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(72) Inventors:
• **KONNO Yuya**
Tokyo 108-8215 (JP)
• **ITO Hideki**
Tokyo 108-8215 (JP)

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(74) Representative: **Studio Torta S.p.A.**
Via Viotti, 9
10121 Torino (IT)

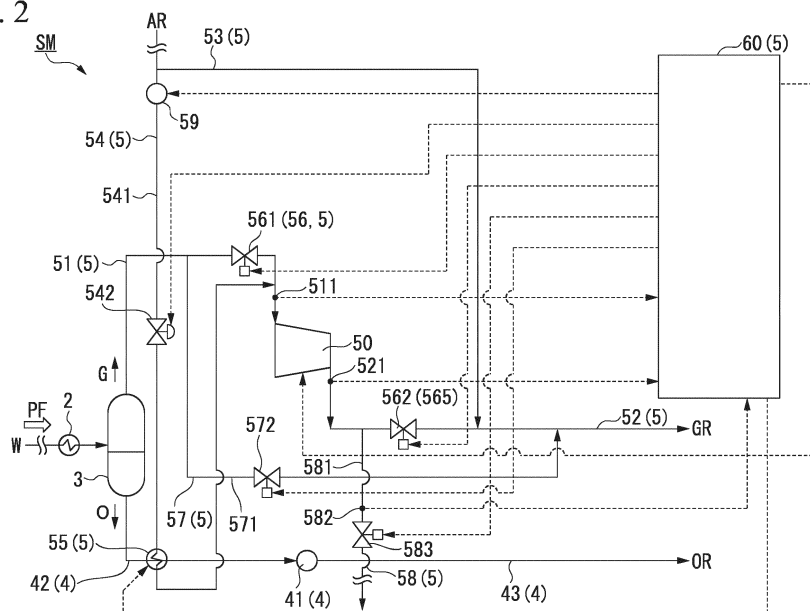
(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo 108-8215 (JP)

(54) **COMPRESSOR SYSTEM, SUBSEA PRODUCTION SYSTEM PROVIDED THEREWITH, AND COMPRESSOR CLEANING METHOD**

(57) A compressor system includes a compressor (50) configured to compress a gas, a compressed gas circulation unit (52) in which a gas compressed by the compressor (50) circulates, a hydrate anti freezing agent supply unit (53) configured to supply a hydrate anti freezing agent for preventing hydration of the gas to the compressed gas circulation unit (52), a compressor hydrate

anti freezing agent supply unit (54) configured to supply part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit (53) to the compressor (50), and a pressure changing unit (59) configured to change a pressure of the hydrate anti freezing agent inside the compressor (50).

FIG. 2



Description**[Solution to Problem]****[Technical Field]**

[0001] The present invention relates to a compressor system, a subsea production system provided therewith and a compressor cleaning method.

[Background Art]

[0002] In subsea production systems configured to extract submarine resources, production fluids mixed with crude oils and natural gases are drawn from production wells drilled to a depth of several thousand meters in the seabed. In the subsea production systems, the drawn production fluids are separated into gases such as natural gases and liquids such as crude oils by a separator such as a scrubber and are then sent to a ship on the sea surface through flow lines that extend under the sea. In this case, in order to send gases such as natural gases to a ship on the sea surface, a compressor installed in the seabed is used.

[0003] In the compressor installed in the seabed in this manner, according to continuous operations, sediments accumulate in internal flow paths through which natural gases circulate. As a result, a flow rate of natural gases that can circulate in the internal flow paths decreases and efficiency of the compressor decreases.

[0004] For such a compressor, for example, a cleaning method in which some condensates that are hydrocarbons contained in liquids separated out in the separator are supplied to the compressor for cleaning is disclosed in Patent Literature 1. In the compressor cleaning method, the condensates decompose and remove sediments, and thus internal flow paths of the compressor are cleaned.

[Citation List]**[Patent Literature]**

[0005] [Patent Literature 1] PCT International Publication No. WO 2013/185801

[Summary of Invention]**[Technical Problem]**

[0006] However, in the above-described cleaning method, condensates harvested from production wells are used. Therefore, there is a risk of a necessary amount of condensates not being reliably harvested from production wells. As a result, there is a problem in that it is difficult to reliably clean the compressor.

[0007] The present invention provides a compressor system capable of reliably cleaning a compressor, a subsea production system provided therewith, and a compressor cleaning method.

[0008] In order to address the above problems, the present invention proposes the following solutions. A compressor system according to an aspect of the present invention includes a compressor configured to compress a gas; a compressed gas circulation unit in which a gas compressed by the compressor circulates; a hydrate anti freezing agent supply unit configured to supply a hydrate anti freezing agent for preventing hydration of the gas to the compressed gas circulation unit; a compressor hydrate anti freezing agent supply unit configured to supply part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit to the compressor; and a pressure changing unit configured to change a pressure of the hydrate anti freezing agent inside the compressor.

[0009] In such a configuration, using the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit to the compressed gas circulation unit in order to prevent hydration of the gas compressed by the compressor, it is possible to effectively remove sediments that are precipitated inside the compressor. When part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit to the compressed gas circulation unit is used, it is possible to reliably supply a necessary amount of the hydrate anti freezing agent to the compressor. When a pressure of the hydrate anti freezing agent inside the compressor is changed by the pressure changing unit, the hydrate anti freezing agent inside the compressor can be stirred. Therefore, it is possible to clean the inside of the compressor effectively using the hydrate anti freezing agent.

[0010] The above compressor system may include a gas discharge unit configured to discharge the gas inside the compressor. The compressor hydrate anti freezing agent supply unit may supply the hydrate anti freezing agent to the compressor from which the gas is discharged by the gas discharge unit.

[0011] In such a configuration, while a gas is discharged and almost none thereof remains inside, the hydrate anti freezing agent is supplied to the compressor and a pressure is changed by the pressure changing unit. Therefore, it is possible to prevent the hydrate anti freezing agent supplied into the compressor from being diluted by the gas. Accordingly, it is possible to efficiently use the hydrate anti freezing agent supplied from the compressor hydrate anti freezing agent supply unit for cleaning the compressor and it is possible to minimize a supply amount of the hydrate anti freezing agent.

[0012] The above compressor system may include a storage unit configured to store the hydrate anti freezing agent inside the compressor. The pressure changing unit may change a pressure of the hydrate anti freezing agent that is stored by the storage unit.

[0013] In such a configuration, while the hydrate anti freezing agent is stored inside the compressor by the storage unit, when a pressure is changed by the pressure

changing unit, it is possible to efficiently stir the hydrate anti freezing agent inside the compressor. Therefore, it is possible to clean the inside of the compressor by using the hydrate anti freezing agent more effectively. When cleaning is performed without discharging the hydrate anti freezing agent from the compressor, it is possible to reduce a supply amount of the hydrate anti freezing agent to the compressor and perform cleaning of the compressor.

[0014] The above compressor system may include a control unit configured to perform supply control such that, when predetermined conditions are satisfied, the compressor hydrate anti freezing agent supply unit starts supply of the hydrate anti freezing agent to the compressor.

[0015] In such a configuration, when the control unit performs supply control of the hydrate anti freezing agent, it is possible to limit supply of the hydrate anti freezing agent to the compressor that is in a state in which cleaning is necessary. Therefore, it is possible to efficiently use the hydrate anti freezing agent supplied from the compressor hydrate anti freezing agent supply unit for cleaning the compressor and it is possible to further minimize a supply amount of the hydrate anti freezing agent.

[0016] In the above compressor system, the control unit may include a first reference determination unit configured to determine whether a difference between characteristic values of the gas on an inlet side of the compressor and an outlet side of the compressor satisfies a predetermined first reference, and a supply start instruction unit configured to send an instruction to the compressor hydrate anti freezing agent supply unit to start supply of the hydrate anti freezing agent to the compressor when the first reference determination unit determines that the first reference is satisfied.

[0017] In such a configuration, when a difference between characteristic values of a gas on the inlet side and the outlet side of the compressor is calculated and the first reference determination unit compares the difference with a predetermined first reference for determination, it is possible to easily determine whether the compressor is in a state in which cleaning is necessary. Based on the determination result, when the supply start instruction unit starts supply of the hydrate anti freezing agent to the compressor, it is possible to perform cleaning of the compressor. Therefore, it is possible to determine whether the compressor is in a state in which cleaning is necessary with high accuracy and it is possible to further limit supply of the hydrate anti freezing agent. Therefore, for the compressor for which cleaning is necessary, it is possible to more efficiently supply the hydrate anti freezing agent from the compressor hydrate anti freezing agent supply unit and it is possible to further minimize a supply amount of the hydrate anti freezing agent.

[0018] The above compressor system includes a heating unit configured to heat the hydrate anti freezing agent. The compressor hydrate anti freezing agent supply unit

may supply the hydrate anti freezing agent heated by the heating unit to the compressor.

[0019] In such a configuration, when the heating unit is provided, it is possible to supply the high temperature hydrate anti freezing agent to the compressor. It is possible to improve solubility of sediments due to the hydrate anti freezing agent that is heated to a high temperature. Therefore, it is possible to increase a dissolution rate of sediments accumulated in the compressor and effectively clean the compressor.

[0020] The above compressor system may include a heating unit configured to heat the hydrate anti freezing agent. The control unit may include a second reference determination unit configured to determine whether a difference between characteristic values of the gas on the inlet side of the compressor and the outlet side of the compressor satisfies a predetermined second reference after supply of the hydrate anti freezing agent to the compressor starts, and a heat supply instruction unit configured to send an instruction to the compressor hydrate anti freezing agent supply unit to supply the hydrate anti freezing agent heated by the heating unit to the compressor when the second reference determination unit determines that the second reference is satisfied.

[0021] In such a configuration, when a difference between characteristic values of a gas on the inlet side and the outlet side of the compressor is calculated and the second reference determination unit compares the difference with the second reference for determination, it is possible to easily determine again whether the compressor is in a state in which cleaning is necessary. Therefore, for example, it is possible to easily determine whether the compressor is in a state that is different from the state determined using the first reference. Based on the determination result, when the heat supply instruction unit sends an instruction to supply the hydrate anti freezing agent heated by the heating unit to the compressor, it is possible to more effectively clean the compressor using the hydrate anti freezing agent that is heated to a high temperature. Therefore, it is possible to perform greater cleaning on the compressor as necessary. Therefore, when the compressor is in a state in which greater cleaning is necessary, it is possible to efficiently supply the heated hydrate anti freezing agent and clean the compressor more efficiently.

[0022] A subsea production system according to a second aspect of the present invention includes the compressor system and a separator configured to separate a production fluid drawn from a production well into the gas and a liquid and supply the result to the compressor.

[0023] In such a configuration, it is also possible to reliably and efficiently clean the compressor that is installed at a position at which maintenance is difficult, for example, in the seabed. Therefore, it is possible to prevent clogging due to sediments and it is possible to reliably send the gas through the compressor.

[0024] A compressor cleaning method according to a third aspect of the present invention is a compressor

cleaning method in which a compressor configured to compress a gas is cleaned. The compressor cleaning method includes a gas discharging process in which the gas inside the compressor is discharged; a compressor hydrate anti freezing agent supply process in which part of a hydrate anti freezing agent for preventing hydration of the gas supplied to a compressed gas circulation unit in which a gas compressed by the compressor circulates is supplied to the compressor from which the gas is discharged in the gas discharging process; and a pressure changing process in which a pressure of the hydrate anti freezing agent inside the compressor is changed.

[0025] In such a configuration, in the compressor hydrate anti freezing agent supply process, without newly preparing and supplying the hydrate anti freezing agent, part of the hydrate anti freezing agent supplied to the compressed gas circulation unit is used. Therefore, it is possible to reliably supply a necessary amount of the hydrate anti freezing agent to the compressor. In the gas discharging process, a gas is discharged from the compressor to the outside. Therefore, in the pressure changing process, while a gas is discharged and almost none remains inside, a pressure of the hydrate anti freezing agent inside the compressor can be changed by the pressure changing unit. Therefore, it is possible to prevent the hydrate anti freezing agent supplied into the compressor from being diluted by the gas, and the hydrate anti freezing agent inside the compressor can be stirred. As a result, it is possible to clean the inside of the compressor by effectively and efficiently using the hydrate anti freezing agent. Therefore, it is possible to efficiently use the supplied hydrate anti freezing agent for cleaning the compressor and it is possible to reliably and effectively clean the compressor while minimizing a supply amount of the hydrate anti freezing agent.

[0026] The above compressor cleaning method may include a storing process in which the hydrate anti freezing agent is stored inside the compressor. In the pressure changing process, a pressure of the hydrate anti freezing agent stored in the storing process may be changed.

[0027] In such a configuration, while the hydrate anti freezing agent is stored inside the compressor in the storing process, when a pressure is changed by the pressure changing unit, it is possible to efficiently stir the hydrate anti freezing agent inside the compressor. Therefore, it is possible to clean the inside of the compressor by using the hydrate anti freezing agent more effectively. When cleaning is performed without discharging the hydrate anti freezing agent from the compressor, it is possible to reduce a supply amount of the hydrate anti freezing agent to the compressor and perform cleaning of the compressor.

[0028] The above compressor cleaning method may include a first reference determining process in which it is determined whether a difference between characteristic values of the gas on an inlet side of the compressor and an outlet side of the compressor satisfies a predetermined first reference, and a supply start process in

which, when it is determined in the first reference determining process that the first reference is satisfied, supply of the hydrate anti freezing agent to the compressor starts.

[0029] In such a configuration, when a difference between characteristic values of a gas on the inlet side and the outlet side of the compressor is calculated and the difference is compared with the first reference in the first reference determining process for determination, it is possible to easily determine whether the compressor is in a state in which cleaning is necessary. Based on the determination result, in the supply start process, it is possible to start supply of the hydrate anti freezing agent to the compressor and it is possible to perform cleaning of the compressor. Therefore, it is possible to determine whether the compressor is in a state in which cleaning is necessary with high accuracy and it is possible to further limit supply of the hydrate anti freezing agent. Therefore, for the compressor for which cleaning is necessary, it is possible to more efficiently supply the hydrate anti freezing agent supplied from the compressor hydrate anti freezing agent supply unit and it is possible to further minimize a supply amount of the hydrate anti freezing agent.

[0030] The above compressor cleaning method may include a second reference determining process in which, after supply of the hydrate anti freezing agent to the compressor starts, it is determined whether a difference between characteristic values of the gas on the inlet side of the compressor and the outlet side of the compressor satisfies a predetermined second reference, and a heat supply process in which, when it is determined in the second reference determining process that the second reference is satisfied, the heated hydrate anti freezing agent is supplied to the compressor.

[0031] In such a configuration, when a difference between characteristic values of a gas on the inlet side and the outlet side of the compressor is calculated and the difference is compared with the second reference in the second reference determining process for determination, it is possible to easily determine again whether the compressor is in a state in which cleaning is necessary. Therefore, for example, it is possible to easily determine whether the compressor is in a state that is different from the state determined using the first reference (for example, whether greater cleaning is necessary for the compressor). Based on the determination result, in the heat supply process, when the hydrate anti freezing agent that is heated to a high temperature is supplied to the compressor, it is possible to more effectively clean the compressor. Therefore, it is possible to perform greater cleaning on the compressor as necessary. Therefore, when the compressor is in a state in which greater cleaning is necessary, it is possible to efficiently supply the heated hydrate anti freezing agent and clean the compressor more efficiently.

[Advantageous Effects of Invention]

[0032] According to the present invention, when part of the hydrate anti freezing agent supplied to the compressed gas circulation unit in which a compressed gas circulates is supplied into the compressor and a pressure is changed, it is possible to efficiently clean the compressor.

[Brief Description of Drawings]

[0033]

Fig. 1 is a diagram schematically showing a subsea production system in an embodiment of the present invention.

Fig. 2 is a systematic diagram showing a subsea module in an embodiment of the present invention.

Fig. 3 is a block diagram showing a control unit in an embodiment of the present invention.

Fig. 4 is a flowchart showing a compressor cleaning method in an embodiment of the present invention.

[Description of Embodiments]

[0034] Hereinafter, embodiments according to the present invention will be described with reference to Fig. 1 to Fig. 4. A subsea production system 1 according to an embodiment of the present invention is a subsea production system that is one for ocean oil and gas field development methods. As shown in Fig. 1, the subsea production system 1 includes a production well W for harvesting a production fluid PF mixed with crude oil O, natural gas G and the like extracted from an oil gas field F that is located several hundreds to thousands of meters from the seabed, a manifold M for collecting and distributing the production fluid PF harvested in the production well W, a flow line FL that is a pipe through which the production fluid PF distribute by the manifold M is conveyed, and a subsea module SM configured to separate the production fluid PF conveyed through the flow line FL into a liquid and a gas and send them to the sea surface. The subsea production system 1 includes a riser R that is a pipe through which the crude oil O and the natural gas G are conveyed to the sea surface from the subsea module SM, an umbilical line AL that is a cable through which power is supplied to the subsea module SM and the like, and a ship S to which the riser R and the umbilical line AL moored in the sea are connected and in which the crude oil O and the natural gas G are stored.

[0035] The manifold M is installed in the vicinity of the production well W of the oil gas field F in the seabed. The manifold M is a device configured to collect and distribute the extracted production fluid PF and convey it through a plurality of flow lines FL.

[0036] The flow line FL is a pipeline through which the production fluid PF is pressure-fed from the manifold M to the subsea module SM according to pressure energy

of the oil gas field F.

[0037] The riser R extends from the subsea module SM of the seabed to the ship S on the sea surface. In the riser R of this embodiment, an oil pipeline OR through which the crude oil O sent from the subsea module SM is conveyed to a storage tank (not shown) disposed in the ship S on the sea surface and a gas pipeline GR through which the natural gas G sent from the subsea module SM is conveyed to the storage tank are separately provided. The riser R includes the gas pipeline GR through which the natural gas G is supplied such that the natural gas G is prevented from freezing due to hydration in the seabed and a pipeline for a hydrate anti freezing agent AR through which a hydrate anti freezing agent is supplied from the ship S.

[0038] The umbilical line AL is a composite cable including a power cable, a hydraulic cable and a signal cable for controlling the subsea module SM. The umbilical line AL sends power and signals from a generator (not shown) in the ship S to the subsea module SM and the manifold M.

[0039] The subsea module SM separates the production fluid PF supplied through the flow line FL into a gas and a liquid and pressure-feeds the gas and the liquid to the sea surface. As shown in Fig. 2, the subsea module SM of this embodiment includes a main heat exchanger 2 configured to cool the production fluid PF drawn from the production well W, a separator 3 configured to separate the production fluid PF cooled in the main heat exchanger 2 into a gas and a liquid, a pump system 4 configured to send the liquid separated out in the separator 3 to the riser R, and a compressor system 5 configured to send the gas separated out by the separator 3 to the riser R.

[0040] The main heat exchanger 2 cools the production fluid PF having a high temperature that is drawn from the production well W and sent to the flow line FL to a temperature at which the production fluid PF can be used in the separator 3. The main heat exchanger 2 of this embodiment cools the production fluid PF according to heat exchange with low temperature seawater of the seabed.

[0041] The separator 3 separates the production fluid PF into the natural gas G that is a gas and the crude oil O that is a liquid. The separator 3 of this embodiment is a scrubber. The separator 3 separates the natural gas G and the crude oil O containing condensates from the production fluid PF. The separator 3 sends the separated crude oil O to the pump system 4. The separator 3 sends the separated natural gas G to the compressor system 5.

[0042] The pump system 4 compresses the crude oil O sent from the separator 3 and sends it to the oil pipeline OR. As shown in Fig. 2, the pump system 4 includes a pump 41 configured to compress the crude oil O, a liquid circulation unit 42 configured to send the crude oil O from the separator 3 to the pump 41, and a compressed liquid circulation unit 43 in which the crude oil O compressed by the pump 41 circulates.

[0043] The pump 41 compresses and sends out the

received crude oil O. The liquid circulation unit 42 supplies the crude oil O from the separator 3 to the pump 41. Specifically, the liquid circulation unit 42 of this embodiment is a pipe that is connected from the separator 3 to the pump 41. The crude oil O circulates inside the liquid circulation unit 42. The compressed liquid circulation unit 43 sends the crude oil O compressed by the pump 41 to the oil pipeline OR. Specifically, the compressed liquid circulation unit 43 of this embodiment is a pipe that is connected from the pump 41 to the oil pipeline OR. The compressed crude oil O circulates inside the compressed liquid circulation unit 43.

[0044] The compressor system 5 compresses the natural gas G sent from the separator 3 and sends it to the gas pipeline GR. As shown in Fig. 2, the compressor system 5 includes a compressor 50 configured to compress the natural gas G, a gas circulation unit 51 configured to send the natural gas G from the separator 3 to the compressor 50, and a compressed gas circulation unit 52 in which the natural gas G compressed by the compressor 50 circulates. The compressor system 5 includes a hydrate anti freezing agent supply unit 53 configured to supply a hydrate anti freezing agent for preventing hydration of the natural gas G to the compressed gas circulation unit 52, a compressor hydrate anti freezing agent supply unit 54 configured to supply part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit 53 to the compressor 50, and a heating unit 55 configured to heat the hydrate anti freezing agent. The compressor system 5 includes a storage unit 56 configured to store the hydrate anti freezing agent inside the compressor 50, a bypass supply unit 57 configured to bypass the compressor 50 and supply the natural gas G to the compressed gas circulation unit 52, a gas discharge unit 58 configured to discharge the natural gas G inside the compressor 50, a pressure changing unit 59 configured to change a pressure of the hydrate anti freezing agent inside the compressor 50, and a control unit 60 configured to perform supply control such that the compressor hydrate anti freezing agent supply unit 54 starts supply of the hydrate anti freezing agent.

[0045] The compressor 50 compresses the natural gas G supplied from the gas circulation unit 51 disposed on an upstream side in a circulation direction of the natural gas G and conveys the compressed gas to the compressed gas circulation unit 52 disposed on a downstream side. The compressor 50 of this embodiment is a multistage centrifugal compressor including a plurality of impellers.

[0046] The gas circulation unit 51 supplies the natural gas G from the separator 3 to the compressor 50. Specifically, the gas circulation unit 51 of this embodiment is a pipe that is connected from the separator 3 to the compressor 50 as shown in Fig. 2. The natural gas G circulates inside the gas circulation unit 51. The gas circulation unit 51 of this embodiment includes an inlet side characteristic value measuring unit 511 configured to measure a characteristic value of the natural gas G on an inlet side

of the compressor 50.

[0047] The inlet side characteristic value measuring unit 511 measures a characteristic value of the natural gas G that flows into the compressor 50. The inlet side characteristic value measuring unit 511 is provided in the vicinity of an inlet port of the compressor 50 of the gas circulation unit 51. The inlet side characteristic value measuring unit 511 of this embodiment is a pressure sensor that measures a pressure value as a characteristic value. The inlet side characteristic value measuring unit 511 transmits the measured pressure value of the natural gas G to the control unit 60.

[0048] The compressed gas circulation unit 52 sends the natural gas G compressed by the compressor 50 to the riser R. Specifically, the compressed gas circulation unit 52 of this embodiment is a pipe that is connected from the compressor 50 to the gas pipeline GR. The compressed natural gas G circulates inside the compressed gas circulation unit 52. The compressed gas circulation unit 52 of this embodiment includes an outlet side characteristic value measuring unit 521 configured to measure a characteristic value of the natural gas G (gas) on an outlet side of the compressor 50.

[0049] The outlet side characteristic value measuring unit 521 measures a characteristic value of the natural gas G discharged from the compressor 50. The outlet side characteristic value measuring unit 521 is provided in the vicinity of an outlet port of the compressor 50 of the compressed gas circulation unit 52. Similarly to the inlet side characteristic value measuring unit 511, the outlet side characteristic value measuring unit 521 of this embodiment is a pressure sensor that measures a pressure value as a characteristic value. The outlet side characteristic value measuring unit 521 transmits the measured pressure value of the natural gas G to the control unit 60.

[0050] The hydrate anti freezing agent supply unit 53 circulates the hydrate anti freezing agent supplied from the ship S on the sea surface through the pipeline for a hydrate anti freezing agent AR to the compressed gas circulation unit 52. The hydrate anti freezing agent supply unit 53 of this embodiment is a pipe that is connected from the pipeline for a hydrate anti freezing agent AR to the compressed gas circulation unit 52. The hydrate anti freezing agent circulates inside the hydrate anti freezing agent supply unit 53. The hydrate anti freezing agent supply unit 53 is connected downstream from a position at which the outlet side characteristic value measuring unit 521 of the compressed gas circulation unit 52 is provided. Also, as the hydrate anti freezing agent of this embodiment, a fluid having lipophilicity and hydrophilicity is preferably used. As the hydrate anti freezing agent, for example, monoethylene glycol used for preventing hydration by preventing hydration of the natural gas G is particularly preferably used.

[0051] The compressor hydrate anti freezing agent supply unit 54 supplies part of the hydrate anti freezing agent that flows in the hydrate anti freezing agent supply

unit 53 to the compressor 50. Specifically, the compressor hydrate anti freezing agent supply unit 54 of this embodiment includes a supply pipe 541 that branches from the hydrate anti freezing agent supply unit 53 and a supply valve 542 configured to adjust a flow of the hydrate anti freezing agent that flows into the supply pipe 541.

[0052] The supply pipe 541 branches from the hydrate anti freezing agent supply unit 53 and is connected to the gas circulation unit 51. Specifically, the supply pipe 541 of this embodiment is connected to the gas circulation unit 51 at a position that is on an upstream side relative to the inlet side characteristic value measuring unit 511 and a downstream side relative to a first circulation valve 561 to be described below.

[0053] The supply valve 542 adjusts supply of the hydrate anti freezing agent into the supply pipe 541. Specifically, when the supply valve 542 of this embodiment is closed, supply of the hydrate anti freezing agent into the supply pipe 541 stops. When the supply valve 542 is opened, supply of the hydrate anti freezing agent into the supply pipe 541 starts. The supply valve 542 is a solenoid valve whose opening and closing operations are controlled by the control unit 60.

[0054] The heating unit 55 is provided in the compressor hydrate anti freezing agent supply unit 54 and heats the hydrate anti freezing agent. The heating unit 55 of this embodiment is provided at a position that is on a downstream side relative to the supply valve 542 of the supply pipe 541 and at which the supply pipe 541 and the liquid circulation unit 42 cross. When the signal is input from the control unit 60, the heating unit 55 heats the hydrate anti freezing agent using heat of the crude oil O that flows in the pump system 4. Specifically, the heating unit 55 heats monoethylene glycol which is a hydrate anti freezing agent that flows in the supply pipe 541, for example, at an ambient temperature of about 20 °C to 50 °C, to a high temperature of 110 °C or higher.

[0055] The storage unit 56 stores the hydrate anti freezing agent supplied from the compressor hydrate anti freezing agent supply unit 54 inside the compressor 50. The storage unit 56 of this embodiment includes the first circulation valve 561 provided on the inlet side of the compressor 50 and a second circulation valve 562 provided on the outlet side of the compressor 50.

[0056] The first circulation valve 561 adjusts supply of the natural gas G inside the gas circulation unit 51. Specifically, the first circulation valve 561 of this embodiment is provided on an upstream side relative to the inlet side characteristic value measuring unit 511 of the gas circulation unit 51. When the first circulation valve 561 of this embodiment is closed, supply of the natural gas G into the gas circulation unit 51 stops. When the first circulation valve 561 is opened, supply of the natural gas G into the gas circulation unit 51 starts. The first circulation valve 561 is a solenoid valve whose opening and closing operations are controlled by the control unit 60.

[0057] The second circulation valve 562 adjusts supply of the natural gas G and the hydrate anti freezing agent

into the compressed gas circulation unit 52. Specifically, the second circulation valve 562 of this embodiment is provided on a downstream side relative to the outlet side characteristic value measuring unit 521 of the compressed gas circulation unit 52. When the second circulation valve 562 of this embodiment is closed, supply of the natural gas G and the hydrate anti freezing agent into the compressed gas circulation unit 52 stops. When the second circulation valve 562 is opened, supply of the natural gas G and the hydrate anti freezing agent into the compressed gas circulation unit 52 starts. The second circulation valve 562 is a solenoid valve whose opening and closing operations are controlled by the control unit 60.

[0058] The bypass supply unit 57 supplies the natural gas G that circulates in the gas circulation unit 51 to the compressed gas circulation unit 52 without it passing through the compressor 50. The bypass supply unit 57 of this embodiment includes a bypass pipe 571 that branches from the gas circulation unit 51 and a bypass valve 572 configured to adjust a flow of the natural gas G that flows into the bypass pipe 571.

[0059] The bypass pipe 571 branches from the gas circulation unit 51 and is connected to the compressed gas circulation unit 52. Specifically, the bypass pipe 571 of this embodiment is connected to the gas circulation unit 51 at a position on an upstream side relative to the inlet side characteristic value measuring unit 511 and the first circulation valve 561. The bypass pipe 571 is connected to the compressed gas circulation unit 52 at a position on a downstream side relative to the outlet side characteristic value measuring unit 521 and the second circulation valve 562.

[0060] The bypass valve 572 adjusts supply of the natural gas G into the bypass pipe 571. Specifically, when the bypass valve 572 of this embodiment is closed, supply of the natural gas G into the bypass pipe 571 stops. When the bypass valve 572 is opened, supply of the natural gas G into the bypass pipe 571 starts. The bypass valve 572 is a solenoid valve whose opening and closing operations are controlled by the control unit 60.

[0061] The gas discharge unit 58 discharges the natural gas G and the hydrate anti freezing agent inside the compressor 50 from the compressed gas circulation unit 52 to the outside. The gas discharge unit 58 of this embodiment includes a discharge pipe 581 that branches from the compressed gas circulation unit 52, a fluid information measuring unit 582 configured to measure information about a fluid that circulates in the discharge pipe 581, and a discharge valve 583 configured to adjust a flow of the natural gas G and the hydrate anti freezing agent that flow in the discharge pipe 581.

[0062] The discharge pipe 581 branches from the compressed gas circulation unit 52 and is connected to a discharge port (not shown). Specifically, the discharge pipe 581 of this embodiment branches from the compressed gas circulation unit 52 at a position that is on a downstream side relative to the outlet side characteristic

value measuring unit 521 and an upstream side relative to the second circulation valve 562.

[0063] The fluid information measuring unit 582 measures a type and a temperature of a fluid that circulates in the discharge pipe 581. The fluid information measuring unit 582 is provided on an upstream side of the discharge valve 583 of the discharge pipe 581. The fluid information measuring unit 582 of this embodiment is a sensor configured to measure a type and a temperature of a fluid that circulates in the discharge pipe 581. The fluid information measuring unit 582 of this embodiment detects whether a type of a fluid that circulates in the discharge pipe 581 has changed and whether a temperature of a fluid has changed and sends information to the control unit 60. Specifically, the fluid information measuring unit 582 of this embodiment sends information indicating that a circulating fluid has been switched from the natural gas G to the hydrate anti freezing agent, information indicating that a temperature of the hydrate anti freezing agent has increased, and information indicating that the hydrate anti freezing agent has been switched to the natural gas G to the control unit 60.

[0064] The discharge valve 583 adjusts supply of the natural gas G and the hydrate anti freezing agent into the discharge pipe 581. Specifically, when the discharge valve 583 of this embodiment is closed, supply of the natural gas G and the hydrate anti freezing agent into the discharge pipe 581 stops. When the discharge valve 583 is opened, supply of the natural gas G and the hydrate anti freezing agent into the discharge pipe 581 starts. The discharge valve 583 is a solenoid valve whose opening and closing operations are controlled by the control unit 60.

[0065] When the pressure changing unit 59 changes a pressure of the hydrate anti freezing agent that circulates in the compressor hydrate anti freezing agent supply unit 54, a pressure of the hydrate anti freezing agent flowed into the compressor 50 is changed. Specifically, the pressure changing unit 59 of this embodiment is a boost pump configured to increase or decrease a pressure of the hydrate anti freezing agent that flows in the supply pipe 541. The pressure changing unit 59 is driven and controlled by the control unit 60. In the pressure changing unit 59 of this embodiment, in a range equal to or lower than a maximum working discharge pressure (for example, 200 bar) when the compressor 50 is designed above a pressure of about one atmosphere, pressurizing is performed with monoethylene glycol that circulates as the hydrate anti freezing agent for a predetermined time.

[0066] When predetermined conditions are satisfied, the control unit 60 performs supply control such that the compressor 50 starts cleaning. The control unit 60 of this embodiment supplies the hydrate anti freezing agent to the compressor 50 and changes a pressure of the hydrate anti freezing agent in the compressor 50.

[0067] Specifically, as shown in Fig. 3, the control unit 60 of this embodiment includes a first input unit 61 con-

figured to receive a characteristic value measured by the inlet side characteristic value measuring unit 511, a second input unit 62 configured to receive a characteristic value measured by the outlet side characteristic value measuring unit 521, and a difference calculation unit 63 configured to calculate a difference between the characteristic value received by the first input unit 61 and the characteristic value received by the second input unit 62. The control unit 60 of this embodiment includes a first reference determination unit 64 configured to determine whether the difference calculated by the difference calculation unit 63 satisfies a predetermined first reference, a supply start instruction unit 65 configured to send an instruction to start supply of the hydrate anti freezing agent to the compressor 50 based on the determination result of the first reference determination unit 64, and a storage and discharge instruction unit 71 configured to discharge the natural gas G inside the compressor 50 and store the hydrate anti freezing agent based on the determination result of the first reference determination unit 64.

[0068] The control unit 60 of this embodiment includes a second reference determination unit 66 configured to determine whether the difference calculated by the difference calculation unit 63 satisfies a predetermined second reference, a heat supply instruction unit 67 configured to send an instruction to supply the hydrate anti freezing agent heated by the heating unit 55 to the compressor 50 based on the determination result of the second reference determination unit 66, and a cleaning termination instruction unit 70 configured to send an instruction to terminate cleaning of the compressor 50 based on the determination result of the second reference determination unit 66. The control unit 60 of this embodiment includes a supply valve instruction unit 68 configured to open or close the supply valve 542 based on an input signal, a first circulation valve instruction unit 72 configured to open or close the first circulation valve 561 based on an input signal, and a second circulation valve instruction unit 73 configured to open or close the second circulation valve 562 based on an input signal.

[0069] The control unit 60 of this embodiment includes a bypass valve instruction unit 74 configured to open or close the bypass valve 572 based on an input signal and a discharge valve instruction unit 75 configured to open or close the discharge valve 583 based on an input signal. The control unit 60 of this embodiment includes a fluid information input unit 76 configured to receive information measured by the fluid information measuring unit 582, a pressure change instruction unit 77 configured to send an instruction to drive the pressure changing unit 59, and a compressor operation adjusting unit 78 configured to send an instruction to the compressor 50 to adjust an operation state from the time at which the operation starts until the operation is stabilized.

[0070] The first input unit 61 receives a pressure value of the natural gas G measured by the inlet side characteristic value measuring unit 511. The first input unit 61

outputs information about the received pressure value to the difference calculation unit 63 and the compressor operation adjusting unit 78. The second input unit 62 receives a pressure value of the natural gas G measured by the outlet side characteristic value measuring unit 521. The second input unit 62 outputs information about the received pressure value to the difference calculation unit 63 and the compressor operation adjusting unit 78.

[0071] The difference calculation unit 63 calculates a difference by subtracting a pressure value on an inlet side of a compressor input by the first input unit 61 from a pressure value on an outlet side of a compressor input by the second input unit 62. The difference calculation unit 63 outputs the calculated difference to the first reference determination unit 64. After the calculated difference is output to the first reference determination unit 64, when information is input again from the first input unit 61 and the second input unit 62, the difference calculation unit 63 outputs the calculated difference to the second reference determination unit 66.

[0072] The first reference determination unit 64 compares information about the difference input from the difference calculation unit 63 with a first reference. Here, the first reference is a value indicating a state in which sediments have precipitated, an internal flow path of the compressor 50 is narrowed, and thus cleaning is necessary. The first reference of this embodiment is set to a value smaller than a value of a rise of a pressure of the natural gas G that is compressed by the compressor 50 in a normal state in which cleaning is not necessary. That is, the first reference of this embodiment is a value of a difference between pressures on the inlet side and the outlet side of the compressor 50 while sediments accumulate and the natural gas G is hardly compressed.

[0073] The first reference determination unit 64 of this embodiment determines whether the input difference value is less than the first reference. When it is determined that the calculated difference is less than the first reference and satisfies the first reference, the first reference determination unit 64 sends a signal to the supply start instruction unit 65 and the storage and discharge instruction unit 71. When it is determined that the calculated difference is greater than the first reference and does not satisfy the first reference, the first reference determination unit 64 sends a signal to the compressor operation adjusting unit 78.

[0074] When the first reference determination unit 64 determines that the first reference is satisfied, the supply start instruction unit 65 sends an instruction to the compressor hydrate anti freezing agent supply unit 54 to start supply of the hydrate anti freezing agent to the compressor 50. When the signal is input from the first reference determination unit 64, the supply start instruction unit 65 of this embodiment sends a signal to the supply valve instruction unit 68 to open the supply valve 542.

[0075] When the first reference determination unit 64 determines that the first reference is satisfied, the storage and discharge instruction unit 71 sends an instruction to

the storage unit 56, the bypass supply unit 57, and the gas discharge unit 58 to discharge the natural gas G from the inside of the compressor 50 and accumulate the hydrate anti freezing agent in the compressor 50. The storage and discharge instruction unit 71 of this embodiment sends a signal to the first circulation valve instruction unit 72 to close the first circulation valve 561. The storage and discharge instruction unit 71 sends a signal to the second circulation valve instruction unit 73 to close the second circulation valve 562. The storage and discharge instruction unit 71 sends a signal to the bypass valve instruction unit 74 to open the bypass valve 572. The storage and discharge instruction unit 71 sends a signal to the discharge valve instruction unit 75 to open the discharge valve 583.

[0076] The second reference determination unit 66 compares the difference information input from the difference calculation unit 63 with a second reference. Here, the second reference is a value indicating a state in which sediments in the internal flow path of the compressor 50 are not sufficiently removed and greater cleaning is necessary. The second reference of this embodiment is set to a value that is smaller than a value of a rise of a pressure of the natural gas G compressed by the compressor 50 in a normal state and is greater than the first reference. That is, the second reference of this embodiment is a value of a difference between pressures on the inlet side and the outlet side of the compressor 50 in a state in which cleaning has been performed once, but the result is not enough to satisfy the first reference, sediments remain in the compressor 50, and the natural gas G is not sufficiently compressed.

[0077] The second reference determination unit 66 of this embodiment determines whether the input difference value is less than the second reference. When it is determined that the calculated difference is less than the second reference and satisfies the second reference, the second reference determination unit 66 sends a signal to the heat supply instruction unit 67. When it is determined that the calculated difference is greater than the second reference and does not satisfy the second reference, the second reference determination unit 66 sends a signal to the cleaning termination instruction unit 70.

[0078] When the second reference determination unit 66 determines that the second reference is satisfied, the heat supply instruction unit 67 sends an instruction to supply the hydrate anti freezing agent heated by the heating unit 55 to the compressor 50. When the signal is input from the second reference determination unit 66, the heat supply instruction unit 67 of this embodiment sends a signal to the heating unit 55 to start heating of the hydrate anti freezing agent.

[0079] When the second reference determination unit 66 determines that the second reference is not satisfied, the cleaning termination instruction unit 70 sends an instruction to the compressor hydrate anti freezing agent supply unit 54 to terminate cleaning of the compressor 50. When the signal is input from the second reference

determination unit 66, the cleaning termination instruction unit 70 of this embodiment sends a signal to the supply valve instruction unit 68, the first circulation valve instruction unit 72, the second circulation valve instruction unit 73, and the discharge valve instruction unit 75.

[0080] Specifically, the cleaning termination instruction unit 70 of this embodiment sends a signal to the supply valve instruction unit 68 to close the supply valve 542. The cleaning termination instruction unit 70 sends a signal to the first circulation valve instruction unit 72 to open the first circulation valve 561. The cleaning termination instruction unit 70 sends a signal to the second circulation valve instruction unit 73 to open the second circulation valve 562. The cleaning termination instruction unit 70 sends a signal to the discharge valve instruction unit 75 to open the discharge valve 583.

[0081] When the signal is input from the supply start instruction unit 65, the supply valve instruction unit 68 sends an instruction to open to the supply valve 542. When the signal is input from the cleaning termination instruction unit 70, the supply valve instruction unit 68 sends an instruction to close to the supply valve 542.

[0082] When the signal is input from the storage and discharge instruction unit 71, the first circulation valve instruction unit 72 sends an instruction to close to the first circulation valve 561. When the signal is input from the cleaning termination instruction unit 70, the first circulation valve instruction unit 72 sends an instruction to open to the first circulation valve 561.

[0083] When the signal is input from the storage and discharge instruction unit 71, the second circulation valve instruction unit 73 sends an instruction to close to the second circulation valve 562. When the signal is input from the cleaning termination instruction unit 70, the second circulation valve instruction unit 73 sends an instruction to open to the second circulation valve 562.

[0084] When the signal is input from the storage and discharge instruction unit 71, the bypass valve instruction unit 74 sends an instruction to open to the bypass valve 572. When the signal is input from the compressor operation adjusting unit 78, the bypass valve instruction unit 74 sends an instruction to close to the bypass valve 572.

[0085] When the signal is input from the storage and discharge instruction unit 71, the discharge valve instruction unit 75 sends an instruction to open to the discharge valve 583. When the signal is input from the cleaning termination instruction unit 70, the discharge valve instruction unit 75 sends an instruction to open to the discharge valve 583. When the signal is input from the fluid information input unit 76, the discharge valve instruction unit 75 sends an instruction to close to the discharge valve 583.

[0086] The fluid information input unit 76 sends a signal to the discharge valve instruction unit 75, the pressure change instruction unit 77, and the compressor operation adjusting unit 78 based on information about a type and a temperature of a fluid measured by the fluid information measuring unit 582.

[0087] Specifically, the fluid information input unit 76 of this embodiment receives information indicating that a fluid flowing in the discharge pipe 581 has been switched from the natural gas G to the hydrate anti freezing agent from the fluid information measuring unit 582. As a result, the fluid information input unit 76 sends a signal to the discharge valve instruction unit 75 to close the discharge valve 583 and sends a signal to the pressure change instruction unit 77 to drive the pressure changing unit 59.

[0088] The fluid information input unit 76 receives information indicating that a temperature of the hydrate anti freezing agent that flows in the discharge pipe 581 has increased from the fluid information measuring unit 582. As a result, the fluid information input unit 76 sends a signal to the pressure change instruction unit 77 to drive the pressure changing unit 59.

[0089] The fluid information input unit 76 receives information indicating that the hydrate anti freezing agent has been switched to the natural gas G from the fluid information measuring unit 582. As a result, the fluid information input unit 76 sends a signal to the discharge valve instruction unit 75 to close the discharge valve 583 and sends a signal to the compressor operation adjusting unit 78 to start an operation of the compressor 50.

[0090] When the signal is input from the fluid information input unit 76, the pressure change instruction unit 77 drives the pressure changing unit 59.

[0091] The compressor operation adjusting unit 78 starts an operation of the compressor 50. The compressor operation adjusting unit 78 sends an instruction to the compressor 50 while monitoring an operation condition of the compressor 50 based on the pressure values on the inlet side and the outlet side of the compressor 50 and thus adjusts an operation state of the compressor 50 until the operation is stabilized.

[0092] Specifically, the compressor operation adjusting unit 78 of this embodiment receives signals from the first reference determination unit 64 and the fluid information input unit 76. As a result, the compressor operation adjusting unit 78 sends an instruction to the compressor 50 to start an operation. The compressor operation adjusting unit 78 receives information about a pressure value from the first input unit 61 and the second input unit 62. The compressor operation adjusting unit 78 sends a signal to the bypass valve instruction unit 74 to gradually close the bypass valve 572 based on information about the received pressure value. More specifically, the compressor operation adjusting unit 78 sends a signal to adjust a degree of opening of the bypass valve 572 according to the received pressure value. As a result, the compressor operation adjusting unit 78 adjusts an operation state of the compressor 50 until the operation is stabilized while monitoring an operation condition of the compressor 50.

[0093] Next, operations of the subsea production system 1 of the above embodiment will be described. The subsea production system 1 of this embodiment collects

the production fluid PF that is harvested from the oil gas field F through the production well W in the manifold M, conveys the collected production fluid PF into the flow line FL according to pressure energy generated when the production fluid PF is extracted from the oil gas field F, and supplies the production fluid PF to the subsea module SM.

[0094] In the subsea module SM, power is supplied to devices from a generator (not shown) in the ship S by the umbilical line AL. The production fluid PF supplied to the subsea module SM is cooled by the main heat exchanger 2 and flows into the separator 3. The production fluid PF flowed into the separator 3 is separated into the crude oil O that is a liquid and the natural gas G that is a gas. Note that the crude oil O separated out in the separator 3 includes condensates and the like.

[0095] The crude oil O separated out in the separator 3 circulates inside the liquid circulation unit 42 and is sent to the pump 41. The pump 41 compresses the crude oil O, sends it to the oil pipeline OR through the compressed liquid circulation unit 43 and supplies it to a crude oil O storage tank (not shown) in the ship S.

[0096] The natural gas G separated out by the separator 3 circulates in the liquid circulation unit 42 and is sent to the compressor 50. In the compressor 50, the natural gas G is compressed and sent to the compressed gas circulation unit 52. In the compressed gas circulation unit 52, the hydrate anti freezing agent is supplied from the hydrate anti freezing agent supply unit 53, and the compressed natural gas G and the hydrate anti freezing agent are sent to the gas pipeline GR. In the compressed gas circulation unit 52, while preventing freezing due to hydration according to the supplied hydrate anti freezing agent, the natural gas G is supplied to a natural gas G storage tank (not shown) in the ship S.

[0097] Next, a cleaning method of the compressor 50 of the above embodiment will be described. In the compressor 50 configured to compress the natural gas G and supply it to the ship S as described above, when an operation continues, sediments are precipitated and accumulate in the compressor 50. By the cleaning method of the compressor 50, cleaning is performed on the compressor 50 in which such sediments accumulate to remove the sediments. The cleaning method of the compressor 50 of this embodiment will be described with reference to Fig. 2 to Fig. 4.

[0098] In the cleaning method of the compressor 50 of this embodiment, as shown in Fig. 4, the compressor 50 is stopped (a compressor stop process S10). After the compressor stop process S10, on the inlet side and the outlet side of the compressor 50, a pressure value is measured and acquired as a characteristic value of the natural gas G that is a gas separated out by the separator 3, and a state of the compressor 50 is measured (a characteristic value acquiring process S100).

[0099] Specifically, in the characteristic value acquiring process S100, the inlet side characteristic value measuring unit 511 measures a pressure value of the

natural gas G that circulates in the gas circulation unit 51 and acquires a pressure value of the natural gas G on the inlet side of the compressor 50. In addition, in the characteristic value acquiring process S100, the outlet side characteristic value measuring unit 521 measures a pressure value of the natural gas G that circulates in the compressed gas circulation unit 52 and acquires a pressure value of the natural gas G on the outlet side of the compressor 50.

[0100] Next, in the cleaning method of the compressor 50 of this embodiment, a difference between the acquired pressure value on the inlet side of the compressor 50 and the acquired pressure value on the outlet side thereof is calculated (a difference calculating process S200). Specifically, in the difference calculating process S200, information about the pressure value measured by the inlet side characteristic value measuring unit 511 is input to the first input unit 61 of the control unit 60. In addition, in the difference calculating process S200, information about the pressure value measured by the outlet side characteristic value measuring unit 521 is input to the second input unit 62 of the control unit 60. In the control unit 60, information input to the first input unit 61 and the second input unit 62 is input to the difference calculation unit 63. In the difference calculation unit 63, a difference between the pressure value on the outlet side of the compressor 50 and the pressure value on the inlet side thereof is calculated by subtracting information input from the first input unit 61 from information input from the second input unit 62.

[0101] Next, in the cleaning method of the compressor 50 of this embodiment, it is determined whether a hydrate anti freezing agent has been supplied to the compressor 50 (a hydrate anti freezing agent supply determining process S300). Specifically, in the hydrate anti freezing agent supply determining process S300, the difference calculation unit 63 determines whether a hydrate anti freezing agent has already been supplied to the compressor 50. In the difference calculation unit 63, when it is determined that information has been input once from the first input unit 61 and the second input unit 62, it is determined that a hydrate anti freezing agent has already been supplied to the compressor 50 and information about the difference is output to the second reference determination unit 66. On the other hand, in the difference calculation unit 63, when it is determined that information has not been input from the first input unit 61 and the second input unit 62, it is determined that a hydrate anti freezing agent has not been supplied to the compressor 50 and information about the difference is output to the first reference determination unit 64.

[0102] When it is determined that a hydrate anti freezing agent has not been supplied to the compressor 50, it is determined whether the calculated difference satisfies a predetermined first reference (a first reference determining process S400). Specifically, in the first reference determining process S400, in the control unit 60, the calculated difference is input from the difference cal-

circulation unit 63 to the first reference determination unit 64. The first reference determination unit 64 determines whether the input difference value is less than the first reference. When it is determined that the calculated difference is less than the first reference, the first reference determination unit 64 sends a signal to the supply start instruction unit 65. On the other hand, when it is determined that the calculated difference is greater than the first reference, the first reference determination unit 64 sends a signal to the compressor operation adjusting unit 78 and starts an operation of the compressor 50 without performing cleaning of the compressor 50.

[0103] When the first reference determination unit 64 determines that the difference is less than the first reference and satisfies the first reference, the natural gas G inside the compressor 50 is discharged (a gas discharging process S450), the hydrate anti freezing agent is supplied into the compressor 50 (a supply start process S500), and the hydrate anti freezing agent is stored in the compressor 50 (a storing process S430). In the cleaning method of the compressor 50 of this embodiment, the storing process S430, the gas discharging process S450, and the supply start process are performed almost at the same time. Specifically, in the cleaning method of the compressor 50 of this embodiment, supply of the natural gas G to the compressor 50 is stopped and the hydrate anti freezing agent can be stored in the compressor 50. Then, in the cleaning method of the compressor 50, the natural gas G in the compressor 50 is discharged and the hydrate anti freezing agent is supplied into the compressor 50.

[0104] More specifically, in the cleaning method of the compressor 50 of this embodiment, in the control unit 60, a signal is sent from the first reference determination unit 64 to the storage and discharge instruction unit 71. In the cleaning method of the compressor 50, in the control unit 60, a signal is sent from the storage and discharge instruction unit 71 to the first circulation valve instruction unit 72, the second circulation valve instruction unit 73, the bypass valve instruction unit 74, and the discharge valve instruction unit 75.

[0105] When a signal is sent from the storage and discharge instruction unit 71, the first circulation valve instruction unit 72 sends an instruction to close to the first circulation valve 561. When the first circulation valve 561 that has received the instruction is closed, circulation of the natural gas G flowing into the compressor 50 from the gas circulation unit 51 is stopped. When a signal is sent from the storage and discharge instruction unit 71, the second circulation valve instruction unit 73 sends an instruction to close to the second circulation valve 562. When the second circulation valve 562 that has received the instruction is closed, circulation of the natural gas G flowing into the compressed gas circulation unit 52 from the compressor 50 is stopped (the storing process S430).

[0106] When a signal is sent from the storage and discharge instruction unit 71, the bypass valve instruction unit 74 sends an instruction to open to the bypass valve

572. When the bypass valve 572 that has received the instruction is opened, the natural gas G flows into the bypass pipe 571 from the gas circulation unit 51. The natural gas G flowed into the bypass pipe 571 flows into the compressed gas circulation unit 52 from a downstream side of the second circulation valve 562 and is sent to the gas pipeline GR.

[0107] When a signal is sent from the storage and discharge instruction unit 71, the discharge valve instruction unit 75 sends an instruction to open to the discharge valve 583. When the discharge valve 583 that has received the instruction is opened, the natural gas G remaining inside the compressor 50 flows into the discharge pipe 581 from an upstream side of the second circulation valve 562 and is discharged to the outside (the gas discharging process S450).

[0108] In the control unit 60, when a signal is sent from the first reference determination unit 64 to the storage and discharge instruction unit 71, a signal is sent from the first reference determination unit 64 to the supply start instruction unit 65 at the same time. The supply start instruction unit 65 sends a signal to the supply valve instruction unit 68 to start supply of the hydrate anti freezing agent. When a signal is sent from the supply start instruction unit 65, the supply valve instruction unit 68 sends an instruction to open to the supply valve 542. When the supply valve 542 that has received the instruction is opened, part of the hydrate anti freezing agent that circulates in the hydrate anti freezing agent supply unit 53 flows into the supply pipe 541. The hydrate anti freezing agent flowed into the supply pipe 541 flows into the gas circulation unit 51 from a downstream side of the first circulation valve 561 and is sent to the compressor 50 (the supply start process S500, a compressor hydrate anti freezing agent supply process S530).

[0109] The hydrate anti freezing agent flows into the discharge pipe 581 on an upstream side of the second circulation valve 562 through the compressed gas circulation unit 52 from the compressor 50. When the hydrate anti freezing agent flows into the discharge pipe 581, the fluid information measuring unit 582 detects that a circulating fluid has been switched from the natural gas G to the hydrate anti freezing agent and sends information to the fluid information input unit 76. The fluid information input unit 76 sends a signal to the discharge valve instruction unit 75 to close the discharge valve 583 based on the information indicating that a fluid flowing in the discharge pipe 581 has been switched from the natural gas G to the hydrate anti freezing agent. When the discharge valve 583 that has received the instruction is closed, flowing of the hydrate anti freezing agent into the discharge pipe 581 is stopped. When flowing of the hydrate anti freezing agent supplied from the supply pipe 541 to the discharge pipe 581 and the compressed gas circulation unit 52 is stopped, the hydrate anti freezing agent accumulates in the compressor 50.

[0110] The fluid information input unit 76 sends a signal to the discharge valve instruction unit 75 and also sends

a signal to the pressure change instruction unit 77 to drive the pressure changing unit 59. When an instruction is received from the pressure change instruction unit 77, the pressure changing unit 59 changes a pressure of the hydrate anti freezing agent inside the compressor 50 (a pressure changing process S550).

[0111] Specifically, in the pressure changing process S550, a pressure of the hydrate anti freezing agent that flows in the supply pipe 541 is increased or decreased over a predetermined time by the pressure changing unit 59. When the hydrate anti freezing agent is sent from the supply pipe 541 to the compressor 50 while performing a pressure shift in which the pressure is changed in this manner, the pressure of the hydrate anti freezing agent inside the compressor 50 is changed.

[0112] After a pressure of the hydrate anti freezing agent is changed, a pressure value of the natural gas G is measured and acquired again on the inlet side and the outlet side of the compressor 50, and a state of the compressor 50 is measured (the characteristic value acquiring process S100). Then, a difference between the acquired pressure value on the inlet side of the compressor 50 and the acquired pressure value on the outlet side thereof is calculated (the difference calculating process S200). Next, it is determined whether a hydrate anti freezing agent has been supplied to the compressor 50 (the hydrate anti freezing agent supply determining process S300). In this case, information has already been input once from the first input unit 61 and the second input unit 62. Therefore, in the hydrate anti freezing agent supply determining process S300, the difference calculation unit 63 determines that a hydrate anti freezing agent has been supplied to the compressor 50 and outputs difference information to the second reference determination unit 66.

[0113] When it is determined that a hydrate anti freezing agent has been supplied to the compressor 50, it is determined whether the calculated difference satisfies a predetermined second reference (a second reference determining process S600). Specifically, in the second reference determining process S600, in the control unit 60, the calculated difference is input from the difference calculation unit 63 to the second reference determination unit 66. The second reference determination unit 66 determines whether the input difference value is less than the second reference. When it is determined that the calculated difference is less than the second reference, the second reference determination unit 66 sends a signal to the heat supply instruction unit 67. On the other hand, when it is determined that the calculated difference is greater than the second reference, the second reference determination unit 66 sends a signal to the cleaning termination instruction unit 70.

[0114] When the second reference determination unit 66 determines that the difference is less than the second reference and satisfies the second reference, the heated hydrate anti freezing agent is supplied to the compressor 50 (a heat supply process S700). Specifically, in the heat

supply process S700, in the control unit 60, a signal is sent from the second reference determination unit 66 to the heat supply instruction unit 67 and a signal is sent from the heat supply instruction unit 67 to the heating unit 55. When a signal is sent from the heat supply instruction unit 67, the heating unit 55 starts heat exchange with the crude oil O that flows in the liquid circulation unit 42 and heats the hydrate anti freezing agent that flows in the supply pipe 541 to a high temperature of 110 °C or higher. The hydrate anti freezing agent heated to a high temperature flows into the gas circulation unit 51. The high temperature hydrate anti freezing agent flowed into the gas circulation unit 51 is supplied to the compressor 50.

[0115] When the high temperature hydrate anti freezing agent is supplied to the compressor 50, the high temperature hydrate anti freezing agent flows into a position on an upstream side relative to the second circulation valve 562 of the compressed gas circulation unit 52 and also a position on an upstream side relative to the discharge valve 583 of the discharge pipe 581. When the high temperature hydrate anti freezing agent flows into the discharge valve 583, the fluid information measuring unit 582 measures that a temperature of the circulating hydrate anti freezing agent has increased and sends information to the fluid information input unit 76. The fluid information input unit 76 sends a signal to the pressure change instruction unit 77 to drive the pressure changing unit 59 based on information indicating that a temperature of the hydrate anti freezing agent that flows in the discharge pipe 581 has increased. When an instruction is received from the pressure change instruction unit 77, the pressure changing unit 59 changes a pressure of the high temperature hydrate anti freezing agent inside the compressor 50 (the pressure changing process S550).

[0116] After a pressure of the high temperature hydrate anti freezing agent is changed, in the same sequence as the above-described processes, the characteristic value acquiring process S100, the difference calculating process S200, and the hydrate anti freezing agent supply determining process S300 are performed. In the hydrate anti freezing agent supply determining process S300, the difference calculation unit 63 determines again that a hydrate anti freezing agent has been supplied to the compressor 50 and outputs difference information to the second reference determination unit 66. When the compressor 50 is sufficiently cleaned, the second reference determination unit 66 determines that the calculated difference is greater than the second reference and sends a signal to the cleaning termination instruction unit 70.

[0117] The compressor operation adjusting unit 78 to which a signal is sent from the second reference determination unit 66 terminates cleaning of the compressor 50 and starts an operation of the compressor 50 (a cleaning terminating process S800). Specifically, in the cleaning terminating process S800, in the control unit 60, a signal is sent from the compressor operation adjusting unit 78 to the supply valve instruction unit 68, the dis-

charge valve instruction unit 75, the first circulation valve instruction unit 72, and the second circulation valve instruction unit 73.

[0118] When a signal is sent from the compressor operation adjusting unit 78, the supply valve instruction unit 68 sends an instruction to close to the supply valve 542. When the supply valve 542 that has received the instruction is closed, supply of the hydrate anti freezing agent into the supply pipe 541 is stopped.

[0119] When a signal is sent from the compressor operation adjusting unit 78, the discharge valve instruction unit 75 sends an instruction to open to the discharge valve 583. When the discharge valve 583 that has received the instruction is opened, the hydrate anti freezing agent remaining inside the compressor 50 flows into the discharge pipe 581 from an upstream side of the second circulation valve 562 and is discharged to the outside.

[0120] When a signal is sent from the compressor operation adjusting unit 78, the first circulation valve instruction unit 72 sends an instruction to open to the first circulation valve 561. When the first circulation valve 561 that has received the instruction is opened, supply of the natural gas G to the compressor 50 from the gas circulation unit 51 starts. When a signal is sent from the compressor operation adjusting unit 78, the second circulation valve instruction unit 73 sends an instruction to open to the second circulation valve 562. When the second circulation valve 562 that has received the instruction is opened, circulation of the natural gas G flowing into the compressed gas circulation unit 52 from the compressor 50 starts. As a result, the natural gas G is sent to the gas pipeline GR together with a hydrate anti freezing agent that has not flowed into the discharge pipe 581.

[0121] While supply of the natural gas G from the gas circulation unit 51 starts and supply of the hydrate anti freezing agent from the supply pipe 541 is stopped, the hydrate anti freezing agent is discharged from the discharge pipe 581. Therefore, the natural gas G also starts to be gradually discharged from the discharge pipe 581. The fluid information measuring unit 582 detects that a fluid circulating in the discharge pipe 581 has been switched from the hydrate anti freezing agent to the natural gas G and sends information to the fluid information input unit 76. The fluid information input unit 76 sends a signal to the discharge valve instruction unit 75 to close the discharge valve 583 based on information indicating that a fluid flowing in the discharge pipe 581 has been switched from the hydrate anti freezing agent to the natural gas G. When the discharge valve 583 that has received the instruction is closed, discharge of the natural gas G from the discharge pipe 581 stops. As a result, the natural gas G only flows in the compressed gas circulation unit 52 toward the gas pipeline GR.

[0122] The fluid information input unit 76 sends a signal to the discharge valve instruction unit 75 and also sends a signal to the compressor operation adjusting unit 78 to start an operation of the compressor 50. The compressor operation adjusting unit 78 that has received the signal

from the fluid information input unit 76 activates the compressor 50. Then, the compressor operation adjusting unit 78 monitors an operation condition of the compressor 50 and sends a signal to the bypass valve instruction unit 74 to adjust a degree of opening of the bypass valve 572 based on information about the pressure value input from the first input unit 61 and the second input unit 62. The compressor operation adjusting unit 78 adjusts an operation state of the compressor 50 until the operation is stabilized while a degree of opening of the bypass valve 572 is adjusted through the bypass valve instruction unit 74.

[0123] According to the compressor system 5 described above, part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit 53 to the compressed gas circulation unit 52 for preventing hydration of the natural gas G compressed by the compressor 50 is supplied to the compressor 50 when the supply valve 542 is opened. The hydrate anti freezing agent not only prevents freezing of the natural gas G and prevents hydration but also removes oil contamination and aqueous contamination due to the lipophilicity and hydrophilicity of the hydrate anti freezing agent. Therefore, it is possible to. Therefore, it is possible to effectively remove sediments that are precipitated inside the compressor 50 by the hydrate anti freezing agent supplied to the compressor 50. When part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit 53 to the compressed gas circulation unit 52 is used, it is possible to reliably supply a necessary amount of the hydrate anti freezing agent to the compressor 50. When a pressure shift in which the pressure of the hydrate anti freezing agent inside the compressor 50 is increased or decreased by the pressure changing unit 59 through the supply pipe 541 is performed, the hydrate anti freezing agent inside the compressor 50 can be stirred. Therefore, it is possible to clean the inside of the compressor 50 by effectively using the hydrate anti freezing agent. Accordingly, it is possible to reliably and effectively clean the compressor 50.

[0124] In the compressor system 5 of this embodiment, while the first circulation valve 561 is closed to stop supply of the natural gas G to the compressor 50 and the second circulation valve 562 is closed, the discharge valve 583 is opened to discharge the natural gas G from the discharge pipe 581 to the outside. In addition, while the natural gas G is discharged and almost none remains inside, the hydrate anti freezing agent is supplied to the compressor 50 and a pressure is changed by the pressure changing unit 59. Therefore, it is possible to prevent the hydrate anti freezing agent supplied into the compressor 50 from being diluted by the natural gas G. Therefore, it is possible to efficiently use the hydrate anti freezing agent supplied from the supply pipe 541 for cleaning the compressor 50 and it is possible to minimize a supply amount of the hydrate anti freezing agent.

[0125] While the first circulation valve 561 and the second circulation valve 562 are closed and the discharge

valve 583 is also closed, when the hydrate anti freezing agent is supplied to the compressor 50, the hydrate anti freezing agent inside the compressor 50 can be stored without being discharged. While the hydrate anti freezing agent is stored inside the compressor 50, when a pressure is changed by the pressure changing unit 59, it is possible to efficiently stir the hydrate anti freezing agent inside the compressor 50. Therefore, it is possible to clean the inside of the compressor 50 by using the hydrate anti freezing agent more effectively. When cleaning is performed without discharging the hydrate anti freezing agent from the compressor 50, it is possible to reduce a supply amount of the hydrate anti freezing agent to the compressor 50 and perform cleaning of the compressor 50.

[0126] When predetermined conditions are satisfied as in the first reference determination unit 64, the control unit 60 causes the hydrate anti freezing agent to flow into the supply pipe 541 from the hydrate anti freezing agent supply unit 53 and supplies it to the compressor 50. That is, when control of supply of the hydrate anti freezing agent to the compressor 50 is performed by the first reference determination unit 64, it is possible to limit supply of the hydrate anti freezing agent to the compressor 50 that is in a state in which cleaning is necessary. Therefore, it is possible to efficiently use the hydrate anti freezing agent for cleaning the compressor 50, and it is possible to further minimize a supply amount of the hydrate anti freezing agent.

[0127] In the control unit 60, a pressure value of the natural gas G on the inlet side of the compressor 50 measured by the inlet side characteristic value measuring unit 511 of the gas circulation unit 51 is input to the first input unit 61. In addition, in the control unit 60, a pressure value of the natural gas G on the outlet side of the compressor 50 measured by the outlet side characteristic value measuring unit 521 of the compressed gas circulation unit 52 is input to the second input unit 62. As a result, it is possible to acquire the pressure values of the natural gas G on the inlet side and the outlet side of the compressor 50. When the difference calculation unit 63 calculates a difference between the acquired pressure values of the natural gas G on the inlet side and the outlet side of the compressor 50 and the first reference determination unit 64 compares the difference with the first reference for determination, it is possible to easily determine whether the compressor 50 is in a state in which cleaning is necessary. Based on the determination result, a signal is sent from the first reference determination unit 64 to the supply start instruction unit 65 and the supply valve 542 is opened through the supply valve instruction unit 68. Therefore, it is possible to start supply of the hydrate anti freezing agent to the supply pipe 541 and it is possible to perform cleaning of the compressor 50. Therefore, it is possible to determine whether the compressor 50 is in a state in which cleaning is necessary with high accuracy and it is possible to further limit supply of the hydrate anti freezing agent. Therefore, for the com-

pressor 50 for which cleaning is necessary, it is possible to more efficiently supply the hydrate anti freezing agent from the supply pipe 541 and it is possible to further minimize a supply amount of the hydrate anti freezing agent.

[0128] When the heating unit 55 configured to heat a hydrate anti freezing agent is provided in the supply pipe 541, it is possible to supply a high temperature hydrate anti freezing agent to the compressor 50. It is possible to improve solubility of sediments due to the hydrate anti freezing agent that is heated to a high temperature. Therefore, it is possible to increase a dissolution rate of sediments accumulated in the compressor 50 and effectively clean the compressor 50.

[0129] The difference calculation unit 63 calculates a difference between the acquired pressure values of the natural gas G on the inlet side and the outlet side of the compressor 50 and the second reference determination unit 66 compares the difference with the second reference that is set to a value greater than the first reference for determination. Therefore, it is possible to easily determine again whether the compressor 50 is in a state in which cleaning is necessary. Therefore, for example, it is possible to easily determine whether the compressor 50 is in a state that is different from the state determined using the first reference (for example, whether greater cleaning is necessary for the compressor 50). Based on the determination result, a signal is sent from the second reference determination unit 66 to the heat supply instruction unit 67 and the heating unit 55 starts heating. Therefore, it is possible to increase a temperature of the hydrate anti freezing agent that flows in the supply pipe 541. As a result, it is possible to supply the hydrate anti freezing agent that is heated to a high temperature to the compressor 50 and it is possible to more effectively clean the compressor 50. Therefore, it is possible to determine whether the compressor 50 is in a state that is different from the state determined using the first reference for cleaning with high accuracy and it is possible to perform greater cleaning on the compressor 50 as necessary. Therefore, when the compressor 50 is in a state in which greater cleaning is necessary, it is possible to efficiently supply the heated hydrate anti freezing agent and clean the compressor 50 more efficiently.

[0130] When monoethylene glycol whose hydrocarbon part has lipophilicity and whose hydroxyl group and ether group have hydrophilicity is used as the hydrate anti freezing agent, it is possible to effectively clean both oil contamination and aquatic contamination in the compressor 50.

[0131] According to the subsea production system 1 described above, it is also possible to reliably and efficiently clean the compressor 50 that is installed at a position at which maintenance is difficult, for example, in the seabed. Therefore, it is possible to prevent clogging due to sediments and it is possible to reliably send the natural gas G to the ship S through the compressor 50.

[0132] According to the cleaning method of the compressor 50 described above, in the compressor hydrate

anti freezing agent supply process S530 (the supply start process S500), part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit 53 to the compressed gas circulation unit 52 is supplied to the compressor 50. That is, without newly preparing and supplying the hydrate anti freezing agent, part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit 53 to the compressed gas circulation unit 52 is used. Therefore, it is possible to reliably supply a necessary amount of the hydrate anti freezing agent to the compressor 50.

[0133] In the gas discharging process S450, while the first circulation valve 561 is closed to stop supply of the natural gas G to the compressor 50 and the second circulation valve 562 is closed, the discharge valve 583 is opened to discharge the natural gas G from the discharge pipe 581 to the outside. Therefore, in the pressure changing process S550, while the natural gas G is discharged and almost none remains inside, it is possible to perform a pressure shift on the hydrate anti freezing agent inside the compressor 50 by increasing or decreasing the pressure by the pressure changing unit 59 through the supply pipe 541. Therefore, it is possible to prevent the hydrate anti freezing agent supplied into the compressor 50 from being diluted by the natural gas G and it is possible to stir the hydrate anti freezing agent inside the compressor 50. As a result, it is possible to clean the inside of the compressor 50 by effectively and efficiently using the hydrate anti freezing agent. Therefore, it is possible to efficiently use the hydrate anti freezing agent supplied from the supply pipe 541 for cleaning the compressor 50 and it is possible to reliably and effectively clean the compressor 50 while minimizing a supply amount of the hydrate anti freezing agent.

[0134] In the storing process S430, while the first circulation valve 561 and the second circulation valve 562 are closed and the discharge valve 583 is also closed, the hydrate anti freezing agent is supplied to the compressor 50. Therefore, the hydrate anti freezing agent inside the compressor 50 can be stored without being discharged. While the hydrate anti freezing agent is stored inside the compressor 50, when a pressure is changed by the pressure changing unit 59, it is possible to efficiently stir the hydrate anti freezing agent inside the compressor 50. Therefore, it is possible to clean the inside of the compressor 50 by using the hydrate anti freezing agent more effectively. When cleaning is performed without discharging the hydrate anti freezing agent from the compressor 50, it is possible to reduce a supply amount of the hydrate anti freezing agent to the compressor 50 and perform cleaning of the compressor 50.

[0135] A difference between the pressure values of the natural gas G on the inlet side and the outlet side of the compressor 50 acquired in the characteristic value acquiring process S100 is calculated in the difference calculating process S200. In the hydrate anti freezing agent supply determining process S300, it is determined whether a hydrate anti freezing agent has been supplied to the

compressor 50. Then, in the first reference determining process S400, the difference is compared with the first reference for determination, and thus it is possible to easily determine whether the compressor 50 is in a state in which cleaning is necessary. Based on the determination result, in the supply start process S500, the supply valve 542 is opened, and thus it is possible to start supply of the hydrate anti freezing agent to the supply pipe 541. As a result, it is possible to start supply of the hydrate anti freezing agent to the compressor 50 and it is possible to perform cleaning of the compressor 50. Therefore, it is possible to determine whether the compressor 50 is in a state in which cleaning is necessary with high accuracy and it is possible to further limit supply of the hydrate anti freezing agent. Therefore, for the compressor 50 for which cleaning is necessary, it is possible to more efficiently supply the hydrate anti freezing agent supplied from the supply pipe 541 and it is possible to further minimize a supply amount of the hydrate anti freezing agent.

[0136] In the hydrate anti freezing agent supply determining process S300, it is determined whether a hydrate anti freezing agent has been supplied to the compressor 50. Then, based on the determination result, in the first reference determining process S400, the second reference determining process S600 is performed. Therefore, it is possible to determine a cleaning state of the compressor 50. Therefore, it is possible to more efficiently clean the compressor 50 according to the cleaning state of the compressor 50.

[0137] A difference between the pressure values of the natural gas G on the inlet side and the outlet side of the compressor 50 acquired in the characteristic value acquiring process S100 is calculated in the difference calculating process S200. In the second reference determining process S600, the difference is compared with the second reference that is set to a value greater than the first reference for determination. Therefore, it is possible to easily determine again whether the compressor 50 is in a state in which cleaning is necessary. Therefore, for example, it is possible to easily determine whether the compressor 50 is in a state that is different from the state determined using the first reference (for example, whether greater cleaning is necessary for the compressor 50). Based on the determination result, in the heat supply process S700, the heating unit 55 starts heating. Therefore, it is possible to increase a temperature of the hydrate anti freezing agent that flows in the supply pipe 541. As a result, it is possible to supply the hydrate anti freezing agent that is heated to a high temperature to the compressor 50 and it is possible to more effectively clean the compressor 50. Therefore, it is possible to determine whether the compressor 50 is in a state that is different from the state determined using the first reference for cleaning with high accuracy and it is possible to perform greater cleaning on the compressor 50 as necessary. Therefore, when the compressor 50 is in a state in which greater cleaning is necessary, it is possible to efficiently supply the heated hydrate anti freezing agent and clean

the compressor 50 more efficiently.

[0138] The embodiments of the present invention have been described in detail above with reference to the drawings, but configurations and combinations thereof in the embodiments are only examples, and additions, omissions, substitutions and other modifications of the configurations can be made without departing from the scope of the present invention. In addition, the present invention is not limited to the embodiments and is only limited by the scope of the appended claims.

[0139] Note that a characteristic value of a gas is not limited to a pressure value of the gas as in this embodiment, and may be a value at which there is a difference in a state before and after the gas is compressed by the compressor. For example, the characteristic value of the gas may be a value obtained by measuring a temperature of the gas, a value obtained by measuring a flow rate of the gas, and a value obtained by calculating an efficiency of the compressor 50.

[0140] When it is determined whether the first reference or the second reference is satisfied, determination of whether to supply the hydrate anti freezing agent may not be based on a single determination result as in this embodiment, but based on a plurality of determinations of whether the first reference or the second reference is satisfied. In such a configuration, it is possible to determine a contamination condition of the compressor 50 with high accuracy.

[Industrial Applicability]

[0141] According to the above-described compressor system, when part of the hydrate anti freezing agent supplied to the compressed gas circulation unit in which a compressed gas circulates is supplied into the compressor and a pressure is changed, it is possible to efficiently clean the compressor.

[Reference Signs List]

[0142]

1	Subsea production system
S	Ship
F	Oil gas field
W	Production well
PF	Production fluid
M	Manifold
FL	Flow line
R	Riser
GR	Gas pipeline
OR	Oil pipeline
AR	Pipeline for a hydrate anti freezing agent
AL	Umbilical line
SM	Subsea module
2	Main heat exchanger
3	Separator
4	Pump system

41	Pump
42	Liquid circulation unit
43	Compressed liquid circulation unit
5	Compressor system
50	Compressor
51	Gas circulation unit
511	Inlet side characteristic value measuring unit
52	Compressed gas circulation unit
521	Outlet side characteristic value measuring unit
10 53	Hydrate anti freezing agent supply unit
54	Compressor hydrate anti freezing agent supply unit
541	Supply pipe
542	Supply valve
15 55	Heating unit
56	Storage unit
561	First circulation valve
562	Second circulation valve
57	Bypass supply valve
20 571	Bypass pipe
572	Bypass valve
58	Gas discharge unit
581	Discharge pipe
582	Fluid information measuring unit
25 583	Discharge valve
59	Pressure changing unit
60	Control unit
61	First input unit
62	Second input unit
30 63	Difference calculation unit
64	First reference determination unit
65	Supply start instruction unit
66	Second reference determination unit
67	Heat supply instruction unit
35 68	Supply valve instruction unit
70	Cleaning termination instruction unit
71	Storage and discharge instruction unit
72	First circulation valve instruction unit
73	Second circulation valve instruction unit
40 74	Bypass valve instruction unit
75	Discharge valve instruction unit
76	Fluid information input unit
77	Pressure change instruction unit
78	Compressor operation adjusting unit
45 S10	Compressor stop process
S100	Characteristic value acquiring process
S200	Difference calculating process
S300	Hydrate anti freezing agent supply determining process
50 S400	First reference determining process
S430	Storing process
S450	Gas discharging process
S550	Pressure changing process
S500	Supply start process
55 S530	Compressor hydrate anti freezing agent supply process
S600	Second reference determining process
S700	Heat supply process

Claims**1.** A compressor system comprising:

a compressor configured to compress a gas; 5
 a compressed gas circulation unit in which a gas
 compressed by the compressor circulates;
 a hydrate anti freezing agent supply unit config-
 ured to supply a hydrate anti freezing agent for
 preventing hydration of the gas to the com- 10
 pressed gas circulation unit;
 a compressor hydrate anti freezing agent supply
 unit configured to supply part of the hydrate anti
 freezing agent supplied from the hydrate anti
 freezing agent supply unit to the compressor; 15
 and
 a pressure changing unit configured to change
 a pressure of the hydrate anti freezing agent in-
 side the compressor.

2. The compressor system according to claim 1, com-
prising

a gas discharge unit configured to discharge the 20
 gas inside the compressor,
 wherein the compressor hydrate anti freezing
 agent supply unit supplies the hydrate anti freez- 25
 ing agent to the compressor from which the gas
 is discharged by the gas discharge unit.

3. The compressor system according to claim 1 or 2,
comprising

a storage unit configured to store the hydrate 30
 anti freezing agent in the compressor,
 wherein the pressure changing unit changes a
 pressure of the hydrate anti freezing agent that 35
 is stored by the storage unit.

4. The compressor system according to any one of
claims 1 to 3, comprising

a control unit configured to perform supply con- 40
 trol such that, when predetermined conditions
 are satisfied, the compressor hydrate anti freez- 45
 ing agent supply unit starts supply of the hydrate
 anti freezing agent to the compressor.

5. The compressor system according to claim 4,

wherein the control unit includes
 a first reference determination unit configured
 to determine whether a difference between
 characteristic values of the gas on an inlet side 50
 of the compressor and an outlet side of the com-
 pressor satisfies a predetermined first refer-
 ence, and
 a supply start instruction unit configured to send

an instruction to the compressor hydrate anti
 freezing agent supply unit to start supply of the
 hydrate anti freezing agent to the compressor
 when the first reference determination unit de-
 termines that the first reference is satisfied.

6. The compressor system according to any one of
claims 1 to 5, comprising

a heating unit configured to heat the hydrate anti
 freezing agent,
 wherein the compressor hydrate anti freezing
 agent supply unit supplies the hydrate anti freez-
 ing agent heated by the heating unit to the com-
 pressor.

7. The compressor system according to claim 5, com-
prising

a heating unit configured to heat the hydrate anti
 freezing agent,
 wherein the control unit includes
 a second reference determination unit config-
 ured to determine whether a difference between
 characteristic values of the gas on the inlet side
 of the compressor and the outlet side of the com-
 pressor satisfies a predetermined second refer-
 ence after supply of the hydrate anti freezing
 agent to the compressor starts, and
 a heat supply instruction unit configured to send
 an instruction to the compressor hydrate anti
 freezing agent supply unit to supply the hydrate
 anti freezing agent heated by the heating unit to
 the compressor when the second reference de-
 termination unit determines that the second re-
 ference is satisfied.

8. A subsea production system comprising:

the compressor system according to any one of
 claims 1 to 7; and
 a separator configured to separate a production
 fluid drawn from a production well into the gas
 and a liquid and supply the result to the com-
 pressor.

9. A compressor cleaning method in which a compres-
sor configured to compress a gas is cleaned, com-
prising:

a gas discharging process in which the gas in-
 side the compressor is discharged;
 a compressor hydrate anti freezing agent supply
 process in which part of a hydrate anti freezing
 agent for preventing hydration of the gas sup-
 plied to a compressed gas circulation unit in
 which a gas compressed by the compressor cir-
 culates is supplied to the compressor from which

the gas is discharged in the gas discharging process; and
 a pressure changing process in which a pressure of the hydrate anti freezing agent in the compressor is changed.

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10. The compressor cleaning method according to claim 9, comprising

a storing process in which the hydrate anti freezing agent is stored in the compressor, wherein, in the pressure changing process, a pressure of the hydrate anti freezing agent stored in the storing process is changed.

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11. The compressor cleaning method according to claim 9 or 10, comprising

a first reference determining process in which it is determined whether a difference between characteristic values of the gas on an inlet side of the compressor and an outlet side of the compressor satisfies a predetermined first reference, and
 a supply start process in which, when it is determined in the first reference determining process that the first reference is satisfied, supply of the hydrate anti freezing agent to the compressor starts.

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12. The compressor cleaning method according to claim 11, comprising

a second reference determining process in which, after supply of the hydrate anti freezing agent to the compressor starts, it is determined whether a difference between characteristic values of the gas on the inlet side of the compressor and the outlet side of the compressor satisfies a predetermined second reference, and
 a heat supply process in which, when it is determined in the second reference determining process that the second reference is satisfied, the heated hydrate anti freezing agent is supplied to the compressor.

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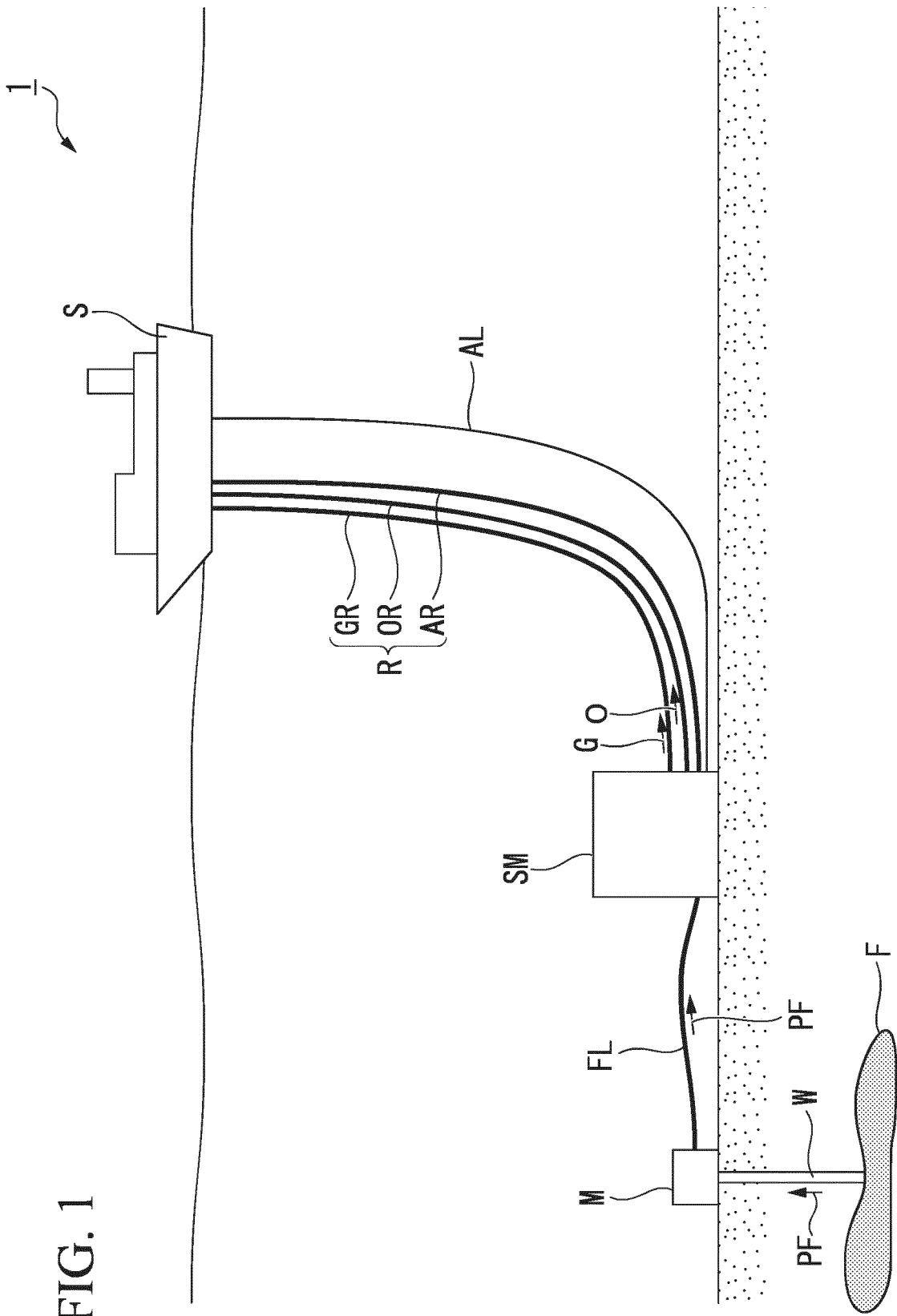


FIG. 2

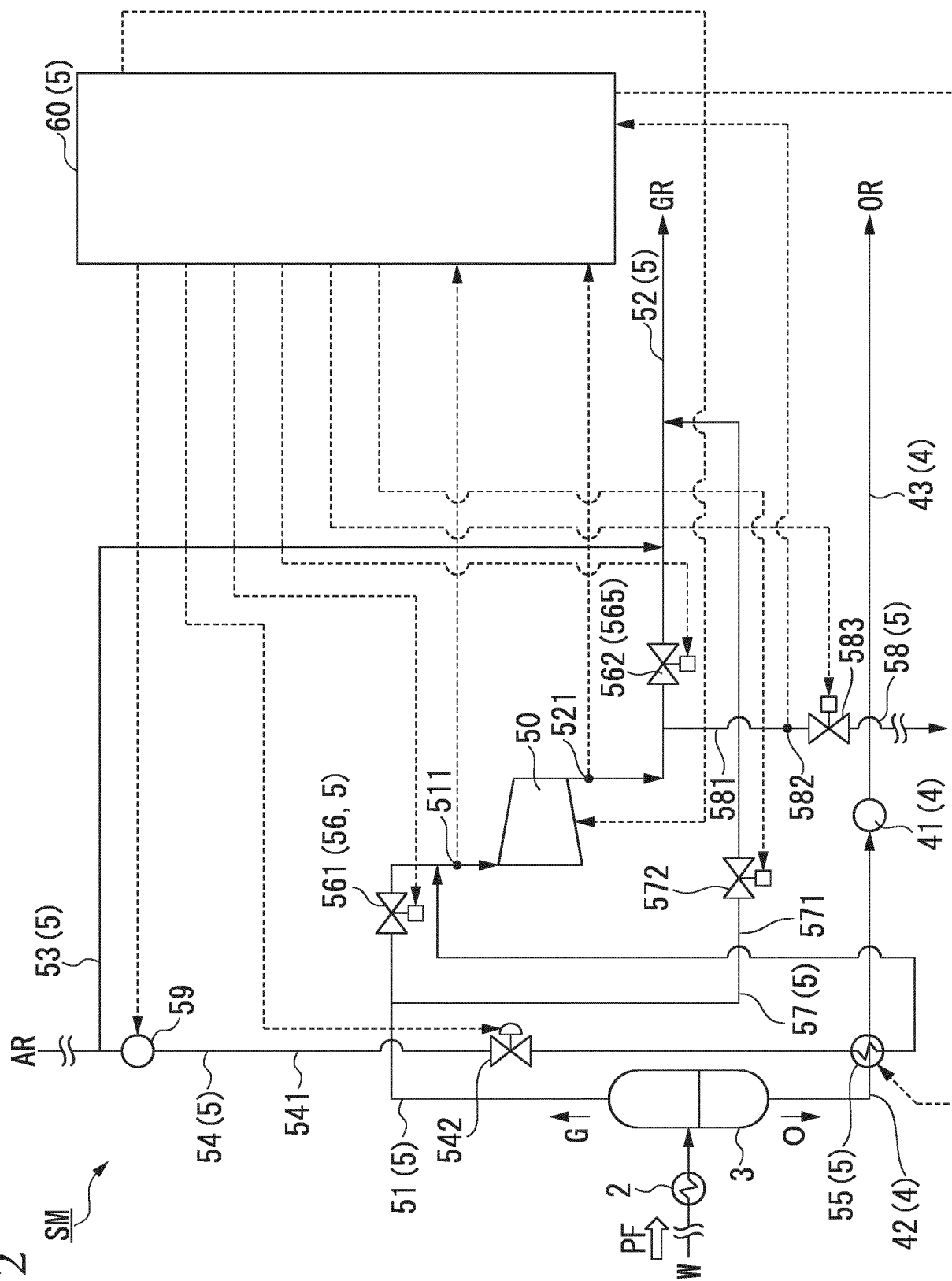


FIG. 3

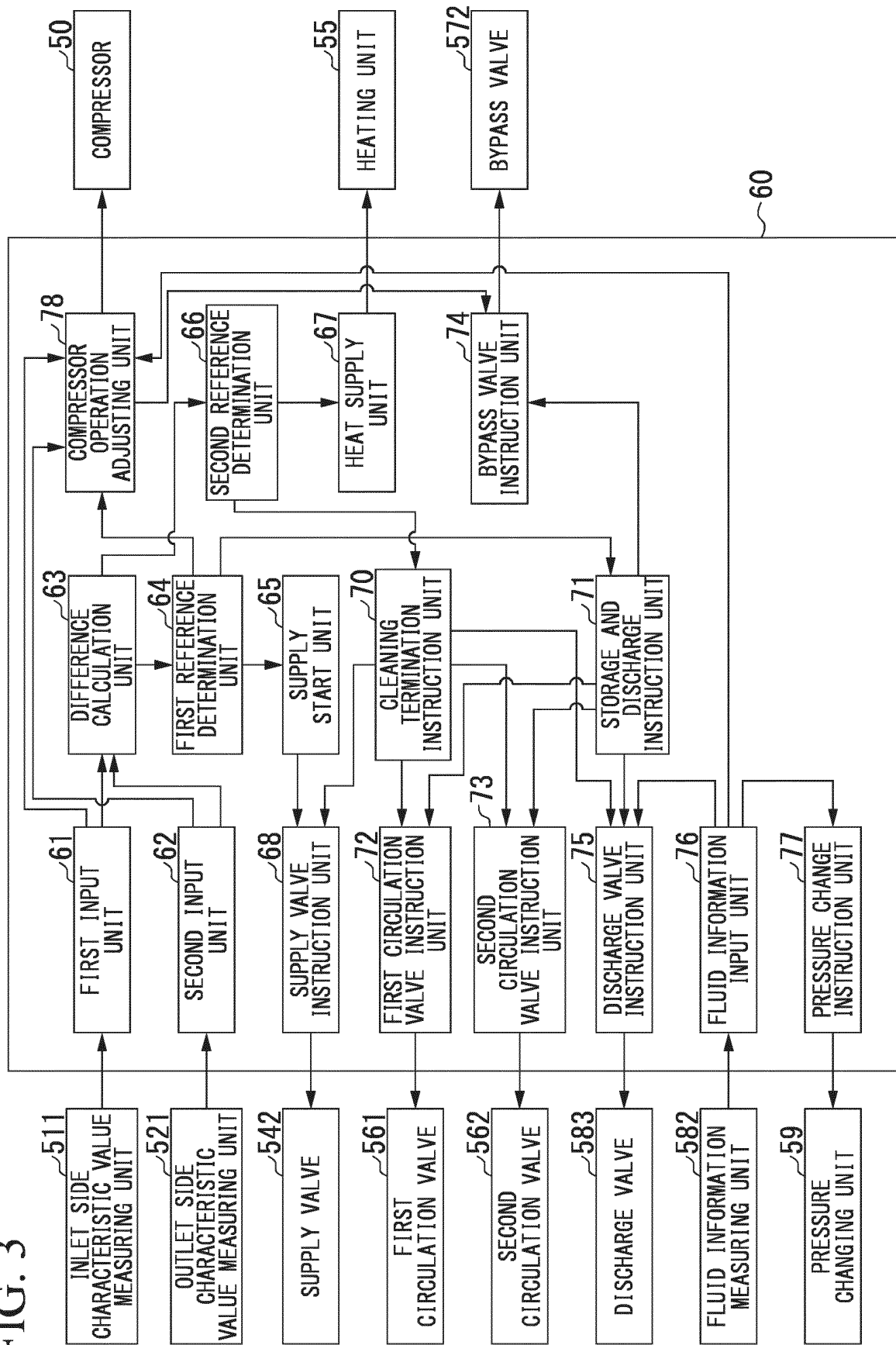
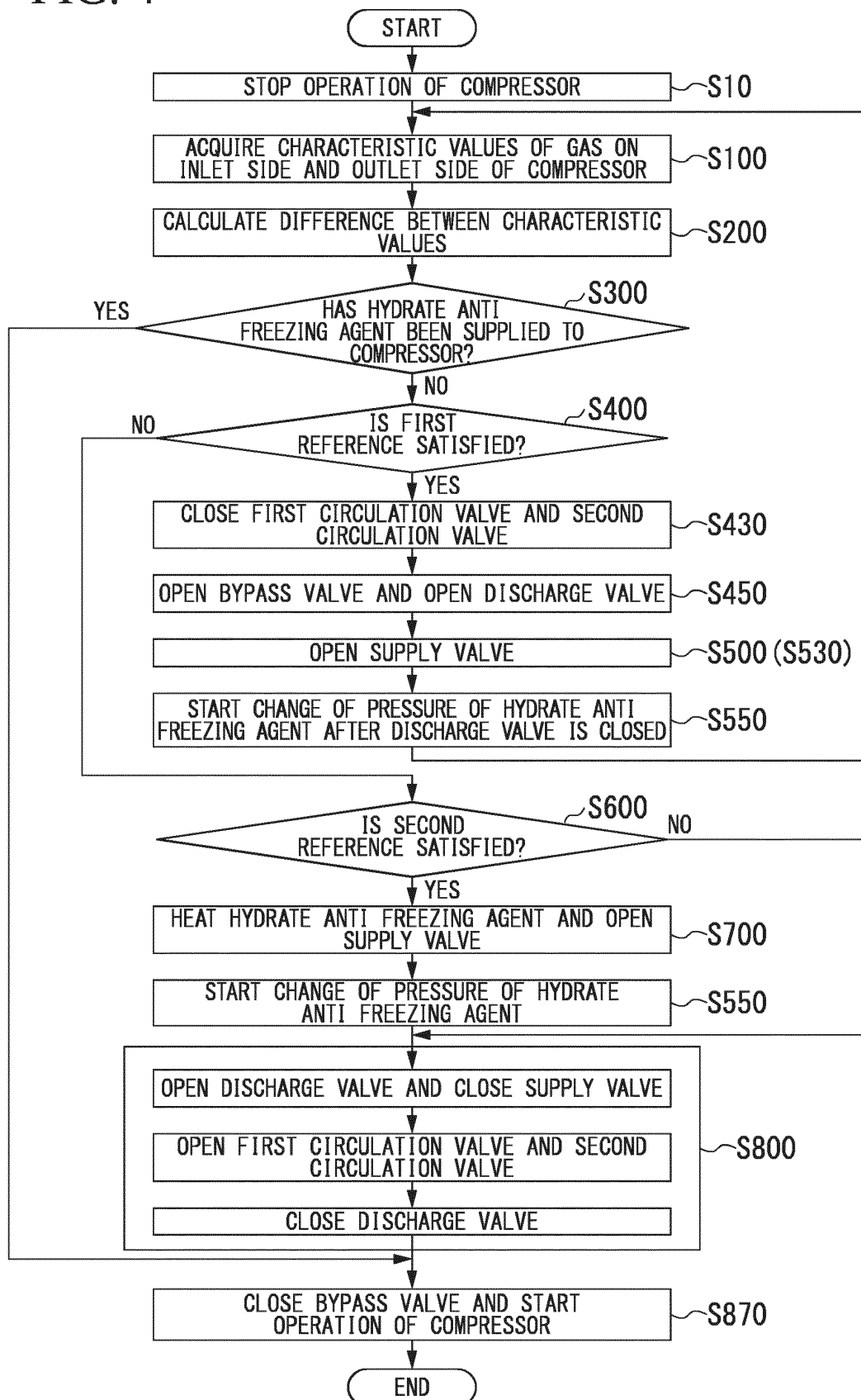


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/051547

A. CLASSIFICATION OF SUBJECT MATTER

E21B43/12(2006.01)i, E21C50/00(2006.01)i, F04D29/70(2006.01)i, F04D31/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B43/12, E21C50/00, F04D29/70, F04D31/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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.
A	WO 2007/004886 A1 (AKER KVAERNER SUBSEA AS), 11 January 2007 (11.01.2007), page 6, line 21 to page 8, line 4; page 9, lines 1 to 22; fig. 1, 3 & US 2009/0050326 A1 & EP 1907705 A & NO 20053296 A	1-12
A	WO 2013/185801 A1 (STATOIL PETROLEUM AS), 19 December 2013 (19.12.2013), entire text; all drawings & CA 2876328 A	1-12



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&"

document member of the same patent family

Date of the actual completion of the international search
09 April 2015 (09.04.15)

Date of mailing of the international search report
21 April 2015 (21.04.15)

Name and mailing address of the ISA/
Japan Patent Office
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Tokyo 100-8915, Japan

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Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/051547

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 193985/1984 (Laid-open No. 108900/1986) (Ishikawajima-Harima Heavy Industries Co., Ltd.), 10 July 1986 (10.07.1986), page 8, lines 2 to 18; all drawings (Family: none)	1-12
A	WO 2013/002644 A1 (AKER SUBSEA AS), 03 January 2013 (03.01.2013), page 2, lines 29 to 34; fig. 1 & NO 20110946 A & AU 2012276386 A	1-12

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

REFERENCES CITED IN THE DESCRIPTION

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