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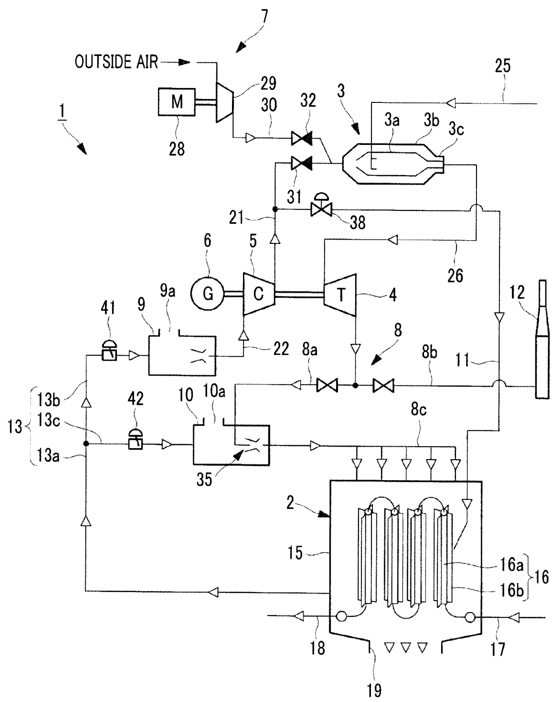
(54) LIQUEFIED-GAS VAPORIZATION METHOD, LIQUEFIED-GAS VAPORIZATION SYSTEM, OFFSHORE FLOATING-BODY STRUCTURE PROVIDED WITH SAID SYSTEM

(57) The purpose of the present invention is to use a compact configuration to economically vaporize a liquefied gas by effectively utilizing boil-off gas in a liquefied-gas tank, without having to take in any sea water. A liquefied-gas vaporization system (1) is provided with: a liquefied-gas vaporization unit (2) in which a liquefied gas stored in a liquefied-gas tank is subjected to heat exchange with a heat medium, and vaporized; a boil-off-gas combustion unit (3) which induces combustion of a boil-off gas of the liquefied gas; a turbine (4) which is rotationally driven by the energy of a combustion gas obtained after combustion has been performed in the boil-off-gas combustion unit (3); and a combustion-gas supply unit (8) which supplies, as the heat medium, to the liquefied-gas vaporization unit (2), the combustion gas discharged from the turbine (4). The boil-off-gas combustion unit (3) is a pressurized combustion unit which has compressed air supplied thereto, and in which the boil-off gas is subjected to pressurized combustion. A compressor (5), which generates the compressed air and supplies the compressed air to the boil-off-gas combustion unit (3) as air for pressurized combustion, is provided on the same axis as that of the turbine (4).

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a liquefied-gas vaporization method, a liquefied-gas vaporization system, and an offshore floating-body structure provided with the system.

Background Art

[0002] A liquefied-gas vaporization system which performs vaporization (gasification) of a liquefied gas is provided in a liquefied-gas carrier ship (in other words, an LNG ship) which transports a liquefied gas, such as an LNG, or an offshore floating-body structure, such as an FSRU (in other words, a liquefied-gas receiving base), which receives a liquefied gas from a liquefied-gas carrier ship, stores the liquefied gas, and supplies the liquefied gas to a city gas line.
[0003] In such a liquefied-gas vaporization system, various methods are conceived as a method of liquefied-gas vaporization. In a general method, a liquefied gas flows in an inner portion of a vaporizer having an open-rack shape and sea water flows over the outside of the vaporizer, in such a manner that the liquefied gas is warmed by the heat of the sea water and is vaporized. However, it becomes difficult to apply the method to a sea area (of Europe, North America, or the like) in which an intake and discharge of sea water are restricted in order to conserve the marine environment.
[0004] In some cases, in a cold sea area, an intake of sea water cannot be performed because the sea water is frozen or the temperature of the sea water is significantly low, in terms of heating water.
[0005] Accordingly, in some cases, a liquefied gas is vaporized without discharging sea water to the outside of a system, by causing heated sea water to be circulated in a closed-loop shape, as a heat medium, or causing the liquefied gas to be heated by a vaporization loop, as disclosed in, for example, PTL 1 or 2.
[0006] In some cases, air heated by a heater is blown, using a blower, to an inner portion of a liquefied-gas vaporization unit, in such a manner that a liquefied gas is vaporized without sea water, as disclosed in PTL 3.
[0007] Meanwhile, in an inner portion of a liquefied-gas tank, a liquefied gas is vaporized by, for example, the heat which is naturally input from the outside, and thus a boil-off gas (a vaporized gas) is generated. It is necessary to handle the boil-off gas, such that the pressure of the tank is prevented from exceeding a design pressure due to the boil-off gas. In a case of the related art, a boil-off gas is supplied to, for example, a propulsion engine or a power generation engine of a liquefied-gas carrier ship and is converted into energy or the boil-off gas is subjected to combustion by a combustor, in such a manner that the boil-off gas is handled.

Citation List

Patent Literature

[0008]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2010-58772
[PTL 1] Japanese Unexamined Patent Application Publication No. 2012-17030
[PTL 1] Japanese Unexamined Patent Application Publication No. 2002-39695

Summary of Invention

Technical Problem

[0009] However, in a case of the related art, a heat medium, such as sea water and air, is heated and a liquefied gas is vaporized by the heat medium, as described above. Therefore, a system of the related art requires a large amount of energy, and thus the system is uneconomical.
[0010] Furthermore, it is necessary to provide an incidental facility, such as a large-scale gas power generation facility, a boiler facility, and a large blower, and thus the cost of investment in facilities increases and it is necessary to provide a large space for allowing the facilities to be installed. Particularly, in a case of a liquefied-gas carrier ship, space is extremely limited, and thus it is difficult to provide the facilities described above.
[0011] It is also possible to conceive a method in which a boil-off gas is subject to combustion and a liquefied gas is vaporized using the heat of the combustion gas. However, when the combustion gas is directly supplied to a liquefied-gas vaporization unit, there is a problem in that the liquefied-gas vaporization unit may be damaged due to a large temperature difference between the combustion gas and the cold heat of the liquefied gas or replacement frequency of a component used in a high-temperature circumstance increases due to a reduced life span. There is a method in which a combustion gas is diluted with a large amount of air such that the temperature of the heat of the combustion gas is reduced. However, there is a problem in terms of power of a blowing machine which supplies the air for dilution, the cost of facilities, and reduction in size.
[0012] The invention is made in view of such a circumstance. An object of the invention is to provide a liquefied-gas vaporization method, a liquefied-gas vaporization system in which a liquefied gas can be effectively vaporized with a compact configuration by effectively utilizing a boil-off gas in a liquefied-gas tank, without having to take in any sea water, and an offshore floating-body structure provided with the system.

Solution to Problem

[0013] To achieve the object described above, the invention provides means described below.

[0014] First, a liquefied-gas vaporization method according to an aspect of the invention is a liquefied-gas vaporization method in which vaporization of a liquefied gas stored in a liquefied-gas tank is promoted by causing the liquefied gas to be subjected to heat exchange with a heat medium. In the method, a boil-off gas generated in the liquefied-gas tank is subjected to combustion, a turbine is driven by the energy of a combustion gas, the combustion gas after driving the turbine is used as the heat medium, and vaporization of the liquefied gas is promoted by the heat of the combustion gas.

[0015] According to the liquefied-gas vaporization method described above, the combustion gas obtained after the boil-off gas generated in the liquefied-gas tank is combusted is expanded by driving the turbine, and thus the temperature of the combustion gas is reduced. Vaporization of the liquefied gas is promoted by the heat of the combustion gas which is expanded and is subjected to a temperature reduction, as described above. The driven turbine can perform a predetermined operation.

[0016] The combustion gas passing through the turbine is expanded, and thus the volume of the combustion gas is increased. Accordingly, the temperature of the combustion gas is decreased. As a result, upon comparison with a case where a combustion gas obtained after, for example, a boil-off gas is subjected to combustion does not pass through the turbine and is directly supplied to the liquefied-gas vaporization unit, in such a manner that a liquefied gas is vaporized, a temperature difference between the combustion gas and the liquefied-gas vaporization unit can be reduced. Accordingly, it is possible to prevent damage to the liquefied-gas vaporization unit and reduction in durability.

[0017] The combustion gas passing through the turbine has a certain amount of pressure. Accordingly, even when the combustion gas is not forcibly sent by, for example, a blower, the combustion gas can be supplied to the liquefied-gas vaporization unit. As a result, the configuration of the liquefied-gas vaporization system can be simplified. The driven turbine can perform a predetermined operation. Thus, the boil-off gas in the liquefied-gas tank is effectively utilized and the liquefied gas can be vaporized with high efficiency.

[0018] The liquefied gas can be vaporized, without any problem, by the heat of the combustion gas obtained by combusting the boil-off gas, as described above. Thus, it is not necessary to heat a heat medium, such as sea water or air. As a result, the liquefied-gas vaporization system of the invention does not require any additional energy. Furthermore, energy can be obtained by operating the turbine. Thus, the liquefied gas can be significantly and effectively vaporized.

[0019] A liquefied-gas vaporization system according to another aspect of the invention is configured to include a liquefied-gas vaporization unit in which a liquefied gas stored in a liquefied-gas tank is subjected to heat exchange with a heat medium, and vaporized, a boil-off-gas combustion unit which induces combustion of a boil-off gas generated in the liquefied-gas tank, a turbine which performs a predetermined operation by being rotationally driven by the energy of a combustion gas obtained after combustion has been performed in the boil-off-gas combustion unit, and a combustion-gas supply unit which supplies, as the heat medium, to the liquefied-gas vaporization unit, the combustion gas discharged from the turbine.

[0020] According to the liquefied-gas vaporization system having the configuration described above, the boil-off gas generated in the liquefied-gas tank is subjected to combustion by the boil-off-gas combustion unit and the turbine is driven by the combustion gas. Then, the combustion gas after driving the turbine passes through the combustion-gas supply unit and is supplied, as the heat medium, to the liquefied-gas vaporization unit, in such a manner that vaporization of the liquefied gas is promoted. In addition, the turbine can perform a predetermined operation.

[0021] The combustion gas after driving the turbine is expanded, and thus the temperature of the combustion gas is decreased. As a result, upon comparison with a case where a combustion gas discharged from, for example, a boil-off-gas combustion portion does not pass through the turbine and is directly supplied to the liquefied-gas vaporization unit, in such a manner that a liquefied gas is vaporized, a temperature difference between the combustion gas and the liquefied-gas vaporization unit can be reduced. Accordingly, it is possible to prevent damage to the liquefied-gas vaporization unit and reduction in durability.

[0022] The combustion gas passing through the turbine has a certain amount of pressure. Accordingly, even when the combustion gas may not be forcibly sent by, for example, a blower, the combustion gas can be supplied to the liquefied-gas vaporization unit. As a result, the configuration of the liquefied-gas vaporization system can be simplified. Furthermore, the liquefied gas can be vaporized, without any problem, by the heat of the combustion gas obtained by combusting the boil-off gas. Thus, it is not necessary to supply additional energy and, further, energy can be obtained by operating the turbine. As a result, the liquefied gas can be significantly effectively vaporized.

[0023] In the configuration described above, the boil-off-gas combustion unit may be a pressurized combustion unit which has compressed air supplied thereto and in which the boil-off gas is subjected to pressurized combustion and a compressor which generates the compressed air and supplies the compressed air to the boil-off-gas combustion unit as air for pressurized combustion, may be provided on the same axis as that of the turbine.

[0024] According to the liquefied-gas vaporization system having the configuration described above, the boil-off-gas combustion unit which is a pressurized combustion unit receives the compressed air from the compressor which is provided on the same axis as that of the turbine and performs pressurized compression of the boil-off gas. Thus, upon comparison with in a case in which a boil-off gas is subjected to combustion at atmospheric pressure, the size of flame during combustion is reduced. As a result, the size of a furnace and the size of a flue are reduced, and thus the size of the liquefied-gas vaporization system can be reduced.

[0025] In the liquefied-gas vaporization system described above, the boil-off-gas combustion unit may include a combustion-gas dilution portion which dilutes the combustion gas by causing the combustion gas to be mixed with a part of the compressed air supplied from the compressor.

[0026] According to the liquefied-gas vaporization system having the configuration described above, the combustion gas discharged from the boil-off-gas combustion unit is diluted with the compressed air, in the combustion-gas dilution portion. Thus, the volume of the combustion gas is increased. The combustion gas which is subjected to dilution is expanded by passing through the turbine. In addition, the volume of the combustion gas is increased. The combustion gas is supplied to the liquefied-gas vaporization unit, in a state where the temperature of the combustion gas is decreased. Accordingly, a large amount of diluted combustion gas having an appropriate temperature is introduced to the liquefied-gas vaporization unit, in such a manner that the liquefied gas can be vaporized with high efficiency. In addition, it is possible to prevent damage to the liquefied-gas vaporization unit and reduction in durability, by reducing a temperature difference between the combustion gas and the liquefied-gas vaporization unit.

[0027] In the configuration described above, the combustion-gas supply unit may include an air eductor which dilutes the combustion gas by causing the combustion gas to be mixed with air for dilution.

[0028] According to the liquefied-gas vaporization system having the configuration described above, when the combustion gas passing through the turbine passes through the air eductor, the combustion gas is mixed with air for dilution, and thus the volume of the combustion gas is further increased. Accordingly, the combustion gas is supplied to the liquefied-gas vaporization unit, in a state where the temperature of the combustion gas is further reduced. Accordingly, a large amount of diluted combustion gas having an appropriate temperature is introduced to the liquefied-gas vaporization unit, in such a manner that the liquefied gas can be vaporized with high efficiency. In addition, it is possible to prevent damage to the liquefied-gas vaporization unit and reduction in durability, by reducing a temperature difference between the combustion gas and the liquefied-gas vaporization unit.

[0029] In the configuration described above, in the air eductor, a mixing ratio of air for dilution may be set to a value in which the combustion gas which is subjected to dilution and is supplied to the liquefied-gas vaporization unit has a temperature of 100°C or less.

[0030] According to the liquefied-gas vaporization system having the configuration described above, the combustion gas which is subjected to dilution and is supplied to the liquefied-gas vaporization unit has a temperature of 100°C or less. Thus, it is possible to prevent damage to the liquefied-gas vaporization unit and reduction in durability, by reducing a temperature difference between the combustion gas and the liquefied-gas vaporization unit.

[0031] In the configuration described above, the liquefied-gas vaporization system may further include a dilution-air supply portion which extracts a part of the compressed air generated in the compressor and supplies, as the air for dilution, the extracted compressed air to the air eductor, and a flow-rate regulating valve which regulates a flow rate of the air for dilution.

[0032] According to the liquefied-gas vaporization system having the configuration described above, a part of the compressed air generated in the compressor is extracted. Then, the extracted compressed air is supplied, as air for dilution, to the air eductor, in a state where the flow rate of the extracted compressed air is adjusted by the flow-rate regulating valve. Accordingly, it is not necessary to control the flow rate of air for dilution, on the turbine side or the boil-off-gas combustion unit side. As a result, it is possible to easily perform control.

[0033] In the configuration described above, the liquefied-gas vaporization unit may have a configuration in which a vaporizing tube through which the liquefied gas flows is provided along an up-down direction, in an inner portion of a casing body, and the combustion gas flows in from an upper portion of the casing body and is discharged from a lower portion of the casing body.

[0034] Moisture is necessarily included in the combustion gas obtained by combusting the boil-off gas of the liquefied gas. Accordingly, when the combustion gas is supplied to the liquefied-gas vaporization unit, there is a concern that the combustion gas may be subjected to heat exchange with the liquefied gas having a low temperature, and thus condensed water is generated and frozen. However, according to the liquefied-gas vaporization system having the configuration described above, the condensed water is discharged from the lower portion of the liquefied-gas vaporization unit. As a result, it is difficult for the condensed water to be frozen, and thus it is possible to vaporize the liquefied gas with high efficiency.

[0035] In the configuration described above, the liquefied-gas vaporization system may further include a compressed-air supply unit which extracts a part of the compressed air generated in the compressor and blows the extracted air to a part of the liquefied-gas vaporization unit, which is a portion in the vicinity of an inlet portion of the liquefied gas.

[0036] According to the liquefied-gas vaporization system having the configuration described above, the compressed air having a high temperature is blown to a part of the liquefied-gas vaporization unit, which is a portion in the vicinity of an inlet portion of the liquefied gas and in which freezing of the condensed water is likely to occur. Thus, it is difficult for the condensed water to be frozen. Furthermore, even when freezing of the condensed water occurs, the compressed air can remove ice by blowing the ice off. As a result, the liquefied-gas vaporization unit is prevented from freezing, and thus it is possible to vaporize the liquefied gas with high efficiency.

[0037] In the configuration described above, the liquefied-gas vaporization system may further include a diluted-combustion-gas supply unit which extracts a part of the combustion gas which has been supplied to the liquefied-gas vaporization unit and is subjected to dilution and supplies the extracted combustion gas to the compressor.

[0038] According to the liquefied-gas vaporization system having the configuration described above, the combustion gas is diluted with the compressed air and includes a large amount of oxygen. Furthermore, the dilute combustion gas which is cooled by being subjected to heat exchange with the liquefied gas, in the liquefied-gas vaporization unit, is supplied to the compressor. As a result, the temperature of intake air of the compressor is reduced, and thus the efficiency of the compressor can be increased.

[0039] In the configuration described above, the diluted-combustion-gas supply unit may also be able to supply the combustion gas extracted from the liquefied-gas vaporization unit to the air eductor.

[0040] According to the liquefied-gas vaporization system having the configuration described above, the combustion gas is subjected, in the liquefied-gas vaporization unit, to heat exchange with the liquefied gas having a low temperature and the combustion gas of which the condensed water is (subjected to dehumidification) separated and which is in a lean state is supplied to the air eductor, in such a manner that the combustion gas which is in a dried and lean state returns to the liquefied-gas vaporization unit. As a result, freezing of the liquefied-gas vaporization unit is prevented by reducing the amount of condensed water of the combustion gas entering the liquefied-gas vaporization unit, and thus the liquefied gas can be vaporized with high efficiency.

[0041] An offshore floating-body structure according to still another aspect of the invention may include the liquefied-gas vaporization system having any one of the configurations described above.

[0042] According to the offshore floating-body structure having the configuration described above, regardless of in a case where the offshore floating-body structure is either a liquefied-gas carrier ship or a liquefied-gas receiving base, the size of the liquefied-gas vaporization system is reduced and it is possible to effectively vaporize, without any problem, the liquefied gas by the heat of the combustion gas obtained by combusting the boil-off gas in the liquefied-gas tank.

Advantageous Effects of Invention

[0043] According to a liquefied-gas vaporization method, a liquefied-gas vaporization system, and an offshore floating-body structure provided with the liquefied-gas vaporization system of the invention, a liquefied gas can be effectively vaporized by effectively utilizing a boil-off gas in a liquefied-gas tank, with a significantly compact configuration in which, for example, a large-scale gas power generation facility and a large-scale boiler facility are not provided, as described above.

[0044] In addition, the liquefied gas can be vaporized without having to take in any sea water. Thus, it is possible to contribute to marine environment conservation.

Brief Description of Drawings

Fig. 1 is a schematic configuration view of a liquefied-gas vaporization system illustrating an embodiment 1 of the invention.

Fig. 2 is a schematic cross-sectional view illustrating the configuration of an air eductor.

Fig. 3 is a schematic configuration view of a liquefied-gas vaporization system illustrating an embodiment 2 of the invention.

Description of Embodiments

Embodiment 1

[0045] Hereinafter, an embodiment of a liquefied-gas vaporization method and a liquefied-gas vaporization system according to the invention will be described with reference to the accompanying drawings.

[0046] Fig. 1 is a schematic configuration view of the liquefied-gas vaporization system illustrating an embodiment 1 of the invention. A liquefied-gas vaporization system 1 is provided in a liquefied-gas carrier ship, such as an LNG carrier ship, or a liquefied-gas receiving base, such as a floating storage and regasification unit (FSRU). The liquefied-gas vaporization system 1 has a configuration in which a liquefied gas stored in a liquefied-gas tank (not illustrated) is vaporized and a boil-off gas generated in the liquefied-gas tank is subjected to combustion. Then, in the liquefied-gas vaporization system 1, vaporization of the liquefied-gas is promoted using heat of the combustion gas.

[0047] The liquefied-gas vaporization system 1 is configured to include a liquefied-gas vaporization unit 2, a boil-off-gas combustion unit 3, a turbine 4, a compressor 5, a generator 6, a starter unit 7, a combustion-gas supply unit 8, air trunks 9 and 10, a compressed-air supply unit 11, a funnel 12, and a diluted-combustion-gas supply unit 13. The compressor 5 and the generator 6 are provided on the same axis as that of the turbine 4.

[0048] The liquefied-gas vaporization unit 2 has a configuration in which the liquefied gas stored in the liquefied-gas tank is subjected to heat exchange with a combustion gas (in other words, a heat medium) of a boil-off gas, in such a manner that the liquefied gas is vaporized. In the inner portion of a casing body 15, a vaporizing tube 16 through which the liquefied gas flows is provided in an up-down direction. The vaporizing tube 16 has a structure in which a plurality of air fins 16b extending in a vertical direction are provided around, for example, a central tube 16a, in such a manner that the surface area of the vaporizing tube 16 is increased. An inlet path 17 is connected to an upstream-side of a group of vaporizing tubes 16 and an outlet path 18 is connected to a downstream-side of the group of the vaporizing tubes 16. The liquefied gas flows in from the inlet path 17 and passes through the inner portion of the vaporizing tube 16. Then, the liquefied gas flows out from the outlet path 18.

[0049] The combustion gas of the boil-off gas flows in, as a heat medium, from the upper portion of the casing body 15 of the liquefied-gas vaporization unit 2, as described below. Then, the combustion gas flows downward along the vaporizing tube 16 extending in the up-down direction and the combustion gas is subjected to heat exchange with the liquefied gas, in such a manner that the liquefied gas is vaporized. Subsequently, the combustion gas is discharged to the outside, from a discharge port 19 which is provided in the lower portion of the casing body 15.

[0050] The turbine 4 is rotationally driven by the energy of the combustion gas obtained after combustion has been performed in the boil-off-gas combustion unit 3, in such a manner that the turbine 4 performs a predetermined operation. In this case, the turbine 4 drives the compressor 5 and the generator 6 which are provided on the same axis as that of the turbine 4. Then, compressed air which is generated in the compressor 5 and has a pressure of 3 atm. passes through a compressed-air supply tube 21. Then, the compressed air is supplied to the boil-off-gas combustion unit 3, as air for pressurized combustion and air for dilution. An air trunk 9 is connected to the intake side of the compressor 5 through an outside-air supply tube 22. Outside air which flows from an inlet port 9a to the air trunk 9 is subjected to rectification, and then the outside air is supplied to the compressor 5.

[0051] The boil-off-gas combustion unit 3 receives the compressed air from the compressor 5 and induces pressurized combustion of the boil-off gas generated in the liquefied-gas tank. In addition, the boil-off-gas combustion unit 3 causes the combustion gas to be mixed with a part of the compressed air supplied from the compressor 5, in such a manner that the boil-off-gas combustion unit 3 dilutes the combustion gas. The boil-off-gas combustion unit 3 includes a combustion chamber 3a and a combustion-gas dilution portion 3b. The combustion chamber 3a forms the central portion of the boil-off-gas combustion unit 3 and has a cylindrical shape. The combustion-gas dilution portion 3b surrounds the outer circumference of the combustion chamber 3a and has a cylindrical shape. The compressed-air supply tube 21 extending from the compressor 5 is connected to one end of the combustion-gas dilution portion 3b. The compressed air supplied from the compressed-air supply tube 21 flows to both the combustion chamber 3a and the combustion-gas dilution portion 3b. A confluence discharge port 3c is provided in the other ends of the combustion chamber 3a and combustion-gas dilution portion 3b.

[0052] A boil-off-gas supply tube 25 extending from the liquefied-gas tank (not illustrated) is provided in a state where the boil-off-gas supply tube 25 diffuses the boil-off gas in the inner portion of the combustion chamber 3a of boil-off-gas combustion unit 3. In the inner portion of the combustion chamber 3a, the compressed air supplied from the compressor 5 and the boil-off gas are mixed at a predetermined ratio and are subjected to combustion. Next, in the confluence discharge port 3c, the combustion gas is mixed with the compressed air passing through the combustion-gas dilution portion 3b, in such a manner that the combustion gas is diluted. Then, the diluted combustion gas passes through a discharge-gas supply tube 26 and is supplied to the turbine 4.

[0053] The starter unit 7 has a configuration in which, when liquefied-gas vaporization system 1 is started, an auxiliary compressor 29 is driven by an electric motor 28 instead of the compressor 5 not subjected to operation and compressed air for starting is generated, and then the compressed air is supplied from a starting-air supply tube 30 to the boil-off-gas combustion unit 3. The starting-air supply tube 30 meets the compressed-air supply tube 21. A check valve 31 is provided in the tubular path 21 and a check valve 32 is provided in the tubular path 30.

[0054] The liquefied-gas vaporization system 1 may have a configuration in which the starter unit 7 is not provided and an electric power is supplied to the generator 6 at the time of starting the liquefied-gas vaporization system 1, in such a manner that the compressor 5 is forcibly driven by the generator 6 instead of an electric motor and compressed air is supplied to the boil-off-gas combustion unit 3.

[0055] The combustion-gas supply unit 8 is a tubular path through which the combustion gas discharged from the turbine 4 is supplied, as a heat medium, to the liquefied-gas vaporization unit 2. The combustion-gas supply unit 8 extends from the turbine 4 and branches into two paths in two directions. The air trunk 10 is connected to the middle of a branch path 8a which is one of the two paths. A branch path 8b which is the other of the two paths is joined to the funnel 12. The branch path 8a passes through the air trunk 10. An end portion of the branch path 8a branches into distribution piping portions 8c and the respective distribution piping portions 8c are connected to the upper portion of the casing body 15 of the liquefied-gas vaporization unit 2.

[0056] In a period of time in which the liquefied-gas vaporization system 1 is started by the starter unit 7, the compressor 5 is operated, and the compressor 5 is stably driven, a combustion gas which is discharged from the turbine 4 and has an unstable temperature and an unstable pressure passes through the branch path 8b. Then, the combustion gas is introduced to the funnel 12 and is discarded. When driving of the compressor 5 is stabilized, the combustion gas passes through the branch path 8a and is supplied to an air eductor 35. Furthermore, even in a case where the amount of the combustion gas is extremely large, the excess amount of combustion gas is discarded from the funnel 12. Switching of branch paths 8a and 8b is performed by opening or closing a gate valve.

[0057] The air eductor 35 is provided in the inner portion of the air trunk 10. The air eductor 35 causes the combustion gas flowing from the combustion-gas supply unit 8 to be mixed with outside air which flows from an inlet port 10a to the air trunk 10 and functions as air for dilution, in such a manner that the air eductor 35 dilutes the combustion gas and increases the amount of the combustion gas.

[0058] Specifically, in the inner portion of the air trunk 10, the branch path 8a of combustion-gas supply unit 8 is bent at a right angle, as illustrated in Fig. 2. One end of the a dilution air tube 36 is open to the inner portion of a bent portion 8R. The other end of the dilution air tube 36 is open to the inner portion of the air trunk 10. Accordingly, when the combustion gas passes through the bent portion 8R of the combustion-gas supply unit 8, air in the inner portion of the air trunk 10 is drawn from a dilution air tube 36 to the inner portion of the combustion-gas supply unit 8 and the air is mixed with the combustion gas, in such a manner that the combustion gas is diluted.

[0059] The combustion gas which is diluted by being mixed with air in the air trunk 10 by the air eductor 35, as described above, passes through the combustion-gas supply unit 8 and flows to the liquefied-gas vaporization unit 2 side. In the air eductor 35, a mixing ratio of air for dilution is set to a value in which the combustion gas which is subjected to dilution and is supplied to the liquefied-gas vaporization unit 2 has a temperature of 100°C or less, preferably, approximately 90°C and the combustion gas has substantially the same concentration as that of air.

[0060] The compressed-air supply unit 11 has a tubular path shape which extracts, from the compressed-air supply tube 21, a part of the compressed air generated in the compressor 5 and blows the extracted air to a part of the inner portion of the liquefied-gas vaporization unit 2, which is the portion in the vicinity (for example, the vaporizing tube 16 located at a position close to the inlet path 17) of an inlet portion of the liquefied gas. The compressed-air supply unit 11 can regulate the flow rate of the compressed air supplied to the liquefied-gas vaporization unit 2, using the flow-rate regulating valve 38 provided in the middle of the compressed-air supply unit 11.

[0061] The diluted-combustion-gas supply unit 13 is formed in a tubular path shape in which a part of the combustion gas which has been supplied to the liquefied-gas vaporization unit 2 and is subjected to dilution so that the concentration is decreased to the value close to that of air is extracted from the casing body 15 and the part of the combustion gas is supplied to the compressor 5 (in other words, the air trunk 9) and the air eductor 35 (in other words, the air trunk 10). In other words, the downstream-side of a combustion-gas supply tube 13a extending from the casing body 15 of the liquefied-gas vaporization unit 2 branches into two branch tubes 13b and 13c. The branch tube 13b which is one of the two branch tubes is connected to the air trunk 9. The branch tube 13c which is the other of the two branch tubes is connected to the air trunk 10. A flow-rate regulating valve 41 is provided in the branch tube 13b and a flow-rate regulating valve 42 is provided in the branch tube 13c. Thus, the extraction amount of diluted combustion gas can be regulated. When the flow-rate regulating valve 41 is open, the diluted combustion gas passes through the air trunk 9 and is supplied to the compressor 5. When the flow-rate regulating valve 42 is open, the diluted combustion gas passes through the air trunk 10 and returns to the liquefied-gas vaporization unit 2.

[0062] The liquefied-gas vaporization system 1 having the configuration described above operates as follows.

[0063] First, when the liquefied-gas vaporization system 1 is started, the compressor 5 is not subjected to operation. Accordingly, the electric motor 28 of the starter unit 7 drives the auxiliary compressor 29, in such a manner that the compressed air for starting is generated. Then, the compressed air is supplied from the starting-air supply tube 30 to both the combustion chamber 3a and the combustion-gas dilution portion 3b of the boil-off-gas combustion unit 3.

[0064] At this time, the boil-off gas passes through the boil-off-gas supply tube 25 and the boil-off gas is supplied, in a diffused manner, from the liquefied-gas tank (not illustrated) to the inner portion of the combustion chamber 3a. Next, ignition is performed and the boil-off gas and compressed air combust. Then, a combustion gas and the compressed air passing through the combustion-gas dilution portion 3b are mixed in the confluence discharge port 3c. Next, the combustion gas which is diluted with the compressed air passes through the discharge-gas supply tube 26 and is supplied to the turbine 4, in such a manner that the turbine 4 is driven. The combustion gas discharged from the boil-off-gas combustion unit 3 has a pressure of, for example, 3 atm. and a temperature of, for example, 500°C.

[0065] The turbine 4 is driven, and thus the compressor 5 provided on the same axis as that of the turbine 4 is operated. Accordingly, outside air is introduced from the air trunk 9, and thus compressed air is generated. Then, the compressed air is supplied from the compressed-air supply tube 21 to both the combustion chamber 3a and the combustion-gas dilution portion 3b of the boil-off-gas combustion unit 3. At this time, the electric motor 28 and the auxiliary compressor 29 of the starter unit 7 are stopped. However, in the boil-off-gas combustion unit 3, combustion of the boil-off gas and dilution of the combustion gas are continuously performed by the compressed air supplied from the compressor 5.

[0066] The combustion gas discharged from the turbine 4 passes through the combustion-gas supply unit 8 and is supplied to the liquefied-gas vaporization unit 2. However, in the middle of the operation, in the inner portion of the air trunk 10, the combustion gas and a large amount of outside air are mixed and diluted by the air eductor 35. Thus, the temperature of the combustion gas of which the pressure is 0.5 atm. and the temperature is 200°C when the combustion gas is discharged from the turbine 4 is decreased to 100°C or less. Furthermore, the concentration of the combustion gas becomes a value close to that of air.

[0067] The combustion gas which is diluted with air and of which the temperature is decreased, as described above, flows in from the upper portion of the casing body 15 to the inner portion of the liquefied-gas vaporization unit 2, and then the combustion gas is diffused. Next, the combustion gas flows downward along the vaporizing tube 16, in a state where the combustion gas equally comes into contact with the group of the vaporizing tubes 16 which extends in the up-down direction, in the inner portion of the casing body 15. Then, the combustion gas is subjected to heat exchange with the liquefied gas flowing through the inner portion of the vaporizing tube 16, in such a manner that the liquefied gas is vaporized. Next, the combustion gas is discharged from the discharge port 19 to the outside.

[0068] The liquefied gas which flows from the inlet path 17 to the liquefied-gas vaporization unit 2 is vaporized in the inner portion of the vaporizing tube 16, as described above. Next, the liquefied gas in a gaseous state flows out from the outlet path 18, and then the liquefied gas is supplied to, for example, a city gas line. Particularly, at a position close to the inlet path 17, a large amount of moisture contained in the combustion gas is subjected to heat exchange with the liquefied gas of a low temperature, and thus the moisture is condensed. As a result, condensed water is generated. There is a concern in that the condensed water may be frozen and significantly reduce the vaporization performance of the liquefied-gas vaporization unit 2. Thus, the flow-rate regulating valve 38 of the compressed-air supply unit 11 is open at, for example, a predetermined time interval and a part of the compressed air which has a high temperature and is generated in the compressor 5 is blown to a liquefied-gas inlet portion (particularly, the upstream portion of the vaporizing tube 16) of the liquefied-gas vaporization unit 2. Accordingly, the frozen ice is removed by being blown off or a portion corresponding to the frozen portion is heated in advance by the heat of the compressed air and is prevented from being frozen, in such a manner that a favorable vaporization performance of the liquefied-gas vaporization unit 2 is maintained. As a result, the liquefied gas can be vaporized with high efficiency.

[0069] The flow-rate regulating valve 41 of the branch tube 13b of two branch tubes 13b and 13c which is branched from the combustion-gas supply tube 13a of the diluted-combustion-gas supply unit 13 is open. Accordingly, a part of the combustion gas which has been supplied to the liquefied-gas vaporization unit 2 and is subjected to dilution so that the concentration of the combustion gas becomes a value close to that of air is extracted and is supplied to the air trunk 9. Then, the part of the combustion gas flows into the compressor 5. The combustion gas in a lean state is subjected to heat exchange with the liquefied gas, and thus the temperature of the combustion gas is cooled to room temperature or less. Thus, the temperature of intake air of the compressor 5 is reduced. As a result, the efficiency of the compressor can be increased. The combustion gas is diluted with air and includes a large amount of oxygen. Thus, even when the combustion gas passes through the compressor 5 and is supplied to the boil-off-gas combustion unit 3, this does not affect combustion of the boil-off gas.

[0070] The flow-rate regulating valve 42 of branch tube 13c is opened, in such a manner that a part of the combustion gas which has been supplied to the liquefied-gas vaporization unit 2 is supplied to the air trunk 10. In the air eductor 35, the supplied combustion gas is mixed, as dilution air, with the combustion gas. In the inner portion of the liquefied-gas vaporization unit 2, the combustion gas is subjected to heat exchange with the liquefied gas of a low temperature, in such a manner that condensed water is separated. In addition, the combustion gas which is subjected to dehumidification and is in a lean state passes through the air trunk 10 (in other words, the air eductor 35) and returns to the liquefied-gas vaporization unit 2. As a result, freezing of the liquefied-gas vaporization unit 2 is prevented by reducing the amount of condensed water in the combustion gas entering the liquefied-gas vaporization unit 2, and thus the liquefied gas can be vaporized with high efficiency.

[0071] According to the liquefied-gas vaporization method and the liquefied-gas vaporization system 1, the liquefied gas stored in the liquefied-gas tank is vaporized by the liquefied-gas vaporization unit 2 and the boil-off gas generated in the liquefied-gas tank is subjected to combustion by the boil-off-gas combustion unit 3, as described above. Next, the turbine 4 is driven by the energy of the combustion gas, and then vaporization of the liquefied gas in the liquefied-gas vaporization unit 2 is promoted by the heat of the combustion gas after driving the turbine 4.

[0072] According to the liquefied-gas vaporization method and the liquefied-gas vaporization system 1, the combustion gas obtained after the boil-off gas generated in the liquefied-gas tank is combusted, is expanded by driving the turbine 4, and thus the temperature of the combustion gas is reduced. Vaporization of the liquefied gas in the liquefied-gas vaporization unit 2 is promoted by the heat of the combustion gas which is expanded and is subjected to a temperature reduction, as described above. The driven turbine 4 can perform a predetermined operation. In other words, in the embodiment, the driven turbine 4 can perform driving of the compressor 5 and the generator 6.

[0073] The combustion gas passing through the turbine 4 is expanded, and thus the volume of the combustion gas is increased. Accordingly, the temperature of the combustion gas is significantly decreased. As a result, upon comparison with a case where a combustion gas obtained after, for example, a boil-off gas is subjected to combustion does not pass through the turbine 4 and is directly supplied to the liquefied-gas vaporization unit 2, in such a manner that a liquefied gas is vaporized, a temperature difference between the combustion gas and the liquefied-gas vaporization unit 2 can be reduced. Accordingly, it is possible to prevent damage to the liquefied-gas vaporization unit 2 and reduction in durability.

[0074] The combustion gas passing through the turbine 4 has a certain amount of pressure. Accordingly, even when the combustion gas is not forcibly sent by, for example, a blower, the combustion gas can be supplied to the liquefied-gas vaporization unit 2. As a result, the configuration of the liquefied-gas vaporization system 1 can be simplified.

[0075] The liquefied gas can be vaporized, without any problem, by the heat of the combustion gas obtained by combusting the boil-off gas, as described above. Thus, it is not necessary to heat a heat medium, such as sea water or air, using additional energy, as in a case of the related art. As a result, the liquefied-gas vaporization system of the invention does not require any additional energy. Furthermore, a predetermined operation (for example, air compression or power generation) can be performed by operating the turbine 4. Thus, the boil-off gas in the liquefied-gas tank is effectively utilized and the liquefied gas can be significantly effectively vaporized.

[0076] The liquefied-gas vaporization system 1 is a pressurized combustion unit in which the boil-off-gas combustion unit 3 receives compressed air from the compressor 5 which is provided on the same axis as that of the turbine 4 and the boil-off gas combusts. Accordingly, upon comparison with in a case in which a boil-off gas is subjected to combustion at atmospheric pressure, the size of flame during combustion is reduced. Thus, the size of the boil-off-gas combustion unit 3 and the size of a flue are reduced. Furthermore, this significantly contributes to reduction in the size of the liquefied-gas vaporization system 1.

[0077] The boil-off-gas combustion unit 3 is configured to include the combustion chamber 3a which induces pressurized combustion of the boil-off gas and the combustion-gas dilution portion 3b which causes the combustion gas to be mixed with a part of the compressed air supplied from the compressor 5, in such a manner that the combustion gas is diluted. Thus, in the combustion-gas dilution portion 3b, the combustion gas discharged from the combustion chamber 3a is diluted with compressed air, and thus the volume of the combustion gas is increased.

[0078] The combustion gas which is subjected to dilution, as described above, is expanded by passing through the turbine 4. In addition, the volume of the combustion gas is increased. The combustion gas is supplied to the liquefied-gas vaporization unit 2, in a state where the temperature of the combustion gas is decreased. Accordingly, a large amount of diluted combustion gas having an appropriate temperature is introduced to the liquefied-gas vaporization unit 2, in such a manner that the liquefied gas can be vaporized with high efficiency. In addition, it is possible to prevent damage to the liquefied-gas vaporization unit 2 and reduction in durability, by reducing a temperature difference between the combustion gas and the liquefied-gas vaporization unit 2.

[0079] The air eductor 35 is provided in the air trunk 10 which is provided in the combustion-gas supply unit 8. The air eductor 35 causes the combustion gas after driving the turbine 4 to be mixed with air for dilution, in such a manner that the air eductor 35 dilutes the combustion gas. In addition, the combustion gas subjected to dilution is supplied to the liquefied-gas vaporization unit 2, in a state where the temperature of the diluted combustion gas is set to 100°C or less, preferable, about 90°C. Thus, when the combustion gas passing through the turbine 4 passes through the air eductor 35, the combustion gas is mixed with air for dilution, and thus the volume of the combustion gas is further increased. Accordingly, the combustion gas is supplied to the liquefied-gas vaporization unit 2, in a state where the temperature of the combustion gas is reduced to 100°C or less.

[0080] Accordingly, a larger amount of diluted combustion gas of an appropriate temperature is introduced to the liquefied-gas vaporization unit 2, in such a manner that the liquefied gas can be vaporized with high efficiency. Furthermore, it is possible to prevent damage to the liquefied-gas vaporization unit 2 and reduction in durability by reducing a temperature difference (a temperature difference between the combustion gas and the liquefied gas) between the combustion gas and the liquefied-gas vaporization unit 2.

[0081] The liquefied-gas vaporization unit 2 has a configuration in which the vaporizing tube 16 through which the liquefied gas flows is provided along the up-down direction, in the inner portion of the casing body 15, and the combustion gas flows in from the upper portion of the casing body 15 and is discharged from the discharge port 19 of the lower portion of the casing body 15. Accordingly, even when moisture which is necessarily included in the combustion gas is condensed by being subjected to heat exchange with the vaporizing tube 16 (in other words, the liquefied gas) having a low temperature, and thus condensed water is generated, the condensed water flows downward by the combustion gas flowing along the vaporizing tube 16 which extends in the vertical direction, in the inner portion of the casing body 15. As a result, it is easy for the condensed water to be discharged from the discharge port 19. Thus, it is possible to reduce a concern that the condensed water may be frozen around the vaporizing tube 16, and thus a heat-exchange performance thereof is decreased. As a result, the liquefied gas can be vaporized with high efficiency.

[0082] When the liquefied-gas vaporization system 1 having the configuration described above is provided in an offshore floating-body structure, such as a liquefied-gas carrier ship and an FSRU, the liquefied-gas vaporization system 1 is configured to have a compact size. In addition, the liquefied gas can be effectively vaporized by the heat of the combustion gas obtained by combusting the boil-off gas in the liquefied-gas tank, without any problem.

Embodiment 2

[0083] Next, an embodiment 2 of the liquefied-gas vaporization system according to the invention will be described with reference to Fig. 3. In a liquefied-gas vaporization system 51 illustrated in Fig. 3, the same reference numerals and letters are given to components of which the configurations are the same as those of the liquefied-gas vaporization system 1 of the embodiment 1 illustrated in Fig. 1. The descriptions thereof will not be repeated.

[0084] In the liquefied-gas vaporization system 51, the compressed-air supply tube 21 extending from the compressor 5 driven by the turbine 4 branches into paths in a two direction. A branch path 21a which is one of the paths described above is connected to the boil-off-gas combustion unit 3, similar to the embodiment 1. A branch path 21b (in other words, a dilution-air supply portion) which is the other of the paths described above is connected to the air trunk 10 (in other words, the air eductor 35) through a flow-rate regulating valve 43.

[0085] A part of the compressed air which is generated in the compressor 5 and has a pressure of approximately 3 atm. is extracted from the branch path 21b. The flow rate of the extracted compressed air is adjusted by the flow regulating valve 43, and then the compressed air is supplied to the air trunk 10. Then, in the inner portion of the air trunk 10, the compressed air is mixed, as air for dilution, with the combustion gas which flows in from the combustion-gas supply unit 8 (in other words, the branch path 8a) and has driven the turbine 4, in such a manner that the combustion gas is diluted, similar to the liquefied-gas vaporization system 1 of the embodiment 1.

[0086] The diluted combustion gas sent from the air eductor 35 is subjected to control so that the diluted combustion gas has a pressure of approximately 1 atm. and a temperature of 100°C or less. Then, the combustion gas is supplied to the liquefied-gas vaporization unit 2.

[0087] In the liquefied-gas vaporization system 1 of the embodiment 1, a turbine side (for example, the boil-off-gas combustion unit 3, the turbine 4, and the compressor 5) and the flow regulating valve 42 which supplies the combustion gas to the air eductor 35 are adjusted, in such a manner that the pressure of the combustion gas (in other words, dilution air) supplied to the liquefied-gas unit 2 is controlled.

[0088] In contrast, in the liquefied-gas vaporization system 51 of the embodiment 2, a part of the compressed air generated by the compressor 5 is extracted and is supplied to the air eductor 35, in a state where the flow rate (in other words, the pressure) of the compressed air is adjusted, in such a manner that the combustion gas is diluted.

[0089] Accordingly, in the liquefied-gas vaporization system 51, it is not necessary to control the flow rate of air for dilution, on the turbine side. As a result, it is possible to easily perform control.

[0090] According to the liquefied-gas vaporization method, the liquefied-gas vaporization system 1 or 51, and the offshore floating-body structure provided with the liquefied-gas vaporization system of the invention, the liquefied gas can be effectively vaporized by effectively utilizing the boil-off gas in the liquefied-gas tank, with a significantly compact configuration in which, for example, a large-scale gas power generation facility and a large-scale boiler facility are not provided, as described above.

[0091] The liquefied gas can be vaporized without having to take in any sea water. Thus, it is possible to contribute to the marine environment conservation.

[0092] It is possible to easily perform a retrofit work in which a liquefied-gas vaporization system of the related art, in which a liquefied gas is vaporized using heated sea water or air as a heat medium, is changed to the liquefied-gas vaporization system according to the invention.

[0093] The invention is not intended to be limited to only the configuration of the embodiment 1 or 2 described above. The invention can be appropriately changed or modified as long as it does not depart from the gist of the invention. An embodiment to which change or modification is applied is also within the range of the scope of the invention.

[0094] It is possible to conceive a configuration in which, for example, the air trunk 9 and the air trunk 10 (in other words, the air eductor 35) are not provided.

[0095] In the embodiments 1 and 2 described above, a diluted gas which is obtained by diluting, with air, a combustion gas obtained by combusting a boil-off gas is directly supplied to the liquefied-gas vaporization unit 2. It is possible to conceive, as a modification example, a configuration in which a liquefied gas passes through a vaporizer having an open-rack shape, instead of the liquefied-gas vaporization unit 2 allowing the liquefied gas to pass therethrough, and the liquefied gas is vaporized by a heat medium, such as heated sea water or air, flowing through a closed-loop circuit of the vaporizer. In this configuration, the heat of the combustion gas obtained by combusting the boil-off gas is used for heating the heat medium.

[0096] It is possible to conceive a configuration in which the liquefied-gas vaporization system 1 of the embodiment 1 and the liquefied-gas vaporization system 51 of the embodiment 2 are used in combination.

Reference Signs List

[0097]

1, 51: liquefied-gas vaporization system
2: liquefied-gas vaporization unit
3: boil-off-gas combustion unit
3a: combustion chamber
3b: combustion-gas dilution portion
4: turbine
5: compressor
8: combustion-gas supply unit
11: compressed-air supply unit
13: diluted-combustion-gas supply unit
15: casing body
16: vaporizing tube
19: discharge port
21b: branch path (dilution-air supply portion)
35: air eductor
43: flow-rate regulating valve

Claims

1. A liquefied-gas vaporization method of promoting vaporization of a liquefied gas stored in a liquefied-gas tank by causing the liquefied gas to be subjected to heat exchange with a heat medium, the method comprising:

causing a boil-off gas generated in the liquefied-gas tank to be subjected to combustion, to drive a turbine by the energy of a combustion gas, and using the combustion gas after driving the turbine as the heat medium, and vaporization of the liquefied gas is promoted by the heat of the combustion gas.

2. A liquefied-gas vaporization system comprising:

a liquefied-gas vaporization unit in which a liquefied gas stored in a liquefied-gas tank is subjected to heat exchange with a heat medium, and vaporized;
a boil-off-gas combustion unit which induces combustion of a boil-off gas generated in the liquefied-gas tank;
a turbine which performs a predetermined operation by being rotationally driven by the energy of a combustion gas obtained after combustion has been performed in the boil-off-gas combustion unit; and
a combustion-gas supply unit which supplies, as the heat medium, to the liquefied-gas vaporization unit, the combustion gas discharged from the turbine.

3. The liquefied-gas vaporization system according to Claim 2,
wherein the boil-off-gas combustion unit is a pressurized combustion unit which has compressed air supplied thereto and in which the boil-off gas is subjected to pressurized combustion, and
wherein a compressor which generates the compressed air and supplies the compressed air to the boil-off-gas combustion unit as air for pressurized combustion, is provided on the same axis as that of the turbine.

4. The liquefied-gas vaporization system according to Claim 3,
wherein the boil-off-gas combustion unit includes a combustion-gas dilution portion which dilutes the combustion gas by causing the combustion gas to be mixed with a part of the compressed air supplied from the compressor.

5. The liquefied-gas vaporization system according to any one of Claims 2 to 4,
wherein the combustion-gas supply unit includes an air eductor which dilutes the combustion gas by causing the combustion gas to be mixed with air for dilution.

6. The liquefied-gas vaporization system according to Claim 5,
wherein, in the air eductor, a mixing ratio of air for dilution is set to a value in which the combustion gas which is subjected to dilution and is supplied to the liquefied-gas vaporization unit has a temperature of 100°C or less.

7. The liquefied-gas vaporization system according to Claim 5 or 6, further comprising:

a dilution-air supply portion which extracts a part of the compressed air generated in the compressor and supplies, as the air for dilution, the extracted compressed air to the air eductor; and
a flow-rate regulating valve which regulates a flow rate of the air for dilution.

8. The liquefied-gas vaporization system according to any one of Claims 2 to 6,
wherein the liquefied-gas vaporization unit has a configuration in which a vaporizing tube through which the liquefied gas flows is provided along an up-down direction, in an inner portion of a casing body, and the combustion gas flows in from an upper portion of the casing body and is discharged from a lower portion of the casing body.

9. The liquefied-gas vaporization system according to any one of Claims 3 to 7, further comprising:

a compressed-air supply unit which extracts a part of the compressed air generated in the compressor and blows the extracted air to a part of the liquefied-gas vaporization unit, which is a portion in the vicinity of an inlet portion of the liquefied gas.

10. The liquefied-gas vaporization system according to any one of Claims 3 to 8, further comprising:

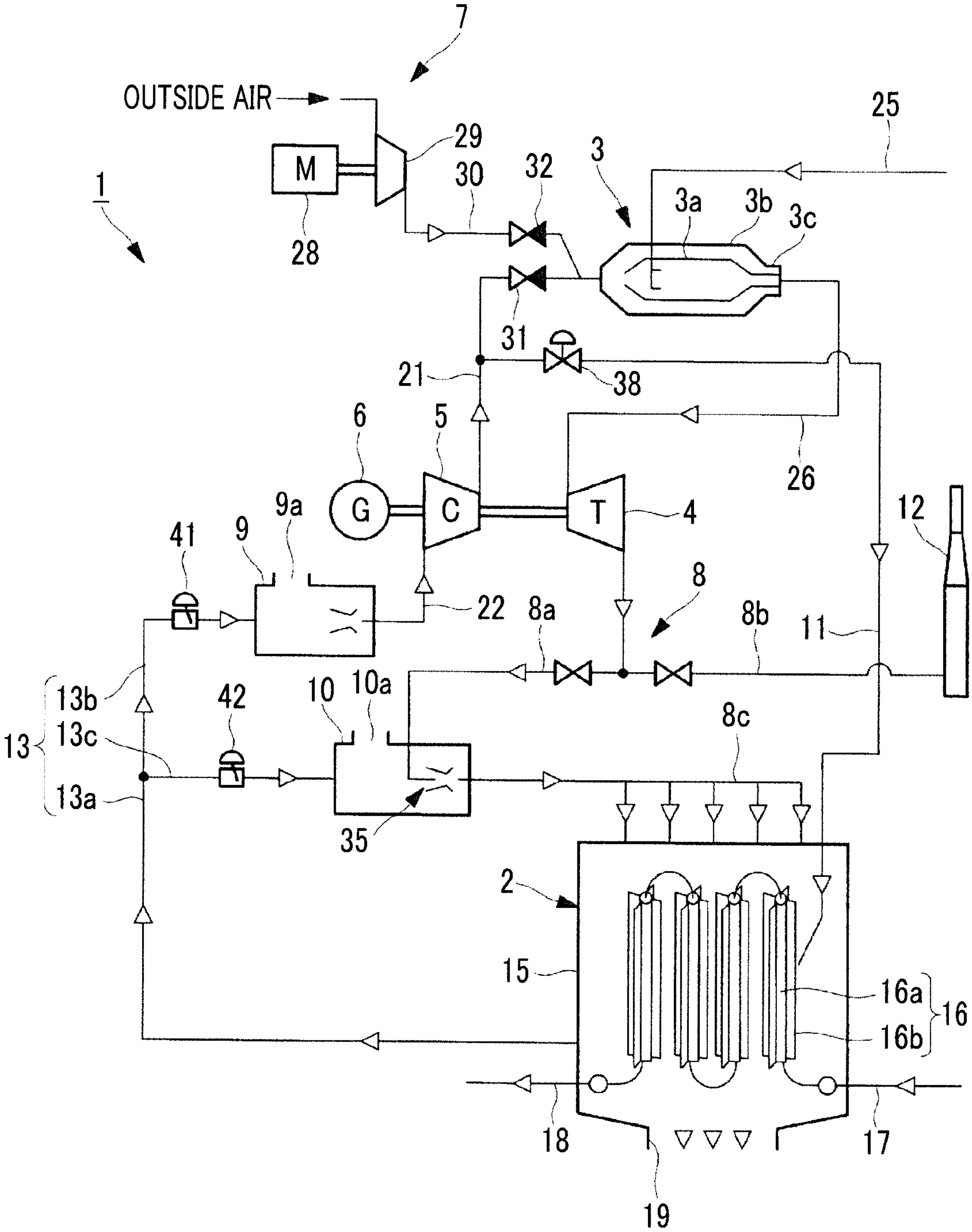
a diluted-combustion-gas supply unit which extracts a part of the combustion gas which has been supplied to the liquefied-gas vaporization unit and is subjected to dilution and supplies the extracted combustion gas to the compressor.

11. The liquefied-gas vaporization system according to Claim 9,
wherein the diluted-combustion-gas supply unit can also supply the combustion gas extracted from the liquefied-gas vaporization unit to the air eductor.

12. An offshore floating-body structure comprising:

the liquefied-gas vaporization system according to any one of Claims 2 to 11.

FIG. 1


7
OUTSIDE AIR
25
29
M
32
3
30
3a
3b
3c
1
28
31
38
21
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26
G
C
T
4
12
41
9
9a
22
8a
8
8b
11
13b
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13c
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13a
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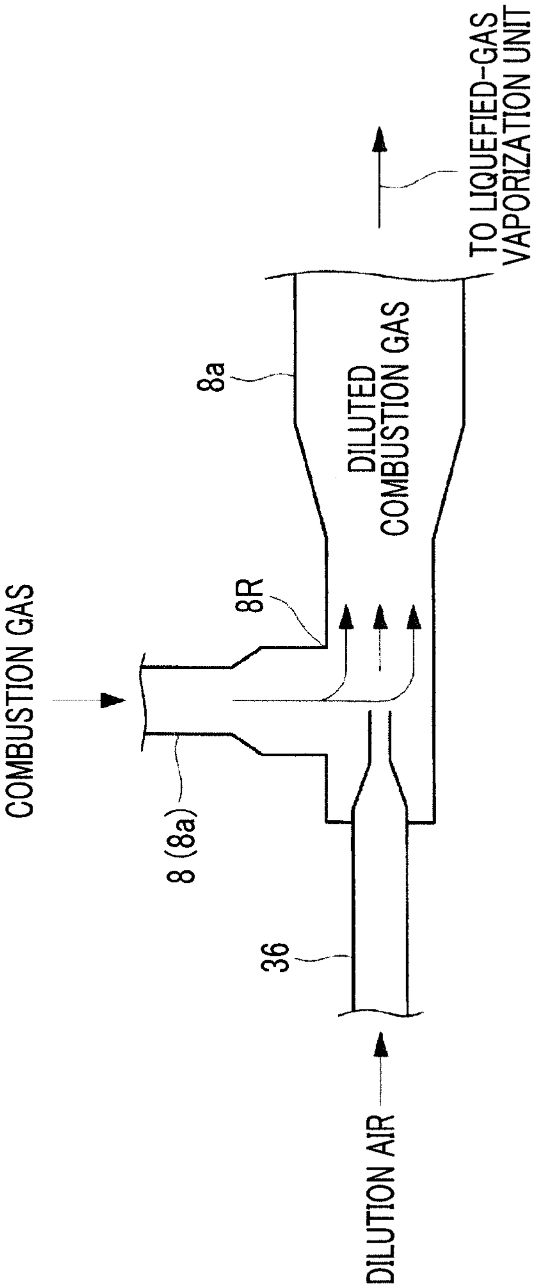
2
15
16a
16
16b
18
17
19

FIG. 2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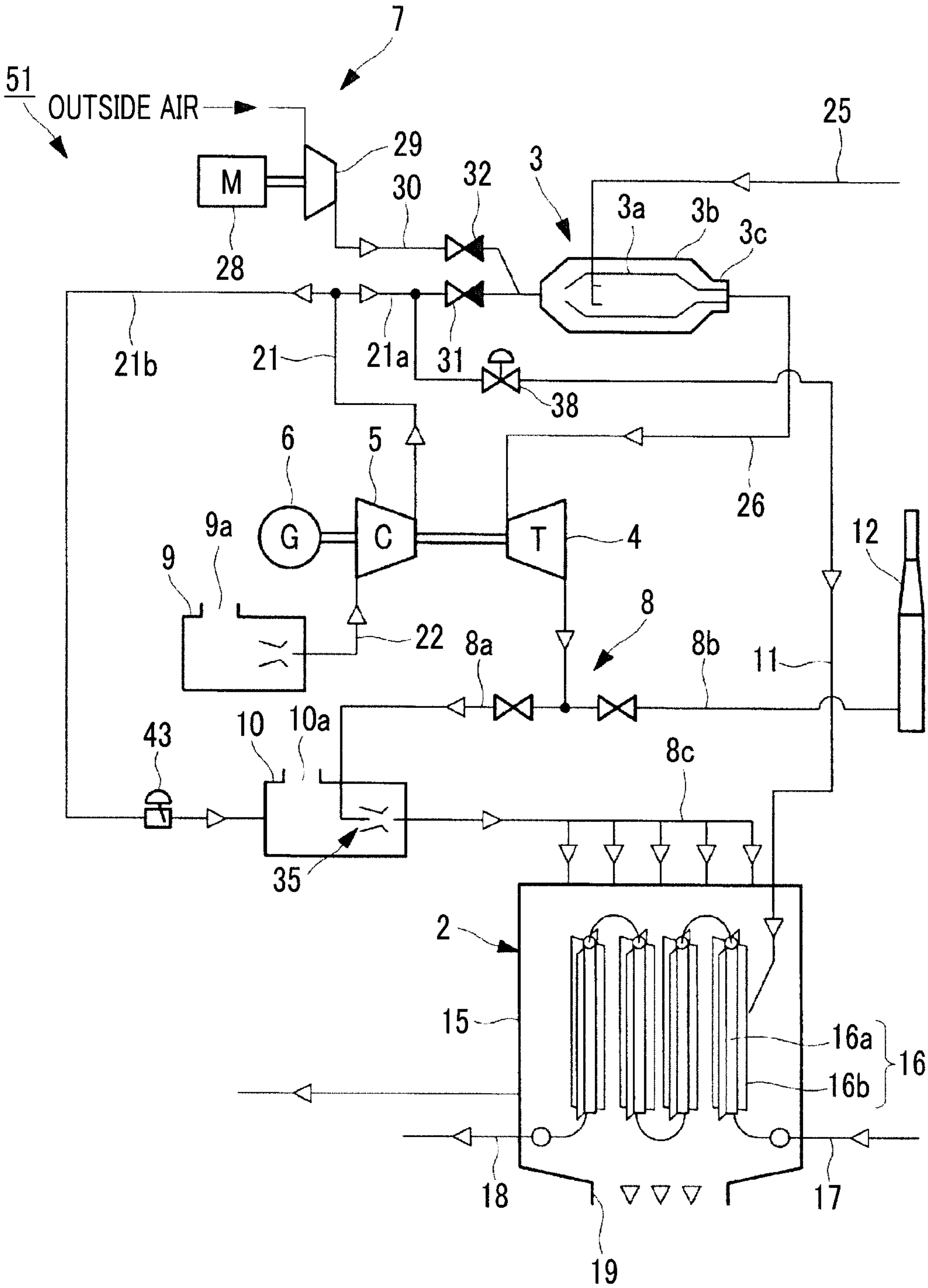
8 (8a)
8R
36
DILUTION AIR
DILUTED
COMBUSTION GAS
8a
TO LIQUEFIED-GAS
VAPORIZATION UNIT

FIG. 3


7
51
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M
28
29
30
32
3
25
3a
3b
3c
21b
21
21a
31
38
26
6
5
G
C
T
4
9a
9
22
8
8a
8b
11
12
43
10
10a
8c
35
2
15
16a
16b
16
18
17
19

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/054667

A. CLASSIFICATION OF SUBJECT MATTER
F17C9/02(2006.01)i, *B63B25/16*(2006.01)i, *F17C13/00*(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)
F17C9/02, B63B25/16, F17C13/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2014
Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

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.
Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 76042/1983(Laid-open No. 181399/1984) (Ishikawajima-Harima Heavy Industries Co., Ltd.), 04 December 1984 (04.12.1984), entire text; fig. 3 (Family: none)	1-6,8,12 7,9-11
Y	JP 10-47598 A (Mitsubishi Heavy Industries, Ltd.), 20 February 1998 (20.02.1998), paragraph [0046]; fig. 1 (Family: none)	1-6,8,12

☒ 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
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"P" document published prior to the international filing date but later than the priority date claimed
"T" 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	Date of mailing of the international search report
19 May, 2014 (19.05.14)	03 June, 2014 (03.06.14)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/054667

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 53-40001 A (Setsuo YAMAMOTO), 12 April 1978 (12.04.1978), entire text; all drawings (Family: none)	1-6,8,12

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2010058772 A **[0008]**
- JP 2012017030 A **[0008]**
- JP 2002039695 A **[0008]**