).

(26) The fuel cell **31** generates electric power (specifically, DC electric power) by an electrochemical reaction between the fuel gas being an example of fuel and an oxidant gas. Typically, the oxidant gas is air and the oxidant is oxygen. That is, the fuel cell ship SH includes the fuel cell **31** that generates electric power by an electrochemical reaction of fuel.

(27) The fuel cell **31** is a fuel cell stack composed of a plurality of stacked cells. For example, each cell of the fuel cell **31** has a solid polymer electrolyte membrane, an anode electrode, a cathode electrode, and a pair of separators. The solid polymer electrolyte membrane is sandwiched between the anode electrode and the cathode electrode. The anode electrode is a negative electrode (fuel electrode). The anode electrode includes an anode catalyst layer and a gas diffusion layer. The cathode electrode is a positive electrode (air electrode). The cathode electrode includes a cathode catalyst layer and a gas diffusion layer. The anode electrode, the solid polymer electrolyte membrane, and the cathode electrode form a Membrane-Electrode Assembly (MEA). The pair of separators sandwich the membrane-electrode assembly. Each separator has a plurality of grooves. Each groove of one separator forms a flow path for the fuel gas. Each groove of the other separator forms a flow path for the oxidant gas.

(28) In the configuration described above of the fuel cell **31**, hydrogen included in the fuel gas is decomposed into hydrogen ions and electrons by the catalyst on the anode electrode side. Hydrogen ions pass through the solid polymer electrolyte membrane and move to the cathode electrode side. On the other hand, the electrons move to the cathode electrode side through an external circuit. As a result, an electric current is generated (electricity is generated). On the cathode electrode side, oxygen included in the oxidant gas combines with the electrons that flow through the external circuit and hydrogen ions that pass through the solid polymer electrolyte membrane to generate water. The generated water is discharged to the outside of the ship via a discharge pipe **31***a*.

(29) The fuel cell **31** supplies generated electric power to the propulsion device **6** and the peripheral equipment **11** which are illustrated in FIG. **2**. The fuel cell **31** may indirectly supply generated electric power to the propulsion device **6** and the peripheral equipment **11** via a circuit such as a DC/DC converter or the like.

(30) The fuel gas supply pipe **32** is a fuel supply pipe for supplying, to the anode electrode of the fuel cell **31**, fuel (for example, the fuel gas) stored in a fuel tank **41** (described later) of the fuel gas storage unit **4**. That is, the fuel cell ship SH includes the fuel gas supply pipe **32** as a fuel supply pipe through which fuel is supplied to the fuel cell **31** from the fuel tank **41** that houses the fuel.

(31) The fuel cell side shutoff valve **33** is an example of a shutoff valve SV that opens or closes the flow path of the fuel gas supply pipe **32**. The opening and closing of the fuel cell side shutoff valve **33** is controlled by the control unit **12***a* (see FIG. **2**). Specifically, the fuel cell side shutoff valve **33** switches between supplying the fuel gas from the fuel tank **41** to the fuel cell **31** and stopping the supply of fuel gas based on the control of the control unit **12***a*. Although only one fuel cell side shutoff valve **33** is provided in the fuel gas supply pipe **32** in a fuel cell compartment **30** (described later), two or more may be provided.

(32) The fuel cell ship SH further includes the fuel cell compartment **30**. The fuel cell compartment **30** is a housing body for housing the fuel cell **31**. The fuel cell compartment **30** is arranged in the engine room **13**.

(33) The fuel cell compartment **30** has a hollow shape. For example, the fuel cell compartment **30** has a hollow and substantially rectangular parallelepiped shape. In this case, the outer walls of the

fuel cell compartment **30** include, for example, a top wall **30***a*, a bottom wall **30***b*, a front wall (not illustrated), a back wall (not illustrated), a side wall **30***c*, and a side wall **30***d*. However, the top surface, bottom surface, front surface, back surface, and side surfaces of the fuel cell compartment **30** can be arbitrarily determined. The shape of the fuel cell compartment **30** is not particularly limited as long as the fuel cell compartment **30** has a space that can house the fuel cell **31**. The fuel cell compartment **30** can also be considered as a container, chamber, or box for housing the fuel cell **31**. The material of the outer wall of the fuel cell compartment **30** is, for example, FRP, but may be an iron plate.

(34) A cell compartment air supply port **30***e* with an opening is provided on the side wall **30***d* of the fuel cell compartment **30**. The cell compartment air supply port **30***e* is connected to a cell compartment air supply pipe **35**, which will be described later. The cell compartment air supply port **30***e* may be provided on an outer wall other than the side wall **30***d* in the fuel cell compartment **30**.

(35) On the other hand, a cell compartment exhaust port **30***f* with an opening is provided on the side wall **30***c* of the fuel cell compartment **30**. The cell compartment exhaust port **30***f* communicates with a duct compartment **90**, which will be described later. The cell compartment exhaust port **30***f* may be provided on an outer wall other than the side wall **30***c* in the fuel cell compartment **30**.

(36) The fuel cell compartment **30** has an interior that is a closed space, with the exception of the cell compartment air supply port **30***e* and the cell compartment exhaust port **30***f*.

(37) A part of the fuel gas supply pipe **32** described above and the fuel cell side shutoff valve **33** are housed in the fuel cell compartment **30**. The fuel cell compartment **30** further houses a cell compartment internal gas detector **34***a* and a cell compartment internal fire detector **34***b*.

(38) The cell compartment internal gas detector **34***a* is a fuel gas detector arranged inside the fuel cell compartment **30**. For example, if the fuel gas is hydrogen gas, the cell compartment internal gas detector **34***a* includes a hydrogen gas detection sensor.

(39) The cell compartment internal gas detector **34***a* is arranged on an inner surface of the top wall **30***a* located at an upper part of the fuel cell compartment **30**. Hydrogen gas as the fuel gas is lighter than air and rises. Therefore, by arranging the cell compartment internal gas detector **34***a* on the top wall **30***a* of the fuel cell compartment **30**, a leaked fuel gas can be reliably detected by the cell compartment internal gas detector **34***a* even if the fuel gas leaks in the fuel cell compartment **30**. The installation position of the cell compartment internal gas detector **34***a* may be located on the most downstream side of the flow path through which the fuel gas flows when the fuel gas leaks in the fuel cell compartment **30**.

(40) If the cell compartment internal gas detector **34***a* detects the fuel gas in the fuel cell compartment **30**, a detection signal is sent from the cell compartment internal gas detector **34***a* to the control unit **12***a*. As a result, the control unit **12***a* can control the fuel cell side shutoff valve **33** provided in the fuel gas supply pipe **32** to stop the supply of fuel gas from the fuel tank **41** to the fuel cell **31**.

(41) The cell compartment internal fire detector **34***b* is a fire detector arranged inside the fuel cell compartment **30**. The cell compartment internal fire detector **34***b* includes, for example, one or more sensors among a smoke sensor for detecting smoke, a heat sensor for detecting heat, and a flame sensor for detecting flame. The cell compartment internal fire detector **34***b* may include a thermocouple type fire detector.

(42) The cell compartment internal fire detector **34***b* is arranged on an inner surface of the top wall **30***a* located at an upper part of the fuel cell compartment **30**. In the unlikely event that a fire occurs inside the fuel cell compartment **30**, the cell compartment internal fire detector **34***b* detects the fire and outputs a detection signal indicating that a fire has occurred to the control unit **12***a*. In this case, the control unit **12***a* can control the fuel cell side shutoff valve **33** to stop the supply of fuel gas from the fuel tank **41** to the fuel cell **31**. As a result, in the fuel cell compartment **30**, the risk of

explosion due to ignition of the fuel gas can be reduced as much as possible.
(43) The cell compartment air supply pipe **35** is connected to the fuel cell compartment **30**. The cell compartment air supply pipe **35** extends from the cell compartment air supply port **30***e* of the fuel cell compartment **30**, to the deck **1***a* and is exposed from the upper surface of the deck **1***a*.
(44) A cell compartment air supply device **36** and a cell compartment external gas detector **37** are arranged at an end portion on the deck **1***a* side of the cell compartment air supply pipe **35**. The cell compartment air supply device **36** and the cell compartment external gas detector **37** are located above the deck **1***a*.
(45) The cell compartment air supply device **36** includes, for example, an inexpensive non-explosion-proof air supply fan, but may include an explosion-proof air supply fan. The drive of the cell compartment air supply device **36** is controlled by the control unit **12***a*. One or more filters (not illustrated) may be arranged in the cell compartment air supply device **36**. The filter removes, for example, dust or sea salt particles.
(46) The cell compartment air supply device **36** supplies air outside the fuel cell compartment **30** to the inside of the fuel cell compartment **30** via the cell compartment air supply pipe **35** and the cell compartment air supply port **30***e*. The air inside the fuel cell compartment **30** is discharged to the duct compartment **90** via the cell compartment exhaust port **30***f*. In this way, the inside of the fuel cell compartment **30** is ventilated. As a result, it is possible to prevent combustible gas (for example, the fuel gas leaking from the fuel cell **31**) from being retained in the fuel cell compartment **30**.
(47) The cell compartment external gas detector **37** detects combustible gas (for example, hydrogen gas floating around the hull **1**) flowing into the fuel cell compartment **30** from the outside. The cell compartment external gas detector **37** is, for example, a combustible gas sensor such as a hydrogen gas sensor. The cell compartment external gas detector **37** is arranged on a side opposite to the cell compartment air supply pipe **35** with respect to the cell compartment air supply device **36**, that is, on the upstream side of the air flow from the outside to the inside of the fuel cell compartment **30**. The cell compartment external gas detector **37** may include a gas sensor that detects a combustible gas other than hydrogen gas. Examples of combustible gases other than hydrogen gas include methane, ethane, propane, and carbon monoxide.
(48) The cell compartment external gas detector **37** outputs, for example, a detection signal indicating the concentration of combustible gas to the control unit **12***a*. As a result, the control unit **12***a* can determine, based on the detection signal, whether the concentration of the combustible gas is equal to or higher than a standard value. Then, if the concentration is equal to or higher than the standard value, the control unit **12***a* can close the fuel cell side shutoff valve **33** to stop the supply of fuel gas from the fuel tank **41** to the fuel cell **31**. The above-mentioned standard value may be determined based on experiments and/or experience.
(49) The fuel cell ship SH further includes a cooling medium tank **38** and a cooling medium pipe **39**. The cooling medium tank **38** stores a cooling medium for cooling the fuel cell **31**. The cooling medium is, for example, an antifreeze liquid having low electrical conductivity. The antifreeze liquid is, for example, a liquid obtained by mixing pure water and ethylene glycol in a predetermined ratio. The cooling medium tank **38** is sealed, but an upper portion may be open.
(50) The cooling medium pipe **39** is a pipe for circulating the cooling medium between the fuel cell **31** and a heat exchanger (not illustrated). A circulation pump (not illustrated) is also provided at a location along the cooling medium pipe **39**. The fuel cell **31** is cooled by driving the circulation pump to supply the cooling medium from the heat exchanger to the fuel cell **31** via the cooling medium pipe **39**. The cooling medium supplied for cooling the fuel cell **31** is also supplied, via the cooling medium pipe **39**, to the cooling medium tank **38**, at which a volume change due to a temperature change of the cooling medium is absorbed and the amount of the cooling medium liquid is monitored.
(51) A cooling tank internal gas detector **38***a* is provided in an upper portion inside the cooling

medium tank **38**. The cooling tank internal gas detector **38***a* is a fuel gas detector that detects the fuel gas existing in the cooling medium tank **38**. As the fuel gas existing in the cooling medium tank **38**, for example, a fuel gas which is leaked in the fuel cell **31** and then enters into the cooling medium tank **38** via the cooling medium pipe **39** can be considered. The fuel gas detection result (for example, fuel gas concentration information) by the cooling tank internal gas detector **38***a* is sent to the control unit **12***a*. As a result, the control unit **12***a* determines, based on the detection result of the cooling tank internal gas detector **38***a*, whether there is a fuel gas leak in the fuel cell **31**, and if there is a leak, the control unit **12***a* can, for example, perform control to stop electric power generation by the fuel cell **31**.
(52) (2-2. Configuration of Fuel Gas Storage Unit)
(53) The fuel gas storage unit **4** of the fuel cell ship SH includes the fuel tank **41**, a gas filling pipe **42**, and a tank side shutoff valve **43**. The tank side shutoff valve **43** is an example of the peripheral equipment **11**.
(54) The fuel tank **41** stores the fuel (for example, the fuel gas) to be supplied to the fuel cell **31**. In FIG. **3**, for convenience, only one fuel tank **41** is illustrated, but the number of fuel tanks **41** is not particularly limited and there may be a plurality of the fuel tanks **41**.
(55) The gas filling pipe **42** is a pipe (fuel filling pipe) for replenishing the fuel tank **41** with fuel (for example, the fuel gas), or filling the fuel tank **41** with an inert gas. One end side of the gas filling pipe **42** is connected to the fuel tank **41**. The other end side of the gas filling pipe **42** is branched into two, and these ends are connected to a fuel gas filling port **82** and an inert gas filling port **84**, respectively. The fuel gas filling port **82** and the inert gas filling port **84** are provided in the duct compartment **90** (particularly, an upper duct compartment **80**) described later.
(56) The above-mentioned inert gas is, for example, nitrogen gas. For example, if the fuel gas remains in the fuel tank **41** when performing maintenance such as inspection or repair of the fuel cell ship SH in the dock (dry dock), there is a danger that an explosion may occur when the fuel gas ignites for some reason. Therefore, at the time of maintenance of the fuel cell ship SH, the fuel tank **41** is filled with the inert gas, and the fuel gas is removed from the fuel tank **41**. As a result, it possible to avoid the danger of explosion.
(57) In the fuel gas supply pipe **32** described above, a side opposite to the connection side with the fuel cell **31** is connected to the fuel tank **41**, and a main valve **41***a* is provided between the fuel cell **31** and the fuel tank **41**. That is, the fuel tank **41** and the fuel cell **31** are connected via the fuel gas supply pipe **32**. The opening and closing of the main valve **41***a* of the fuel tank **41** is controlled by the control unit **12***a*.
(58) The tank side shutoff valve **43** is an example of a shutoff valve SV that opens or closes the flow path of the fuel gas supply pipe **32**. The opening and closing of the tank side shutoff valve **43** is controlled by the control unit **12***a*. More specifically, the tank side shutoff valve **43** switches between supplying the fuel gas from the fuel tank **41** to the fuel cell **31** and stopping the supply of fuel gas based on the control of the control unit **12***a*. Although only one tank side shutoff valve **43** is provided in the fuel gas supply pipe **32** in a tank compartment **40** described later, two or more tank side shutoff valves **43** may be provided.
(59) The fuel cell ship SH further includes the tank compartment **40**. The tank compartment **40** is a housing body that houses the fuel tank **41**. The tank compartment **40** is arranged in the fuel room **14**.
(60) The tank compartment **40** has a hollow shape. For example, the tank compartment **40** has a hollow and substantially rectangular parallelepiped shape. In this case, the outer walls of the tank compartment **40** include, for example, a top wall **40***a*, a bottom wall **40***b*, a front wall (not illustrated), a back wall (not illustrated), a side wall **40***c*, and a side wall **40***d*. However, the top surface, bottom surface, front surface, back surface, and side surfaces of the tank compartment **40** can be arbitrarily determined. The shape of the tank compartment **40** is not particularly limited as long as the tank compartment **40** has a space that can house at least one fuel tank **41**. The tank

compartment **40** can also be considered as a container, chamber, or box for housing the fuel tank **41**. The material of the outer wall of the tank compartment **40** is, for example, FRP, but may be an iron plate.
(61) A tank compartment air supply port **40***e* with an opening is provided on the side wall **40***c* of the tank compartment **40**. The tank compartment air supply port **40***e* is connected to a tank compartment air supply pipe **45** described later. The tank compartment air supply port **40***e* may be provided on an outer wall other than the side wall **40***c* in the tank compartment **40**.
(62) On the other hand, a tank compartment exhaust port **40***f* with an opening is provided on the top wall **40***a* of the tank compartment **40**. The tank compartment exhaust port **40***f* communicates with a vent pipe **10**. The vent pipe **10** is a pipe for guiding air inside the tank compartment **40** to the outside of the ship. The tank compartment exhaust port **40***f* may be provided on an outer wall other than the top wall **40***a* in the tank compartment **40**.
(63) The tank compartment **40** has an interior that is a closed space except for the tank compartment air supply port **40***e* and the tank compartment exhaust port **40***f*.
(64) As illustrated in FIG. **1**, two vent pipes **10** are provided on the left and right sides, respectively. The vent pipes **10** are located on the stern side with respect to the center of the hull **1** in the front-rear direction. The reason why the two vent pipes **10** are provided is that the fuel cell ship SH of the present embodiment includes two fuel cell compartments **30** on the right and left sides and two tank compartments **40** on the right and left sides, and two duct compartments **90** on the right and left sides, which will be described later. That is, the vent pipe **10** located on the left side of the hull **1** is provided corresponding to the fuel cell compartment **30**, the tank compartment **40**, and the duct compartment **90** located on the left side of the hull **1**. The vent pipe **10** located on the right side of the hull **1** is provided corresponding to the fuel cell compartment **30**, the tank compartment **40**, and the duct compartment **90** located on the right side of the hull **1**.
(65) A part of the fuel gas supply pipe **32** described above and the tank side shutoff valve **43** are housed in the tank compartment **40**. The tank compartment **40** further houses a tank compartment internal gas detector **44***a* and a tank compartment internal fire detector **44***b*.
(66) The tank compartment internal gas detector **44***a* is a fuel gas detector arranged inside the tank compartment **40**. For example, if the fuel gas is hydrogen gas, the tank compartment internal gas detector **44***a* includes a hydrogen gas detection sensor.
(67) The tank compartment internal gas detector **44***a* is arranged on the top wall **40***a* located at the upper part of the tank compartment **40** to be close to the tank compartment exhaust port **40***f* or inside the tank compartment exhaust port **40***f*. In the unlikely event that the fuel gas leaks from the fuel tank **41** in the tank compartment **40**, the leaked fuel gas goes toward the vent pipe **10** through the tank compartment exhaust port **40***f*. That is, the tank compartment exhaust port **40***f* is located on the most downstream side of the flow path through which the fuel gas flows when the fuel gas leaks inside the tank compartment **40**. Therefore, by arranging the tank compartment internal gas detector **44***a* at a position near the tank compartment exhaust port **40***f* or inside the tank compartment exhaust port **40***f*, a fuel gas leaked in the tank compartment **40** can be reliably detected by the tank compartment internal gas detector **44***a* located on the most downstream side of the flow path, regardless of where the fuel gas leaks.
(68) If the tank compartment internal gas detector **44***a* detects the fuel gas inside the tank compartment **40**, a detection signal is sent from the tank compartment internal gas detector **44***a* to the control unit **12***a*. As a result, the control unit **12***a* can control the tank side shutoff valve **43** provided in the fuel gas supply pipe **32** to stop the supply of fuel gas from the fuel tank **41** to the fuel cell **31**. The details of control for opening and closing of the tank side shutoff valve **43** will be described later.
(69) The tank compartment internal fire detector **44***b* is a fire detector arranged inside the tank compartment **40**. The tank compartment internal fire detector **44***b* includes, for example, one or more sensors among a smoke sensor for detecting smoke, a heat sensor for detecting heat, and a

flame sensor for detecting flame. The tank compartment internal fire detector **44***b* may include a thermocouple type fire detector.
(70) The tank compartment internal fire detector **44***b* is arranged on an inner surface of the top wall **40***a* located at an upper part of the tank compartment **40**. In the unlikely event that a fire occurs inside the tank compartment **40**, the tank compartment internal fire detector **44***b* detects the fire and outputs a detection signal indicating that a fire has occurred to the control unit **12***a*. In this case, the control unit **12***a* can control the tank side shutoff valve **43** to stop the supply of fuel gas from the fuel tank **41** to the fuel cell **31**. As a result, in the tank compartment **40**, the risk of explosion due to ignition of the fuel gas can be reduced as much as possible.
(71) The tank compartment air supply pipe **45** is connected to the tank compartment **40**. The tank compartment air supply pipe **45** extends from the tank compartment air supply port **40***e* of the tank compartment **40** to the deck **1***a*, and is exposed from an upper surface of the deck **1***a*.
(72) A tank compartment air supply device **46** and a tank compartment external gas detector **47** are arranged at an end portion on the deck **1***a* side of the tank compartment air supply pipe **45**. The tank compartment air supply device **46** and the tank compartment external gas detector **47** are located above the deck **1***a*.
(73) The tank compartment air supply device **46** includes, for example, an inexpensive non-explosion-proof air supply fan, but may include an explosion-proof air supply fan. The drive of the tank compartment air supply device **46** is controlled by the control unit **12***a*. One or more filters (not illustrated) may be arranged in the tank compartment air supply device **46**. The filter removes, for example, dust or sea salt particles.
(74) The tank compartment air supply device **46** supplies air outside the tank compartment **40** to the inside of the tank compartment **40** via the tank compartment air supply pipe **45** and the tank compartment air supply port **40***e*. The air inside the tank compartment **40** is discharged to the vent pipe **10** via the tank compartment exhaust port **40***f*. In this way, the inside of the tank compartment **40** is ventilated. As a result, even if the fuel gas leaks from the fuel tank **41** in the tank compartment **40**, the retention of the fuel gas can be suppressed.
(75) The tank compartment external gas detector **47** detects combustible gas (for example, hydrogen gas floating around the hull **1**) flowing into the tank compartment **40** from the outside. The tank compartment external gas detector **47** is, for example, a combustible gas sensor such as a hydrogen gas sensor. The tank compartment external gas detector **47** is arranged on a side opposite to the tank compartment air supply pipe **45** with respect to the tank compartment air supply device **46**, that is, on the upstream side of the air flow from the outside to the inside of the tank compartment **40**. The tank compartment external gas detector **47** may include a gas sensor that detects a combustible gas other than hydrogen gas.
(76) The tank compartment external gas detector **47** outputs, for example, a detection signal indicating the concentration of combustible gas to the control unit **12***a*. As a result, the control unit **12***a* can determine, based on the detection signal, whether the concentration of the combustible gas is equal to or higher than a standard value. Then, if the concentration is equal to or higher than the standard value, the control unit **12***a* can close the tank side shutoff valve **43** to stop the supply of fuel gas from the fuel tank **41** to the fuel cell **31**. The above-mentioned standard value may be determined based on experiments and/or experience.
(77) (2-3. Duct Compartment)
(78) The fuel cell ship SH further includes a lower duct compartment **70** and the upper duct compartment **80**. Here, the lower duct compartment **70** and the upper duct compartment **80** are collectively referred to as a duct compartment **90**. The duct compartment **90** is a housing body that houses various pipes. For example, the duct compartment **90** houses a part of the fuel gas supply pipe **32**. The inside of the lower duct compartment **70** and the inside of the upper duct compartment **80** communicate with each other via a duct communication portion **91**. In the following, details of the lower duct compartment **70** and the upper duct compartment **80** will be described.

(79) <2-3-1. Lower Duct Compartment>
(80) The lower duct compartment **70** is located below the deck **1***a*. More specifically, the lower duct compartment **70** is arranged in the engine room **13**. In the engine room **13**, the lower duct compartment **70** is located on the stern side with respect to the fuel cell compartment **30**. That is, below the deck **1***a*, the lower duct compartment **70** is located between the fuel cell compartment **30** and the tank compartment **40**. The lower duct compartment **70** houses a part of the fuel gas supply pipe **32** and a part of the gas filling pipe **42**.
(81) Here, the "part of the fuel gas supply pipe **32**" housed in the lower duct compartment **70** refers to a portion of the fuel gas supply pipe **32** located between the fuel cell compartment **30** and the tank compartment **40**. The "part of the gas filling pipe **42**" housed in the lower duct compartment **70** refers to a portion of the gas filling pipe **42** located between the tank compartment **40** and the upper duct compartment **80**.
(82) The material of the lower duct compartment **70** is, for example, FRP, but may be an iron plate. The lower duct compartment **70** has a hollow shape. For example, the lower duct compartment **70** has a hollow and substantially rectangular parallelepiped shape. In this case, the outer walls of the lower duct compartment **70** include, for example, a top wall **70***a*, a bottom wall **70***b*, a front wall (not illustrated), a back wall (not illustrated), a side wall **70***c*, and a side wall **70***d*. However, the top surface, bottom surface, front surface, back surface, and side surfaces of the lower duct compartment **70** can be arbitrarily determined. The shape of the lower duct compartment **70** is not particularly limited as long as the lower duct compartment **70** has a space that can house a part of the fuel gas supply pipe **32** and the like. The lower duct compartment **70** can also be regarded as a container, a chamber, or a box for housing a part of the fuel gas supply pipe **32** and the like.
(83) A lower duct compartment air supply port **70***e* with an opening is provided in the side wall **70***d* of the lower duct compartment **70**. The lower duct compartment air supply port **70***e* is connected to a lower duct compartment air supply pipe **74** described later. The lower duct compartment air supply port **70***e* may be provided on an outer wall other than the side wall **70***d* in the lower duct compartment **70**.
(84) On the other hand, a lower duct compartment communication port **70***f* with an opening is provided in the top wall **70***a* of the lower duct compartment **70**. The lower duct compartment communication port **70***f* communicates with the duct communication portion **91** described above. The lower duct compartment communication port **70***f* may be provided on an outer wall other than the top wall **70***a* in the lower duct compartment **70**.
(85) A cell compartment communication port **70***g* with an opening is provided in the side wall **70***d* of the lower duct compartment **70**. The cell compartment communication port **70***g* is connected to the cell compartment exhaust port **30***f* of the fuel cell compartment **30** described above via a communication pipe **92**. As a result, the air inside the fuel cell compartment **30** flows into the lower duct compartment **70** via the cell compartment exhaust port **30***f*, the communication pipe **92**, and the cell compartment communication port **70***g*. The cell compartment communication port **70***g* may be provided on an outer wall other than the side wall **70***d* in the lower duct compartment **70**.
(86) The communication pipe **92** includes, for example, a double pipe having an inner pipe and an outer pipe. Examples of the inner pipe include the fuel gas supply pipe **32**. The outer pipe is located on the outside of the inner pipe in the radial direction. The gas inside the fuel cell compartment **30** travels between the inner pipe and the outer pipe of the communication pipe **92**, from the cell compartment exhaust port **30***f* to the cell compartment communication port **70***g* of the lower duct compartment **70**.
(87) The lower duct compartment **70** has a closed space inside except for the lower duct compartment air supply port **70***e*, the lower duct compartment communication port **70***f*, and the cell compartment communication port **70***g*.
(88) The lower duct compartment **70** houses a part of a fuel gas discharge pipe **71**. The fuel gas discharge pipe **71** is a fuel discharge pipe provided by branching from the fuel gas supply pipe **32**

located in the lower duct compartment **70**. For example, the fuel gas discharge pipe **71** is provided by branching from the fuel gas supply pipe **32** between the two shutoff valves SV.

(89) More specifically, the fuel gas discharge pipe **71** is provided by branching from the fuel gas supply pipe **32** between the tank side shutoff valve **43** in the tank compartment **40** and the fuel cell side shutoff valve **33** in the fuel cell compartment **30**. The fuel gas discharge pipe **71** extends from the inside of the lower duct compartment **70** to the inside of the upper duct compartment **80** via the lower duct compartment communication port **70***f* and the duct communication portion **91**, and further communicates with the inside of the vent pipe **10**. Therefore, the "part of the fuel gas discharge pipe **71**" housed in the lower duct compartment **70** refers to a portion of the fuel gas discharge pipe **71** located between the point of the branching from the fuel gas supply pipe **32** and the upper duct compartment **80**.

(90) The lower duct compartment **70** further houses a release valve **72**. The release valve **72** is an on-off valve installed in the fuel gas discharge pipe **71** to open or close the flow path of the fuel gas discharge pipe **71**. The release valve **72** is an example of peripheral equipment **11**. The opening and closing of the release valve **72** are controlled by the control unit **12***a*. The release valve **72** may be installed in the upper duct compartment **80**.

(91) The lower duct compartment **70** further houses a lower duct compartment internal gas detector **73**. The lower duct compartment internal gas detector **73** is a fuel gas detector arranged inside the lower duct compartment **70**. For example, if the fuel gas is hydrogen gas, the lower duct compartment internal gas detector **73** includes a hydrogen gas detection sensor.

(92) The lower duct compartment internal gas detector **73** is arranged on the top wall **70***a* located at an upper portion of the lower duct compartment **70** to be close to the lower duct compartment communication port **70***f* or inside the lower duct compartment communication port **70***f*. In the unlikely event that the fuel gas leaks from the fuel gas supply pipe **32** in the lower duct compartment **70**, the leaked fuel gas goes toward the upper duct compartment **80** through the lower duct compartment communication port **70***f*. That is, the lower duct compartment communication port **70***f* is located on the most downstream side of the flow path through which the fuel gas flows when the fuel gas leaks in the lower duct compartment **70**. Therefore, by arranging the lower duct compartment internal gas detector **73** at a position close to the lower duct compartment communication port **70***f* or inside the lower duct compartment communication port **70***f*, a fuel gas leaked in the lower duct compartment **70** can be reliably detected by the lower duct compartment internal gas detector **73** located on the most downstream side of the flow path, regardless of where the fuel gas leaks.

(93) If the lower duct compartment internal gas detector **73** detects the fuel gas in the lower duct compartment **70**, a detection signal is sent from the lower duct compartment internal gas detector **73** to the control unit **12***a*. As a result, the control unit **12***a* can perform control described later to stop the electric power generation of the fuel cell **31** based on the detection signal.

(94) The lower duct compartment **70** may further house a fire detector that detects a fire inside the lower duct compartment **70**.

(95) The lower duct compartment air supply pipe **74** is connected to the lower duct compartment **70**. The lower duct compartment air supply pipe **74** extends from the lower duct compartment air supply port **70***e* of the lower duct compartment **70** to the deck **1***a* and is exposed from the upper surface of the deck **1***a*.

(96) A lower duct compartment air supply device **75** and a lower duct compartment external gas detector **76** are arranged at an end portion on the deck **1***a* side of the lower duct compartment air supply pipe **74**. The lower duct compartment air supply device **75** and the lower duct compartment external gas detector **76** are located above the deck **1***a*.

(97) The lower duct compartment air supply device **75** includes, for example, an inexpensive non-explosion-proof air supply fan, but may include an explosion-proof air supply fan. The drive of the lower duct compartment air supply device **75** is controlled by the control unit **12***a*. One or more

filters (not illustrated) may be arranged in the lower duct compartment air supply device **75**. The filter removes, for example, dust or sea salt particles.
(98) The lower duct compartment air supply device **75** supplies the air outside the lower duct compartment **70** (duct compartment **90**) to the inside of the lower duct compartment **70** via the lower duct compartment air supply pipe **74** and the lower duct compartment air supply port **70***e*. The air inside the lower duct compartment **70** is discharged to the upper duct compartment **80** through the lower duct compartment communication port **70***f*. In this way, the inside of the lower duct compartment **70** is ventilated. As a result, even if the fuel gas leaks from the fuel gas supply pipe **32** in the lower duct compartment **70**, retention of the fuel gas can be suppressed.
(99) The lower duct compartment external gas detector **76** detects combustible gas (for example, hydrogen gas floating around the hull **1**) flowing into the duct compartment **90** from the outside. The lower duct compartment external gas detector **76** is, for example, a combustible gas sensor such as a hydrogen gas sensor. The lower duct compartment external gas detector **76** is arranged on a side opposite to the lower duct compartment air supply pipe **74** with respect to the lower duct compartment air supply device **75**, that is, on the upstream side of the air flow from the outside to the inside of the duct compartment **90**. The lower duct compartment external gas detector **76** may include a gas sensor that detects a combustible gas other than hydrogen gas.
(100) The lower duct compartment external gas detector **76** outputs, for example, a detection signal indicating the concentration of combustible gas to the control unit **12***a*. As a result, the control unit **12***a* can determine, based on the detection signal, whether the concentration of the combustible gas is equal to or higher than a standard value. Then, if the concentration is equal to or higher than the standard value, the control unit **12***a* can control the shutoff valves SV to stop the supply of fuel gas from the fuel tank **41** to the fuel cell **31**. The above-mentioned standard value may be determined based on experiments and/or experience.
(101) <2-3-2. Upper Duct Compartment>
(102) The upper duct compartment **80** is located on the deck **1***a*. More specifically, the upper duct compartment **80** is arranged on the deck **1***a* to cover an area partially including the lower duct compartment **70** and the tank compartment **40**. The upper duct compartment **80** houses a part of the fuel gas discharge pipe **71** and a part of the gas filling pipe **42**.
(103) Here, the “part of the fuel gas discharge pipe **71**” housed in the upper duct compartment **80** refers to a portion of the fuel gas discharge pipe **71** that extends from the lower duct compartment **70** toward the vent pipe **10**. The “part of the gas filling pipe **42**” housed in the upper duct compartment **80** refers to a portion of the gas filling pipe **42** that extends from the lower duct compartment **70** to the fuel gas filling port **82** described later.
(104) The material of the upper duct compartment **80** is, for example, FRP, but may be an iron plate. The upper duct compartment **80** has a hollow shape. For example, the upper duct compartment **80** has a hollow and substantially rectangular parallelepiped shape. In this case, the outer walls of the upper duct compartment **80** include, for example, a top wall **80***a*, a bottom wall **80***b*, a front wall (not illustrated), a back wall (not illustrated), a side wall **80***c*, and a side wall **80***d*. However, the top surface, bottom surface, front surface, back surface, and side surfaces of the upper duct compartment **80** can be arbitrarily determined. The shape of the upper duct compartment **80** is not particularly limited as long as the upper duct compartment **80** has a space that can house a part of the fuel gas discharge pipe **71** and the like. The upper duct compartment **80** can also be regarded as a container, a chamber, or a box for housing the part of the fuel gas discharge pipe **71** and the like.
(105) The fuel gas discharge pipe **71**, as described above, communicates with the inside of the vent pipe **10**. Thus, when the release valve **72** is opened, the gas inside the fuel gas discharge pipe **71** (for example, the fuel gas) flows from an end portion **71***a* of the fuel gas discharge pipe **71** into the vent pipe **10** and is released from the vent pipe **10** to the outside of the ship. Here, it is desirable that, in the vent pipe **10**, the end portion **71***a* of the fuel gas discharge pipe **71** faces upward, that is,

faces the open port side of the vent pipe **10**. In this case, the discharge direction of gas discharged from the end portion **71***a* of the fuel gas discharge pipe **71** is upward.
(106) For example, if the fuel gas is discharged sideways from the end portion **71***a* of the fuel gas discharge pipe **71**, the discharged fuel gas reaches the inner wall surface of the vent pipe **10** and then flows downward. This may result in unwanted detection by the tank compartment internal gas detector **44***a* in the tank compartment **40**. By the end portion **71***a* of the fuel gas discharge pipe **71** facing upward inside the vent pipe **10** as described above, it is possible to reduce unwanted detection by the tank compartment internal gas detector **44***a* due to the fuel gas discharged from the end portion **71***a*.
(107) An upper duct compartment air supply port **80***e* with an opening is provided in the bottom wall **80***b* of the upper duct compartment **80**. The upper duct compartment air supply port **80***e* communicates with the duct communication portion **91**. Therefore, the upper duct compartment **80** communicates with the lower duct compartment **70** via the upper duct compartment air supply port **80***e*, the duct communication portion **91**, and the lower duct compartment communication port **70***f*. The upper duct compartment air supply port **80***e* may be provided on an outer wall other than the bottom wall **80***b* in the upper duct compartment **80**.
(108) The upper duct compartment **80** has a vent pipe communication portion **81**. The vent pipe communication portion **81** is a pipe by which the inside of the upper duct compartment **80** communicates with the vent pipe **10**. In FIG. **3**, the vent pipe communication portion **81** is illustrated as having a shape bent upward from the horizontal orientation, but the shape of the vent pipe communication portion **81** is not limited to the shape in FIG. **3**. The reason why the vent pipe communication portion **81** is bent upward is similar to the reason why the end portion **71***a* of the fuel gas discharge pipe **71** is bent upward. That is, the vent pipe communication portion **81** is bent upward to reduce unwanted detection by the tank compartment internal gas detector **44***a* due to the fuel gas discharged from the vent pipe communication portion **81**, which will be described later.
(109) The vent pipe **10** extends upward from the tank compartment **40** and passes through the interior of the upper duct compartment **80**. More specifically, the vent pipe **10** passes through the bottom wall **80***b* of the upper duct compartment **80**, enters the inside of the vent pipe **10**, and passes through the top wall **80***a*. Although the top wall **80***a* is actually inclined as illustrated in FIG. **1**, the top wall **80***a* is illustrated as being horizontal in FIG. **3**, for convenience. The vent pipe communication portion **81** is provided in the upper duct compartment **80** to penetrate through the side wall of the vent pipe **10**. As a result, the upper duct compartment **80** communicates with the vent pipe **10** via the vent pipe communication portion **81**.
(110) Therefore, the air inside the upper duct compartment **80** is discharged to the outside of the ship through the vent pipe communication portion **81** and the vent pipe **10**. In this way, it is possible to ventilate the inside of the upper duct compartment **80**. If the fuel gas leaks from the fuel gas discharge pipe **71** in the upper duct compartment **80**, the leaked fuel gas is discharged to the outside of the ship through the vent pipe communication portion **81** and the vent pipe **10**. In this way, it is possible to prevent the leaked fuel gas from being retained in the upper duct compartment **80**.
(111) The upper duct compartment **80** and the lower duct compartment **70** communicate with each other via the duct communication portion **91**. As a result, (1) air taken into the inside of the lower duct compartment **70** via the lower duct compartment air supply pipe **74**, (2) a fuel gas leaked from the fuel gas supply pipe **32** in the lower duct compartment **70** for some reason, and (3) air or a fuel gas discharged from the fuel cell compartment **30** to the lower duct compartment **70** via the communication pipe **92** can be discharged to the outside of the ship via the upper duct compartment **80** and the vent pipe **10**. In this way, it is possible to suppress the retention of the fuel gas inside the lower duct compartment **70** and inside the fuel cell compartment **30**.
(112) The fuel gas filling port **82** and a fuel gas check valve **83** are provided in the upper duct compartment **80**. The fuel gas filling port **82** is a fuel filling port that serves as an inlet for filling

the fuel tank **41** with fuel (for example, the fuel gas), and is connected to the gas filling pipe **42**.
(113) The fuel gas check valve **83** is provided in the gas filling pipe **42**. More specifically, the fuel gas check valve **83** is located between the point where an inert gas pipe **87** (described later) branches from the gas filling pipe **42** and the fuel gas filling port **82**.
(114) The fuel gas supplied from the fuel gas filling port **82** travels through the fuel gas check valve **83** and the gas filling pipe **42**, and is supplied to the fuel tank **41** in the tank compartment **40**. As a result, the fuel gas is filled in the fuel tank **41** and stored. The fuel gas check valve **83** is provided to prevent backflow of the fuel gas from the fuel tank **41** side to the fuel gas filling port **82**.
(115) The upper duct compartment **80** is further provided with the inert gas filling port **84**, an on-off valve **85**, an inert gas check valve **86**, and the inert gas pipe **87**. The inert gas filling port **84** is an inlet for filling the fuel tank **41** with an inert gas, and is connected to the inert gas pipe **87**. The inert gas pipe **87** is provided by branching from the gas filling pipe **42** in the upper duct compartment **80**. The on-off valve **85** and the inert gas check valve **86** are provided in the inert gas pipe **87**. In the inert gas pipe **87**, the on-off valve **85** is located between the inert gas filling port **84** and the inert gas check valve **86**.
(116) The on-off valve **85** opens or closes the flow path of the inert gas pipe **87**. In a configuration in which the inert gas check valve **86** is provided in the inert gas pipe **87**, installation of the on-off valve **85** may be omitted.
(117) When inert gas is supplied to the inert gas filling port **84** and the on-off valve **85** opens the flow path of the inert gas pipe **87** in a state in which the fuel gas is not supplied to the fuel gas filling port **82**, the inert gas is supplied to the fuel tank **41** in the tank compartment **40** through the inert gas check valve **86**, and via the inert gas pipe **87** and the gas filling pipe **42**. In addition, the tank side shutoff valve **43** opens the flow path of the fuel gas supply pipe **32**, the fuel cell side shutoff valve **33** closes the flow path of the fuel gas supply pipe **32**, and the release valve **72** opens the flow path of the fuel gas discharge pipe **71**, whereby the fuel gas remaining in the fuel tank **41** is discharged to the vent pipe **10** via the fuel gas supply pipe **32** and the fuel gas discharge pipe **71**. As a result, the fuel gas can be removed from the fuel tank **41** (purge process). In this process, the main valve **41** is opened or closed at the right time.
(118) There may be a pipe from the gas filling pipe **42** that is directly connected to the fuel gas supply pipe **32** between the fuel tank **41** and the tank side shutoff valve **43** (tank method). In this configuration, when performing a purge process for the fuel tank **41** using the inert gas, it is necessary to fill the fuel tank **41** with the inert gas in a state in which the tank side shutoff valve **43** is closed, and after that, to open the tank side shutoff valve **43** for the purpose of facilitating the release of the inert gas from the fuel tank **41**.
(119) The fuel gas filling port **82** and the inert gas filling port **84** are provided in the upper duct compartment **80** as described above. Here, when the fuel gas filling port **82** and a fuel gas filling port lid portion **82***a* (described later) is considered as one and the inert gas filling port **84** and an inert gas filling port lid portion **84***a* (described later) is considered as one, it can be said that the fuel gas filling port **82** and the inert gas filling port **84** are located at a boundary surface between the inside and the outside of the upper duct compartment **80**. Therefore, “the fuel gas filling port **82** and the inert gas filling port **84** are provided in the upper duct compartment **80**” includes a case where the fuel gas filling port **82** and the inert gas filling port **84** are provided at the boundary surface of the upper duct compartment **80**.
(120) An upper duct compartment internal gas detector **88** is housed in the upper duct compartment **80**. The upper duct compartment internal gas detector **88** is a fuel gas detector arranged inside the upper duct compartment **80**. For example, if the fuel gas is hydrogen gas, the upper duct compartment internal gas detector **88** includes a hydrogen gas detection sensor.
(121) The upper duct compartment internal gas detector **88** is arranged on the top wall **80***a* located in an upper portion of the upper duct compartment **80**. Hydrogen gas as the fuel gas is lighter than air and rises. Therefore, if the fuel gas leaks in the upper duct compartment **80**, the leaked fuel gas

can be reliably detected by the upper duct compartment internal gas detector **88**. To more reliably detect the fuel gas leaked in the upper duct compartment **80**, the upper duct compartment internal gas detector **88** may be arranged at a position close to the vent pipe communication portion **81**.
(122) If the upper duct compartment internal gas detector **88** detects the fuel gas in the upper duct compartment **80**, a detection signal is sent from the upper duct compartment internal gas detector **88** to the control unit **12***a*. As a result, the control unit **12***a* can perform control described later to stop the electric power generation of the fuel cell **31** based on the detection signal.
(123) The upper duct compartment **80** may further house a fire detector that detects a fire inside the upper duct compartment **80**.
(124) (2-4. Supplementary Information about Vent Pipe)
(125) Inside the vent pipe **10**, a vent pipe internal gas detector **10***a* is provided further on the downstream side than a discharge port **81***a* of the vent pipe communication portion **81**. The downstream side refers to the downstream side in the air flow direction when the air inside the tank compartment **40** flows inside the vent pipe **10** and is discharged to the outside of the ship. For example, if the fuel gas is hydrogen gas, the vent pipe internal gas detector **10***a* includes a diffusion type or suction type hydrogen gas detection sensor. A detection signal from the vent pipe internal gas detector **10***a* is sent to the control unit **12***a*.
(126) For example, in a state where the control unit **12***a* outputs a signal (closing signal) for closing the release valve **72**, if the vent pipe internal gas detector **10***a* detects the fuel gas even though the tank compartment internal gas detector **44***a* and the upper duct compartment internal gas detector **88** do not detect the fuel gas, it is possible to determine that the release valve **72** is not completely blocking the flow path of the fuel gas discharge pipe **71**, that is, the release valve **72** is malfunctioning. In this case, by sending a notification to the outside, for example, the control unit **12***a* can prompt a maintenance person to inspect, repair, or replace the release valve **72**. The notification to the outside includes a monitor display, output of an alarm sound, transmission of information to an external terminal, and the like.
(127) [3. Concentration of Hazardous Sites in Duct Compartment]
(128) Next, concentration of hazardous sites through which the fuel gas passes in the duct compartment **90**, in the above-described fuel cell ship SH, will be described with reference to FIGS. **1** to **3** as well as FIGS. **4** and **5**. FIG. **4** is an enlarged perspective view illustrating a portion A in FIG. **1**. FIG. **5** is a perspective view of the portion A in FIG. **1** in which the fuel gas filling port lid portion **82***a* and the inert gas filling port lid portion **84***a* are not illustrated.
(129) The fuel gas filling port lid portion **82***a* is pivotably provided with respect to an upper window portion **82***b* illustrated in FIG. **5**. The fuel gas filling port **82** provided in the upper duct compartment **80** is located inside the upper window portion **82***b*. By pivoting the fuel gas filling port lid portion **82***a* to open the upper window portion **82***b*, the fuel gas filling port **82** is exposed to the outside. As a result, it becomes possible to fill the fuel tank **41** with the fuel gas via the fuel gas filling port **82**. On the other hand, by pivoting the fuel gas filling port lid portion **82***a* to close the upper window portion **82***b*, the fuel gas filling port **82** is hidden. The fuel cell ship SH navigates in such a state where the fuel gas filling port **82** is hidden by the fuel gas filling port lid portion **82***a*.
(130) The inert gas filling port lid portion **84***a* is pivotably provided with respect to a lower window portion **84***b* illustrated in FIG. **5**. The inert gas filling port **84** and the on-off valve **85** provided in the upper duct compartment **80** are located inside the lower window portion **84***b*. By pivoting the inert gas filling port lid portion **84***a* to open the lower window portion **84***b*, the inert gas filling port **84** and the on-off valve **85** are exposed to the outside. As a result, it becomes possible to open the on-off valve **85**, and fill the fuel tank **41** with the inert gas via the inert gas filling port **84**. On the other hand, by pivoting the fuel gas filling port lid portion **84***a* to close the lower window portion **84***b*, the inert gas filling port **84** and the on-off valve **85** are hidden. The fuel cell ship SH navigates in such a state where the inert gas filling port **84** and the on-off valve **85** are hidden by the inert gas filling port lid portion **84***a*.

(131) As described above, the fuel cell ship SH includes the duct compartment **90** that houses a part of the fuel gas supply pipe **32** (fuel supply pipe), the vent pipe **10** that communicates (via the vent pipe communication portion **81**) with the duct compartment **90** (particularly, the upper duct compartment **80**), and the fuel gas filling port **82** (fuel filling port) that serves as an inlet for filling the fuel tank **41** with fuel. As illustrated in FIGS. **1**, **3**, and **5**, the fuel gas filling port **82** is provided in the duct compartment **90** (particularly, the upper duct compartment **80**).
(132) In the unlikely event that the fuel gas leaks from the fuel gas supply pipe **32** in the duct compartment **90**, the leaked fuel gas travels toward the vent pipe **10** (via the vent pipe communication portion **81**) and passes through the vent pipe **10** to be discharged to the outside of the duct compartment **90** (for example, the outside of the ship). In filling the fuel tank **41** with the fuel gas, the fuel gas is supplied to the fuel tank **41** through the fuel gas filling port **82**. Therefore, the vent pipe **10** and the fuel gas filling port **82** are hazardous sites through which the fuel gas passes. To ensure safety, it may be required not to arrange various electrical equipment (for example, the lower duct compartment air supply device **75** being a non-explosion-proof air supply fan) around the hazardous sites (for example, within a radius of 1.5 m). Therefore, if the vent pipe **10** and the fuel gas filling port **82** are provided apart from each other, the hazardous locations where various electrical equipment cannot be arranged will increase.
(133) By providing the fuel gas filling port **82** in the duct compartment **90** that communicates with the vent pipe **10**, the hazardous sites through which the fuel gas passes (the fuel gas filling port **82** and the vent pipe **10**) are concentrated in the duct compartment **90**. This makes it possible to narrow the hazardous location in which various electrical equipment cannot be arranged (the range of the hazardous location can be made compact), as compared with a configuration in which the fuel gas filling port **82** and the vent pipe **10** are provided apart from each other (for example, in separate compartments). As a result, the degree of freedom of arranging various electrical equipment can be increased.
(134) The fuel cell ship SH includes the fuel gas discharge pipe **71** (fuel discharge pipe) provided by branching from the fuel gas supply pipe **32** (fuel supply pipe), and also includes the gas filling pipe **42** (fuel filling pipe) that connects the fuel gas filling port **82** (fuel filling port) and the fuel tank **41**. The duct compartment **90** houses the fuel gas discharge pipe **71** and the gas filling pipe **42** (see FIG. **3**).
(135) As with the fuel gas filling port **82** and the vent pipe **10**, the fuel gas discharge pipe **71** and the gas filling pipe **42** are also hazardous sites through which the fuel gas passes. The configuration in which the duct compartment **90** houses the fuel gas discharge pipe **71** and the gas filling pipe **42**, which are hazardous sites, together, makes it possible to narrow the hazardous location as compared with a configuration in which these pipes are provided in different locations. Therefore, similar to the above, the degree of freedom of arranging various electrical equipment can be increased.
(136) The fuel cell ship SH includes the inert gas filling port **84** that serves as an inlet for filling the fuel tank **41** with an inert gas, and also includes the inert gas pipe **87** connected to the inert gas filling port **84** and the gas filling pipe **42**. The duct compartment **90** further houses the inert gas pipe **87** (see FIG. **3**).
(137) In this configuration, the pipes for supplying gas to the fuel tank **41** can be gathered in the duct compartment **90** to realize a compact arrangement. That is, the gas filling pipe **42** for supplying the fuel gas to the fuel tank **41** and the inert gas pipe **87** for supplying the inert gas to the fuel tank **41** can be gathered in the duct compartment **90** to realize a compact arrangement.
(138) The fuel cell ship SH includes the fuel cell compartment **30** in which the fuel cell **31** is installed, and also includes the communication pipe **92** by which the fuel cell compartment **30** communicates with the duct compartment **90** (for example, the lower duct compartment **70**) (see FIG. **3**).
(139) In this configuration, the exhaust gas from the fuel cell compartment **30** can be discharged to

the duct compartment **90** via the communication pipe **92**, and can be discharged from the duct compartment **90** to the outside (for example, the outside of the ship) via the vent pipe **10**. Therefore, the total number of vent pipes can be reduced and the configuration can be simplified as compared with the configuration in which a dedicated vent pipe (independent of the other compartments) is separately provided in the fuel cell compartment **30**. Even in the unlikely event that the fuel gas leaks in the fuel cell compartment **30**, the leaked fuel gas is guided to the duct compartment **90** via the communication pipe **92**. That is, the sites through which the leaked fuel gas passes are concentrated in the duct compartment **90**. As a result, the hazardous location is narrowed as compared with, for example, a configuration in which a dedicated vent pipe is provided in the fuel cell compartment **30**. This makes it possible to further increase the degree of freedom of arranging various electrical equipment.
(140) The fuel cell ship SH includes the tank compartment **40** in which the fuel tank **41** is installed. The vent pipe **10** communicates with both the duct compartment **90** (particularly, the upper duct compartment **80**) and the tank compartment **40** (see FIG. **3**).
(141) In this configuration, the exhaust gas from the tank compartment **40** can be discharged to the outside (for example, the outside of the ship) via the vent pipe **10**. The vent pipe **10** for evacuation is shared by the tank compartment **40** and the duct compartment **90**, because of which it is possible to reduce the total number of vent pipes as compared with a configuration in which vent pipes are separately provided in the tank compartment **40** and the duct compartment **90**, and thus simplify the configuration. Even in the unlikely event that the fuel gas leaks from at least one of the tank compartment **40** and the duct compartment **90**, the leaked fuel gas is concentrated in one vent pipe **10** and discharged to the outside. As a result, the hazardous location is narrowed as compared with, for example, a configuration in which separate vent pipes are provided in the tank compartment **40** and the duct compartment **90** to discharge the fuel gas from the separate vent pipes. This makes it possible to further increase the degree of freedom of arranging various electrical equipment.
(142) In the present embodiment, the lower duct compartment air supply device **75** is arranged around the duct compartment **90**. The lower duct compartment air supply device **75** is an example of electrical equipment EM (see FIG. **3**) arranged around the duct compartment **90**. That is, the fuel cell ship SH of the present embodiment includes the electrical equipment EM arranged around the duct compartment **90**. In this case, the degree of freedom of arranging the electrical equipment EM around the duct compartment **90** can be increased.
(143) In particular, the electrical equipment EM includes a duct compartment air supply device (lower duct compartment air supply device **75**) that supplies air to the inside of the duct compartment **90** (lower duct compartment **70**). In this case, the degree of freedom of arranging the lower duct compartment air supply device **75** around the duct compartment **90** can be increased.
(144) [4. Measures to be Taken when Fuel Gas Leak Occurs in Duct Compartment]
(145) As described above, the hazardous sites through which the fuel gas passes are concentrated in the duct compartment **90**. Therefore, to take appropriate measures when a fuel gas leak occurs in the duct compartment **90**, fuel gas detectors (the upper duct compartment internal gas detector **88** and the lower duct compartment internal gas detector **73**) that detect the fuel gas being the fuel in a gaseous state are installed inside the duct compartment **90**. The control unit **12***a* controls the electric power generation of the fuel cell **31** based on the detection signal output from the fuel gas detector. Only the upper duct compartment internal gas detector **88** may be installed in the duct compartment **90**. That is, the lower duct compartment internal gas detector **73** may not be installed. This is because hydrogen that has leaked in the lower duct compartment **70** will eventually flow into the upper duct compartment **80** and be detected by the upper duct compartment internal gas detector **88**.
(146) FIG. **6** is a flowchart of processing based on detection of the fuel gas in the duct compartment **90**. If the lower duct compartment internal gas detector **73** or the upper duct compartment internal gas detector **88** detects that the concentration of the fuel gas in the lower duct

compartment **70** or the upper duct compartment **80** is equal to or higher than the standard value, and the detection signal is sent to the control unit **12***a* (S1), then the control unit **12***a* stops the driving of the fuel cell **31** to stop the electric power generation of the fuel cell **31** (S2). As the standard value, for example, 40% LEL can be considered, but the standard value may be appropriately determined based on experiments or experience.
(147) Subsequently, the control unit **12***a* closes the main valve **41***a* of the fuel tank **41** (S3). As a result, the supply of fuel gas from the fuel tank **41** to the fuel cell **31** is stopped. In addition to closing the main valve **41***a*, the control unit **12***a* may also perform a control to close the shutoff valve SV (the tank side shutoff valve **43**, the fuel cell side shutoff valve **33**) provided in the fuel gas supply pipe **32**.
(148) As described above, the fuel cell ship SH includes the control unit **12***a* that controls the electric power generation of fuel cell **31**. If the fuel gas detector (the upper duct compartment internal gas detector **88**, the lower duct compartment internal gas detector **73**) detects that the concentration of the fuel gas is equal to or higher than a predetermined standard value, the control unit **12***a* stops the electric power generation of the fuel cell **31** (S1, S2).
(149) When a fuel gas leak equal to or higher than the standard value is detected in the duct compartment **90**, the electric power generation of the fuel cell **31** can be safely stopped.
(150) In particular, if the fuel gas detector detects that the concentration of the fuel gas is equal to or higher than the predetermined standard value, the control unit **12***a* closes the main valve **41***a* of the fuel tank **41** (S3). By closing the main valve **41***a*, the supply of fuel gas from the fuel tank **41** to the fuel cell **31** is stopped, and thus the electric power generation of the fuel cell **31** can be reliably stopped.
(151) In the present embodiment, the fuel gas is used as the fuel supplied from the fuel tank **41** to the fuel cell **31**, but the fuel is not limited to a gas and may be a liquid. When a liquid fuel is used, if the liquid fuel leaks from a pipe, the leaked liquid fuel vaporizes and becomes a gas (a fuel gas).
(152) Embodiments of the present invention have been described above; however, the scope of the present invention is not limited to these embodiments, and can be extended or modified without departing from the gist of the invention.
INDUSTRIAL APPLICABILITY
(153) The present invention can be used, for example, in a fuel cell ship.
REFERENCE SIGNS LIST
(154) **1** Hull **6** Propulsion device **10** Vent pipe **12***a* Control unit **30** Fuel cell compartment **31** fuel cell **32** Fuel gas supply pipe (fuel supply pipe) **40** Tank compartment **41** Fuel tank **41***a* Main valve **42** Gas filling pipe (fuel filling pipe) **70** Lower duct compartment (duct compartment) **71** Fuel gas discharge pipe **73** Lower duct compartment internal gas detector (Fuel gas detector) **75** Lower duct compartment air supply device (duct compartment air supply device) **80** Upper duct compartment (duct compartment) **82** Fuel gas filling port (fuel filling port) **84** Inert gas filling port **87** Inert gas pipe **88** Upper duct compartment internal gas detector (Fuel gas detector) **90** Duct compartment **92** Communication pipe EM Electrical equipment SH Fuel cell ship

Claims

1. A fuel cell ship comprising: a fuel cell configured to generate electric power by an electrochemical reaction of fuel; a propulsion device configured to generate propulsive force on a hull by electric power supplied from the fuel cell; a fuel supply pipe configured to provide the fuel from a fuel tank housing the fuel to the fuel cell; a duct compartment that houses a part of the fuel supply pipe; a vent pipe configured to communicate with the duct compartment; and a fuel filling port configured as an inlet for filling the fuel tank with the fuel, and wherein the fuel filling port is provided in the duct compartment.
2. The fuel cell ship according to claim 1, further comprising: a fuel discharge pipe provided by

branching from the fuel supply pipe; and a fuel filling pipe configured to connect the fuel filling port and the fuel tank, and wherein the duct compartment is configured to house the fuel discharge pipe and the fuel filling pipe.

3. The fuel cell ship according to claim 2, further comprising: an inert gas filling port configured as an inlet for filling the fuel tank with an inert gas; and an inert gas pipe connected to the inert gas filling port and the fuel filling pipe, wherein the duct compartment is further configured to house the inert gas pipe.

4. The fuel cell ship according to claim 1, further comprising: a fuel cell compartment installed with the fuel cell; and a communication pipe by which the fuel cell compartment is configured to communicate with the duct compartment.

5. The fuel cell ship according to claim 1, further comprising a tank compartment installed with the fuel tank, wherein the vent pipe is configured to communicate with both the duct compartment and the tank compartment.

6. The fuel cell ship according to claim 1, further comprising electrical equipment arranged around the duct compartment.

7. The fuel cell ship according to claim 6, wherein the electrical equipment includes a duct compartment air supply device configured to supply air to inside of the duct compartment.

8. The fuel cell ship according to claim 1, further comprising: a control unit configured to control electric power generation of the fuel cell, wherein: a fuel gas detector is configured to detect a fuel gas being the fuel in a gaseous state is installed inside the duct compartment, and based on detection by the fuel gas detector that a concentration of the fuel gas is equal to or greater than a predetermined standard value, the control unit is configured to stop the electric power generation of the fuel cell.

9. The fuel cell ship according to claim 8, wherein, based on detection by the fuel gas detector that the concentration of the fuel gas is equal to or greater than the predetermined standard value, the control unit is configured to close a main valve of the fuel tank.