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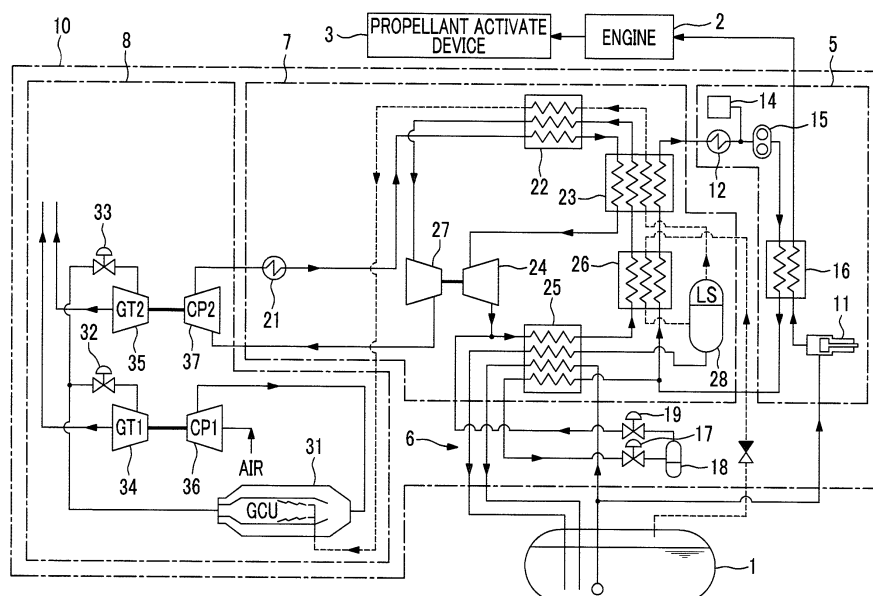
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(54) **TANK INTERNAL PRESSURE SUPPRESSION DEVICE**

(57) In order to readily manufacture a device that utilizes boil-off gas generated in a tank, a tank internal pressure suppression device comprises: a gas combustion unit (31) that generates pressurized exhaust gas by using compressed air and combusting boil-off gas generated inside an LNG tank (1); a compressor (36) that generates compressed air by using driving power generated in a pressurized exhaust gas expansion process by an air-compression gas turbine (34), to compress air; and a

load (37) that utilizes recovered driving power generated, using pressurized exhaust gas, by a power recovery gas turbine (35) different from the air-compression gas turbine (34). This kind of tank internal pressure suppression device is capable of having a simpler configuration than other tank internal pressure suppression devices (10) whereby the load (37) utilizes driving power generated by the air-compression gas turbine (34).

FIG. 1



Description

Technical Field

[0001] The present invention relates to a tank internal pressure suppression device, and particularly, to a tank internal pressure suppression device that suppresses an increase in an internal pressure of a tank that stores LNG.

Background Art

[0002] An LNG tank that stores Liquefied Natural Gas (LNG) is known. Boil-off gas is generated inside the LNG tank, and thus, an internal pressure of the LNG tank increases. It is necessary to extract and process the boil-off gas so that the internal pressure does not exceed an allowable pressure of the LNG tank.

[0003] Japanese Patent No. 4859980 discloses an LNG cold heat gas turbine that uses boil-off gas generated in an LNG tank. In this LNG cold heat gas turbine, an internal pressure is decreased by extracting a portion of the boil-off gas from the LNG tank, and thus, it is possible to maintain soundness of the LNG tank.

Citation List

Patent Literature

[0004] [PTL 1] Japanese Patent No. 4859980

Summary of Invention

Technical Problem

[0005] In many cases, boil-off gas generated in an LNG tank is combusted and discarded in an air-cooling type incinerator, or the boil-off gas is supplied to a boiler of a vessel as a fuel and surplus steam is cooled and condensed by sea water to be discarded, and thus, it is preferable to effectively use the boil-off gas. Meanwhile, in order to use the boil-off gas in a vessel, it is preferable to more simply configure a device that uses the boil-off gas.

[0006] An object of the present invention is to provide a tank internal pressure suppression device that effectively uses boil-off gas generated in a tank and is more easily configured.

Solution to Problem

[0007] A tank internal pressure suppression device according to the present invention includes a gas combustion unit, a plurality of gas turbines, a compressor, and a load. The gas combustion unit generates pressurized exhaust gas by combusting boil-off gas generated inside a tank using compressed air. The plurality of gas turbines generate a plurality of driving powers using the pressurized exhaust gas. The compressor compresses air using

the driving power generated by an air-compression gas turbine among the plurality of gas turbines, and generates compressed air. The load uses recovered driving power generated by a power recovery gas turbine which is different from the air-compression gas turbine among the plurality of gas turbines.

[0008] The tank internal pressure suppression device is effectively used to supply rotational driving power required in a vessel. That is, when a flow rate of the pressurized exhaust gas which is generated by combusting the boil-off gas through the compressed air using the gas combustion unit is greater than a flow rate of the pressurized exhaust gas required by the air-compression gas turbine generating the compressed air, the present device is established, and the flow rate of surplus pressurized exhaust gas which is equal to or greater than the flow rate required by the air-compression gas turbine is used for the recovered driving power generated by the air-compression gas turbine and the separate power recovery gas turbine and can be effectively used for other loads. In the tank internal pressure suppression device, other loads can use the recovered driving power for the purpose of use other than air compression. Accordingly, compared to other tank internal pressure suppression devices which are configured to generate the compressed air required for the gas combustion unit by an air-compression gas turbine which uses other drive sources, since other drive sources are not required, it is possible to achieve a simpler configuration.

[0009] The gas combustion unit may include a plurality of gas combustor elements corresponding to the plurality of gas turbines. In this case, an arbitrary gas turbine among the plurality of gas turbines generates the driving power using the pressurized exhaust gas generated by the gas combustor element corresponding to the arbitrary gas turbine among the plurality of gas combustor elements.

[0010] In the tank internal pressure suppression device, the boil-off gas is supplied to each of the plurality of gas combustor elements so that a supplied amount of the boil-off gas is changed, and thus, it is possible to change the plurality of driving powers generated by the plurality of gas turbines. Since it is possible to more appropriately change the loads which use the plurality of driving powers, it is possible to achieve a simpler configuration.

[0011] The tank internal pressure suppression device according to the present invention may further include a refrigerator that supplies low-temperature LNG, which is generated by cooling LNG through a refrigeration cycle which uses high-pressure refrigerant gas, to the tank. In this case, the load generates the high-pressure refrigerant gas by compressing low-pressure refrigerant gas using the surplus driving power.

[0012] In the tank internal pressure suppression device, since the driving power for generating the high-pressure refrigerant gas uses the surplus driving power recovered by the power recovery gas turbine, compared

to other devices in which the driving power for generating the high-pressure refrigerant gas is generated by an electric motor or the like which uses electricity, it is possible to decrease consumption of power energy.

[0013] The refrigerator may further include: a heat exchanger A that generates low-temperature and high-pressure refrigerant gas by cooling the high-pressure refrigerant gas; an expansion turbine that generates low-temperature and low-pressure refrigerant gas by adiabatically expanding the low-temperature and high-pressure refrigerant gas; and a heat exchanger B that generates the low-temperature LNG by cooling the LNG stored in the tank using the low-temperature and low-pressure refrigerant gas. In this case, the heat exchanger A and the heat exchanger B generate the low-pressure refrigerant gas by heating the low-temperature and low-pressure refrigerant gas.

[0014] In the refrigerator, since the high-pressure refrigerant gas immediately before the adiabatic expansion is performed is precooled using the low-temperature and low-pressure refrigerant gas used to cool the LNG, compared to other refrigerators which perform cooling without using the low-temperature and low-pressure refrigeration gas, it is possible to effectively use a cold heat source. Accordingly, it is possible to more appropriately generate the low-temperature and low-pressure refrigerant gas, and it is possible to prevent generation of the boil-off gas by cooling the LNG more effectively.

[0015] The refrigerator may further include a condenser that generates liquefied boil-off gas by liquefying the boil-off gas. In this case, the heat exchanger B supplies low-temperature liquefied boil-off gas, which is generated by cooling the liquefied boil-off gas, to the tank. The condenser heats the low-temperature and low-pressure refrigerant gas.

[0016] In the tank internal pressure suppression device, since the refrigerator liquefies the boil-off gas, generation of the boil-off gas is prevented, and it is possible to appropriately decrease the internal pressure of the tank.

[0017] The tank internal pressure suppression device according to the present invention may further include a cold heat storage system. In this case, the heat exchanger B stores liquefied refrigerant gas, which is generated by cooling low-temperature refrigerant gas, in the cold heat storage system, and cools the LNG using the liquefied refrigerant gas.

[0018] In the tank internal pressure suppression device, since the refrigerator generates the liquefied refrigerant gas or the refrigerator cools the LNG using the liquefied refrigerant gas, it is possible to appropriately cool the LNG even when the load of the refrigerator is changed.

[0019] The tank internal pressure suppression device according to the present invention may further include an LNG heating device that generates high-temperature LNG by heating the LNG using high-temperature refrigerant gas. In this case, the refrigerator generates the

high-temperature refrigerant gas by heating the low-temperature refrigerant gas. The LNG heating device generates the low-temperature refrigerant gas by cooling the high-temperature refrigerant gas.

[0020] In the tank internal pressure suppression device, since the LNG is cooled using the cold heat of the low-temperature refrigerant gas generated by the LNG heating device, it is possible to decrease the load of the refrigerator.

[0021] A vessel according to the present invention includes the tank internal pressure suppression device according to claim 7; an engine that generates propulsion driving power using the high-temperature LNG; and a propulsion device that propels a vessel main body using the propulsion driving power.

[0022] In the vehicle, since the tank internal pressure suppression device drives the refrigerator by the boil-off gas, it is possible to save energy with respect to the driving power in the vessel using a simpler configuration.

[0023] A tank internal pressure suppression method according to the present invention, includes: a step of generating pressurized exhaust gas by combusting boil-off gas using compressed air; a step of generating the compressed air by compressing air using driving power which is generated using the pressurized exhaust gas by an air-compression gas turbine among a plurality of gas turbines; and a step of operating a load using recovered driving power which is generated using the pressurized exhaust gas by a power recovery gas turbine different from the air-compression gas turbine among the plurality of gas turbines.

[0024] In the tank internal pressure suppression device in which the tank internal pressure suppression method is performed, since the air-compression gas turbine and the separate power recovery gas turbine use the pressurized exhaust gas, compared to other tank internal pressure suppression devices which use the driving power generated by the air-compression gas turbine for purposes other than compression of air, it is possible to the generated boil-off gas more effectively, and it is possible to achieve a simpler configuration.

[0025] Another tank internal pressure suppression device according to the present invention includes: a refrigerator that generates liquefied boil-off gas by cooling boil-off gas generated inside a tank which stores LNG and supplies the liquefied boil-off gas to the tank; and an LNG heating device that generates high-temperature LNG by heating the LNG using high-temperature refrigerant gas. In this case, the refrigerator generates the high-temperature refrigerant gas by heating low-temperature refrigerant gas. The LNG heating device generates the low-temperature refrigerant gas by cooling the high-temperature refrigerant gas.

[0026] In the tank internal pressure suppression device, since the LNG is cooled using the cold heat of the low-temperature refrigerant gas cooled by the LNG heating device, it is possible to decrease the load of the refrigerator.

Advantageous Effects of Invention

[0027] The tank internal pressure suppression device according to the present invention can effectively use boil-off gas generated in a tank, and can be easily configured.

Brief Description of Drawings

[0028]

Fig. 1 is a block diagram showing a vessel including a tank internal pressures suppression device.

Fig. 2 is a block diagram showing another gas combustion system.

Description of Embodiments

[0029] An embodiment of a tank internal pressure suppression device will be described below with reference to the drawings. As shown in Fig. 1, a tank internal pressure suppression device 10 is used in a vessel. The vessel includes an LNG tank 1, an engine 2, and a propulsion device 3 in addition to the tank internal pressure suppression device 10, and includes a vessel main body (not shown). The tank internal pressure suppression device 10, the LNG tank 1, the engine 2, and the propulsion device 3 are installed in the vessel main body.

[0030] The LNG tank 1 stores LNG. In the LNG tank 1, the internal pressure of the LNG tank needs to be decreased and soundness of the LNG tank needs to be maintained so that the internal pressure does not exceed a predetermined allowable internal pressure. The LNG tank 1 stores a predetermined amount of LNG in the tank internal pressure suppression device 10, and the LNG is evaporated since the boiling point of the LNG is approximately -160°C . Accordingly, generated boil-off gas is supplied to the tank internal pressure suppression device 10 at a predetermined flow rate. After the boil-off gas is heat-exchanged with each of heat exchangers described below, the boil-off gas is supplied to a gas combustion unit 31 of a combustion system 8 described below.

[0031] Meanwhile, the pressure of the LNG is increased by a booster pump 11 described below, the temperature of the LNG is increased by a heat exchanger 16 described below in a liquid state, and thus, high-temperature LNG is generated. The engine 2 generates driving power by combusting the high-temperature LNG supplied from the tank internal pressure suppression device 10. The propulsion device 3 generates a propulsive force which propels the vessel main body, using the driving power generated by the engine 2.

[0032] The tank internal pressure suppression device 10 includes an LNG heating device 5, a cold heat storage system 6, a refrigerator 7, and the combustion system 8, and includes a control device (not shown). The LNG heating device 5 includes the booster pump 11, a heating device 12, a refrigerant gas supply device 14, a circulator

15, and the heat exchanger 16. The booster pump 11 increases the pressure of the LNG supplied to the tank internal pressure suppression device 10 from the LNG tank 1, and supplies the LNG to the heat exchanger 16.

5 The refrigerator 7 is configured of a refrigeration cycle which uses a nitrogen refrigerant, includes nitrogen gas A operated in a system through which the nitrogen is circulated by the LNG heating device 5 and the refrigerator 7, and nitrogen gas B operated in a system through which the nitrogen is circulated by the refrigerator 7 and the combustion system 8. The t nitrogen gas A and the nitrogen gas B are combined with each other via the cold heat storage system 6. The heating device 12 heats the high-temperature nitrogen gas A which is supplied from the refrigerator 7, using sea water or the like. The refrigerant gas supply device 14 mixes nitrogen gas with the high-temperature nitrogen gas A which is heated by the heating device 12 when an amount of the high-temperature nitrogen gas A supplied from the refrigerator 7 is less than a predetermined amount. The circulator 15 increases the pressure of the high-temperature nitrogen gas A heated by the heating device 12, and supplies the high-temperature nitrogen gas A to the heat exchanger 16.

25 **[0033]** The heat exchanger 16 transmits the heat of the high-temperature nitrogen gas A supplied from the circulator 15 to the LNG supplied from the booster pump 11. That is, the heat exchanger 16 generates low-temperature nitrogen gas A by cooling the high-temperature nitrogen gas A supplied from the circulator 15 using the LNG, and generates high-temperature LNG by heating the LNG supplied from the booster pump 11. The LNG heating device 5 supplies the low-temperature nitrogen gas A generated by the heat exchanger 16 to the refrigerator 7. The tank internal pressure suppression device 10 supplies the high-temperature LNG generated by the heat exchanger 16 to the engine 2.

35 **[0034]** The cold heat storage system 6 includes a valve 17, a liquefied nitrogen tank 18, and a valve 19. The valve 17 supplies liquefied nitrogen generated by the refrigerator 7 to the liquefied nitrogen tank 18, and a flow rate of the liquefied nitrogen supplied to the liquefied nitrogen tank 18 is changed by the control of the control device. The liquefied nitrogen tank 18 stores the liquefied nitrogen supplied from the valve 17. The valve 19 supplies the liquefied nitrogen stored in the liquefied nitrogen tank 18 to the refrigerator 7, and the flow rate of the liquefied nitrogen supplied to the refrigerator 7 is changed by the control of the control device.

45 **[0035]** The refrigerator 7 includes a cooling device 21, a first precooling device 22, a second precooling device 23, an expansion turbine 24, a heat exchanger 25, a condenser 26, a blower 27, and a gas-liquid separation device 28.

55 **[0036]** The cooling device 21 cools high-pressure nitrogen gas B, which is supplied from the combustion system 8 to the refrigerator 7, using sea water or the like. The first precooling device 22 transmits the heat of the

high-pressure nitrogen gas B cooled by the cooling device 21 to low-temperature and low-pressure nitrogen gas B and the low-temperature boil-off gas heated by the second precooling device 23. That is, the first precooling device 22 further cools the high-pressure nitrogen gas B cooled by the cooling device 21, and heats the low-temperature and low-pressure nitrogen gas B and the boil-off gas heated by the second precooling device 23. The second precooling device 23 transmits the heat of the high-pressure nitrogen gas B cooled by the first precooling device 22 to the low-temperature nitrogen gas B and the low-temperature and low-pressure nitrogen gas B heated by the condenser 26, and low-temperature boil-off gas generated by the gas-liquid separation device 28. That is, the second precooling device 23 cools the high-pressure nitrogen gas B cooled by the first precooling device 22, heats the low-temperature nitrogen gas B and the low-temperature and low-pressure nitrogen gas B heated by the condenser 26, and heats the low-temperature boil-off gas generated by the gas-liquid separation device 28. In this case, the refrigerator 7 supplies boil-off gas for combustion, which is generated by heating the low-temperature boil-off gas generated by the gas-liquid separation device 28 using the first precooling device 22 and the second precooling device 23, to the combustion system 8.

[0037] The expansion turbine 24 adiabatically expands low-temperature and high-pressure nitrogen gas B in which the high-pressure nitrogen gas B supplied from the combustion system 8 is cooled by the cooling device 21, the first precooling device 22, and the second precooling device 23, generates the low-temperature and low-pressure nitrogen gas B, and generates rotational driving power.

[0038] The heat exchanger 25 transmits the heat of the liquefied boil-off gas generated by the gas-liquid separation device 28, the heat of the LNG supplied from the LNG tank 1, and the condensation heat of the low-temperature nitrogen gas A supplied from the LNG heating device 5 and the low-temperature and low-temperature nitrogen gas B generated by the expansion turbine 24 and the liquefied nitrogen stored in the cold heat storage system 6. That is, the heat exchanger 25 generates the low-temperature LNG by cooling the LNG supplied from the LNG tank 1, and generates the low-temperature liquefied boil-off gas by cooling the liquefied boil-off gas generated by the gas-liquid separation device 28. Moreover, the heat exchanger 25 generates the liquefied nitrogen by cooling the low-temperature nitrogen gas A supplied from the LNG heating device 5. In addition, the heat exchanger 25 mixes the low-temperature and low-pressure nitrogen gas B generated by the expansion turbine 24 with the liquefied nitrogen supplied from the cold heat storage system 6, and heats the low-temperature and low-pressure nitrogen gas B. In this case, the refrigerator 7 supplies the low-temperature LNG and the low-temperature liquefied boil-off gas to the LNG tank 1, and supplies the liquefied nitrogen to the cold heat storage

system 6.

[0039] The condenser 26 transmits the condensation heat of the boil-off gas supplied from the LNG tank 1 to the refrigerator 7 to the low-temperature nitrogen gas A supplied from the LNG heating device 5, and the nitrogen gas B supplied from the heat exchanger 25. That is, the condenser 26 cools the boil-off gas so that the boil-off gas supplied from the LNG tank 1 to the refrigerator 7 is liquefied. In addition, the condenser 26 heats the low-temperature nitrogen gas A supplied from the LNG heating device 5, and further heats the low-temperature and low-pressure nitrogen gas heated by the heat exchanger 25. In this case, the refrigerator 7 supplies the high-temperature nitrogen gas A, which is generated by heating the low-temperature nitrogen gas A supplied from the LNG heating device 5 using the second precooling device 23 and the condenser 26, to the LNG heating device 5.

[0040] That is, the first precooling device 22 and the second precooling device 23 generate the low-pressure nitrogen gas A by heating the low-temperature and low-pressure nitrogen gas B which is used by the heat exchanger 25 and the condenser 26. The blower 27 increases the pressure of the low-pressure nitrogen gas B using the rotational driving power generated by the expansion turbine 24. In this case, the refrigerator 7 supplies the low-pressure nitrogen gas B, of which the pressure has been increased, to the combustion system 8.

[0041] The gas-liquid separation device 28 performs gas-liquid separation on the boil-off gas cooled by the condenser 26, and generates the liquefied boil-off gas which is liquid, and the low-temperature boil-off gas which is gas.

[0042] The combustion system 8 includes the gas combustion unit 31, a first flow rate adjusting valve 32, the second flow rate adjusting valve 33, an air-compression gas turbine 34, a refrigerant gas compression gas turbine 35, an air compressor 36, and a refrigerant gas compressor 37. The gas combustion unit 31 combusts the boil-off gas for combustion which is supplied from the refrigerator 7, using the compressed air generated by the air compressor 36, and generates high-temperature and high pressure pressurized exhaust gas.

[0043] The first flow rate adjusting valve 32 supplies the pressurized exhaust gas generated by the gas combustion unit 31 to the air-compression gas turbine 34, and changes the flow rate of the pressurized exhaust gas supplied to the air-compression gas turbine 34 by the control of the control device. The second flow rate adjusting valve 33 supplies the pressurized exhaust gas generated by the gas combustion unit 31 to the refrigerant gas compression gas turbine 35, and changes the flow rate of the pressurized exhaust gas supplied to the refrigerant gas compression gas turbine 35 by the control of the control device.

[0044] The air-compression gas turbine 34 generates rotation driving power using kinetic energy of the pressurized exhaust gas supplied from the first flow rate adjusting valve 32. The refrigerant gas compression gas

turbine 35 generates rotational driving power using kinetic energy of the pressurized exhaust gas supplied from the second flow rate adjusting valve 33.

[0045] The air compressor 36 compresses air using the rotational driving power generated by the air-compression gas turbine 34, and thus, generates compressed air. The refrigerant gas compressor 37 compresses the low-pressure nitrogen gas B generated by the refrigerator 7 using the rotational driving power generated by the refrigerant gas compression gas turbine 35, and thus, generates the high-pressure nitrogen gas B.

[0046] Regarding the rotational driving power of the refrigerant gas compressor 37, when the refrigerant gas compressor 37 uses the rotational driving power generated by the air-compression gas turbine 34, it is necessary to dispose the air-compression gas turbine 34, the air compressor 36, and the refrigerant gas compressor 37 in one row on a straight line, or it is necessary to include a device which changes the direction of the rotary axis of the rotational driving power.

[0047] Meanwhile, in the tank internal pressure suppression device 10, the refrigerant gas compressor 37 uses the rotational driving power which is generated by the air-compression gas turbine 34 and the separate refrigerant gas compression gas turbine 35. That is, the pressurized exhaust gas generated by the gas combustion unit 31 is dividedly supplied to the air-compression gas turbine 34 and the separate refrigerant gas compression gas turbine 35, thus it is not necessary to dispose the air-compression gas turbine 34, the air compressor 36, and the refrigerant gas compressor 37 in one row on a straight line, or it is not necessary to include a device which changes the direction of the rotary axis of the rotational driving power, and thus, it is possible to more easily manufacture the tank internal pressure suppression device. Accordingly, it is possible to more easily install the tank internal pressure suppression device 10 in the vessel main body.

[0048] The control device is a computer, and is electrically connected to the valve 17, the valve 19, the first flow rate adjusting valve 32, and the second flow rate adjusting valve 33 so as to transmit information.

[0049] When a load of the refrigerator 7 is smaller than a predetermined load, the control device controls the valve 17 so that the liquefied nitrogen generated by the refrigerator 7 is supplied to the liquefied nitrogen tank 18, and controls the valve 19 so that the liquefied nitrogen stored in the liquefied nitrogen tank 18 is not supplied to the refrigerator 7. In addition, when the load of the refrigerator 7 is larger than the predetermined load, the control device controls the valve 17 so that the liquefied nitrogen generated by the refrigerator 7 is not supplied to the liquefied nitrogen tank 18, and controls the valve 19 so that the liquefied nitrogen stored in the liquefied nitrogen tank 18 is supplied to the refrigerator 7.

[0050] Moreover, in order to maintain an amount of air supplied to the gas combustion unit 31 so as to be at a

predetermined flow rate, the control device controls the first flow rate adjusting valve 32 so that the rotational driving power generated by the air-compression gas turbine 34 is not changed, that is, so that the rotational driving power is equal to predetermined driving power. In addition, the control device controls the second flow rate adjusting valve 33 so that the rotational driving power generated by the refrigerant gas compression gas turbine 35 is not changed, that is, so that the rotational driving power is equal to the predetermined driving power.

[0051] An embodiment of a tank internal pressure suppression method is performed by the tank internal pressure suppression device 10, and includes an operation of a refrigeration loop, an operation of a cold heat storage loop, and an operation of a boil-off gas system.

[0052] In the refrigeration loop, the nitrogen gas B circulates through a refrigerant circuit which is formed of the refrigerant gas compressor 37, the cooling device 21, the first precooling device 22, the second precooling device 23, the expansion turbine 24, the heat exchanger 25, the condenser 26, and the blower 27. That is, the refrigerant gas compressor 37 generates the high-pressure nitrogen gas B by compressing the low-pressure nitrogen gas B generated by the refrigerator 7. The cooling device 21, the first precooling device 22, and the second precooling device 23 generate the low-temperature and high-pressure nitrogen gas B by precooling the high-pressure nitrogen gas B. The expansion turbine 24 generates the low-temperature and low-pressure nitrogen gas B by adiabatically expanding the low-temperature and high-pressure nitrogen gas B.

[0053] The heat exchanger 25 transmits the cold heat of the low-temperature and high-pressure nitrogen gas B to the liquefied boil-off gas generated by the gas-liquid separation device 28 and the LNG supplied from the LNG tank 1, and thus, cools the liquefied boil-off gas and the LNG. In this case, the tank internal pressure suppression device 10 supplies the low-temperature liquefied boil-off gas which is generated by cooling the liquefied boil-off gas and the low-temperature LNG which is generated by cooling the LNG in the LNG tank 1.

[0054] The condenser 26 cools the boil-off gas by transmitting the cold heat of the low-temperature and low-pressure nitrogen gas B supplied from the heat exchanger 25, to the boil-off gas supplied from the LNG tank 1 to the refrigerator 7. The first precooling device 22 and the second precooling device 23 generate low-pressure nitrogen gas by heating the second low-temperature and low-pressure nitrogen gas which is used by the heat exchanger 25 and the condenser 26. The refrigerator 7 supplies the low-pressure nitrogen gas B to the refrigerant gas compressor 37.

[0055] In the refrigeration loop, the refrigerator 7 can more appropriately generate the low-temperature and low-pressure nitrogen gas B by adiabatically expanding the low-temperature and high-pressure nitrogen gas B in which the high-pressure nitrogen gas B is precooled, and can more appropriately cool the LNG and the lique-

fied boil-off gas. In addition, since the refrigerator 7 uses the cold heat of the low-temperature and low-pressure nitrogen gas B so as to precool the high-pressure nitrogen gas B, it is possible to further decrease energy consumption.

[0056] Moreover, in the refrigeration loop, since the tank internal pressure suppression device 10 supplies the low-temperature LNG and the low-temperature liquefied boil-off gas to the LNG tank 1, it is possible to more appropriately cool the LNG stored in the LNG tank 1, and it is possible to more appropriately suppress the increase of the internal pressure of the LNG tank 1.

[0057] In the cold heat storage loop, the nitrogen gas circulates through a refrigerant circuit formed of the refrigerator 7, the heating device 12, the circulator 15, and the heat exchanger 16. That is, in this case, the condenser 26 of the refrigerator 7 cools the boil-off gas by transmitting the cold heat of the low-temperature nitrogen gas A which is supplied from the heating device 12 to the boil-off gas which is supplied from the LNG tank 1 to the refrigerator 7. The second precooling device 23 of the refrigerator 7 further cools the high-pressure nitrogen gas B by transmitting the cold heat of the low-temperature nitrogen gas to the high-pressure nitrogen gas B cooled by the first precooling device 22. The refrigerator 7 supplies the high-temperature nitrogen gas A, which is generated by heating the low-temperature nitrogen gas B using the condenser 26 and the first precooling device 22, to the heating device 12.

[0058] The heating device 12 heats the high-temperature nitrogen gas A. The circulator 15 supplies the high-temperature nitrogen gas A to the heat exchanger 16. The heat exchanger 16 cools the high-temperature nitrogen gas A by transmitting the heat of the high-temperature nitrogen gas A to the LNG supplied from the LNG tank 1, and heats the LNG. The LNG heating device 5 supplies the high-temperature LNG generated by heating the LNG to the engine 2, and supplies the low-temperature nitrogen gas A generated by cooling the high-temperature nitrogen gas A to the refrigerator 7.

[0059] In this case, the engine 2 generates the driving power by combusting the heated high-temperature LNG. The propulsion device 3 generates the propulsive force which propels the vessel main body using the driving power. The vessel main body is propelled by the propulsive force.

[0060] In addition, the heat exchanger 25 of the refrigerator 7 generates the liquefied nitrogen by cooling the low-temperature nitrogen gas A supplied from the LNG heating device 5. When the load of the refrigerator 7 is smaller than a predetermined load, the control device supplies the liquefied nitrogen generated by the refrigerator 7 to the liquefied nitrogen tank 18 by controlling the valve 17, and stops the supply of the liquefied nitrogen stored in the liquefied nitrogen tank 18 to the refrigerator 7 by controlling the valve 19. In addition, when the load of the refrigerator 7 is larger than the predetermined load, the control device stops the supply of the liquefied nitro-

gen generated by the refrigerator 7 to the liquefied nitrogen tank 18 by controlling the valve 17, and supplies the liquefied nitrogen stored in the liquefied nitrogen tank 18 to the refrigerator 7 by controlling the valve 19.

[0061] When the liquefied nitrogen from the cold heat storage system 6 is supplied to the refrigerator 7, the heat exchanger 25 of the refrigerator 7 further transmits the cold heat of the liquefied nitrogen to the liquefied boil-off gas generated by the gas-liquid separation device 28 and the LNG supplied from the LNG tank 1 to cool the LNG and the liquefied boil-off gas. The refrigerator 7 supplies the low-temperature LNG generated by cooling the LNG and the low-temperature liquefied boil-off gas generated by cooling the liquefied boil-off gas to the LNG tank 1.

[0062] In the cold heat storage loop, since the refrigerator 7 uses the cold heat of the low-temperature nitrogen gas A supplied from the LNG heating device 5, it is possible to decrease the load required for the cooling, and it is possible to more appropriately cool the LNG and the liquefied boil-off gas. In addition, since the refrigerator 7 uses the cold heat of the low-temperature nitrogen gas A supplied from the LNG heating device 5, it is possible to decrease consumption of the energy supplied from the outside. Since the tank internal pressure suppression device 10 decreases consumption of the energy required by the refrigerator 7, it is possible to decrease consumption of the energy supplied from the outside.

[0063] Moreover, since the refrigerator 7 uses the liquefied nitrogen stored by the cold heat storage system 6, even when the load of the refrigerator 7 is changed, it is possible to stably cool the LNG, and it is possible to stably liquefy and cool the boil-off gas. Since the refrigerator 7 stably cools the LNG and the boil-off gas, the tank internal pressure suppression device 10 can more stably control the increase of the internal pressure of the LNG tank 1.

[0064] The boil-off gas system is formed of the condenser 26, the gas-liquid separation device 28, the second precooling device 23, and the first precooling device 22. The condenser 26 generates the low-temperature boil-off gas by cooling the boil-off gas supplied from the LNG tank 1. The gas-liquid separation device 28 generates the liquefied boil-off gas which is liquid and the low-temperature boil-off gas which is gas by performing gas-liquid separation of the low-temperature boil-off gas. The second precooling device 23 and the first precooling device 22 generate the boil-off gas for combustion by heating the low-temperature boil-off gas. The refrigerator 7 supplies the boil-off gas for combustion to the combustion system 8.

[0065] The gas combustion unit 31 of the combustion system 8 combusts the boil-off gas for combustion supplied from the refrigerator 7, using the compressed air generated by the air compressor 36, and generates the high-temperature and high-pressure pressurized exhaust gas.

[0066] The control device supplies the pressurized ex-

haust gas to the air-compression gas turbine 34 at a predetermined flow rate so that the rotational driving power generated by the air-compression gas turbine 34 is constant by controlling the first flow rate adjusting valve 32. In addition, the control device supplies the pressurized exhaust gas to the refrigerant gas compression gas turbine 35 at a predetermined flow rate so that the rotational driving power generated by the refrigerant gas compression gas turbine 35 is constant by controlling the second flow rate adjusting valve 33.

[0067] The air-compression gas turbine 34 generates the rotational driving power using the kinetic energy of the pressurized exhaust gas supplied from the first flow rate adjusting valve 32. The air compressor 36 generates the compressed air by compressing air using the rotational driving power generated by the air-compression gas turbine 34.

[0068] The refrigerant gas compression gas turbine 35 generates the rotational driving power using the kinetic energy of the pressurized exhaust gas supplied from the second flow rate adjusting valve 33. The refrigerant gas compressor 37 generates the high-pressure nitrogen gas B by compressing the low-pressure nitrogen gas B generated by the refrigerator 7 using the rotational driving power generated by the refrigerant gas compression gas turbine 35.

[0069] In the boil-off gas system, the tank internal pressure suppression device 10 extracts the boil-off gas generated in the LNG tank 1 from the LNG tank 1, and it is possible to appropriately control the increase of the internal pressure of the LNG tank 1.

[0070] In addition, since the driving power is recovered by using the pressurized exhaust gas in which the boil-off gas is combusted by the gas combustion unit 31, and the refrigerator 7 is operated by the driving power, the LNG and the boil-off gas are stably cooled, and thus, it is possible to more stably suppress the increase of the internal pressure of the LNG tank 1.

[0071] Moreover, it is possible to use the tank internal pressure suppression device 10 in applications other than the vessel. For example, as the applications, the tank internal pressure suppression device 10 may be used in a single LNG tank 1, and float type liquefied natural gas production, storage, and shipping facility which ships the liquefied natural gas stored at sea in the tank. Similarly to in the tank internal pressure suppression device 10 of the above-described embodiment, it is possible to appropriately suppress the increase of the internal pressure of the LNG tank through the tank internal pressure suppression device used in the applications.

[0072] The refrigerator 7 can cool the LNG and the boil-off gas without using the low-temperature nitrogen gas A cooled by the LNG heating device 5. Accordingly, when it is not necessary to heat the LNG, for example, when the tank internal pressure suppression device 10 is not used in the vessel, the LNG heating device 5 can be replaced with a nitrogen gas supply device which supplies nitrogen gas to the refrigerator 7 without heating

the LNG. In this case, the heat exchanger 25 of the refrigerator 7 generates the liquefied nitrogen by liquefying the nitrogen gas supplied from the nitrogen gas supply device. Similarly to in the tank internal pressure suppression device 10 of the above-described embodiment, also by this tank internal pressure suppression device, it is possible to more stably suppress the increase of the internal pressure of the LNG tank 1. However, compared to the tank internal pressure suppression device, in the tank internal pressure suppression device 10 of the above-described embodiment, since the LNG and the boil-off gas is cooled using the low-temperature nitrogen gas cooled by the LNG heating device 5, it is possible to decrease the load of the refrigerator 7.

[0073] In addition, in the tank internal pressure suppression device 10, since the LNG and the boil-off gas can be sufficiently cooled, it is possible to omit the cold heat storage system 6. Similar to the tank internal pressure suppression device 10 of the above-described embodiment, also in this tank internal pressure suppression device in which the cold heat storage system 6 is omitted, it is possible to more appropriately suppress the increase of the internal pressure of the LNG tank 1.

[0074] The refrigerator 7 can be replaced with another refrigerator which precools the high-temperature nitrogen gas immediately before being adiabatically expanded without using the low-temperature and low-pressure refrigerant gas. For example, the refrigerator precools the high-pressure nitrogen by using the atmospheric cold heat. Similarly to in the tank internal pressure suppression device 10 of the above-described embodiment, also in this tank internal pressure suppression device in which the refrigerator is included, it is possible to appropriately suppress the increase of the internal pressure of the LNG tank 1. Moreover, in the refrigerator 7, the condenser 26 may be omitted. The refrigerator in which the condenser 26 is omitted can cool the LNG similar to the refrigerator 7, and it is possible to appropriately suppress the increase of the internal pressure of the LNG tank 1.

[0075] In another embodiment of the tank internal pressure suppression device, the combustion system 8 of the above-described embodiment is replaced with another combustion system. As shown in Fig. 2, a combustion system 50 includes a plurality of flow rate adjusting valves 51-1 to 51-n ($n = 2, 3, 4, \dots$), a plurality of gas combustion units 52-1 to 52-n, a plurality of gas turbines 53-1 to 53-n, an air compressor 54, and a refrigerant gas compressor 55.

[0076] The plurality of flow rate adjusting valves 51-1 to 51-n corresponds to the plurality of gas combustion units 52-1 to 52-n. An arbitrary flow rate adjusting valve 51-i ($i = 1, 2, 3, \dots, n$) among the plurality of flow rate adjusting valves 51-1 to 51-n supplies the boil-off gas for combustion generated by the refrigerator 7 to the gas combustion unit 52-i corresponding to the flow rate adjusting valve 51-i among the plurality of gas combustion units 52-1 to 52-n. In addition, the flow rate adjusting valve 51-i changes the flow rate of the boil-off gas for

combustion supplied to the gas combustion unit 52-i by the control of the control device.

[0077] The arbitrary gas combustion unit 52-i among the plurality of gas combustion units 52-1 to 52-n generates the high-temperature and high-pressure pressurized exhaust gas by combusting the boil-off gas for combustion supplied from the flow rate adjusting valve 51-i using the compressed air supplied from the air compressor 54.

[0078] The plurality of gas turbines 53-1 to 53-n corresponds to the plurality of gas combustion units 52-1 to 52-n. An arbitrary gas turbine 53-i among the plurality of gas turbines 53-1 to 53-n generates the rotational driving power using the kinetic energy of the pressurized exhaust gas generated by the gas combustion unit 52-i corresponding to the gas turbine 53-i among the plurality of gas combustion units 52-1 to 52-n.

[0079] The air compressor 54 generates the compressed air by compressing air using the rotational driving power generated by the air-compression gas turbine 53-1 among the plurality of gas turbines 53-1 to 53-n. The air compressor 54 supplies the generated compressed air to the plurality of gas combustion units 52-1 to 52-n.

[0080] The refrigerant gas compressor 55 generates the high-pressure nitrogen gas by compressing the low-pressure nitrogen gas generated by the refrigerator 7, using the rotational driving power generated by the refrigerant gas compression gas turbine 53-2 among the plurality of gas turbines 53-1 to 53-n. The refrigerant gas compressor 55 supplies the generated high-pressure nitrogen gas to the refrigerator 7.

[0081] In this case, the control device controls the flow rate adjusting valve 51-i so that the rotational driving power generated by the air-compression gas turbine 53-i is not changed, that is, the rotational driving power is equal to predetermined driving power.

[0082] Similarly to in the tank internal pressure suppression device 10 of the above-described embodiment, in this tank internal pressure suppression device including the combustion system 50, it is possible to effectively use surplus energy generated from the boil-off gas for combustion generated by the refrigerator 7, and it is possible to easily manufacture the tank internal pressure suppression device. In addition, compared to the tank internal pressure suppression device 10 of the above-described embodiment, also in this tank internal pressure suppression device, by changing the flow rate of the boil-off gas for combustion which is generated by the refrigerator 7 and supplied to each of the plurality of gas combustion units 52-1 to 52-n, it is possible to more easily change the plurality of rotational driving powers generated by the plurality of gas turbines 53-1 to 53-n. Accordingly, it is possible to effectively use the plurality of rotational driving powers with respect to the loads for driving other devices.

[0083] Moreover, the refrigerator 7 can be replaced with another device which appropriately supplies the boil-

off gas generated by the LNG tank 1 to the combustion system 8 or the combustion system 50 without cooling the LNG and the boil-off gas. Similarly to in the tank internal pressure suppression device 10 of the above-described embodiment, also in the tank internal pressure suppression device in which the refrigerator 7 is omitted, it is possible to appropriately control the increase of the internal pressure of the LNG tank 1 by extracting the boil-off gas from the LNG tank 1. In addition, similarly to in the tank internal pressure suppression device 10 of the above-described embodiment, also in this tank internal pressure suppression device, since the load different from the air compressor 54 (36) uses the rotational driving powers which are generated by the air-compression gas turbine 53-1 (34) and the separate gas turbine, it is possible to more easily manufacture the tank internal pressure suppression device.

[0084] In addition, the refrigerant gas compressor 55 (37) can use driving power which is generated by a driving power source different from the refrigerant gas compression gas turbine 53-2 (35). For example, the driving power source may include a motor which generates the rotational driving power using electric power. Similarly to in the tank internal pressure suppression device 10 of the above-described embodiment, also in the tank internal pressure suppression device in which this driving power source is used, it is possible to more appropriately suppress the increase of the internal pressure of the LNG tank 1. Compared to this tank internal pressure suppression device, in the tank internal pressure suppression device 10 of the above-described embodiment, it is possible to more effectively use surplus driving power generated by the boil-off gas, and it is possible to further decrease consumption of energy.

Reference Signs List

[0085]

- 1: LNG TANK
- 2: ENGINE
- 3: PROPULSION DEVICE
- 5: LNG HEATING DEVICE
- 6: COLD HEAT STORAGE SYSTEM
- 7: REFRIGERATOR
- 8: COMBUSTION SYSTEM
- 10: TANK INTERNAL PRESSURE SUPPRESSION DEVICE
- 11: BOOSTER PUMP
- 12: HEATING DEVICE
- 14: REFRIGERANT GAS SUPPLY DEVICE
- 15: CIRCULATOR
- 16: HEAT EXCHANGER
- 22: FIRST PRECOOLING DEVICE
- 23: SECOND PRECOOLING DEVICE
- 24: EXPANSION TURBINE
- 25: HEAT EXCHANGER
- 26: CONDENSER

32: FIRST FLOW RATE ADJUSTING VALVE
 33: SECOND FLOW RATE ADJUSTING VALVE
 34: AIR-COMPRESSION GAS TURBINE
 35: REFRIGERANT GAS COMPRESSION GAS
 TURBINE 5
 36: AIR COMPRESSOR
 37: REFRIGERANT GAS COMPRESSOR
 50: COMBUSTION SYSTEM
 51-1 to 51-n: PLURALITY OF FLOW RATE AD-
 JUSTING VALVE 10
 53-1 to 53-n: PLURALITY OF GAS TURBINE
 54: AIR COMPRESSOR
 55: REFRIGERANT GAS COMPRESSOR 15

Claims

1. A tank internal pressure suppression device, comprising:

a gas combustion unit that generates pressurized exhaust gas by combusting boil-off gas generated inside a tank using compressed air; a plurality of gas turbines that divide and use the pressurized exhaust gas, and generate a plurality of driving powers;
 a compressor that compresses air using the driving power generated by an air-compression gas turbine among the plurality of gas turbines, and generates the compressed air; and
 a load that uses recovered driving power generated by a power recovery gas turbine different from the air-compression gas turbine among the plurality of gas turbines.

2. The tank internal pressure suppression device according to claim 1,
 wherein the gas combustion unit includes a plurality of gas combustor elements corresponding to the plurality of gas turbines, and
 wherein an arbitrary gas turbine among the plurality of gas turbines generates the driving power using the pressurized exhaust gas generated by the gas combustor element corresponding to the arbitrary gas turbine among the plurality of gas combustor elements.

3. The tank internal pressure suppression device according to claim 1 or 2, further comprising:

a refrigerator that supplies low-temperature LNG, which is generated by cooling the LNG using high-pressure refrigerant gas, to the tank, wherein the load generates the high-pressure refrigerant gas by compressing low-pressure refrigerant gas using the recovered driving power.

4. The tank internal pressure suppression device ac-

cording to claim 3,
 wherein the refrigerator includes:

a heat exchanger A that generates low-temperature and high-pressure refrigerant gas by cooling the high-pressure refrigerant gas;
 an expansion turbine that generates low-temperature and low-pressure refrigerant gas by adiabatically expanding the low-temperature and high-pressure refrigerant gas; and
 a heat exchanger B that generates the low-temperature LNG by cooling the LNG stored in the tank using the low-temperature and low-pressure refrigerant gas,
 wherein the heat exchanger A and the heat exchanger B generate the low-pressure refrigerant gas by heating the low-temperature and low-pressure refrigerant gas.

5. The tank internal pressure suppression device according to claim 4,
 wherein the refrigerator further includes a condenser that generates liquefied boil-off gas by liquefying the boil-off gas,

wherein the heat exchanger B supplies low-temperature liquefied boil-off gas, which is generated by cooling the liquefied boil-off gas, to the tank, and
 wherein the condenser heats the low-temperature and low-pressure refrigerant gas.

6. The tank internal pressure suppression device according to any one of claims 3 to 5, further comprising:

a cold heat storage system,
 wherein the heat exchanger B stores liquefied refrigerant gas, which is generated by cooling low-temperature refrigerant gas, in the cold heat storage system, and cools the LNG using the liquefied refrigerant gas.

7. The tank internal pressure suppression device according to claim 6, further comprising:

an LNG heating device that generates high-temperature LNG by heating the LNG using high-temperature refrigerant gas,
 wherein the refrigerator generates the high-temperature refrigerant gas by heating the low-temperature refrigerant gas, and
 wherein the LNG heating device generates the low-temperature refrigerant gas by cooling the high-temperature refrigerant gas.

8. A vessel, comprising:

the tank internal pressure suppression device according to claim 7;

an engine that generates propulsion driving power using the high-temperature LNG; and a propulsion device that propels a vessel main body using the propulsion driving power.

9. A tank internal pressure suppression method, comprising:

a step of generating pressurized exhaust gas by combusting boil-off gas using compressed air; a step of generating the compressed air by compressing air using driving power which is generated using the pressurized exhaust gas through an air-compression gas turbine among a plurality of gas turbines; and a step of operating a load using recovered driving power which is generated using the pressurized exhaust gas by a power recovery gas turbine different from the air-compression gas turbine among the plurality of gas turbines.

10. A tank internal pressure suppression device, comprising:

a refrigerator that generates liquefied boil-off gas by cooling boil-off gas generated inside a tank which stores LNG and supplies the liquefied boil-off gas to the tank; and an LNG heating device that generates high-temperature LNG by heating the LNG using high-temperature refrigerant gas, wherein the refrigerator generates the high-temperature refrigerant gas by heating low-temperature refrigerant gas, and wherein the LNG heating device generates the low-temperature refrigerant gas by cooling the high-temperature refrigerant gas.

Amended claims under Art. 19.1 PCT

1. (Amended) A tank internal pressure suppression device, comprising:

a gas combustion unit that generates pressurized exhaust gas by combusting boil-off gas generated inside a tank using compressed air; a plurality of gas turbines that generate a plurality of motive forces using the pressurized exhaust gas; a compressor that compresses air using the motive force generated by an air-compression gas turbine among the plurality of gas turbines, and generates the compressed air; a refrigerant gas compressor that generates compressed high-pressure refrigerant gas using a recovered motive force which is generated by a motive force recovery gas turbine different

from the air-compression gas turbine among the plurality of gas turbines; and a refrigerator that supplies low-temperature LNG, which is generated by cooling LNG stored in the tank using the high-pressure refrigerant gas, to the tank.

2. The tank internal pressure suppression device according to claim 1, wherein the gas combustion unit includes a plurality of gas combustor elements corresponding to the plurality of gas turbines, and wherein an arbitrary gas turbine among the plurality of gas turbines generates the motive force using the pressurized exhaust gas generated by the gas combustor element corresponding to the arbitrary gas turbine among the plurality of gas combustor elements.

3. (Deleted)

4. (Amended) The tank internal pressure suppression device according to claim 1 or 2, wherein the refrigerator includes:

a first heat exchanger that generates low-temperature and high-pressure refrigerant gas by cooling the high-pressure refrigerant gas; an expansion turbine that generates low-temperature and low-pressure refrigerant gas by adiabatically expanding the low-temperature and high-pressure refrigerant gas; and a second heat exchanger that generates the low-temperature LNG by cooling the LNG using the low-temperature and low-pressure refrigerant gas, wherein the first heat exchanger and the second heat exchanger generate the low-pressure refrigerant gas by heating the low-temperature and low-pressure refrigerant gas, and wherein the refrigerator gas compressor generates the high-pressure refrigerant gas by compressing the low-pressure refrigerant gas.

5. The tank internal pressure suppression device according to claim 4, wherein the refrigerator further includes a condenser that generates liquefied boil-off gas by liquefying the boil-off gas, wherein the second heat exchanger supplies low-temperature liquefied boil-off gas, which is generated by cooling the liquefied boil-off gas, to the tank, and wherein the condenser heats the low-temperature and low-pressure refrigerant gas.

6. (Amended) The tank internal pressure suppression device according to any one of claims 1 to 5,

further comprising:

a cold heat storage system,
wherein the second heat exchanger stores liquefied refrigerant gas, which is generated by cooling low-temperature refrigerant gas, in the cold heat storage system, and cools the LNG using the liquefied refrigerant gas. 5

7. The tank internal pressure suppression device according to claim 6, further comprising: 10

an LNG heating device that generates high-temperature LNG by heating the LNG using high-temperature refrigerant gas, wherein the refrigerator generates the high-temperature refrigerant gas by heating the low-temperature refrigerant gas, and wherein the LNG heating device generates the low-temperature refrigerant gas by cooling the high-temperature refrigerant gas. 15 20

8. A vessel, comprising:

the tank internal pressure suppression device according to claim 7; 25
an engine that generates a propulsion motive force using the high-temperature LNG; and
a propulsion device that propels a vessel main body using the propulsion motive force. 30

9. (Amended) A tank internal pressure suppression method, comprising:

a step of generating pressurized exhaust gas by combusting boil-off gas generated inside tank using compressed air; 35
a step of generating the compressed air by compressing air using a motive force which is generated using the pressurized exhaust gas through an air-compression gas turbine among a plurality of gas turbines; 40
a step of generating compressed high-pressure refrigerant gas using a recovered motive force which is generated using the pressurized exhaust gas by a motive force recovery gas turbine different from the air-compression gas turbine among the plurality of gas turbines; and 45
a step of supplying low-temperature LNG, which is generated by cooling LNG stored in the tank using the high-pressure refrigerant gas, to the tank. 50

10. (Deleted)

55

FIG. 1

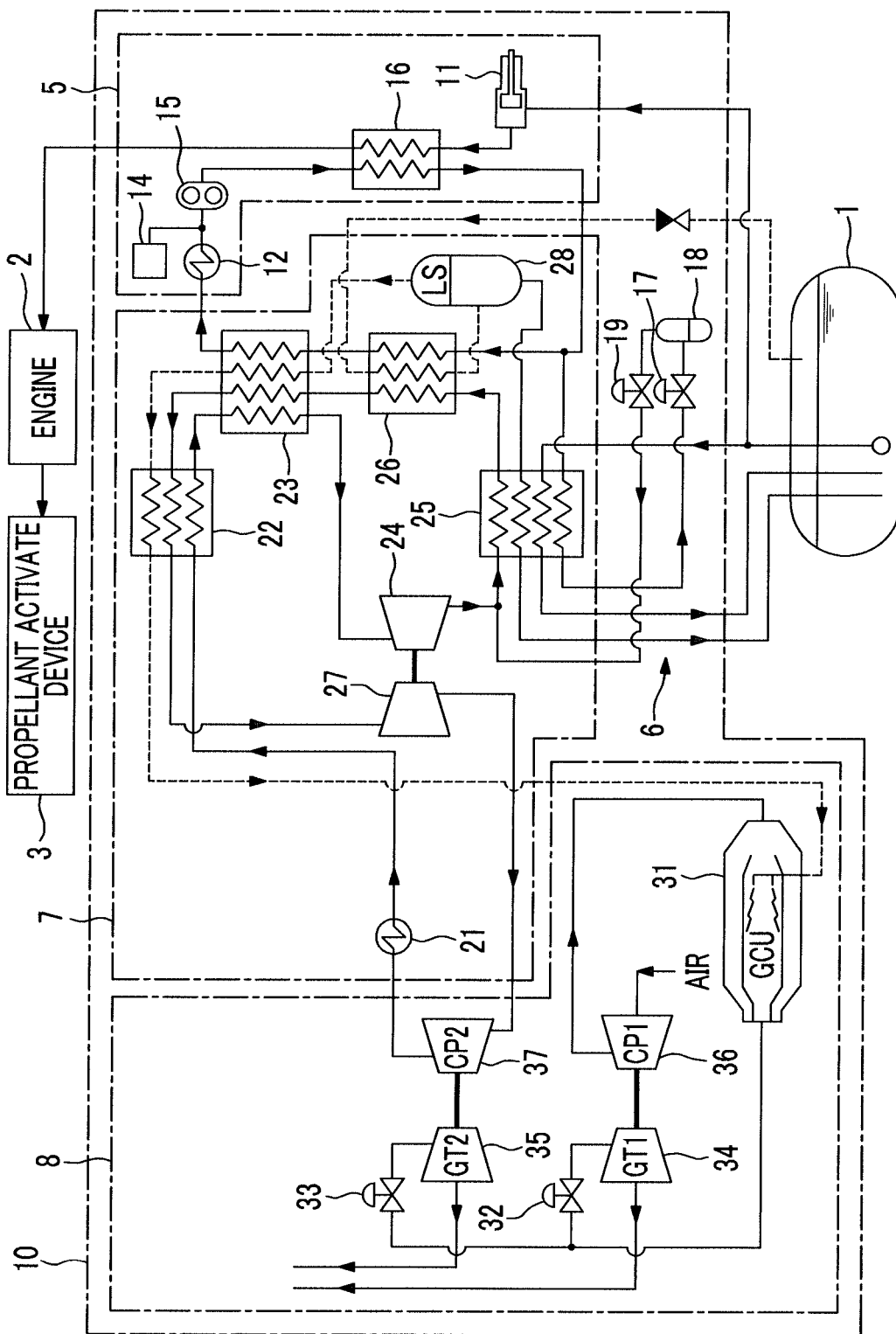
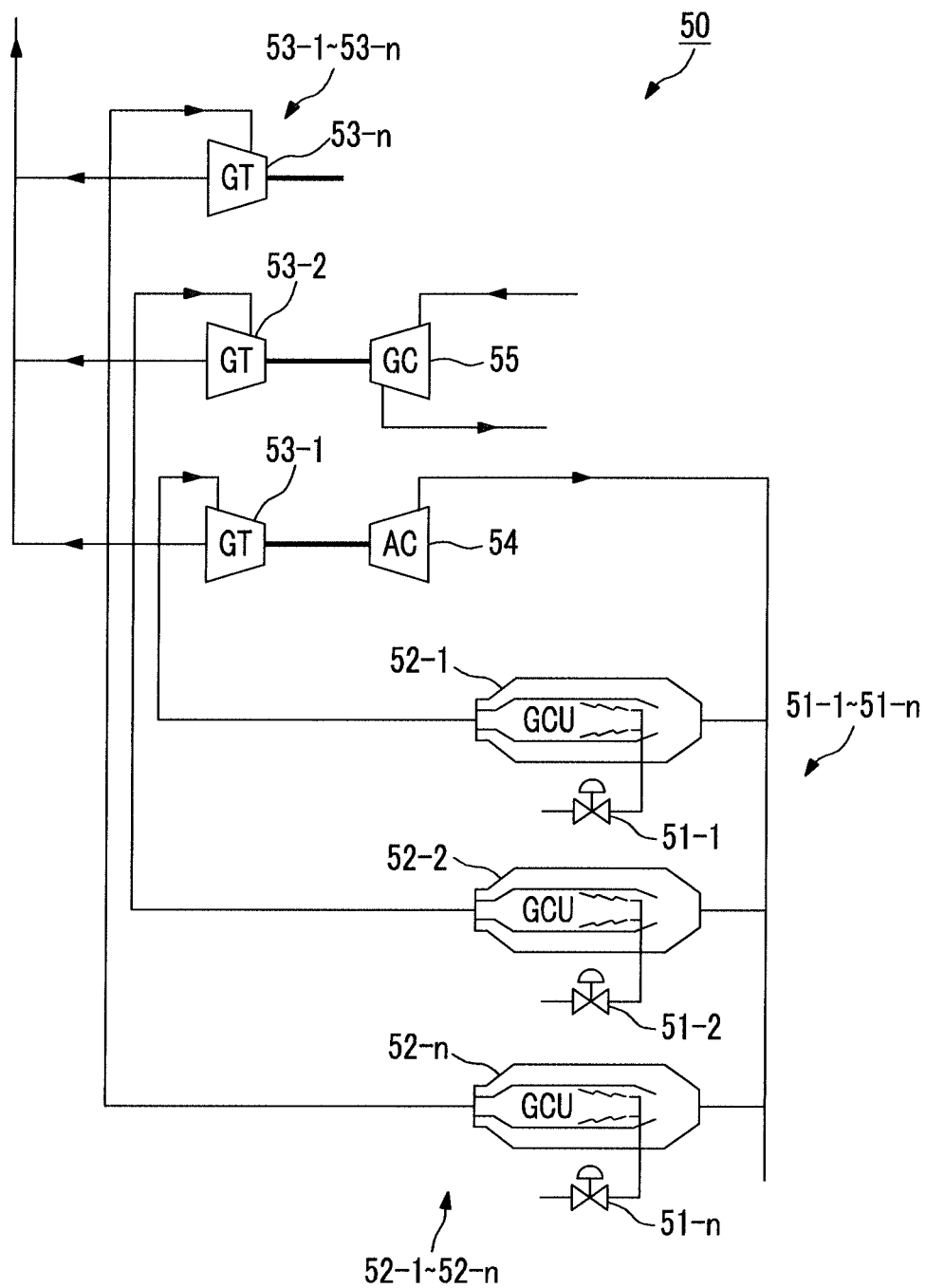


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/054087

A. CLASSIFICATION OF SUBJECT MATTER

F17C13/00(2006.01)i, B63B25/16(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)

F17C1/00-13/12, B63B25/16, F02B43/00, F02C1/00-9/58

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	WO 2008/136119 A1 (Hitachi, Ltd.), 13 November 2008 (13.11.2008), paragraphs [0019] to [0137], [0173] to [0188]; fig. 1, 5 & JP 4859980 B2	1-2, 9
Y	WO 2010/092945 A1 (Kawasaki Heavy Industries, Ltd.), 19 August 2010 (19.08.2010), paragraphs [0036] to [0039]; fig. 1 (Family: none)	1-2, 9
X A	JP 2009-204026 A (Mitsubishi Heavy Industries, Ltd.), 10 September 2009 (10.09.2009), paragraphs [0027] to [0056]; fig. 1 (Family: none)	10 3-8

☒ 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

"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

20 May, 2014 (20.05.14)

Date of mailing of the international search report

03 June, 2014 (03.06.14)

Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/054087

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 10-2012-0052500 A (DAEWOO SHIPBUILDING & MARINE ENGINEERING CO., LTD.), 24 May 2012 (24.05.2012), paragraphs [0012] to [0024]; fig. 1 to 2 (Family: none)	1, 8-9
A	JP 2010-274905 A (MAN Diesel SE), 09 December 2010 (09.12.2010), paragraphs [0034] to [0052]; fig. 1 & CN 101898548 A & KR 10-2010-0127692 A & DE 102009022711 A1	1, 8-9
A	JP 4-5703 Y2 (Osaka Gas Co., Ltd.), 18 February 1992 (18.02.1992), column 3, line 43 to column 4, line 16; fig. 2 (Family: none)	1, 9
A	US 2928254 A (THE GARRETT CORP.), 15 March 1960 (15.03.1960), column 2, line 29 to column 3, line 40; fig. 3 (Family: none)	10

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/054087

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/054087

Continuation of Box No.III of continuation of first sheet(2)

In brief, the special technical feature of the invention in Claims 1-9 relates to generating pressurized exhaust gas by burning boil-off gas and diverting the pressurized exhaust for use in generating compressed air by compressing air using an air-compressing gas turbine and to operating a load using a power-collecting gas turbine that differs from the air-compressing gas turbine. In brief, the special technical feature of the invention in Claim 10 relates to generating a liquefied boil-off gas by cooling the boil-off gas and generating a high temperature refrigerant gas by heating a low temperature refrigerant gas using a refrigerator, and to generating a high temperature LNG by heating LNG using high temperature refrigerant gas and generating a low temperature refrigerant gas by cooling high temperature refrigerant gas using an LNG-heating device. Since there is no technical relationship between these inventions involving one or more of the same or corresponding special technical features, these inventions are not so linked as to form a single general inventive concept.

The invention in Claim 3 is not adequately supported by the description. This is because there is substantially no description or suggestion regarding the matter in Claim 3 of "a refrigerator for supplying low temperature LNG, which is generated by cooling the LNG using a high pressure refrigerant gas, to the tank" in the description. To begin with, said matter does not match the matter in Claim 4, which refers back to Claim 3, of "generating low temperature LNG by cooling LNG stored in the tank using the low temperature low pressure refrigerant gas".

Moreover, given that the matter of "the load generating the high pressure refrigerant gas by compressing low pressure refrigerant gas using the collected power" is described in Claim 3, in approving the invention in Claim 3, it is difficult to conveniently ignore only the matter of "the refrigerator for supplying low temperature LNG, which is generated by cooling the LNG using high pressure refrigerant gas, to the tank" in Claim 3. Since it is appropriate to interpret the "refrigerator" that is supported by the description to be the one described in Claim 4, the search was conducted with the limited interpretation that the invention in Claim 3 is provided with a "refrigerator" as described in Claim 4.

INTERNATIONAL SEARCH REPORT

International application No.

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5 The invention in Claim 3 is not adequately supported by the description. This is because there is substantially no description or suggestion regarding the matter in Claim 3 of "a refrigerator for supplying low temperature LNG, which is generated by cooling the LNG using a high pressure refrigerant gas, to the tank" in the description. To begin with, said matter does not match the matter in Claim 4, which cites Claim 3, of "generating low temperature LNG by cooling LNG stored in the tank using the low temperature low pressure refrigerant gas".

10 Moreover, given that the matter of "the load generating the high pressure refrigerant gas by compressing low pressure refrigerant gas using the collected power" is described in Claim 3, in approving the invention in Claim 3, it is difficult to conveniently ignore only the matter of "the refrigerator for supplying low temperature LNG, which is generated by cooling the LNG using high pressure refrigerant gas, to the tank" in Claim 3. Since it is appropriate to interpret the "refrigerator" that is supported by the description to be the one described in Claim 4, the search was conducted with the limited interpretation that the invention in Claim 3 is provided with a "refrigerator" as described in Claim 4.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4859980 B [0003] [0004]