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(54) BOIL-OFF GAS RECOVERY SYSTEM

ABDAMPF-RÜCKGEWINNUNGSSYSTEM

SYSTÈME DE RÉCUPÉRATION DU GAZ PAR ÉVAPORATION

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(73) Proprietor: **Kabushiki Kaisha Kobe Seiko Sho (Kobe Steel, Ltd.)**
Kobe-shi, Hyogo, 651-8585 (JP)

(72) Inventors:
- **TEZUKA, Satoshi**
  Takasago-shi, Hyogo 676-8670 (JP)
- **SEYAMA, Katsuhiro**
  Takasago-shi, Hyogo 676-8670 (JP)
- **AKAMO, Naoki**
  Takasago-shi, Hyogo 676-8670 (JP)

(74) Representative: **TBK**
Bavariaring 4-6
80336 München (DE)

(56) References cited:
WO-A1-2011/084813 **KR-A- 20160 126 955**
US-A1- 2016 114 876

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Description

BACKGROUND OF THE INVENTION

(FIELD OF THE INVENTION)

[0001] The present invention relates to a boil-off gas recovery system.

(DESCRIPTION OF THE RELATED ART)

[0002] In a liquefied natural gas transportation ship, since a liquefied natural gas stored in a tank is gasified by heat coming from the outside when transferred at sea, a boil-off gas is generated. This boil-off gas is effectively utilized as fuel for an engine, a steam boiler, or a generator in the ship, and an extra gas is re-liquefied and then returned to the tank. As a technique to re-liquefy the boil-off gas generated in the tank and to return the boil-off gas to the tank in such a way, a boil-off gas recovery system described in JP 2015-158263 A is known.

[0003] In the boil-off gas recovery system of JP 2015-158263 A, as described in FIG. 7, a boil-off gas generated in a tank 11 is compressed by an oil supply type compressor 15, and part of the compressed boil-off gas is re-liquefied through cooling by a heat exchanger 14 and expansion by an expansion valve 17 and then returned to the tank 11. Lubricating oil used in the compressor 15 can be mixed into the boil-off gas discharged from the compressor 15. Therefore, in the boil-off gas recovery system of JP 2015-158263 A, a filter for removing oil content contained in the boil-off gas is arranged in a second pipe 16.

[0004] In the boil-off gas recovery system of JP 2015-158263 A, the oil content contained in the boil-off gas is removed by the filter. However, the oil content in a vaporous state may sometimes pass through the filter. Therefore, it is difficult to sufficiently remove the oil content in a vaporous state. Thus, since the oil content passing through the filter is coagulated and precipitated in a flow passage of the heat exchanger 14, the flow passage is narrowed down. As a result, there is a problem that a heat exchange performance is remarkably deteriorated.

[0005] Furthermore, a boil-off gas recovery system according to the preamble of claim 1 is known from KR 2016 0126955 A. Further boil-off gas recovery systems are disclosed in US 2016/114876 A1 and WO 2011/084813 A1.

SUMMARY OF THE INVENTION

[0006] The present invention is achieved in consideration with the above problem, and an object of the present invention is to provide a boil-off gas recovery system capable of suppressing performance deterioration of a heat exchanger in a boil-off gas re-liquefying system.

[0007] A boil-off gas recovery system according to the present invention includes a tank where a liquefied gas is stored, a reciprocating compressor to which poly-α-olefin lubricating oil is supplied, the compressor that compresses a boil-off gas generated by vaporization of part of the liquefied gas in the tank, an oil separation unit that separates the poly-α-olefin lubricating oil contained in the boil-off gas which is discharged from the compressor, and a re-liquefying system having a heat exchanger that cools the boil-off gas from which the poly-α-olefin lubricating oil is already separated by the oil separation unit by heat exchange with the boil-off gas supplied to the compressor from the tank, the re-liquefying system where the liquefied boil-off gas is returned to the tank.

[0008] The above boil-off gas recovery system includes the compressor to which the poly-α-olefin lubricating oil is supplied. The poly-α-olefin lubricating oil has much less vapor pressure than mineral lubricating oil generally used in a reciprocating compressor. Therefore, in comparison to a boil-off gas recovery system including the reciprocating compressor in which the mineral lubricating oil is used, an amount of oil content in a vaporous state contained in the boil-off gas which is discharged from the compressor can be reduced to a great extent. Thus, by separating the oil content in a mist state or a liquid state contained in the boil-off gas after compression by the oil separation unit, an amount of the oil content flowing into the heat exchanger in the re-liquefying system can be reduced to a great extent. Therefore, since precipitation of the oil content in a flow passage of the heat exchanger is suppressed, performance deterioration of the heat exchanger can be suppressed.

[0009] The above boil-off gas recovery system may further include a reuse system where the poly-α-olefin lubricating oil separated by the oil separation unit is returned to the compressor.

[0010] With this configuration, by reusing the poly-α-olefin lubricating oil, cost can be reduced. In particular, since the poly-α-olefin lubricating oil is expensive, a cost reduction effect by including the reuse system is remarkable.

[0011] As clear from the above description, according to the present invention, the boil-off gas recovery system capable of suppressing the performance deterioration of the heat exchanger in the boil-off gas re-liquefying system can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG. 1 is a diagram schematically showing a configuration of a boil-off gas recovery system according to a first embodiment of the present invention.

FIG. 2 is a diagram schematically showing a configuration of a re-liquefying system provided in the above boil-off gas recovery system.

FIG. 3 is a diagram schematically showing a configuration of a reuse system provided in the above boil-off gas recovery system.

FIG. 4 is a diagram schematically showing a configuration of a boil-off gas recovery system according to one of other embodiments of the present invention.

FIG. 5 is a diagram schematically showing a configuration of a boil-off gas recovery system according to one of other embodiments of the present invention.

FIG. 6 is a diagram schematically showing a configuration of a boil-off gas recovery system according to one of other embodiments of the present invention.

FIG. 7 is a diagram schematically showing a configuration of a boil-off gas recovery system according to the conventional example.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] Hereinafter, a boil-off gas recovery system according to embodiments of the present invention will be described in detail on the basis of the drawings.

(FIRST EMBODIMENT)

[0014] Firstly, a boil-off gas recovery system 1 according to a first embodiment of the present invention will be described with reference to FIGS. 1 to 3. FIG. 1 is a schematic configuration diagram showing the boil-off gas recovery system 1 according to the first embodiment. FIG. 2 is a schematic configuration diagram showing a re-liquefying system 9 in the boil-off gas recovery system 1 according to the first embodiment. FIG. 3 is a schematic configuration diagram showing a reuse system 50 in the boil-off gas recovery system 1 according to the first embodiment.

<Entire Configuration of Boil-off Gas Recovery System>

[0015] The boil-off gas recovery system 1 is installed in a ship that transports a liquefied gas such as a liquefied natural gas. As shown in FIG. 1, the boil-off gas recovery system 1 mainly includes a tank 2, a compressor group 3, a cooler 51, a separator 14 (oil separation unit), the re-liquefying system 9, the reuse system 50, pipes connecting these constituent elements to each other, and various control valves provided in the pipes.

[0016] The tank 2 is to store a liquefied gas 100 such as a liquefied natural gas. The liquefied natural gas is stored in the tank 2 in a temperature state of about -160°C. In the tank 2, by vaporization of part of the liquefied gas 100 due to in-coming of heat from the outside, a boil-off gas 100A is generated. The tank 2 is not limited to the one to store the liquefied natural gas but may be the one to store other types of the liquefied gas 100 such as a liquefied petroleum gas.

[0017] The compressor group 3 is connected to the tank 2 via a first pipe 4. The boil-off gas 100A generated in the tank 2 passes through the inside of the first pipe 4 and is supplied to the compressor group 3. The compressor group 3 includes a non-oil supply type compressor 3a that does not require lubricating oil, and an oil supply type compressor 3b that requires the lubricating oil. The non-oil supply type and oil supply type compressors 3a, 3b compress the boil-off gas 100A generated due to vaporization of part of the liquefied gas 100 in the tank 2. The oil supply type compressor 3b is arranged in a subsequent part of the non-oil supply type compressor 3a. The non-oil supply type compressor 3a may be omitted.

[0018] The non-oil supply type compressor 3a has two compression stages 3aa. The oil supply type compressor 3b has three compression stages 3bb. The number of the compression stages can be set in accordance with the types of the liquefied gas 100 so that pressure of the boil-off gas can be boosted to be pressure required for re-liquefaction. Therefore, the number of the compression stages is not limited to five of the present embodiment but may be four or less or may be six or more.

[0019] Each of the non-oil supply type and oil supply type compressors 3a, 3b is a reciprocating compressor. That is, the compressors 3a, 3b boost the pressure of the boil-off gas suctioned into a cylinder via a suction port by reciprocating motion of a piston and discharge the boil-off gas whose pressure is boosted from a discharge port. A cylinder valve is provided in each of the suction port and the discharge port.

[0020] Poly-α-olefin (PAO) lubricating oil is supplied to the oil supply type compressor 3b. The poly-α-olefin lubricating oil has a narrower molecular mass distribution and much less vapor pressure than mineral lubricating oil generally used in a reciprocating compressor. That is, the poly-α-olefin lubricating oil has a much less vaporous component than the mineral lubricating oil. The lubricating oil used in the compressor 3b can be mixed into the boil-off gas discharged from the oil supply type compressor 3b. However, by using the poly-α-olefin lubricating oil having a less vaporous component, an amount of oil content in a vaporous state contained in the boil-off gas which is discharged from the oil supply type compressor 3b can be reduced to a great extent.

[0021] The poly-α-olefin lubricating oil contains base oil made of poly-α-olefin or the hydrogenated product of poly-α-olefin, and various additive agents. Poly-α-olefin is an oligomer or a polymer obtained by polymerizing a straight-chain alpha-olefin having a double bond at a terminal (alpha position) as a material. The poly-α-olefin lubricating oil is synthesized lubricating oil characterized in a high viscosity index and a low pour point.

[0022] As a monomer used for polymerization of poly-α-olefin, for example, α-olefin of 3 to 20 carbons can be used, and α-olefin of 8 to 12 carbons is preferably used. Specifically, the α-olefin includes propylene, 1-butene, 1-pentene, 1-hexene, 1-octene, 1-nonene, 1-decene, 1-dodecene, 1-tridecene, 1-tetradecene, 1-pentadecene, 1-hexadecene, 1-heptadecene, 1-octadecene, 1-nonadecene, and 1-eicosene. In particular, α-olefin selected from the group consisting of 1-octene, 1-decene, and 1-

dodecene is preferable, and 1-decene is more preferable.

[0023] The cooler 51 is to cool the boil-off gas compressed by the compressors 3a, 3b, and is arranged in a subsequent part of the compressors 3a, 3b. The cooler 51 cools the boil-off gas by heat exchange with using sea water, for example. By cooling in the cooler 51, a temperature of the boil-off gas supplied to an engine 6 and the like can be adjusted to be a predetermined temperature. At this time, the oil content in a vaporous state contained in the boil-off gas can also be condensed.

[0024] The separator 14 is to separate poly-α-olefin lubricating oil in a liquid state (mist state) contained in the boil-off gas which is discharged from the compressor 3b, and is arranged in a subsequent part of the cooler 51. The separator 14 is connected to the compressor 3b via a second pipe 5. The cooler 51 is provided in the middle of the second pipe 5. As shown in FIG. 1, the separator 14 has a main body portion 25 having a cylindrical shape, and a small diameter portion 26 having a cylindrical shape whose diameter is smaller than that of the main body portion 25, the small diameter portion being arranged in the main body portion 25. An outer surface of this small diameter portion 26 is formed in a mesh shape.

[0025] The boil-off gas cooled by the cooler 51 passes through the inside of the second pipe 5 and flows into the small diameter portion 26 from the upper end side of the small diameter portion 26 of the separator 14. As shown by a broken line in FIG. 1, the boil-off gas flows from an upper end toward a lower end in the small diameter portion 26 and then passes through the mesh on the outer surface of the small diameter portion 26. At this time, the lubricating oil in a mist state contained in the boil-off gas does not pass through the mesh but is accumulated on a bottom of the small diameter portion 26. The boil-off gas passes through the mesh of the small diameter portion 26 and then flows out of the separator 14 from a gas outlet provided on a side surface of the main body portion 25. In such a way, by using a mesh structure of the small diameter portion 26, the lubricating oil contained in the boil-off gas can be separated. The oil content accumulated on the bottom of the small diameter portion 26 passes through mesh holes and drips down to a bottom of the main body portion 25 (reference numeral 101 in FIG. 1). A level sensor 24 that detects whether or not a liquid level of the oil content 101 accumulated on the bottom of the main body portion 25 exceeds a predetermined reference level is provided in the separator 14.

[0026] One end of a gas outlet pipe 5A is connected to a gas outlet of the separator 14. As shown in FIG. 1, the gas outlet pipe 5A branches into three at a first part 5AA. The branching pipes are connected to the engine 6, a gas combustion unit 7, and a generator 8, respectively. Thereby, the boil-off gas from which the oil content in a liquid state is already removed by the separator 14 can be respectively supplied to the engine 6, the gas combustion unit 7, and the generator 8. Control valves (not shown) may be respectively provided in the branching pipes. By controlling open/close of these control valves, supply amounts of the boil-off gas to the engine 6, the gas combustion unit 7, and the generator 8 can be adjusted.

[0027] The engine 6 generates propulsion force for a ship by combusting the supplied boil-off gas. The generator 8 generates electric power required for driving various devices of the ship by performing power generation with the supplied boil-off gas as fuel. The gas combustion unit 7 combusts and safely processes an extra boil-off gas in a case where a generation amount of the boil-off gas exceeds an amount required as fuel for the engine 6 and the generator 8.

<Re-liquefying System>

[0028] Next, the re-liquefying system 9 provided in the above boil-off gas recovery system 1 will be described mainly with reference to FIGS. 1 and 2. The re-liquefying system 9 cools and expands to re-liquefy the boil-off gas whose pressure is boosted by the compressors 3a, 3b. The re-liquefying system 9 mainly has a third pipe 10, a heat exchanger 16, a fourth pipe 17, an expansion valve 18, a gas-liquid separation unit 19, a fifth pipe 21, and a sixth pipe 20.

[0029] The third pipe 10 has one end connected to a second part 5AB of the gas outlet pipe 5A placed on the upstream side of the first part 5AA, and the other end connected to the heat exchanger 16. Thereby, the boil-off gas from which the oil content in a liquid state is already separated by the separator 14 passes through the gas outlet pipe 5A, flows into the third pipe 10 from the second part 5AB, and is supplied to the heat exchanger 16. As shown in FIG. 1, a first control valve 29 is provided in the third pipe 10. By controlling open/close of this valve, an amount of the boil-off gas flowing into the third pipe 10 from the gas outlet pipe 5A can be adjusted.

[0030] The heat exchanger 16 cools the boil-off gas to a liquefiable temperature (for example, -100°C). As shown in FIG. 2, the heat exchanger 16 has a low-temperature side passage 16a through which the boil-off gas fed to the compressors 3a, 3b from the tank 2 passes, and a high-temperature side passage 16b through which the boil-off gas from which the oil content (poly-α-olefin lubricating oil) in a liquid state is already separated by the separator 14 passes.

[0031] The heat exchanger 16 performs heat exchange between the boil-off gas supplied to the compressors 3a, 3b from the tank 2 (boil-off gas passing through the low-temperature side passage 16a) and the boil-off gas from which the oil content in a liquid state is already separated by the separator 14 (boil-off gas passing through the high-temperature side passage 16b). By this heat exchange, the boil-off gas passing through the high-temperature side passage 16b is cooled. At this time, part of the boil-off gas may be liquefied. The boil-off gas passing through the low-temperature side passage 16a is heated, for example, from -160°C to -50°C.

[0032] As shown in FIG. 2, the first pipe 4 is connected to an inlet and an outlet of the low-temperature side passage 16a. The other end of the third pipe 10 is connected to an inlet of the high-temperature side passage 16b. One end of the fourth pipe 17 is connected to an outlet of the high-temperature side passage 16b.

[0033] The fourth pipe 17 has the one end connected to the heat exchanger 16, and the other end connected to the gas-liquid separation unit 19. The expansion valve 18 is to expand the boil-off gas cooled in the heat exchanger 16 to reduce the pressure, and is provided in the middle of the fourth pipe 17. By this expansion valve 18, part of the boil-off gas is liquefied.

[0034] The gas-liquid separation unit 19 is to separate the boil-off gas partly liquefied by the heat exchanger 16 and the expansion valve 18 into a liquid component and a gas component. One end of the fifth pipe 21 and one end of the sixth pipe 20 are respectively connected to the gas-liquid separation unit 19.

[0035] The sixth pipe 20 has the one end connected to a bottom portion of the gas-liquid separation unit 19, and the other end connected to the tank 2. Thereby, the liquid component of the boil-off gas separated in the gas-liquid separation unit 19 can be returned to the tank 2 via the sixth pipe 20.

[0036] The fifth pipe 21 connects the gas-liquid separation unit 19 and the first pipe 4 to each other, and also connects the gas-liquid separation unit 19 and the gas combustion unit 7 to each other. More specifically, the fifth pipe 21 branches into two branching pipes 21A, 21B at a first part 21AA. One branching pipe 21A is connected to the first pipe 4 on the outlet side of the heat exchanger 16, and the other branching pipe 21B is connected to the gas combustion unit 7. Thereby, the gas component of the boil-off gas separated in the gas-liquid separation unit 19 can respectively flow into the first pipe 4 and the gas combustion unit 7 via the fifth pipe 21.

[0037] As shown in FIG. 2, a second control valve 31 and a third control valve 30 are respectively provided in the branching pipes 21A, 21B. By these valves, opening degrees of flow passages of the boil-off gas in the branching pipes 21A, 21B can be adjusted. Thereby, an amount of the boil-off gas flowing into the side of the first pipe 4 and an amount of the boil-off gas flowing into the side of the gas combustion unit 7 can be respectively adjusted.

<Reuse System>

[0038] Next, the reuse system 50 provided in the above boil-off gas recovery system 1 will be described mainly with reference to FIGS. 1 and 3. The reuse system 50 is to return the lubricating oil (poly-α-olefin lubricating oil) in a liquid state separated from the boil-off gas by the separator 14 to the oil supply type compressor 3b. As shown in FIG. 3, the reuse system 50 mainly has a first oil pipe 52, a fourth control valve 52A, a strainer 53, an oil tank 54, an oil supplementation source 551, a second oil pipe 57, an oil pump 56, an oil charging unit 55, and plural (three in the present embodiment) third oil pipes 55A, 55B, 55C.

[0039] The first oil pipe 52 has one end connected to a bottom portion of the main body portion 25 in the separator 14, and the other end connected to an upper portion of the oil tank 54. The fourth control valve 52A and the strainer 53 are provided in the first oil pipe 52. As shown in FIG. 3, the strainer 53 is provided on the downstream side of the fourth control valve 52A.

[0040] By opening the fourth control valve 52A, the lubricating oil accumulated on the bottom of the separator 14 (main body portion 25) can flow into the first oil pipe 52. The fourth control valve 52A may be opened when the level sensor 24 detects the fact that the liquid level of the oil content 101 exceeds the predetermined reference level. By the lubricating oil passing through the strainer 53, foreign substances and the like contained in the lubricating oil can be removed.

[0041] The oil tank 54 stores the lubricating oil from which foreign substances are removed by the strainer 53. The oil supplementation source 551 for supplementing unused poly-α-olefin lubricating oil is connected to the oil tank 54. Thereby, by adding the unused lubricating oil to the lubricating oil recovered by the separator 14 from the oil supplementation source 551, an amount of the lubricating oil in the oil tank 54 can be adjusted.

[0042] The second oil pipe 57 has one end connected to a lower portion of the oil tank 54, and the other end connected to an inlet of the oil charging unit 55. The oil pump 56 is provided in the middle of the second oil pipe 57. By activating this oil pump 56, the lubricating oil stored in the oil tank 54 can be supplied to the oil charging unit 55 via the second oil pipe 57.

[0043] The oil charging unit 55 is to supply the lubricating oil to the oil supply type compressor 3b. The oil charging unit 55 is activated by a motor 55D. The oil charging unit 55 has plural (three in the present embodiment) outlets, and one ends of the third oil pipes 55A, 55B, 55C are respectively connected to the outlets. The other ends of the third oil pipes 55A, 55B, 55C are respectively connected to the compression stages 3bb. The number of the outlets in the oil charging unit 55 and the number of the third oil pipes are the same as the number of the compression stages in the oil supply type compressor 3b. Thereby, the lubricating oil can be supplied to the oil supply type compressor 3b from the oil charging unit 55 via the third oil pipes 55A, 55B, 55C. In such a way, the poly-α-olefin lubricating oil recovered by the separator 14 can be returned to the oil supply type compressor 3b and reused as lubricating oil for the piston.

<Operations and Effects>

[0044] Next, characteristic configurations and operations and effects of the boil-off gas recovery system 1 according to the above first embodiment will be described.

[0045] The above boil-off gas recovery system 1 includes the tank 2 where the liquefied gas 100 is stored, the reciprocating compressor 3b to which the poly-α-olefin lubricating oil is supplied, the compressor that compresses the boil-off gas 100A generated by vaporization of part of the liquefied gas 100 in the tank 2, the separator 14 (oil separation unit) that separates the poly-α-olefin lubricating oil in a mist state contained in the boil-off gas which is discharged from the compressor 3b, and the re-liquefying system 9 having the heat exchanger 16 that cools the boil-off gas from which the poly-α-olefin lubricating oil in a mist state is already separated by the separator 14 by heat exchange with the boil-off gas supplied to the compressor 3b from the tank 2, the re-liquefying system where the liquefied boil-off gas is returned to the tank 2.

[0046] The above boil-off gas recovery system 1 includes the compressor 3b to which the poly-α-olefin lubricating oil is supplied. The poly-α-olefin lubricating oil has much less vapor pressure than the mineral lubricating oil generally used in the reciprocating compressor. Therefore, in comparison to the boil-off gas recovery system including the reciprocating compressor in which the mineral lubricating oil is used, the amount of the oil content in a vaporous state contained in the boil-off gas which is discharged from the compressor 3b can be reduced to a great extent. Thus, by separating the oil content in a mist state or a liquid state contained in the boil-off gas after compression by the separator 14, the amount of the oil content flowing into the heat exchanger 16 of the re-liquefying system 9 can be reduced to a great extent. Therefore, since precipitation of the oil content in a flow passage of the heat exchanger 16 is suppressed, performance deterioration of the heat exchanger 16 can be suppressed.

[0047] With the above boil-off gas recovery system 1, precipitation of the oil content in the fourth pipe 17 placed on the downstream side of the heat exchanger 16 can also be suppressed. When the oil content is condensed and precipitated in the fourth pipe 17, at the time of restart of the system or the like, there is a possibility that the oil content brought into a liquid state under a normal temperature is brought to the downstream side together with the boil-off gas and mixed into the tank 2. For this, with the above boil-off gas recovery system 1, the precipitation of the oil content in the fourth pipe 17 can also be suppressed. Thus, mixture of the oil content into the tank 2 can also be prevented.

[0048] The above boil-off gas recovery system 1 includes the reuse system 50 where the poly-α-olefin lubricating oil separated by the separator 14 is returned to the compressor 3b. By reusing the poly-α-olefin lubricating oil by this reuse system 50, cost can be reduced. In particular, since the poly-α-olefin lubricating oil is expensive, a cost reduction effect by including the reuse system 50 is remarkable.

(OTHER EMBODIMENTS)

[0049] Finally, other embodiments of the present invention will be described.

[0050] In the above first embodiment, the case where the boil-off gas recovery system 1 includes the lubricating oil reuse system 50 is described. However, the present invention is not limited to this. As shown in FIG. 4, a boil-off gas recovery system 1A where a lubricating oil reuse system is omitted may be provided.

[0051] In the boil-off gas recovery system 1 according to the above first embodiment, the cooler 51 may be omitted.

[0052] In the above first embodiment, the case where the lubricating oil is separated from the boil-off gas by using the separator 14 having the small diameter portion 26 whose outer surface is formed in a mesh shape is described as one example of the oil separation unit. However, the lubricating oil can also be separated by other oil separation units. For example, an oil separation unit using a baffle plate or an oil separation unit of centrifugal separation may be used.

[0053] In the above first embodiment, the configuration in which the boil-off gas after passing through the last compression stage 3bb is guided to the re-liquefying system 9 is described. However, the present invention is not limited to this. As shown in FIG. 5, the third pipe 10 in the re-liquefying system 9 may be connected to a portion between the compression stages 3bb in the oil supply type compressor 3b. In this case, the cooler 51 and the separator 14 are also arranged in the portion between the compression stages 3bb. Thereby, the boil-off gas extracted from a middle part of the compressor 3b can be guided to the re-liquefying system 9.

[0054] In the above first embodiment, the case where the third oil pipes 55A, 55B, 55C for returning the lubricating oil separated from the boil-off gas are directly connected to the oil supply type compressor 3b is described. However, the present invention is not limited to this. As shown in FIG. 6, each of the third oil pipes 55A, 55B, 55C may be connected to a portion between the compression stages 3aa, 3bb. With this configuration, in comparison to the case where the third oil pipes 55A, 55B, 55C are directly connected to the oil supply type compressor 3b, power required for pressure-feeding the lubricating oil can be less required.

[0055] The present invention is not limited to the configuration in which the lubricating oil recovered by the separator 14 and the unused lubricating oil are mixed and then supplied to the oil supply type compressor 3b as in the reuse system 50 in the above first embodiment. The lubricating oil recovered by the separator 14 and the unused lubricating oil may be separately supplied to the compressor 3b. The oil charging unit 55 may be omitted and the lubricating oil may be supplied to the oil supply type compressor 3b directly from the oil tank 54 by the oil pump 56.

[0056] The embodiments disclosed herein should be understood as not restriction but only examples in all aspects. The scope of the present invention is indicated not by the above description but by the claims, and is intended to include equivalent meanings to the claims and all modifications within the scope.

[0057] A boil-off gas recovery system capable of suppressing performance deterioration of a heat exchanger in a boil-off gas re-liquefying system is provided.

[0058] A boil-off gas recovery system includes a tank where a liquefied gas is stored, a reciprocating compressor to which poly-α-olefin lubricating oil is supplied, the compressor that compresses a boil-off gas generated by vaporization of part of the liquefied gas in the tank, a separator that separates the poly-α-olefin lubricating oil contained in the boil-off gas which is discharged from the compressor, and a re-liquefying system having a heat exchanger that cools the boil-off gas from which the poly-α-olefin lubricating oil is already separated by the separator by heat exchange with the boil-off gas supplied to the compressor from the tank, the re-liquefying system where the liquefied boil-off gas is returned to the tank.

Claims

1. A boil-off gas recovery system (1) comprising:

a tank (2) where a liquefied gas is stored;
a reciprocating compressor (3b) to which lubricating oil is supplied, the compressor (3b) that compresses a boil-off gas generated by vaporization of part of the liquefied gas in the tank (2);
an oil separation unit (14) that separates the lubricating oil contained in the boil-off gas which is discharged from the compressor (3b); and
a re-liquefying system (9) having a heat exchanger (16) that cools the boil-off gas from which the lubricating oil is already separated by the oil separation unit (14) by heat exchange with the boil-off gas supplied to the compressor (3b) from the tank (2), the re-liquefying system (9) where the liquefied boil-off gas is returned to the tank (2), **characterized in that**
the lubricating oil is a poly-α-olefin.

2. The boil-off gas recovery system (1) according to claim 1, further comprising:
a reuse system (50) where the poly-α-olefin lubricating oil separated by the oil separation unit (14) is returned to the compressor (3b).

Patentansprüche

1. Abdampfgas-Rückgewinnungssystem (1) mit:

einem Tank (2), wo ein verflüssigtes Gas gespeichert ist;
einem Hubkolbenverdichter (3b), welchem Schmieröl zugeführt wird, wobei der Verdichter (3b) ein Abdampfgas verdichtet, das durch Verdampfen eines Teils des verflüssigten Gases in dem Tank (2) erzeugt wird;
eine Ölabscheideeinheit (14), die das Schmieröl abscheidet, das in dem Abdampfgas enthalten ist, welches von dem Verdichter (3b) abgegeben wird; und
ein Rückverflüssigungssystem (9) mit einem Wärmetauscher (16), der das Abdampfgas, von welchem das Schmieröl bereits durch die Ölabscheideeinheit (14) abgeschieden ist, durch Wärmeaustausch mit dem Abdampfgas kühlt, das dem Verdichter (3b) aus dem Tank (2) zugeführt wird, wobei das verflüssigte Abdampfgas von dem Rückverflüssigungssystem (9) in den Tank (2) zurückgeführt wird, **dadurch gekennzeichnet, dass**
das Schmieröl ein Poly-α-Olefin ist.

2. Abdampfgas-Rückgewinnungssystem (1) nach Anspruch 1, ferner mit:
einem Wiederverwendungssystem (50), bei dem das durch die Ölabscheideeinheit (14) abgeschiedene Poly-α-Olefin-Schmieröl in den Verdichter (3b) zurückgeführt wird.

Revendications

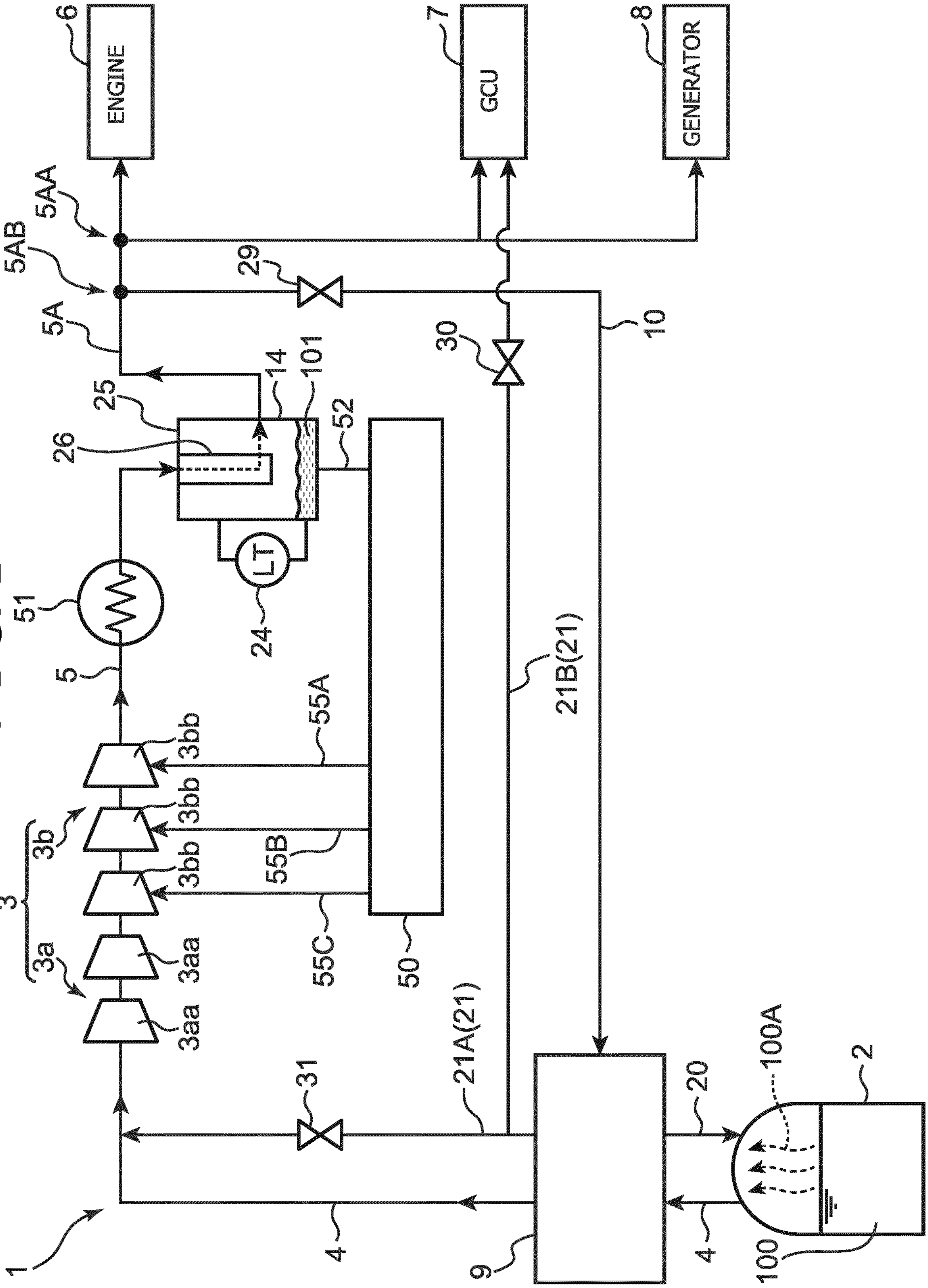
1. Système de récupération de gaz d'évaporation (1) comprenant :

un réservoir (2) dans lequel est stocké un gaz liquéfié;
un compresseur réciproque (3b) auquel l'huile de lubrification est fournie, le compresseur (3b) qui comprime un gaz d'évaporation généré par vaporisation d'une partie du gaz liquéfié dans le réservoir (2) ;
une unité de séparation d'huile (14) qui sépare l'huile de lubrification contenue dans le gaz d'évaporation qui est déchargé du compresseur (3b) ; et
un système de re-liquéfaction (9) ayant un échangeur de chaleur (16) qui refroidit le gaz d'évaporation duquel l'huile de lubrification est déjà séparée par l'unité de séparation d'huile (14) par échange de chaleur avec le gaz d'évaporation fourni au compresseur (3b) depuis le réservoir (2), le système de re-liquéfaction (9) où le gaz d'évaporation liquéfié est ramené au réservoir (2), **caractérisé en ce que** :
l'huile de lubrification est une poly-α-oléfine.

2. Système de récupération de gaz d'évaporation (1) selon la revendication 1, comprenant en outre :

un système de réutilisation (50) dans lequel l'huile de lubrification à base de poly-α-oléfine séparée par l'unité de séparation d'huile (14) est ramenée au compresseur (3b).

FIG. 1


ENGINE
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2
3
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3aa
3b
3bb
4
5
5A
5AA
5AB
6
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8
9
10
14
20
21A(21)
21B(21)
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25
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29
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31
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51
52
55A
55B
55C
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100A
101

FIG. 2

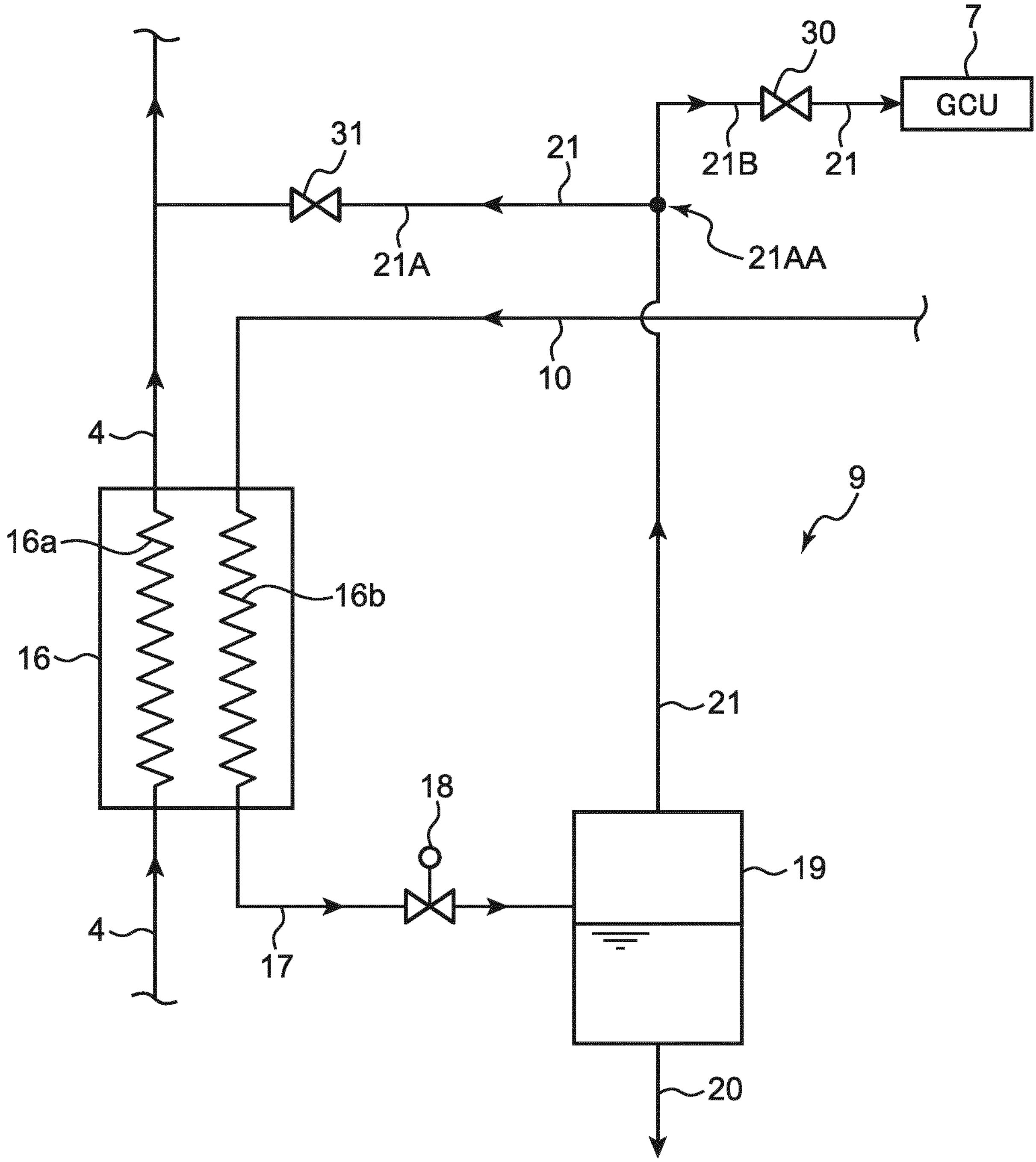
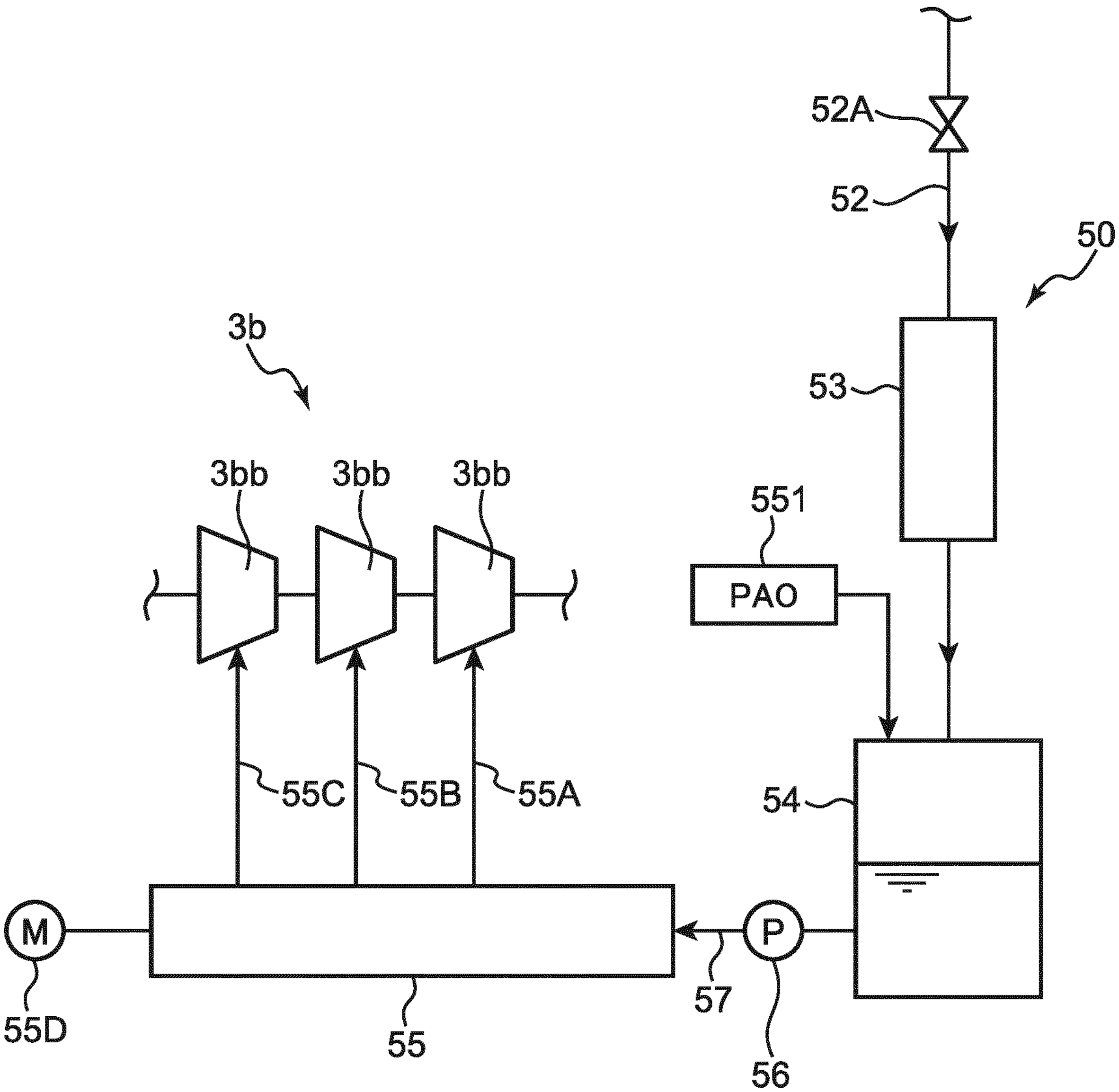
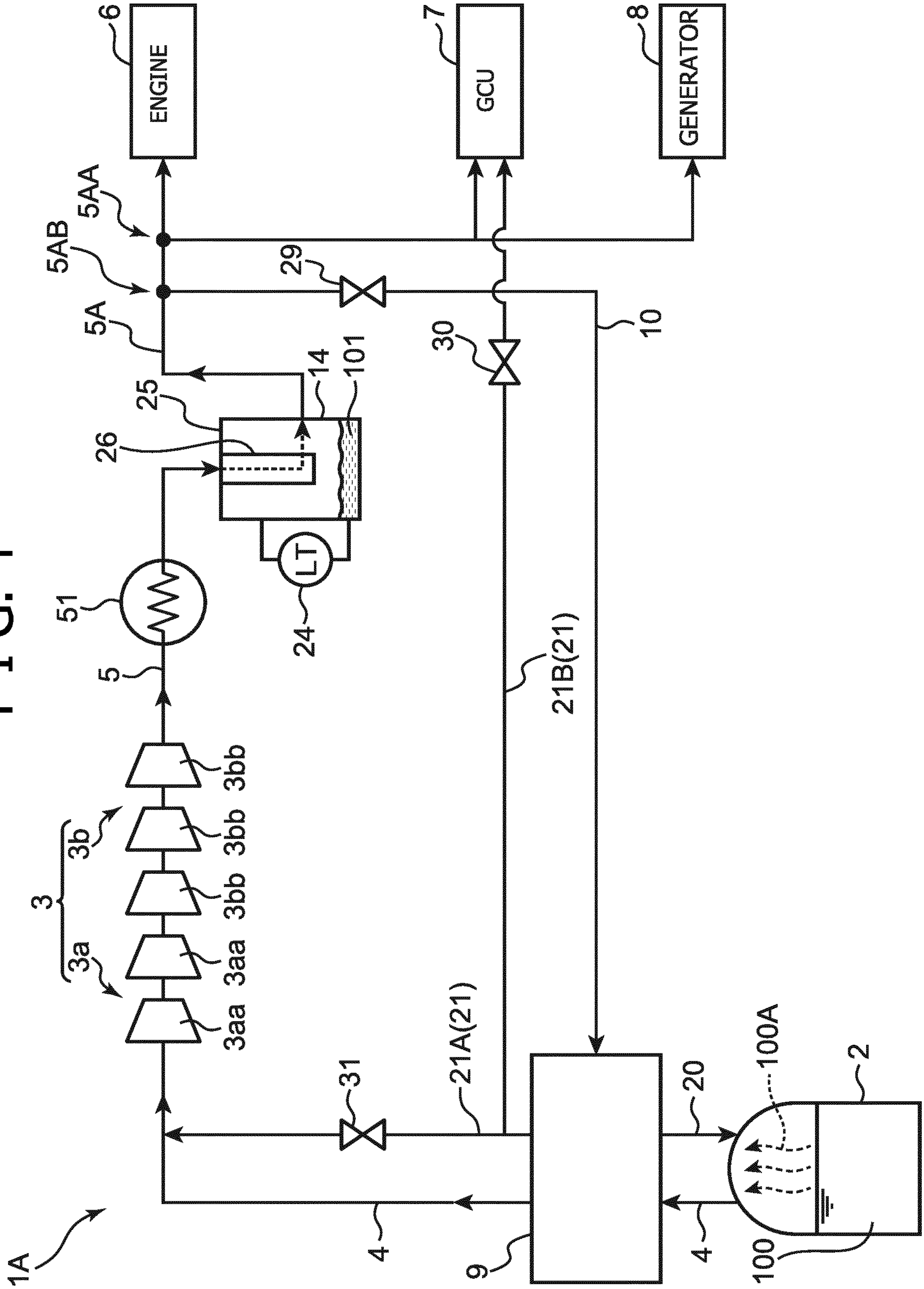


FIG. 3



F I G. 4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7
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14
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21A(21)
21B(21)
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26
29
30
31
51
100
100A
101

FIG. 5

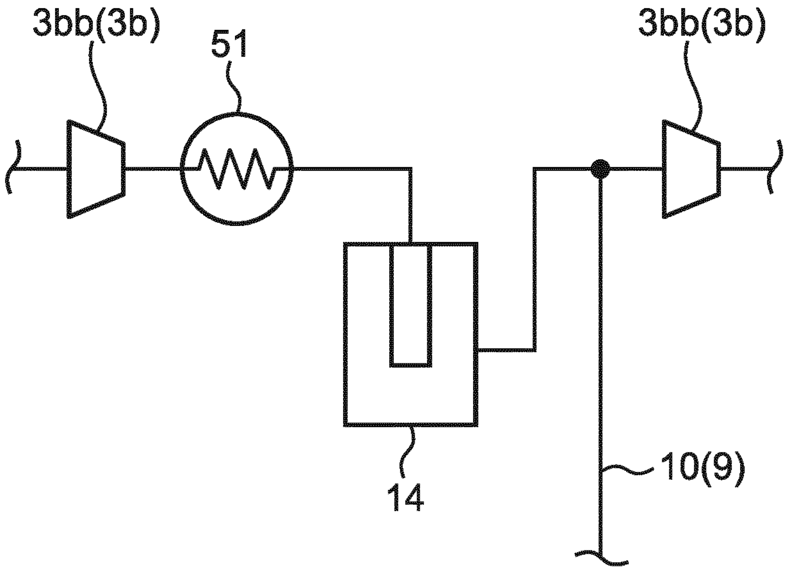
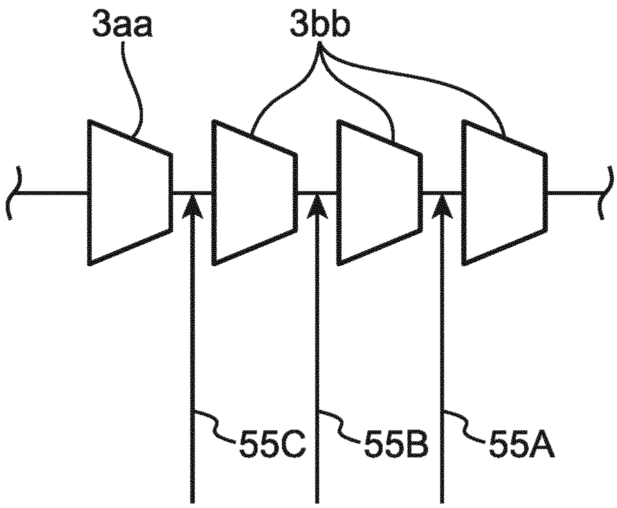
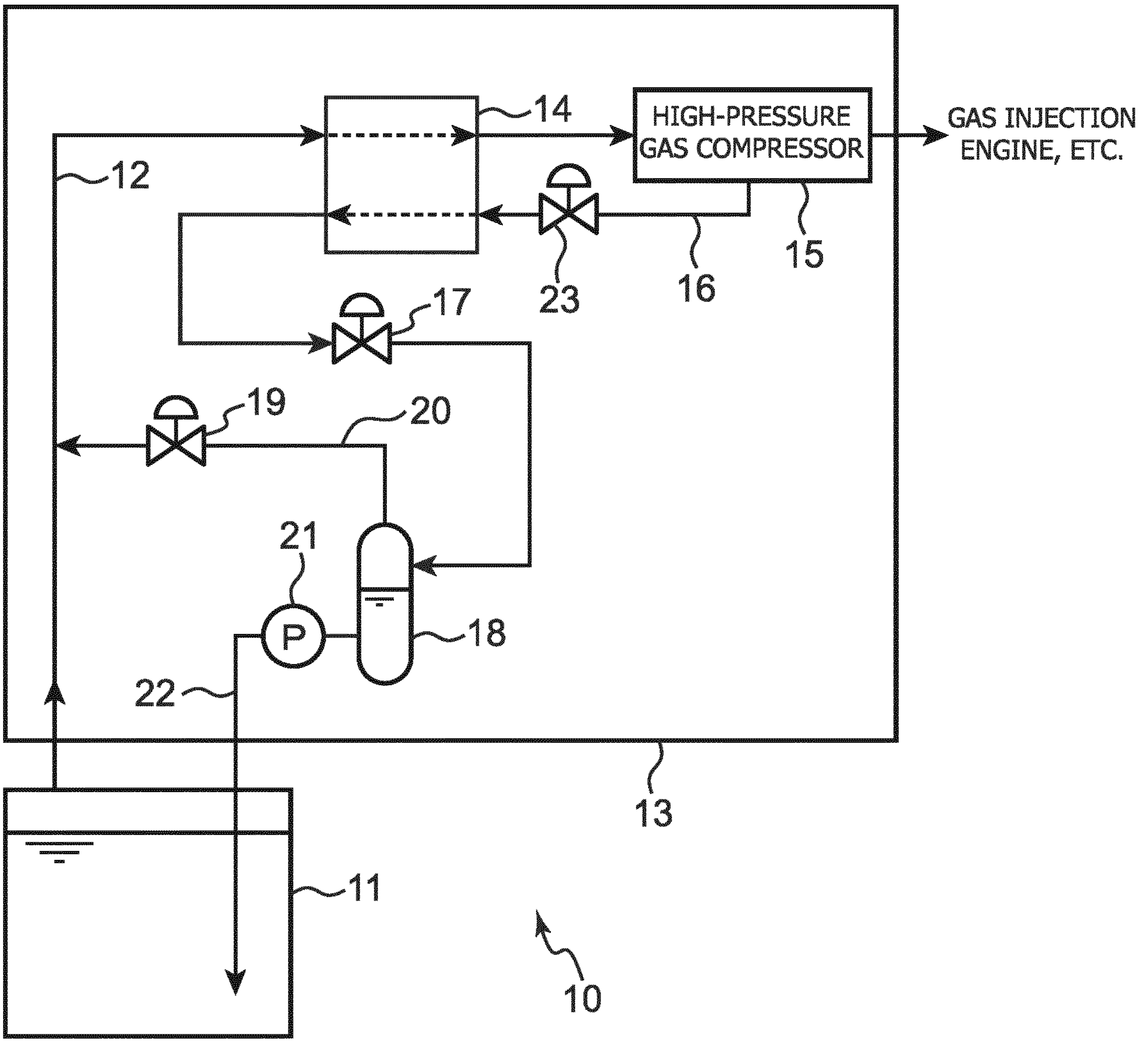


FIG. 6



F I G. 7


14
HIGH-PRESSURE
GAS COMPRESSOR
GAS INJECTION
ENGINE, ETC.
12
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P
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2015158263 A **[0002] [0003] [0004]**
- KR 20160126955 A **[0005]**
- US 2016114876 A1 **[0005]**
- WO 2011084813 A1 **[0005]**