



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
08.01.2020 Bulletin 2020/02

(51) Int Cl.:
F23D 23/00 ^(2006.01) **B63B 25/16** ^(2006.01)
F23M 5/08 ^(2006.01)

(21) Application number: **18761294.0**

(86) International application number:
PCT/JP2018/000374

(22) Date of filing: **10.01.2018**

(87) International publication number:
WO 2018/159106 (07.09.2018 Gazette 2018/36)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD TN

(72) Inventors:
• **TERAHARA, Takazumi**
Nagasaki-shi
Nagasaki 850-8610 (JP)
• **TAKAMOTO, Kenta**
Nagasaki-shi
Nagasaki 850-8610 (JP)
• **AMANO, Hideki**
Nagasaki-shi
Nagasaki 850-8610 (JP)

(30) Priority: **28.02.2017 JP 2017035870**

(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Chiyoda-ku,
Tokyo
1008332 (JP)

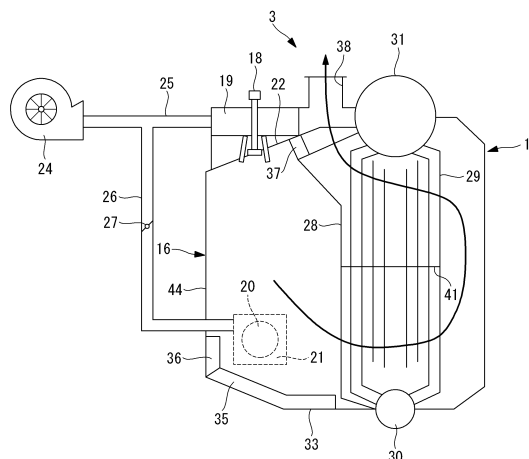
(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) **BOILER, SHIP COMPRISING BOILER, AND INERT GAS GENERATION METHOD**

(57) The present invention aims to generate steam by using energy that occurs at the time of generating an inert gas. A boiler (3) includes: a furnace (16); a steam generation unit (17); an upper burner (18) that is provided in the upper portion in the furnace (16) and combusts fuel; and a lower burner (20) that is provided in the lower portion in the furnace (16), combusts the fuel, and generates an inert gas having an oxygen content of 1% or less, at which no reaction occurs with a flammable gas.

A side water-cooling wall (32) and a bottom water-cooling wall (33) are provided along the furnace bottom of the furnace (16) and the side wall of the lower portion of the furnace (16), and a bottom refractory (35) and a side refractory (36) are respectively provided between the side water-cooling wall (32) and a flame formed by the lower burner (20) and between the bottom water-cooling wall (33) and the flame.

FIG. 2



Description

[Technical Field]

[0001] The present invention relates to a boiler, a ship equipped with the boiler, and a method for generating an inert gas.

[Background Art]

[0002] Before the inspection or repair of a liquefied natural gas (LNG) tank mounted in an LNG carrier, the work is necessary to remove a fuel gas in the tank and set the environment in the tank to the same degree as the atmosphere so that a worker can work in the tank. At the time of setting the environment in the tank to the same degree as the atmosphere, an inert gas is utilized. This is because, since the fuel gas and the air may cause a combustion reaction if air is directly supplied into the tank to remove the fuel gas, the tank is once filled with an inert gas to remove the fuel gas, and air is then supplied into the tank. Therefore, some LNG carriers are equipped with a dedicated device for generating an inert gas (inert gas generator (IGG), etc.). Further, in some crude oil tankers and the like, a combustion flue gas of a boiler or the like is utilized as an inert gas.

[0003] Systems utilizing the combustion flue gas of the boiler or the like as an inert gas include, for example, a system in Patent Literature (PTL) 1. PTL 1 discloses a volatile organic compound (VOC) gas treatment system that utilizes, as an inert gas, a flue gas from a boiler which is cleaned by a scrubber (and from which a sulfur component and the like are removed).

[0004] Further, due to the need for the inert gas that is utilized in the LNG carrier to satisfy a condition as severe as an oxygen content of about 1%, the combustion flue gas of the boiler or the like cannot be utilized as an inert gas in a normal LNG carrier, and a dedicated device for generating an inert gas is mounted.

[Citation List]

[Patent Literature]

[0005] [PTL 1]
Japanese Patent No. 5916777

[Summary of Invention]

[Technical Problem]

[0006] However, when the dedicated device for generating an inert gas is mounted, the dedicated device only combusts light oil or the like, and hence it has not been possible to effectively utilize energy that occurs at the time of generating an inert gas.

[0007] Further, in the configuration of PTL 1, the boiler is provided with only one burner, so that one burner is to

cover the function of generating steam in the boiler and the function of generating an inert gas. A burner provided in a normal ship boiler cannot sufficiently reduce an oxygen content of a combustion flue gas due to the constraint of needing to satisfy the function of generating steam, and the generated inert gas may react with a flammable gas in a fuel tank.

[0008] In addition, the burner for the ship boiler has a large capacity for the purpose of generating predetermined steam, and the burner may generate more combustion gas than necessary when intended to generate an inert gas. This requires additional installation of a small-capacity burner.

[0009] The present invention has been made in view of such circumstances, and an object of the present invention is to provide a boiler capable of generating steam by using energy that occurs at the time of generating an inert gas, a ship equipped with the boiler, and a method for generating an inert gas.

[Solution to Problem]

[0010] For solving the above problem, the following means are employed in the boiler, the ship equipped with the boiler, and the method for generating an inert gas according to the present invention.

[0011] The boiler according to one aspect of the present invention includes: a furnace; a first burner that combusts fuel in the furnace; and a second burner that is provided separately from the first burner and combusts fuel in the furnace to generate an inert gas.

[0012] In the above configuration, in addition to the first burner, the second burner for generating an inert gas in the furnace is provided. This makes it possible to generate an inert gas having an oxygen content at which no reaction occurs with a flammable gas, without providing a dedicated device for generating an inert gas (inert gas generator (IGG), etc.). Further, it is possible to generate steam by using energy that occurs at the time of generating the inert gas.

[0013] The inert gas is a gas having an oxygen content at which no reaction occurs with a flammable gas. The oxygen content at which no reaction occurs with a flammable gas means an oxygen content at which no ignition occurs in air (e.g., atmospheric pressure, etc.), for example, 1% or less.

[0014] In a boiler according to one aspect of the present invention, the first burner is disposed in an upper portion of the furnace and forms a flame downward, and the second burner is disposed in a lower portion of the furnace.

[0015] In the above configuration, the first burner is disposed in the upper portion of the furnace, and the second burner is disposed in the lower portion of the furnace. This enables the first burner and the second burner to be disposed at positions apart from each other. It is thus possible to prevent the first burner from being damaged by the radiant heat of the flame of the second burner, while simultaneously preventing the second burner from

being damaged by the radiant heat of the flame of the first burner. Further, with the first burner forming the flame downward, the heat flux of the flame of the first burner decreases in the lower portion of the furnace. Thus, by disposing the second burner in the lower portion of the furnace, it is possible to further prevent the second burner from being damaged by the flame of the first burner.

[0016] Moreover, the second burner is disposed apart from the first burner and thus does not affect the space in which the first burner is disposed. Hence it is possible to sufficiently ensure the installation space for the first burner.

[0017] A boiler according to one aspect of the present invention may include: a water-cooling wall provided along a furnace bottom of the furnace and a side wall of the lower portion of the furnace; and a refractory provided between the water-cooling wall and a flame formed by the second burner.

[0018] In the above configuration, the refractory is provided between the water-cooling wall and the flame formed by the second burner. It is thereby possible to reduce the heat exchange between the flame and the water-cooling wall, so that the flame formed by the second burner is less likely to be cooled by the water-cooling wall. Thereby, the combustion temperature of the flame formed by the second burner can be kept high, thus promoting the combustion of the fuel by the second burner. Hence the oxygen content of the flue gas generated by the combustion in the second burner is reduced, so that an inert gas having a lower oxygen content can be generated by the second burner. Further, since the water-cooling wall and the flame do not come into direct contact, it is possible to prevent the generation of carbon monoxide caused by quenching of the flame.

[0019] Moreover, the second burner is disposed in the lower portion of the furnace. This makes it possible to limit the range of the flame formed by the second burner and to thereby reduce the range in which the refractory is provided. In addition, since the refractory is provided at the bottom of the furnace and in the lower periphery of the furnace, it is possible to facilitate the work of installing the refractory.

[0020] A boiler according to one aspect of the present invention may include a wind box that supplies combustion air to the second burner; and a fan that supplies a seal gas into the wind box during operation of the first burner and stoppage of the second burner.

[0021] In the above configuration, seal air is supplied into the wind box surrounding the second burner during the operation of the first burner and the stoppage of the second burner. During the operation of the first burner, the furnace is filled with a high-temperature combustion gas due to the flame formed by the first burner. At this time, with the seal gas being supplied into the wind box surrounding the second burner, the high-temperature combustion gas is prevented by the seal gas from flowing into the wind box from the furnace. Therefore, during the stoppage of the second burner, the high-temperature

combustion gas does not flow into the wind box surrounding the second burner, and the second burner is not exposed to the high-temperature combustion gas. As a result, during the operation of the first burner and the stoppage of the second burner, the second burner can be prevented from being damaged by the heat of the flame formed by the first burner.

[0022] A ship according to one aspect of the present invention includes a boiler according to any one of the aforementioned aspects and a fuel tank to which the inert gas generated by the boiler is supplied.

[0023] In the above configuration, the inert gas generated by the boiler is supplied to the fuel tank. That is, it is possible to use the flue gas of the boiler as an inert gas. Hence there is no need to separately provide a device for generating an inert gas, thereby enabling space-saving in the ship. Moreover, since the boiler generates an inert gas having an oxygen content at which no reaction occurs with a flammable gas, it is possible to supply the inert gas discharged from the boiler to the fuel tank without performing the process of further reducing the oxygen content in the inert gas. Hence there is no need to separately provide a device for reducing the oxygen content, so that it is possible to simplify the structure of the ship and save the space in the ship.

[0024] A ship according to one aspect of the present invention may include another boiler which is provided separately from the boiler and to which a fuel gas is supplied from the fuel tank.

[0025] In the above configuration, the other boiler, to which a fuel gas is supplied from the fuel tank, is provided separately from the boiler that generates an inert gas. Thus, when the fuel tank is supplied with an inert gas from the boiler that generates an inert gas, the fuel gas containing the inert gas discharged out of the fuel tank can be combusted and oxidized in the other boiler. By combusting and oxidizing the fuel gas containing the inert gas, the fuel gas is not discharged to the atmosphere, and there is thus no need to install equipment such as a gas fuel unit (e.g., gas combustion unit (GCU)). Further, steam can be generated while the fuel gas discharged out of the fuel tank is combusted in the other boiler, so that the energy efficiency of the entire ship can be improved when the generated steam is utilized in the ship or when power is generated by driving a generator turbine with the generated steam.

[0026] A method for generating an inert gas in a boiler according to one aspect of the present invention, the boiler including a furnace, a first burner that combusts fuel in the furnace, a second burner that is provided separately from the first burner and combusts fuel in the furnace to generate an inert gas having an oxygen content at which no reaction occurs with a flammable gas, and a steam generation unit that generates steam by using a combustion flue gas generated in the furnace, the method including: a second burner combustion step of combusting the fuel only in the second burner; and a steam generation step of generating steam in the steam gen-

eration unit.

[0027] In the above configuration, it is possible to generate an inert gas without providing a dedicated device for generating an inert gas (inert gas generator (IGG), etc.). Further, it is possible to generate steam by using the energy of the generated an inert gas.

[Advantageous Effects of Invention]

[0028] According to the present invention, it is possible to generate steam by using energy that occurs at the time of generating an inert gas.

[Brief Description of Drawings]

[0029]

[Fig. 1] Fig. 1 is a schematic configuration view illustrating a ship mounted with a boiler according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is a schematic side view of the boiler mounted in the ship of Fig. 1.

[Fig. 3] Fig. 3 is a schematic plan view of the boiler of Fig. 2.

[Fig. 4] Fig. 4 is a schematic configuration view illustrating a ship according to a second embodiment of the present invention.

[Description of Embodiments]

[0030] Hereinafter, an embodiment of the boiler, the ship equipped with the boiler, and the method for generating an inert gas according to the present invention will be described with reference to the drawings.

[First Embodiment]

[0031] A first embodiment of the present invention will be described below using Figs. 1 to 3.

[0032] As illustrated in Fig. 1, the ship according to the present embodiment is, for example, an LNG carrier 1 that transports an LNG. The LNG carrier 1 is mounted with an LNG tank (fuel tank) 2 that stores an LNG at the time of transportation, and a boiler 3 that generates an inert gas to be supplied to the LNG tank 2 at the time of inspection and repair of the LNG tank 2.

[0033] The boiler 3 is connected to the LNG tank 2 through an inert gas supply pipe 4. Inert gas flows inside the inert gas supply pipe 4, and a combustion gas generated in the boiler 3 is supplied to the LNG tank 2 through the inert gas supply pipe 4. The inert gas supply pipe 4 is provided with a scrubber 5, a cooler 6, a dryer 7, and a booster fan 8 in order from the upstream side of the combustion gas flow. The combustion gas flowing through the inert gas supply pipe 4 is cleaned by the scrubber 5 removing sulfur components, soot and the like. The cleaned combustion gas is cooled by the cooler 6 and is then dried by the dryer 7. The dried combustion

gas is supplied as an inert gas into the LNG tank 2 by the booster 8. Further, a combustion gas discharge pipe 9 is branched off from the inert gas supply pipe 4 between the boiler 3 and the scrubber 5. A part of the combustion gas generated in the boiler 3 is discharged from a stack (not illustrated) through the combustion discharge pipe 9.

[0034] A vent pipe 10 is connected to the LNG tank 2. The fuel gas, discharged by the inert gas being supplied into the LNG tank 2, is discharged to the atmosphere through the vent pipe 10. When air is supplied into the LNG tank 2 after the filling with the inert gas, the inert gas is discharged to the atmosphere through the vent pipe 10.

[0035] As illustrated in Fig. 2, the boiler 3 includes a furnace 16 that combusts a combustion gas, and a steam generation unit 17 that generates steam by using the combustion gas generated in the furnace 16. The furnace 16 is a space surrounded by side water-cooling walls 32, a ceiling water-cooling wall 22, and a bottom water-cooling wall 33. The side water-cooling wall 32 is provided along the side wall constituting the lateral side of the furnace, the bottom water-cooling wall 33 is provided along the furnace bottom constituting the lower portion of the furnace 16, and the ceiling water-cooling wall 22 is provided along a ceiling constituting the upper portion of the furnace 16. Further, the side water-cooling wall 32 includes a front-surface water-cooling wall 23 constituting the front surface (the upward surface in Fig. 3) of the furnace 16, a rear-surface water-cooling wall 43 constituting the rear surface of the furnace 16, and a side-surface water-cooling wall 44 constituting the surface except for the front and rear surfaces of the furnace 16. Each of the side water-cooling walls 32 is provided with a plurality of water wall tubes 34 extending in the vertical direction and arranged in parallel with predetermined intervals, and water or steam is flowing inside the water wall tube 34. The ceiling water-cooling wall 22 and the bottom water-cooling wall 33 also have substantially the same configuration as the side water-cooling wall 32. However, a plurality of water wall tubes 34 constituting the ceiling water-cooling wall 22 and the bottom water-cooling wall 33 extend in the horizontal direction. In Fig. 2, the water wall tubes 34 are omitted for the illustration.

[0036] As illustrated in Figs. 2 and 3, the furnace 16 includes an upper burner (first burner) 18 installed in the upper portion of the furnace 16, an upper wind box 19 surrounding the upper burner 18, a lower burner (second burner) 20 installed in the lower portion of the furnace 16, and a lower wind box 21 surrounding the lower burner 20. The upper burner 18 is provided on the ceiling water-cooling wall 22 and forms a flame downward. The upper burner 18 performs combustion using, as fuel, the LNG in the LNG tank 2 or oil supplied from an oil supply device.

[0037] The lower burner 20 is provided on the front-surface water-cooling wall 23 and forms a flame in a direction which is horizontal and in which the steam generation unit 17 is not provided. That is, the lower burner 20 forms a flame from the front surface toward the rear

surface of the furnace 16. By forming a flame in this manner, the flame does not directly touch components and the like constituting the steam generation unit 17, thus enabling the prevention of damage to the components constituting the steam generation unit 17. The lower burner 20 performs combustion using, as fuel, oil supplied from the oil supply device. The lower burner 20 is a small-capacity burner capable of forming a flame by using less combustion air per unit fuel than the upper burner 18. In addition, the lower burner 20 is disposed so as to ensure the length of the flame. Note that Figs. 2 and 3 illustrate an example in which one each of the upper burner 18 and the lower burner 20 is provided, but two or more each of the upper burners 18 and the lower burners 20 may be provided.

[0038] The steam generation unit 17 includes a front bank tube 28 disposed on the boundary with the furnace 16, an steam generating tubes 29 disposed on the downstream side of the combustion gas flow of the front bank tube 28 and extending in the vertical direction, a partition plate 41 provided at the substantially central position in the vertical direction of the steam generating tubes 29, a water drum 30 provided below the steam generating tubes 29, a steam drum 31 provided above the steam generating tubes 29, and a combustion gas discharge duct 38 connected to the inert gas supply pipe 4.

[0039] Further, in the furnace 16, a bottom refractory (refractory) 35 is provided so as to cover the bottom water-cooling wall from above. Of the side water-cooling wall 32 located in the lower portion of the furnace 16, on the rear-surface water-cooling wall 43 and the side-surface water-cooling wall 44 except for the front-surface water-cooling wall 23 where the lower burner 20 is provided, a side refractory 36 (refractory) is provided so as to cover the rear-surface water-cooling wall 43 and the side-surface water-cooling wall 44 in the direction from the center of the furnace 16. That is, the bottom refractory 35 and the side refractory 36 are provided respectively between the bottom water-cooling wall 33 and the flame formed by the lower burner 20 and between the side water-cooling wall 32 and the flame. In order to ensure the combustion gas flow, a ceiling refractory 37 is provided between the front bank tube 28 and the ceiling portion 22.

[0040] Further, the boiler 3 externally has a forced draft (FD) fan 24 that supplies combustion air to the upper burner 18 and the lower burner 20, an upper-burner air supply line 25 configured to supply the combustion air from the FD fan 24 to the upper burner 18 via the upper wind box 19, and a lower-burner air supply line 26 that is branched off from the upper-burner air supply line 25 and configured to supply the combustion air from the FD fan 24 to the lower burner 20 via the lower wind box 21. The lower-burner air supply line 26 is provided with a flow regulating valve 27 that regulates the flow rate of the flowing combustion air. Note that a plurality of FD fans may be provided, and the FD fan for supplying combustion air to the upper burner 18 may be different from the FD fan for supplying combustion air to the lower burner

20. The boiler 3 externally has a steam supply pipe 39 (cf. Fig. 1) that supplies steam generated in the boiler 3 to a steam turbine (not illustrated) and equipment using steam, a fuel supply pipe 40 (cf. Fig. 1) that supplies fuel such as light oil from a fuel supply device (not illustrated) to the upper burner 18 and the lower burner 20, and a fuel gas supply pipe 11 that supplies fuel out of the LNG tank 2 to the upper burner 18 and the lower burner 20.

[0041] Next, a method for generating an inert gas according to the present embodiment will be described.

[0042] Using the combustion air supplied through the lower-burner air supply line 26, the lower burner 20 combusts the fuel supplied through the fuel supply pipe 40 to form a flame (second burner combustion step). The lower burner 20 is a small-capacity burner for forming a flame by using less combustion air per unit fuel and is disposed so as to ensure the length of the flame, so that the space in the furnace can be used effectively, and the combustion gas generated by the combustion in the lower burner 20 has a low oxygen content. Hence the oxygen content of the combustion gas introduced into the steam generation unit 17 is in a low state. Specifically, the combustion gas introduced into the steam generation unit 17 has an oxygen content of 1% or less. At the time of performing the combustion in the lower burner 20 to generate the combustion gas with a low oxygen content, the combustion is not performed in the upper burner 18.

[0043] As indicated by an arrow in Fig. 2, the combustion gas introduced into the steam generation unit 17 passes through the front bank tube 28 and the steam generating tubes 29 in this order to generate steam by the heat exchange with water or water vapor flowing inside the front bank tube 28 and the steam generating tubes 29 (steam generation step). When passing through the steam generating tubes 29, the combustion gas flows so as to turn at the partition plate 41. The combustion gas having completed the heat exchange flows from the combustion gas discharge hole 38 into the inert gas supply pipe 4 as an inert gas. The inert gas having flown into the inert gas supply pipe 4 passes through the scrubber 5, the cooler 6, and the dryer 7 and is supplied into the LNG tank 2 by the booster 8.

[0044] In the case of generating steam alone in the boiler 3 while not generating an inert gas, the fuel is supplied only to the upper burner 18, and the fuel is not supplied to the lower burner 20. That is, the combustion is performed only in the upper burner 18, and the combustion is not performed in the lower burner 20. In the case of performing the combustion in the upper burner 18 and not performing the combustion in the lower burner 20, the opening of the flow regulating valve 27 provided in the lower-burner air supply line 26 is regulated to supply a small amount of air into the lower wind box 21. The air supplied into the lower wind box 21 flows into the furnace 16 via the lower wind box 21 and thereby serves as cooling air and seal air to prevent the high-temperature combustion gas or the like of the furnace 16 from flowing into the lower wind box 21. That is, the air flowing through

the lower-burner air supply line 26 serves as the combustion air when the combustion is performed in the lower burner 20 (i.e., when an inert gas is generated), and serves as the seal air and the cooling air when the combustion is performed only in the upper burner 18 while the combustion is not performed in the lower burner 20 (i.e., when only steam is generated) .

[0045] According to the present embodiment, the following effects are exerted.

[0046] In the present embodiment, in addition to the upper burner 18, the lower burner 20 for generating an inert gas in the furnace 16 is provided. It is thereby possible to generate, in the boiler 3, an inert gas having an oxygen content of 1% or less, at which no reaction occurs with a flammable gas, without providing a dedicated device for generating an inert gas (inert gas generator (IGG), etc.). Further, it is possible to generate steam by using energy that occurs at the time of generating the inert gas.

[0047] The upper burner 18 is disposed in the upper portion of the furnace 16, and the lower burner 20 is disposed in the lower portion of the furnace 16. This enables the upper burner 18 and the lower burner 20 to be disposed at positions apart from each other. It is thus possible to prevent the upper burner 18 from being damaged by the radiant heat of the flame of the lower burner 20, while simultaneously preventing the lower burner 20 from being damaged by the radiant heat of the flame of the upper burner 18. Further, with the upper burner 18 forming the flame downward, the heat flux of the flame of the upper burner 18 decreases in the lower portion of the furnace 16. Thus, by disposing the lower burner 20 in the lower portion of the furnace 16, it is possible to further prevent the lower burner 20 from being damaged by the flame of the upper burner 18.

[0048] Moreover, the lower burner 20 is disposed apart from the upper burner 18 and thus does not affect the space in which the upper burner 18 is disposed. Hence it is possible to sufficiently ensure the installation space for the upper burner 18.

[0049] The side refractory 36 and the bottom refractory 35 are provided respectively between the side water-cooling wall 32 and the flame formed by the lower burner 20 and between the bottom water-cooling wall 33 and the flame. It is thereby possible to reduce the heat exchange between the flame formed by the lower burner 20 and the side water-cooling wall 32 and between the flame and the bottom water-cooling wall 33, so that the flame formed by the lower burner 20 is less likely to be cooled by the side water-cooling wall 32 and the bottom water-cooling wall 33. Thereby, the combustion temperature of the flame formed by the lower burner 20 can be kept high, thus promoting the combustion of the fuel by the lower burner 20. Hence the oxygen content of the combustion gas generated by the combustion in the lower burner 20 is reduced, so that an inert gas having a lower oxygen content can be generated in the furnace 16. Further, since the flame formed by the lower burner

20 does not come into direct contact with the side water-cooling wall 32 or the bottom water-cooling wall 33, it is possible to prevent the generation of carbon monoxide caused by quenching of the flame. Moreover, the refractory is not provided so as to cover the entire surface of the side water-cooling wall 32 of the furnace 16. Specifically, the refractory is not provided on the front-surface water-cooling wall 23 where the lower burner 20 is provided. With such a configuration formed, it is possible to ensure the heat absorption in the furnace 16.

[0050] The lower burner 20 is disposed in the lower portion of the furnace 16. This makes it possible to limit the range of the flame formed by the lower burner 20 and to thereby reduce the range in which the refractory is provided. In addition, since the refractory is provided at the bottom of the furnace 16 and in the lower portion of the furnace 16, it is possible to facilitate the work of installing the refractory.

[0051] Further, a seal gas is supplied into the lower wind box 21 surrounding the lower burner 20 during the operation of the upper burner 18 and the stoppage of the lower burner 20. During the operation of the upper burner 18, the furnace 16 is filled with a high-temperature combustion gas due to the flame formed by the upper burner 18. At this time, with the seal gas being supplied into the lower wind box 21 surrounding the lower burner 20, the high-temperature combustion gas is prevented by the seal gas from flowing into the wind box 21 from the furnace 16. Therefore, during the stoppage of the lower burner 20, the high-temperature combustion gas does not flow into the lower wind box 21, and the lower burner 20 is not exposed to the high-temperature combustion gas. As a result, during the operation of the upper burner 18 and the stoppage of the lower burner 20, it is possible to prevent the lower burner 20 from being damaged by the heat of the flame formed by the upper burner 18. In addition, the seal gas has a low temperature and can thus cool the lower burner 20, thereby preventing the lower burner 20 from being damaged.

[0052] The inert gas generated by the boiler 3 is supplied to the fuel tank. That is, it is possible to use the combustion flue gas of the boiler 3 as an inert gas. Hence there is no need to separately provide a device for generating an inert gas, thus enabling space-saving in the LNG carrier 1. Moreover, since the boiler 3 generates the inert gas having an oxygen content of 1 % or less, at which no reaction occurs with a flammable gas, it is possible to supply the inert gas discharged from the boiler 3 to the LNG tank 2 without performing the process of further reducing the oxygen content in the inert gas.

[Second Embodiment]

[0053] Next, a second embodiment of the present invention will be described below using Fig. 4.

[0054] The present embodiment basically has a similar structure to the first embodiment and is different from the first embodiment mainly in that an LNG carrier 60 is

equipped with two boilers having different features. Therefore, the same constituents as those of the first embodiment are denoted by the same reference numerals, and the description thereof will be omitted.

[0055] The LNG carrier 60 according to the present embodiment includes a flammable gas supply pipe 51 branched off from the vent pipe 10. The first flammable gas supply pipe 51 is connected to the boiler 50, and a flammable fuel gas in the LNG tank 2 is supplied to the boiler 50 by a supply compressor 52 provided in the middle position of the flammable gas supply pipe 51. Further, a second flammable gas supply pipe 54 for supplying a flammable gas from the LNG tank 2 to the boiler 56 is branched off from the middle position of the first flammable gas supply pipe 51. Note that the second flammable gas supply pipe 54 may not be branched from the middle position of the flammable gas supply pipe 51 but may be provided so as to directly connect the LNG tank 2 and the boiler 56.

[0056] The boiler 56 has substantially the same configuration as the boiler 3 described in the first embodiment, but the burner provided is different from that in the boiler 3. Specifically, only a burner 55 for generating an inert gas with a low oxygen content is provided in the boiler 56, and the burner 55 is provided in the upper part of the boiler 56.

[0057] Further, the boiler 50 has substantially the same configuration as the boiler 3 described in the first embodiment but is different from the boiler 3 in not including the lower burner 20 that generates an inert gas with a low oxygen content, the lower wind box 21, the side refractory 36, or the bottom refractory 35.

[0058] According to the present embodiment, the following effects are exerted.

[0059] In the present embodiment, the boiler 50, to which the flammable fuel gas is supplied from the LNG tank 2, is provided separately from the boiler 56 that generates an inert gas. Thereby, when the LNG tank 2 is supplied with an inert gas from the boiler 56 that generates an inert gas, the flammable fuel gas and the inert gas discharged out of the LNG tank 2 can be combusted in the boiler 50. Therefore, steam can be generated while the flammable fuel gas and the inert gas discharged out of the LNG tank 2 are combusted in the boiler 50, so that the energy efficiency of the entire LNG carrier 1 can be improved by utilizing the steam in the equipment in the LNG carrier 1.

[0060] The present invention is not limited to the invention according to each of the above embodiments, and modifications can be appropriately made without departing from the scope of the present invention. For example, in the second embodiment, the boiler 56 and the boiler 50 have been the boilers with different structures from the structure of the boiler 3 described in the first embodiment, but the boiler 56 and the boiler 50 may have the same structure as that of the boiler 3.

[0061] In each of the above embodiments, the refractory has not been provided on the entire surface of the

furnace 16, and the refractory has not been provided on the surface where the lower burner 20 is provided, but the refractory may be provided on the entire surface of the side wall 23 of the furnace 16. With such a configuration formed, the heat exchange between the flame formed by the lower burner 20 and the side water-cooling wall 32 can further be reduced, and the combustion temperature of the flame formed by the lower burner 20 can be kept high. Moreover, it is possible to prevent the direct contact between the side water-cooling wall 32 and the flame formed by the lower burner 20 and further prevent the generation of carbon monoxide.

[Reference Signs List]

[0062]

- | | |
|----|--|
| 1 | LNG carrier |
| 2 | LNG tank (fuel tank) |
| 3 | boiler |
| 4 | inert gas supply pipe |
| 16 | furnace |
| 17 | steam generation unit |
| 18 | upper burner (first burner) |
| 19 | upper wind box |
| 20 | lower burner (second burner) |
| 21 | lower wind box |
| 22 | ceiling water-cooling wall |
| 23 | front-surface water-cooling wall |
| 25 | upper-burner air supply line |
| 26 | lower-burner air supply line |
| 27 | flow regulating valve |
| 29 | steam generating tubes |
| 32 | side water-cooling wall (water-cooling wall) |
| 33 | bottom water-cooling wall (water-cooling wall) |
| 34 | water wall tube |
| 35 | bottom refractory (refractory) |
| 36 | side refractory (refractory) |
| 50 | boiler |

Claims

1. A boiler comprising:
 - a furnace;
 - a first burner that combusts fuel in the furnace; and
 - a second burner that is provided separately from the first burner and combusts fuel in the furnace to generate an inert gas.
2. The boiler according to claim 1, wherein the first burner is disposed in an upper portion of the furnace and forms a flame downward, and the second burner is disposed in a lower portion of the furnace.

3. The boiler according to claim 2, comprising:

a water-cooling wall provided along a furnace bottom of the furnace and a side wall of the lower portion of the furnace; and
a refractory provided between the water-cooling wall and a flame formed by the second burner.

the second burner is disposed in a lower portion of the furnace.

2. (deleted)

3. (amended) The boiler according to claim 1, comprising:

4. The boiler according to any one of claims 1 to 3, comprising:

a wind box that surrounds the second burner; and
a fan that supplies a seal gas into the wind box during operation of the first burner and stoppage of the second burner.

a water-cooling wall provided along a furnace bottom of the furnace and a side wall of the lower portion of the furnace; and
a refractory provided between the water-cooling wall and a flame formed by the second burner.

4. (amended) The boiler according to claim 1 or 3, comprising:

5. A ship comprising:

the boiler according to any one of claims 1 to 4; and
a fuel tank to which the inert gas generated by the boiler is supplied.

a wind box that surrounds the second burner; and
a fan that supplies a seal gas into the wind box during operation of the first burner and stoppage of the second burner.

5. (amended) A ship comprising:

6. The ship according to claim 5, comprising another boiler which is provided separately from the boiler and to which a fuel gas is supplied from the fuel tank.

the boiler according to any one of claims 1, 3 and 4; and
a fuel tank to which the inert gas generated by the boiler is supplied.

7. A method for generating an inert gas in a boiler, the boiler including
a furnace,
a first burner that combusts fuel in the furnace,
a second burner that is provided separately from the first burner and combusts fuel in the furnace to generate an inert gas, and
a steam generation unit that generates steam by using a combustion flue gas generated in the furnace, the method comprising:

a second burner combustion step of combusting the fuel only in the second burner; and
a steam generation step of generating steam in the steam generation unit.

6. The ship according to claim 5, comprising another boiler which is provided separately from the boiler and to which a fuel gas is supplied from the fuel tank.

7. A method for generating an inert gas in a boiler, the boiler including
a furnace,
a first burner that combusts fuel in the furnace,
a second burner that is provided separately from the first burner and combusts fuel in the furnace to generate an inert gas, and
a steam generation unit that generates steam by using a combustion flue gas generated in the furnace, the method comprising:

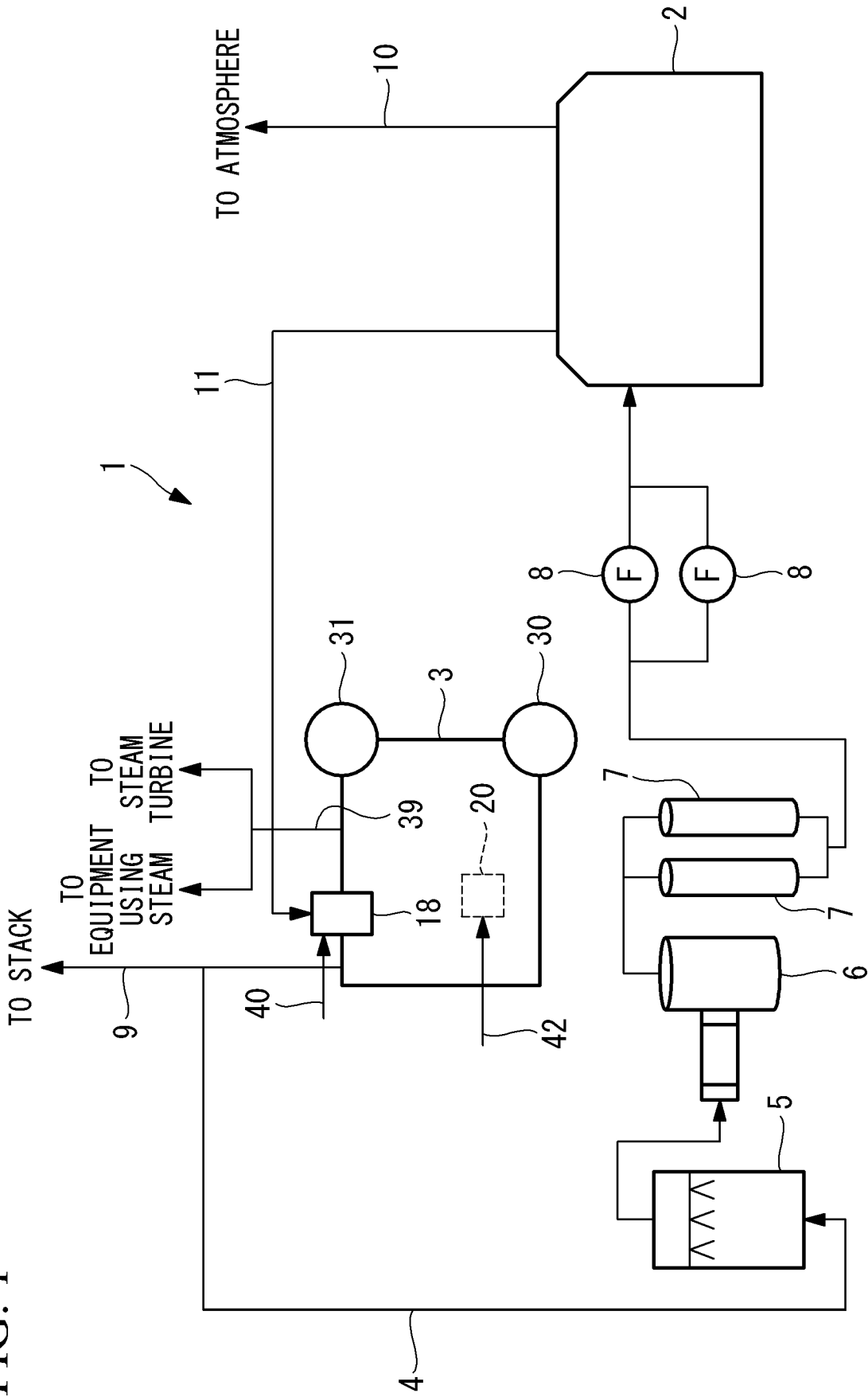
Amended claims under Art. 19.1 PCT

1. (amended) A boiler comprising:

a furnace;
a first burner that combusts fuel in the furnace; and
a second burner that is provided separately from the first burner and combusts fuel in the furnace to generate an inert gas, wherein
the first burner is disposed in an upper portion of the furnace and forms a flame downward, and

a second burner combustion step of combusting the fuel only in the second burner; and
a steam generation step of generating steam in the steam generation unit.

FIG. 1



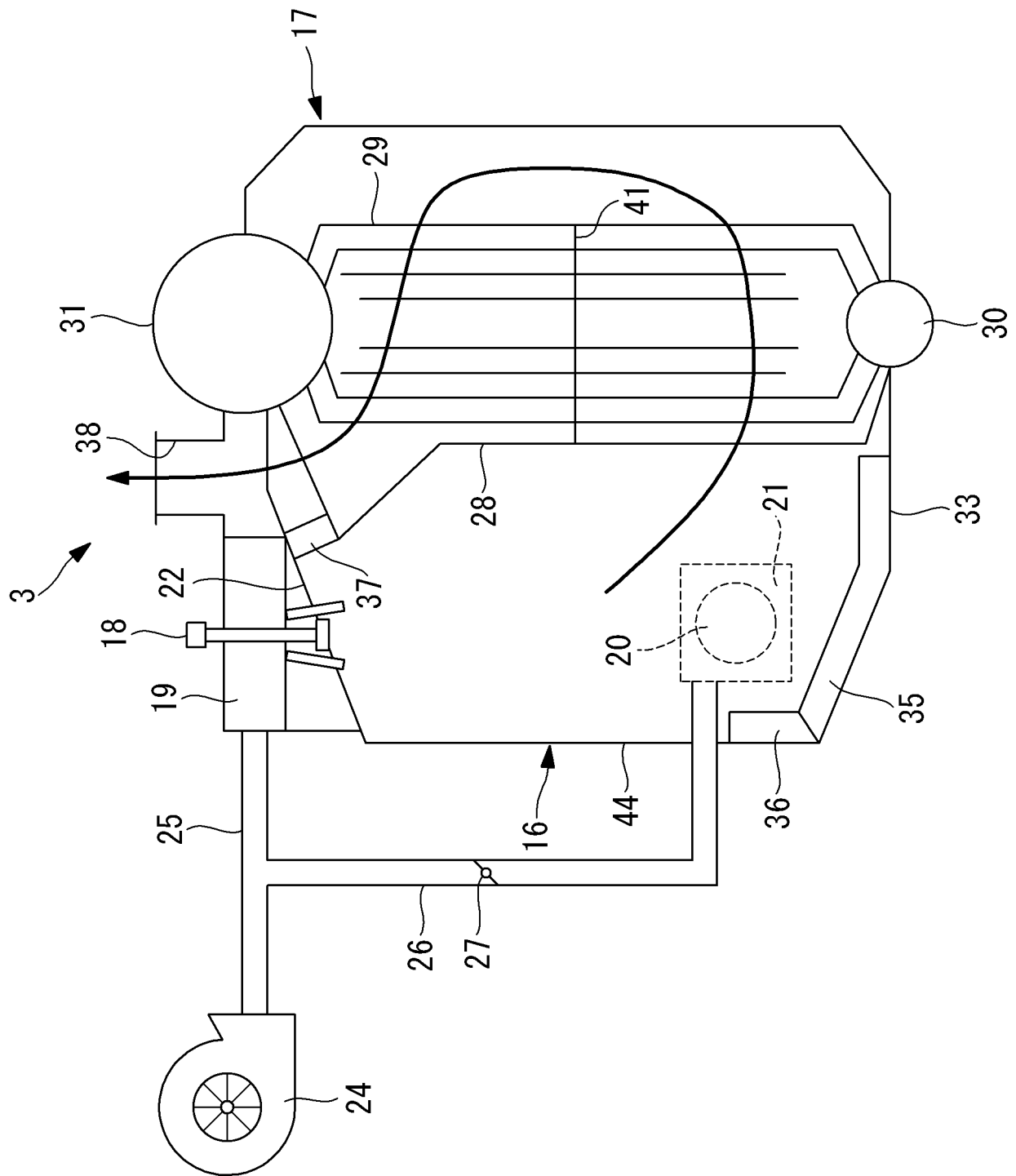


FIG. 2

FIG. 3

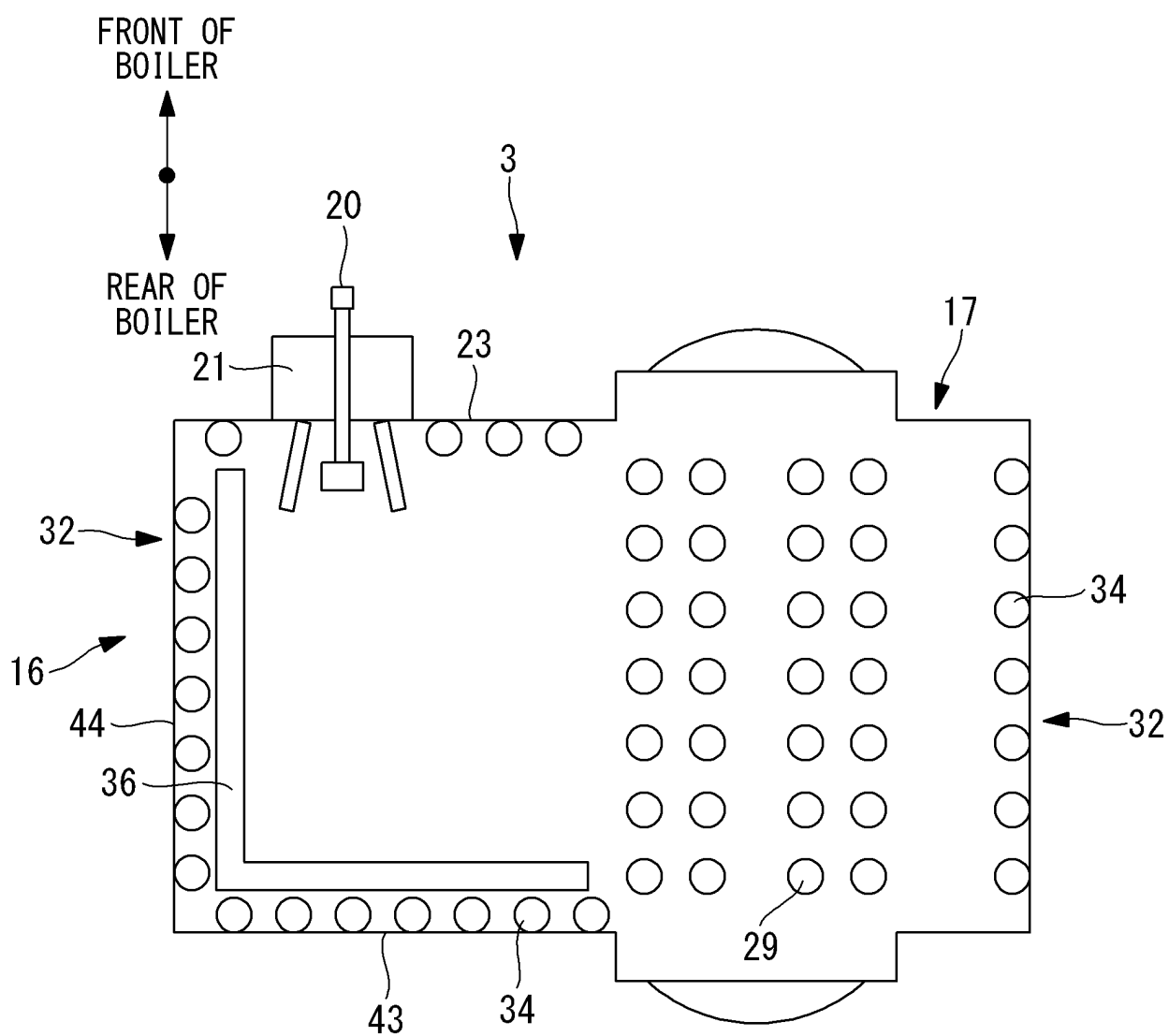
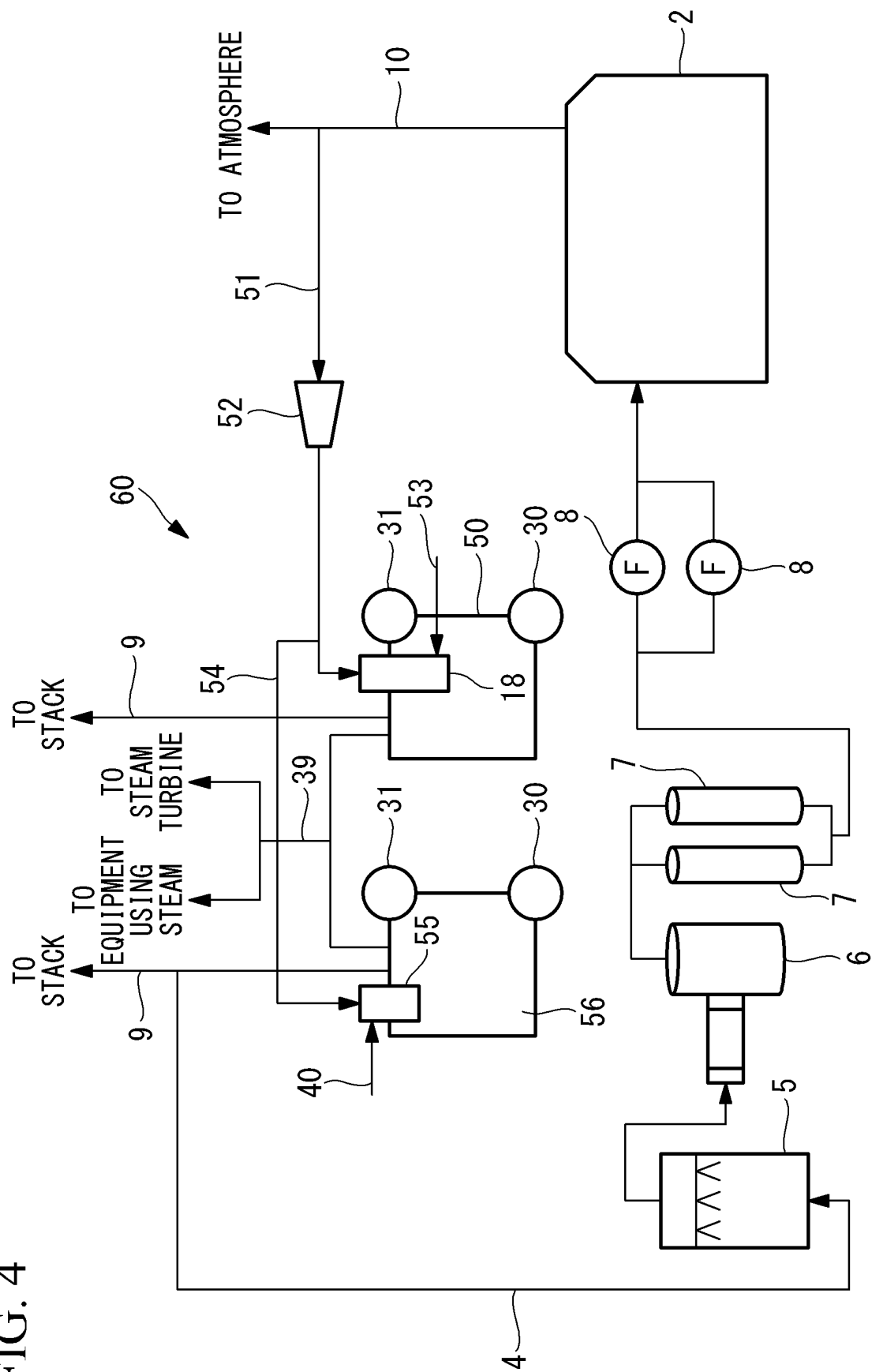


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/000374

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F23D23/00 (2006.01) i, B63B25/16 (2006.01) i, F23M5/08 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. F23D23/00, B63B25/16, F23M5/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 109219/1984 (Laid-open No. 024400/1986) (ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIES CO., LTD.) 13 February 1986, specification, page 2, line 1 to page 3, line 3, page 5, line 2 to page 11, line 7, fig. 1-2 (Family: none)	1, 5, 7 4, 6 2-3
X Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 159297/1980 (Laid-open No. 081999/1982) (MITSUBISHI HEAVY INDUSTRIES, LTD.) 20 May 1982, specification, page 1, line 4 to page 5, line 3, fig. 1-3 (Family: none)	1, 7 4, 6 2-3

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
20 March 2018 (20.03.2018)Date of mailing of the international search report
03 April 2018 (03.04.2018)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/000374

5	C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Y	JP 2001-315693 A (KAWASAKI HEAVY INDUSTRIES, LTD.) 13 November 2001, fig. 1 (Family: none)	6
10	A	Microfilm of the specification and drawings	1-7
		annexed to the request of Japanese Utility Model	
		Application No. 083547/1978 (Laid-open No.	
		183739/1979) (HITACHI Zosen CORP.) 26 December	
15		1979, entire text, all drawings (Family: none)	
20			
25			
30			
35			
40			
45			
50			
55			

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 5916777 B [0005]