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(54) **CRYOPUMP SYSTEM AND REGENERATION CONTROLLER**

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(57) **ABSTRACT**

A cryopump system includes a plurality of cryopumps each of which includes a cryopump container, an exhaust valve that exhausts an exhaust fluid from the cryopump container, and an exhaust purge valve that supplies a purge gas to the exhaust valve or downstream thereof and an exhaust line through which the exhaust fluid is exhausted from the plurality of cryopumps to a treatment device, the exhaust line including a plurality of branch lines and a merging line, the plurality of branch lines each connected to the exhaust valve and the exhaust purge valve of a corresponding cryopump, the merging line connecting the plurality of branch lines to the treatment device.

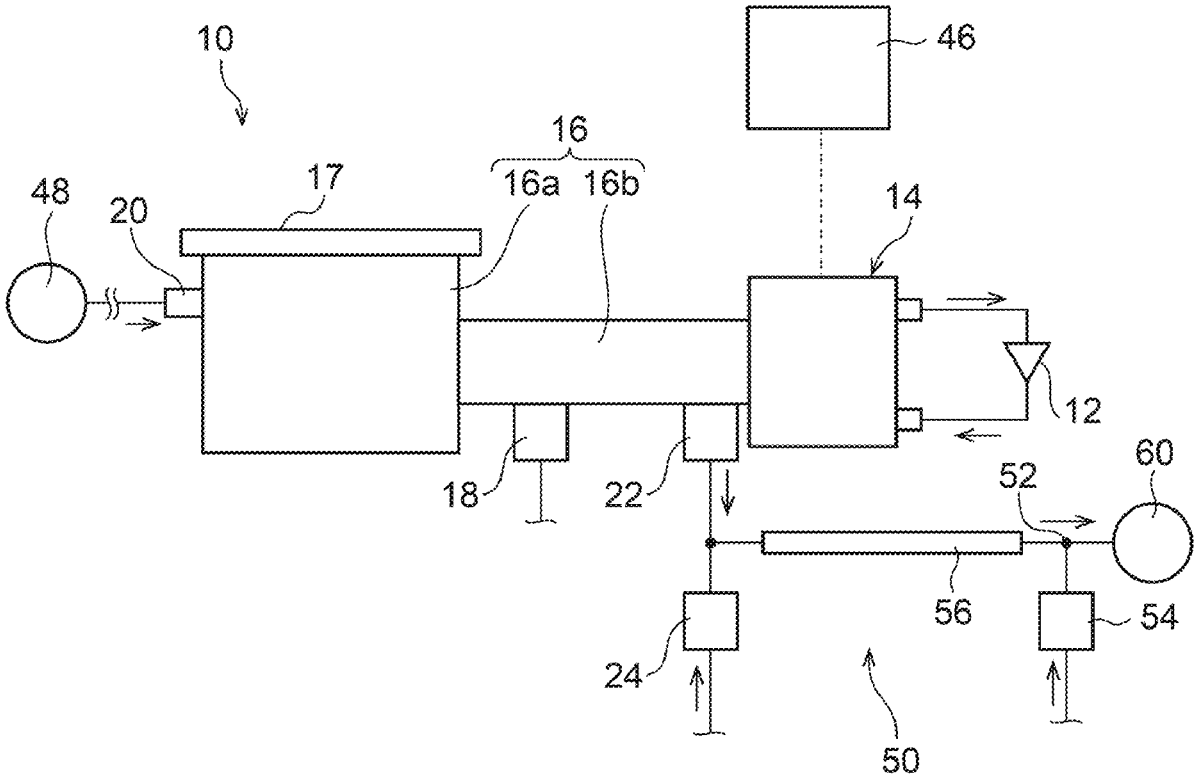
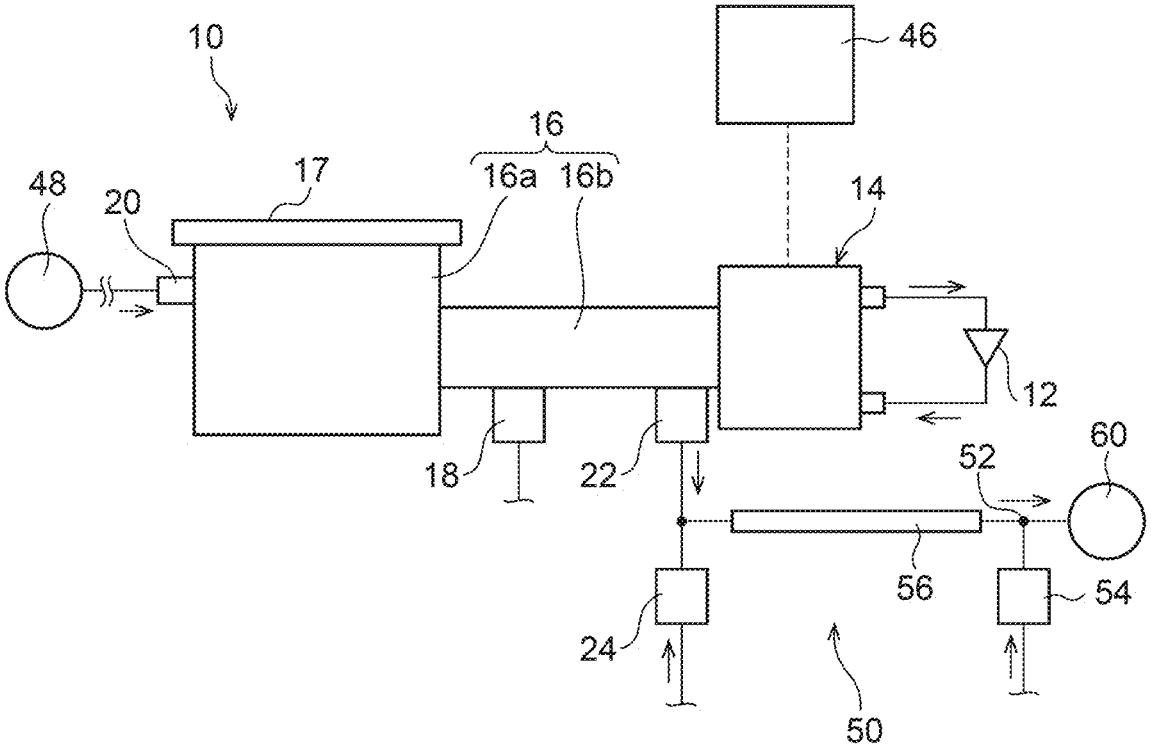


FIG. 1



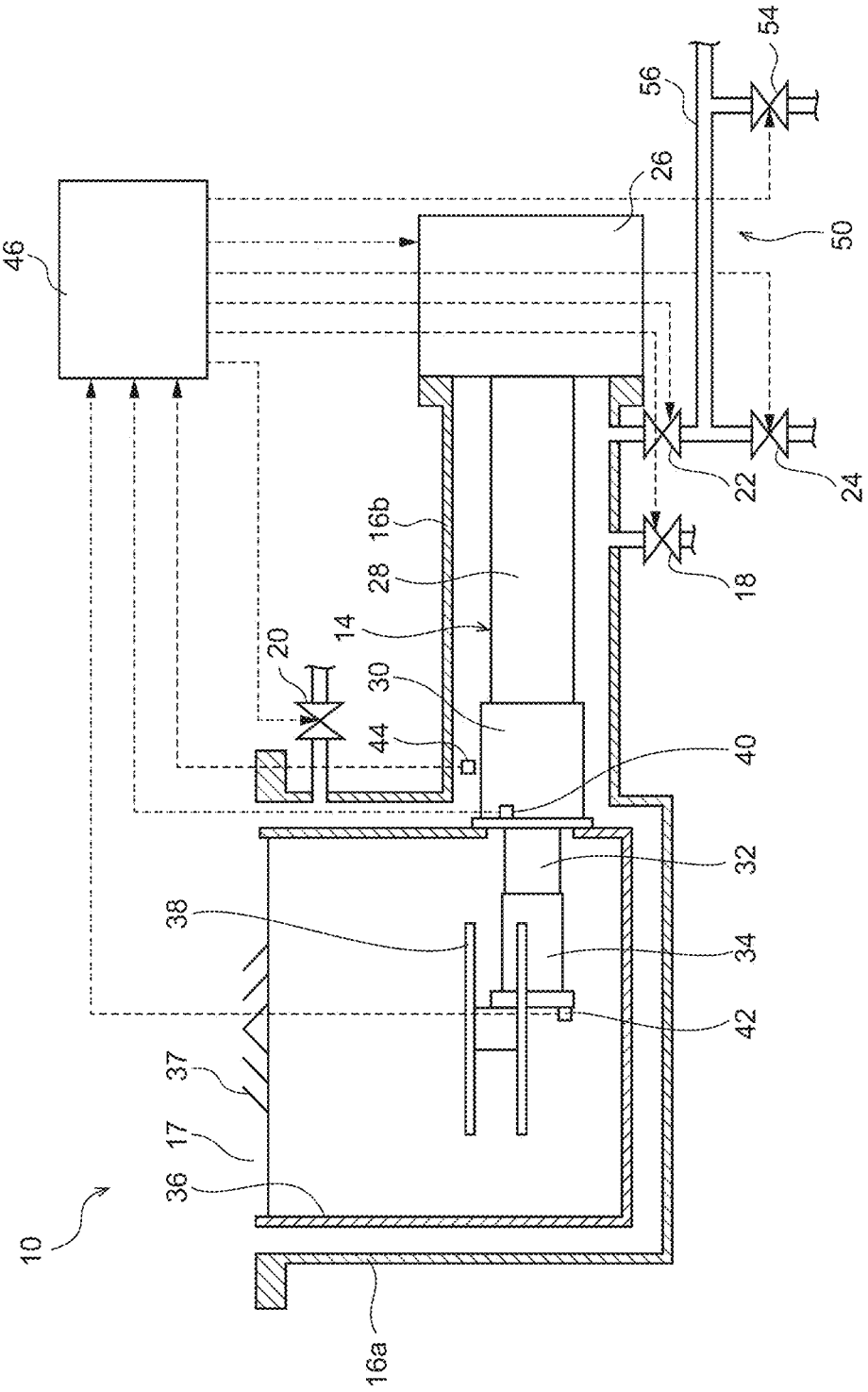

54
56
26
46
50
22
24
16b
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18
14
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44
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32
38
34
42
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17
36
10
16a

FIG. 2

FIG. 3A

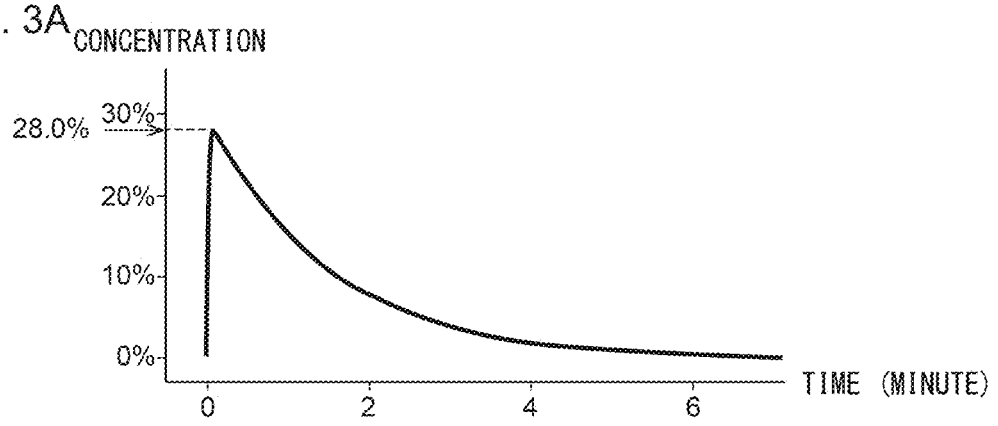


FIG. 3B

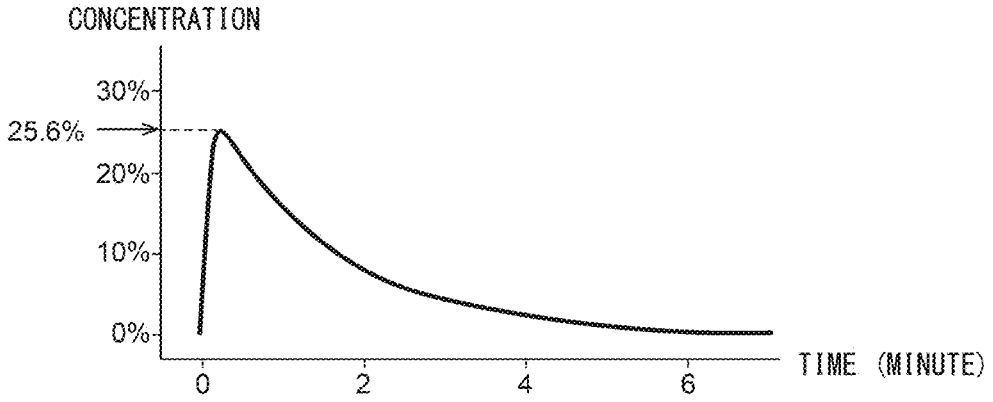


FIG. 3C

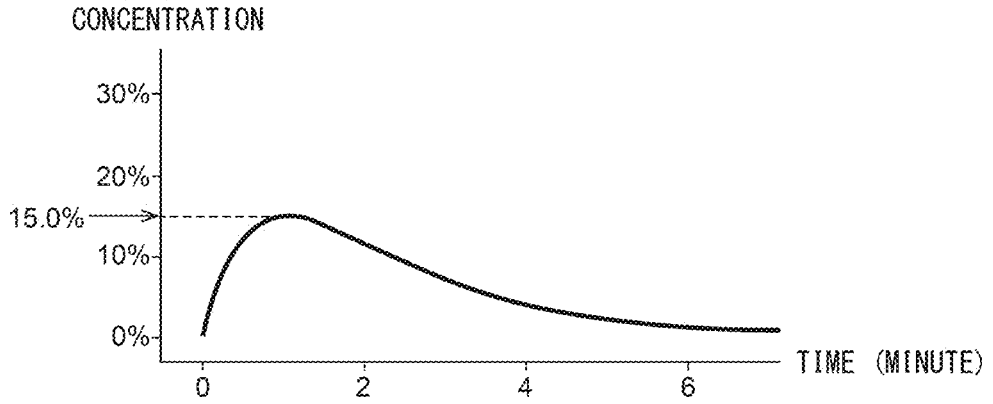


FIG. 4A

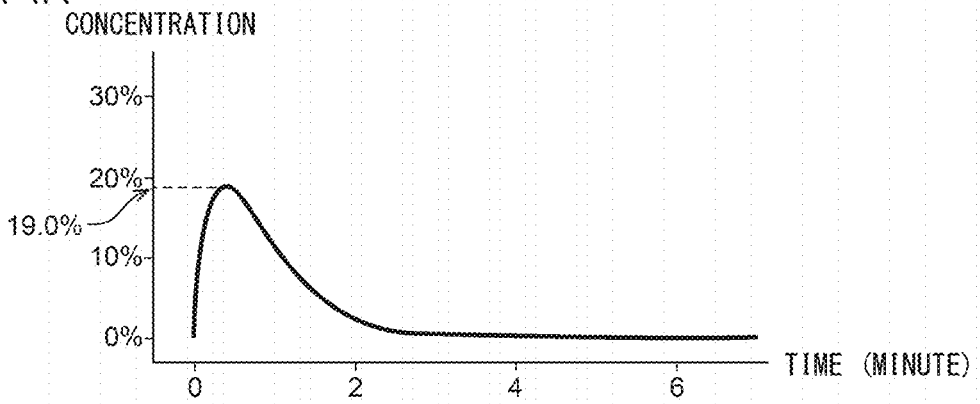


FIG. 4B

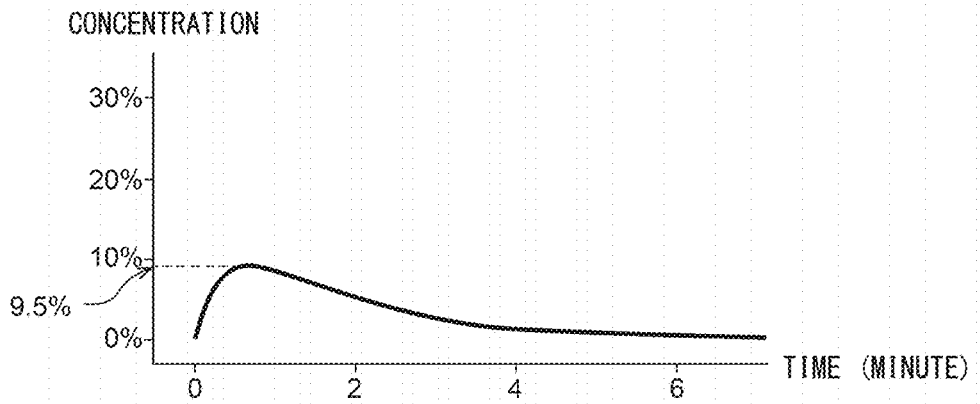


FIG. 4C

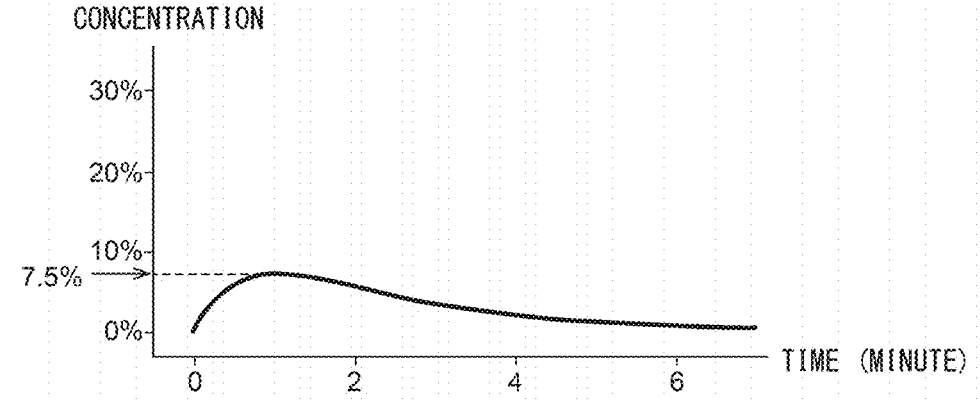
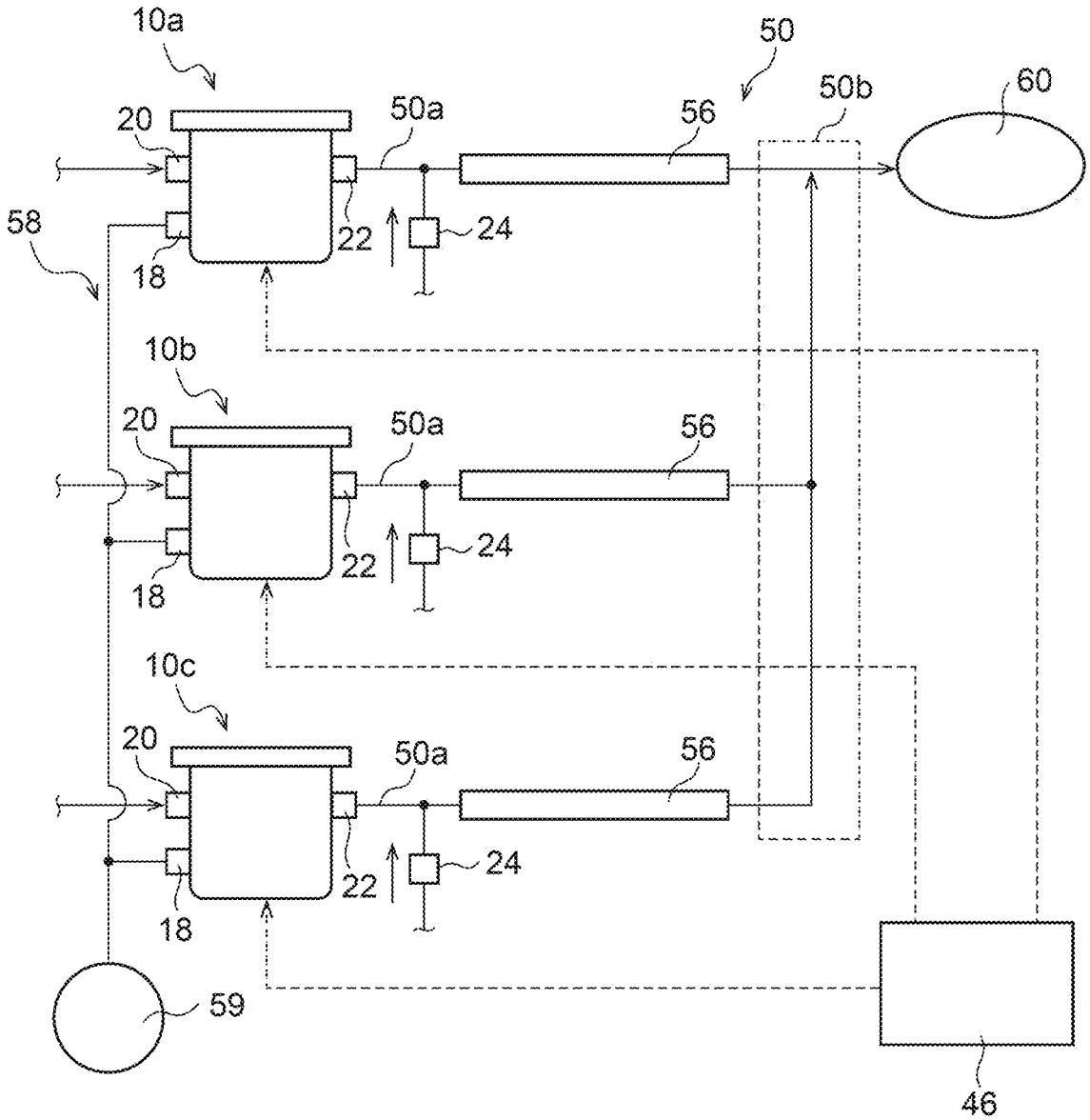


FIG. 5


10a
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50b
60
20
50a
56
58
22
24
18
10b
20
50a
56
22
24
18
10c
20
50a
56
22
24
18
59
46

CRYOPUMP SYSTEM AND REGENERATION CONTROLLER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This is a bypass continuation of International PCT Application No. PCT/JP2022/048620, filed on Dec. 28, 2022, which claims priority to Japanese Patent Application No. 2022-013219, filed on Jan. 31, 2022, which are incorporated by reference herein in their entirety.

BACKGROUND

Technical Field

[0002] Certain embodiments of the present invention relate to a cryopump system and a regeneration controller for a cryopump system.

Description of Related Art

[0003] A cryopump is a vacuum pump that captures gas molecules through condensation and adsorption on a cryopanel cooled to a cryogenic temperature and that exhausts the gas molecules. The cryopump is generally used in order to realize a clean vacuum environment which is required for a semiconductor circuit manufacturing process or the like. Since the cryopump is a so-called gas storage type vacuum pump, regeneration to periodically exhaust captured gases to the outside is required.

SUMMARY

[0004] According to an aspect of the present invention, there is provided a cryopump system including a plurality of cryopumps each of which includes a cryopump container, an exhaust valve that exhausts an exhaust fluid from the cryopump container, and an exhaust purge valve that supplies a purge gas to the exhaust valve or downstream thereof and an exhaust line through which the exhaust fluid is exhausted from the plurality of cryopumps to a treatment device, the exhaust line including a plurality of branch lines and a merging line, the plurality of branch lines each connected to the exhaust valve and the exhaust purge valve of a corresponding cryopump, the merging line connecting the plurality of branch lines to the treatment device.

[0005] According to another aspect of the present invention, there is provided a regeneration controller for a cryopump system. The cryopump system includes a plurality of cryopumps, each of which includes a cryopump container, an exhaust valve that exhausts an exhaust fluid from the cryopump container, and an exhaust purge valve that supplies a purge gas to the exhaust valve or downstream thereof, and an exhaust line through which the exhaust fluid is exhausted from the plurality of cryopumps to a treatment device, the exhaust line including a plurality of branch lines and a merging line, the plurality of branch lines each connected to the exhaust valve and the exhaust purge valve of a corresponding cryopump, the merging line connecting the plurality of branch lines with the treatment device. The plurality of cryopumps include a first cryopump and a second cryopump. The regeneration controller is configured to control the first cryopump so that the exhaust fluid is exhausted from the first cryopump to the treatment device and concurrently to control the second cryopump so that the purge gas is supplied from the second cryopump to the merging line of the exhaust line.

[0006] According to still another aspect of the present invention, there is provided a cryopump system including a cryopump that includes a cryopump container, an exhaust valve which exhausts an exhaust fluid from the cryopump container, and a first exhaust purge valve which supplies a purge gas to the exhaust valve or downstream thereof and an additional exhaust purge valve that is connected to the exhaust valve and the exhaust purge valve, that is provided at an exhaust line through which the exhaust fluid is exhausted from the cryopump to a treatment device, and that supplies the purge gas to a treatment device side with respect to the first exhaust purge valve.

[0007] Any combination of the components described above and a combination obtained by switching the components and expressions of the present invention between methods, devices, systems, and the like are also effective as an embodiment of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** schematically shows a cryopump system according to an embodiment.

[0009] FIG. **2** schematically shows the cryopump system according to the embodiment.

[0010] FIGS. **3**A to **3**C are graphs showing a concentration change of a hydrogen gas in an exhaust fluid from a cryopump according to the embodiment.

[0011] FIGS. **4**A to **4**C are graphs showing a concentration change of the hydrogen gas in the exhaust fluid from the cryopump according to the embodiment.

[0012] FIG. **5** schematically shows a cryopump system according to the other embodiment.

DETAILED DESCRIPTION

[0013] In the semiconductor manufacturing process, a hazardous gas having various hazards such as explosiveness, corrosiveness, toxicity, and the like is used in some cases. The hazardous gas stored in the cryopump is exhausted from the cryopump through regeneration and is treated to be harmless or to reduce the hazards by a treatment device called an abatement device. In this case, the hazardous gas is diluted by supplying a purge gas to the cryopump, and the concentration of the hazardous gas flowing into the treatment device is decreased, so that safety can be improved.

[0014] However, immediately after regeneration start, due to a rise in the temperature of the cryopump, the stored hazardous gas can be rapidly re-vaporized, and a hazardous gas concentration can significantly increase. In order to ensure that the hazardous gas concentration is maintained sufficiently low for safety, a large amount of purge gas is required.

[0015] It is desirable to efficiently dilute a hazardous gas that is exhausted from a cryopump and that flows into a treatment device.

[0016] Hereinafter, embodiments for carrying out the present invention will be described in detail with reference to the drawings. In the description and drawings, the same or equivalent components, members, and processing will be assigned with the same reference symbols, and redundant description thereof will be omitted as appropriate. The scales and shapes of shown parts are set for convenience in order to make the description easy to understand and are not to be

understood as limiting unless stated otherwise. The embodiments are merely examples and do not limit the scope of the present invention. All characteristics and combinations to be described in the embodiments are not necessarily essential to the invention.

[0017] FIGS. **1** and **2** schematically show a cryopump system according to an embodiment. FIG. **1** schematically shows appearance of a cryopump **10**, and FIG. **2** schematically shows an internal structure of the cryopump **10**. The cryopump **10** is attached to a vacuum chamber of, for example, an ion implanter, a sputtering device, a vapor deposition device, or other vacuum process devices and is used in order to increase a degree of vacuum inside the vacuum chamber to a level which is required for a desired vacuum process. For example, a high degree of vacuum of approximately 10^{-5} Pa to 10^{-8} Pa is realized in the vacuum chamber.

[0018] The cryopump **10** includes a compressor **12**, a cryocooler **14**, and a cryopump container **16**. The cryopump container **16** includes a cryopump intake port **17**. In addition, the cryopump **10** includes a rough valve **18**, a body purge valve **20**, an exhaust valve **22**, and an exhaust purge valve **24**, and these are provided at the cryopump container **16**.

[0019] The compressor **12** is configured to collect a refrigerant gas from the cryocooler **14**, to pressurize the collected refrigerant gas, and to supply the refrigerant gas to the cryocooler **14** again. The cryocooler **14** is also referred to as an expander or a cold head and constitutes a cryogenic refrigerator together with the compressor **12**. A thermodynamic cycle, through which chill is generated, is configured by performing circulation of the refrigerant gas between the compressor **12** and the cryocooler **14** with an appropriate combination of pressure fluctuations and volume fluctuations of the refrigerant gas in the cryocooler **14**, and thereby the cryocooler **14** can provide cryogenic temperature cooling. Although the refrigerant gas is typically a helium gas, other appropriate gases may be used. In order to facilitate understanding, a direction in which the refrigerant gas flows is indicated with arrows in FIG. **1**. Although the cryogenic refrigerator is, for example, a two-stage Gifford-McMahon (GM) cryocooler, the cryocooler may be a pulse tube cryocooler, a Stirling cryocooler, or other types of cryogenic refrigerators.

[0020] As shown in FIG. **2**, the cryocooler **14** includes a room temperature portion **26**, a first cylinder **28**, a first cooling stage **30**, a second cylinder **32**, and a second cooling stage **34**. The cryocooler **14** is configured to cool the first cooling stage **30** to a first cooling temperature and the second cooling stage **34** to a second cooling temperature. The second cooling temperature is lower than the first cooling temperature. For example, the first cooling stage **30** is cooled to approximately 65 K to 120 K, preferably 80 K to 100 K, and the second cooling stage **34** is cooled to approximately 10 K to 20 K. The first cooling stage **30** and the second cooling stage **34** may also be referred to as a high-temperature cooling stage and a low-temperature cooling stage, respectively. In this manner, as the first cooling stage **30** and the second cooling stage **34** are cooled to the respective target cooling temperatures, the cryopump **10** can perform a vacuum exhaust operation.

[0021] The first cylinder **28** connects the first cooling stage **30** to the room temperature portion **26**, and accordingly, the first cooling stage **30** is structurally supported by the room temperature portion **26**. The second cylinder **32** connects the second cooling stage **34** to the first cooling stage **30**, and accordingly, the second cooling stage **34** is structurally supported by the first cooling stage **30**. The first cylinder **28** and the second cylinder **32** coaxially extend along a radial direction, and the room temperature portion **26**, the first cylinder **28**, the first cooling stage **30**, the second cylinder **32**, and the second cooling stage **34** are linearly arranged in a line in this order.

[0022] In a case where the cryocooler **14** is a two-stage GM cryocooler, a first displacer and a second displacer (not shown) are disposed to be reciprocal inside the first cylinder **28** and the second cylinder **32**, respectively. A first regenerator and a second regenerator (not shown) are incorporated into the first displacer and the second displacer, respectively. In addition, the room temperature portion **26** includes a drive mechanism (not shown) such as a motor for reciprocating the first displacer and the second displacer. The drive mechanism includes a flow path switching mechanism that switches between flow paths for a working gas (for example, helium) to periodically repeat supply and exhaust of the working gas to and from the cryocooler **14**.

[0023] In addition, the cryopump **10** includes a radiation shield **36** and a cryopanel **38**. In order to provide a cryogenic temperature surface for protecting the cryopanel **38** from radiant heat from the outside of the cryopump **10** or the cryopump container **16**, the radiation shield **36** is thermally coupled to the first cooling stage **30** and is cooled to the first cooling temperature.

[0024] The radiation shield **36** has, for example, a tubular shape and is disposed to surround the cryopanel **38** and the second cooling stage **34**. An end portion of the radiation shield **36** on a cryopump intake port **17** side is opened, and a gas that enters through the cryopump intake port **17** from the outside of the cryopump **10** can be received in the radiation shield **36**. An end portion of the radiation shield **36** on an opposite side to the cryopump intake port **17** is closed, or may include an opening and be opened. There is a gap between the radiation shield **36** and the cryopanel **38**, and the radiation shield **36** is not in contact with the cryopanel **38**. The radiation shield **36** is also not in contact with the cryopump container **16**.

[0025] An inlet baffle **37** may be provided at the cryopump intake port **17** or between the cryopump intake port **17** and the cryopanel **38** in order to protect the cryopanel **38** from radiant heat from an external heat source of the cryopump **10** (for example, a heat source in the vacuum chamber to which the cryopump **10** is attached). The inlet baffle **37** may be fixed to an open end of the radiation shield **36** and be thermally coupled to the first cooling stage **30** of the cryocooler **14** via the radiation shield **36**. Alternatively, the inlet baffle **37** may be attached to the first cooling stage **30**. The inlet baffle **37** is cooled to the same temperature as the radiation shield **36** and can condense a so-called type **1** gas (a gas that condenses at a relatively high temperature, such as steam) on a surface thereof.

[0026] In order to provide a cryogenic surface that condenses a type **2** gas (for example, a gas that condenses at a relatively low temperature, such as argon and nitrogen), the cryopanel **38** is thermally coupled to the second cooling stage **34** and is cooled to the second cooling temperature. In addition, in order to adsorb a type **3** gas (for example, a non-condensable gas, such as hydrogen), for example, activated carbon or other adsorbents are disposed on at least a

part of a surface (for example, a surface on the opposite side to the cryopump intake port **17**) of the cryopanel **38**. A gas that enters the radiation shield **36** from the outside of the cryopump **10** through the cryopump intake port **17** is captured on the cryopanel **38** through condensation or adsorption. Since various known configurations can be adopted as appropriate as forms that can be taken, such as the disposition and shape of the radiation shield **36** or the cryopanel **38**, description thereof will not be made in detail herein.

[0027] The cryopump container **16** includes a container body **16***a* and a cryocooler accommodating tube **16***b*. The cryopump container **16** is a vacuum chamber designed to maintain vacuum during a vacuum exhaust operation of the cryopump **10** and to withstand the pressure of an ambient environment (for example, the atmospheric pressure). The container body **16***a* has a tubular shape of which one end includes the cryopump intake port **17** and the other end is closed. The radiation shield **36** is accommodated in the container body **16***a*, and the cryopanel **38** is accommodated in the radiation shield **36** together with the second cooling stage **34** as described above. The cryocooler accommodating tube **16***b* includes one end coupled to the container body **16***a* and the other end fixed to the room temperature portion **26** of the cryocooler **14**. The cryocooler **14** is inserted into the cryocooler accommodating tube **16***b*, and the first cylinder **28** is accommodated in the cryocooler accommodating tube **16***b*.

[0028] In the embodiment, the cryopump **10** is a so-called horizontal cryopump in which the cryocooler **14** is provided at a side portion of the container body **16***a*. A cryocooler insertion opening is provided in the side portion of the container body **16***a*, and the cryocooler accommodating tube **16***b* is coupled to the side portion of the container body **16***a* at the cryocooler insertion opening. Similarly, a hole through which the cryocooler **14** passes is also provided in a side portion of the radiation shield **36** adjacent to the cryocooler insertion opening of the container body **16***a*. The second cylinder **32** and the second cooling stage **34** of the cryocooler **14** are inserted into the radiation shield **36** through the hole, and the radiation shield **36** is thermally coupled to the first cooling stage **30** around the hole of the side portion.

[0029] The cryopump can be provided at a site where the cryopump is to be used in various postures. For example, the cryopump **10** can be provided in a shown horizontal posture, that is, a posture in which the cryopump intake port **17** faces upward. In this case, a bottom portion of the container body **16***a* is positioned below the cryopump intake port **17**, and the cryocooler **14** extends in a horizontal direction.

[0030] The cryopump **10** includes a first temperature sensor **40** for measuring the temperature of the first cooling stage **30** and a second temperature sensor **42** for measuring the temperature of the second cooling stage **34**. The first temperature sensor **40** is attached to the first cooling stage **30**. The second temperature sensor **42** is attached to the second cooling stage **34**. The first temperature sensor **40** can measure the temperature of the radiation shield **36** and output a first measured temperature signal indicating the measured temperature of the radiation shield **36**. The second temperature sensor **42** can measure the temperature of the cryopanel **38** and output a second measured temperature signal indicating the measured temperature of the cryopanel **38**. In addition, a pressure sensor **44** is provided inside the cryopump container **16**. The pressure sensor **44** is provided in, for example, the cryocooler accommodating tube **16***b*, can measure the internal pressure of the cryopump container **16**, and can output a measured pressure signal indicating the measured pressure.

[0031] In addition, the cryopump **10** includes a controller **46** that controls the cryopump **10**. The controller **46** may be provided integrally with the cryopump **10** or may be configured as a control device separate from the cryopump **10**.

[0032] The controller **46** may control the cryocooler **14** based on a cooling temperature of the radiation shield **36** and/or the cryopanel **38** in a vacuum exhaust operation of the cryopump **10**. The controller **46** may be connected to the first temperature sensor **40** to receive a first measured temperature signal from the first temperature sensor **40** and may be connected to the second temperature sensor **42** to receive a second measured temperature signal from the second temperature sensor **42**.

[0033] In addition, the controller **46** can operate as a regeneration controller of the cryopump **10**. In a regeneration operation of the cryopump **10**, the controller **46** may control the cryocooler **14**, the rough valve **18**, the body purge valve **20**, the exhaust valve **22**, and the exhaust purge valve **24** based on a pressure in the cryopump container **16** (or, as necessary, based on the temperature of the cryopanel **38** and the pressure in the cryopump container **16**). The controller **46** may be connected to the pressure sensor **44** to receive a measured pressure signal from the pressure sensor **44**.

[0034] An internal configuration of the controller **46** is realized by an element or a circuit including a CPU and a memory of a computer as a hardware configuration and is realized by a computer program or the like as a software configuration, but is shown in the drawings as a functional block realized in cooperation therewith as appropriate. It is clear for those skilled in the art that the functional blocks can be realized in various manners in combination with hardware and software.

[0035] For example, the controller **46** can be mounted in combination with a processor (hardware), such as a central processing unit (CPU) and a microcomputer, and a software program executed by the processor (hardware). The software program may be a computer program for causing the controller **46** to execute regeneration of the cryopump **10**.

[0036] The rough valve **18** is provided at the cryopump container **16**, for example, the cryocooler accommodating tube **16***b*. The rough valve **18** is connected to a rough pump (not shown) provided outside the cryopump **10**. The rough pump is a vacuum pump for evacuating the cryopump **10** to an operation start pressure thereof. When the rough valve **18** is opened through control of the controller **46**, the cryopump container **16** communicates with the rough pump, and when the rough valve **18** is closed, the cryopump container **16** is blocked from the rough pump. The cryopump **10** can be depressurized by opening the rough valve **18** and operating the rough pump.

[0037] The body purge valve **20** is provided at the cryopump container **16**, for example, the container body **16***a*. The body purge valve **20** is connected to a purge gas source **48** or a purge gas supply device provided outside the cryopump **10**. When the body purge valve **20** is opened through control of the controller **46**, a purge gas is supplied from the purge gas source **48** to the cryopump container **16**, and when the body purge valve **20** is closed, purge gas supply to the cryopump container **16** is blocked. By opening the body purge valve **20** and introducing the purge gas into

the cryopump container **16**, the cryopump **10** can be pressurized. In addition, the temperature of the cryopump **10** can be increased from a cryogenic temperature to the room temperature or a temperature higher than the room temperature.

[0038] A purge gas may be, for example, a nitrogen gas or other dry gases, and the temperature of the purge gas may be adjusted to, for example, a room temperature (higher than 0° C., for example, 15° C. to 30° C.) or may be heated to a temperature higher than the room temperature (for example, 50° C. or lower or 80° C. or lower).

[0039] The exhaust valve **22** is provided at the cryopump container **16**, for example, the cryocooler accommodating tube **16***b*. The exhaust valve **22** is provided as an outlet of the cryopump container **16** in order to exhaust a fluid from the inside to the outside of the cryopump **10**. The exhaust valve **22** is also an inlet to an exhaust line **50** to be described later. When the exhaust valve **22** is opened through control of the controller **46**, the fluid is exhausted from the cryopump container **16**, and when the exhaust valve **22** is closed, fluid exhaust from the cryopump container **16** is blocked. The fluid exhausted from the exhaust valve **22** is basically a gas, but may be a liquid or a mixture of a gas and a liquid. The exhaust valve **22** may be, for example, a normally closed type control valve. In addition, the exhaust valve **22** may function as a vent valve or a safety valve or may be configured to be mechanically opened when a predetermined differential pressure acts. In this case, the exhaust valve **22** is mechanically opened without requiring control when a pressure inside the cryopump becomes high for some reason. Accordingly, the high pressure inside can be released to the exhaust line **50**.

[0040] The exhaust purge valve **24** is provided in order to supply a purge gas to the exhaust line **50**. The exhaust valve **22** and the exhaust purge valve **24** may be separately provided, and the exhaust purge valve **24** may be connected by a pipe downstream of the exhaust valve **22**. Alternatively, the exhaust purge valve **24** may be provided integrally with the exhaust valve **22** to supply the purge gas to the exhaust valve **22** or downstream thereof. The exhaust purge valve **24** may be provided at the cryopump container **16**, for example, the cryocooler accommodating tube **16***b*. The exhaust purge valve **24** is connected to the purge gas source **48** or another purge gas source. When the exhaust purge valve **24** is opened through control of the controller **46**, the purge gas is supplied from the purge gas source **48** to the exhaust line **50**, and when the exhaust purge valve **24** is closed, purge gas supply to the exhaust line **50** is blocked.

[0041] The exhaust line **50** is provided in order to exhaust an exhaust fluid from the cryopump **10** to a treatment device **60**, is connected to the exhaust valve **22** and the exhaust purge valve **24** at an upstream end thereof, and is connected to the treatment device **60** at a downstream end thereof.

[0042] The treatment device **60** may be, for example, an abatement device that treats a hazardous gas (for example, a hydrogen gas, other gases having explosiveness, or other gases having corrosiveness or toxicity) contained in an exhaust fluid to generate a harmless gas or may be a treatment device that treats the hazardous gas to reduce a hazard thereof. Since a known abatement device or treatment device can be adopted as appropriate as the treatment device **60**, details thereof will not be described herein.

[0043] The exhaust line **50** includes an (additional) purge gas receiving port **52** on a treatment device **60** side with respect to the exhaust purge valve **24**. The purge gas receiving port **52** is at the downstream end of the exhaust line **50** and is connected to the treatment device **60**. As shown, the purge gas receiving port **52** may be adjacent to the treatment device **60**. Alternatively, the purge gas receiving port **52** and the treatment device **60** may not be adjacent to each other, and the purge gas receiving port **52** may be connected to the treatment device **60** via other devices included in the exhaust line **50**.

[0044] An additional exhaust purge valve **54** may be connected to the purge gas receiving port **52**. The additional exhaust purge valve **54** may be connected to the purge gas source **48** or another purge gas source. The exhaust purge valve **54** may constitute a part of the cryopump **10** and may be controlled by the controller **46**. When the exhaust purge valve **54** is opened, a purge gas is supplied from the purge gas source **48** to the exhaust line **50**, and when the exhaust purge valve **54** is closed, purge gas supply to the exhaust line **50** is blocked.

[0045] Therefore, the exhaust purge valve **24** supplies a purge gas to the exhaust line **50** on an upstream side (exhaust valve **22** side) of the exhaust line **50**, and the additional exhaust purge valve **54** supplies the purge gas to the exhaust line **50** on a downstream side (treatment device **60** side) of the exhaust line **50**. The body purge valve **20** enables "body purge" in which the purge gas is supplied to the container body **16***a* of the cryopump container **16**, the exhaust purge valve **24** enables "upstream purge" in which the purge gas is supplied to the upstream end of the exhaust line **50**, and the additional exhaust purge valve **54** enables "downstream purge" in which the purge gas is supplied to the downstream end of the exhaust line **50**.

[0046] The flow rate of each of body purge, upstream purge, and downstream purge may be selected from, for example, a range of 20 L/min to 100 L/min. The flow rates of the body purge, the upstream purge, and the downstream purge may be equal to each other or may be different from each other. As will be described later, the flow rate of the downstream purge may be great compared to the flow rate of the upstream purge (or the body purge).

[0047] As will be described later, the exhaust valve **22** and the exhaust purge valve **24** of another cryopump **10** may be connected to the purge gas receiving port **52**, and downstream purge of the exhaust line **50** may be performed by supply of a purge gas from another cryopump **10**.

[0048] The exhaust line **50** includes a buffer volume **56**, and an exhaust fluid from the cryopump container **16** flows from the exhaust valve **22** into the treatment device **60** by passing through the buffer volume **56**. The exhaust purge valve **24** supplies a purge gas to the upstream side of the exhaust line **50** with respect to the buffer volume **56**, and the additional exhaust purge valve **54** supplies the purge gas to the downstream side of the exhaust line **50** with respect to the buffer volume **56**.

[0049] It is advantageous to provide the buffer volume **56** at the exhaust line **50** in suppressing a concentration peak of a hazardous gas in the exhaust line **50** as will be described later. The buffer volume **56** may be, for example, 1 liter (L) or larger or 3 L or larger. From a perspective of space saving, the buffer volume **56** may have, for example, a volume of 30 L or less or 10 L or less. The buffer volume **56** may be a volume of a pipe constituting the exhaust line **50**, that is, a pipe connecting the exhaust valve **22** to the treatment device **60**. Alternatively, in a case where a large volume is desired

for the buffer volume **56**, the buffer volume **56** may be configured by a pipe constituting the exhaust line **50** and a buffer tank connected to the pipe. The pipe may be a flexible pipe or a rigid pipe.

[0050] A gas is accumulated in the cryopump **10** as a vacuum exhaust operation of the cryopump **10** is continued. Regeneration of the cryopump **10** is performed in order to exhaust the accumulated gas to the outside. The regeneration of the cryopump **10** generally includes a temperature raising process, an exhaust process, and a cool-down process.

[0051] A temperature raising process includes raising the temperature of the cryopump **10** to a melting point of a hazardous gas or a temperature exceeding the melting point among gases captured in the cryopump **10** and further raising the temperature of the cryopump **10** to a regeneration temperature. The hazardous gas is typically, for example, a type **2** gas or a type **3** gas, and the melting point of the hazardous gas is, for example, 100 K or less. The regeneration temperature is, for example, a room temperature or a temperature higher than the room temperature. Accordingly, in many cases, the hazardous gas is re-vaporized in a first half of the temperature raising process, particularly immediately after the start and is exhausted from the cryopump **10** to be flowed into the treatment device **60**. The hazardous gas is removed from the cryopump **10** in the temperature raising process.

[0052] A heat source for raising the temperature is, for example, the cryocooler **14**. The cryocooler **14** enables a temperature raising operation (a so-called reverse temperature rise). That is, the cryocooler **14** is configured such that adiabatic compression occurs in a working gas when the drive mechanism provided at the room temperature portion **26** operates in a direction opposite to a direction in a cooling operation. The cryocooler **14** heats the first cooling stage **30** and the second cooling stage **34** with compression heat obtained in such a manner. The radiation shield **36** and the cryopanel **38** are heated with the first cooling stage **30** and the second cooling stage **34** as heat sources, respectively. In addition, also a purge gas supplied from the body purge valve **20** into the cryopump container **16** also contributes to a temperature rise of the cryopump **10**. Alternatively, the cryopump **10** may be provided with, for example, a heating device such as an electric heater. For example, the electric heater that can be controlled independently of the operation of the cryocooler **14** may be mounted on the first cooling stage **30** and/or the second cooling stage **34** of the cryocooler **14**.

[0053] In an exhaust process, a gas captured in the cryopump **10** is re-vaporized or liquefied and is exhausted through the exhaust line **50** or the rough valve **18** as a gas, a liquid, or a mixture of a gas and a liquid. Since a type **2** gas and a type **3** gas can already be easily exhausted from the cryopump **10** in a temperature raising process, the exhaust process is a process of mainly exhausting a type **1** gas. When the exhaust process is completed, a cooldown process is started. In the cool-down process, the cryopump **10** is re-cooled to a cryogenic temperature for a vacuum exhaust operation. In such a manner, when regeneration is completed, the cryopump **10** can start a vacuum exhaust operation again.

[0054] One main application of the cryopump **10** is vacuum exhaust of the ion implanter. In this case, a hydrogen gas is stored in the cryopump **10**. The hydrogen gas captured in the cryopanel **38** can be re-vaporized at once during regeneration, particularly immediately after the start of the regeneration (temperature raising process). Although the hydrogen gas is diluted through body purge in the cryopump container **16**, an exhaust fluid flowing from the cryopump container **16** to the treatment device **60** through the exhaust line **50** can temporarily contain the hydrogen gas at a considerably high concentration. Since the high-concentration hydrogen gas has a risk of explosion or combustion, it is desired to suppress a concentration peak of the hydrogen gas in the exhaust fluid as low as possible for safety management of the cryopump **10** and the exhaust line **50**.

[0055] FIGS. **3**A to **3**C are graphs showing a concentration change of a hydrogen gas in an exhaust fluid from the cryopump **10** according to the embodiment. In each of the drawings, results of the inventor calculating a hydrogen gas concentration in the exhaust fluid at the purge gas receiving port **52** of the exhaust line **50**, that is, the exhaust fluid flowing into the treatment device **60** are shown. In each of the drawings, a vertical axis represents a concentration (%) of a hydrogen gas, and a horizontal axis represents an elapsed time (minute) from a regeneration start time point.

[0056] Calculation conditions are as follows. The volume of the cryopump **10** (that is, the cryopump container **16**) is set to 30 L, and an initial concentration of a hydrogen gas in the cryopump container **16** is set to 60% (corresponding to a maximum storage capacity of the hydrogen gas of the cryopump **10**). In addition, the flow rate of body purge (the flow rate of a purge gas supplied from the body purge valve **20** to the cryopump container **16**) is set to 20 L/min, the flow rate of upstream purge (the flow rate of the purge gas supplied upstream of the exhaust line **50** from the exhaust purge valve **24**) is set to 20 L/min, and the flow rate of downstream purge is set to 0 L/min (that is, the downstream purge is not performed). The conditions are common to the calculation of FIGS. **3**A to **3**C. The size of the buffer volume **56** is different, the buffer volume **56** is set to 1 L in FIG. **3**A, the buffer volume **56** is set to 3 L in FIG. **3**B, and the buffer volume **56** is set to 30 L in FIG. **3**C.

[0057] When regeneration (temperature raising process) is started, the body purge valve **20**, the exhaust valve **22**, and the exhaust purge valve **24** are simultaneously opened by the controller **46**. At a regeneration start time point, a hydrogen gas concentration at the purge gas receiving port **52** is 0%, as shown. By transporting an exhaust fluid downstream of the exhaust line **50** from the cryopump container **16** together with body purge and upstream purge, the hydrogen gas concentration at the purge gas receiving port **52** temporarily increases, and the concentration reaches a peak. After then, as the exhaust fluid flows into the treatment device **60**, the hydrogen gas concentration at the purge gas receiving port **52** gradually decreases again to 0%. Such a tendency of a concentration change is common regardless of the size of the buffer volume **56**, as shown in FIGS. **3**A to **3**C.

[0058] Due to an effect of upstream purge having the same flow rate as in body purge, a hydrogen gas concentration peak of an exhaust fluid upstream of the buffer volume **56** is estimated to be half (that is, 30%) of the initial concentration. From there, as the exhaust fluid flowing into the buffer volume **56** and a purge gas that initially fills the buffer volume **56** are mixed, it is expected that the hydrogen gas concentration peak downstream of the buffer volume **56**, that

is, at the purge gas receiving port **52** is further lowered to some extent according to the volume of the buffer volume **56**.

[0059] By comparing the hydrogen gas concentration peaks shown in FIGS. **3**A to **3**C, the effect of the buffer volume **56** can be clarified. In fact, as shown in FIG. **3**A, in a case where the buffer volume **56** is set to 1 L, the hydrogen gas concentration peak is 28.0%. As shown in FIG. **3**B, in a case where the buffer volume **56** is set to 3 L, the hydrogen gas concentration peak is 25.6%. As shown in FIG. **3**C, in a case where the buffer volume **56** is set to 30 L, the hydrogen gas concentration peak is 15.0%. In such a manner, the larger the buffer volume **56**, the lower the hydrogen gas concentration peak of an exhaust fluid can be.

[0060] FIGS. **4**A to **4**C are graphs showing a concentration change of a hydrogen gas in an exhaust fluid from the cryopump **10** according to the embodiment. In each of the drawings, as in FIGS. **3**A to **3**C, results of the inventor calculating a hydrogen gas concentration in the exhaust fluid at the purge gas receiving port **52** of the exhaust line **50** are shown. In each of the drawings, a vertical axis represents a concentration (%) of the hydrogen gas, and a horizontal axis represents an elapsed time (minute) from a regeneration start time point.

[0061] Calculation conditions are as follows. The volume of the cryopump **10** (that is, the cryopump container **16**) is set to 30 L, and an initial concentration of a hydrogen gas in the cryopump container **16** is set to 60%. In addition, the buffer volume **56** is set to 30 L. The conditions are common to the calculation of FIGS. **4**A to **4**C. The only difference is a purge flow rate. In FIG. **4**A, a flow rate of 40 L/min is added to body purge, the body purge is 60 L/min, upstream purge is 20 L/min, and downstream purge is not performed. In FIG. **4**B, a flow rate of 40 L/min is added to the upstream purge, the body purge is 20 L/min, the upstream purge is 60 L/min, and the downstream purge is not performed. In FIG. **4**C, the downstream purge is performed, the body purge is 20 L/min, the upstream purge is 20 L/min, and the downstream purge is 40 L/min.

[0062] When regeneration (temperature raising process) is started, the body purge valve **20**, the exhaust valve **22**, the exhaust purge valve **24**, and the additional exhaust purge valve **54** (in a case where downstream purge is performed) are simultaneously opened by the controller **46**. The tendency of a change in a hydrogen gas concentration at the purge gas receiving port **52** is that the concentration is initially 0% and temporarily increases to reach a concentration peak, and then gradually decreases to 0% again. This is common to FIGS. **4**A to **4**C.

[0063] By comparing the hydrogen gas concentration peaks shown in FIGS. **3**C and **4**A to **4**C, an effect of a difference in a supply location of a purge gas can be clarified. As shown in FIG. **4**A, in a case where body purge is set to 60 L/min, the hydrogen gas concentration peak at the purge gas receiving port **52** is 19.0%. When FIG. **4**A and FIG. **3**C are compared, as the body purge is increased from 20 L/min to 60 L/min, the hydrogen gas concentration peak at the purge gas receiving port **52** is increased from 15% to 19%. Since an exhaust fluid containing a hydrogen gas is exhausted to be more rapidly pushed out from the cryopump container **16** to the exhaust line **50** with a flow rate increase in the body purge, it is considered to result in the increase in the concentration peak.

[0064] As shown in FIG. **4**B, in a case where upstream purge is set to 60 L/min, the hydrogen gas concentration peak at the purge gas receiving port **52** is 9.5%. When FIG. **4**B and FIG. **3**C are compared, as the upstream purge is increased from 20 L/min to 60 L/min, the hydrogen gas concentration peak at the purge gas receiving port **52** is reduced from 15% to 9.5%. Therefore, a flow rate increase in the upstream purge is effective in suppressing the hydrogen gas concentration peak.

[0065] As shown in FIG. **4**C, in a case where downstream purge is set to 40 L/min, the hydrogen gas concentration peak at the purge gas receiving port **52** is 7.5%. When FIG. **4**C and FIG. **3**C are compared, as downstream purge is newly added, the hydrogen gas concentration peak at the purge gas receiving port **52** is reduced from 15% to 7.5%. The hydrogen gas concentration peak is low compared to the flow rate increase in the upstream purge shown in FIG. **4**B. Therefore, the downstream purge is most effective in suppressing the hydrogen gas concentration peak. It is considered that supplying the purge gas on the downstream side (treatment device **60** side) of the exhaust line **50** as much as possible contributes to the decrease in the hydrogen gas concentration peak.

[0066] Next, a flow rate ratio of body purge, upstream purge, and downstream purge will be focused on. According to the study of the inventor, when a cryopump volume and the buffer volume are set to be constant, a hydrogen gas concentration peak at the purge gas receiving port **52** is determined by the flow rate ratio of the body purge, the upstream purge, and the downstream purge. The magnitudes of the flow rates of the body purge, the upstream purge, and the downstream purge itself affect a time required for exhaust (a time until the hydrogen gas concentration becomes 0% again from the regeneration start), but do not affect the hydrogen gas concentration peak at the purge gas receiving port **52**.

[0067] In view of this, increasing the flow rate of downstream purge compared to the flow rate of body purge (or upstream purge) is effective in order to suppress a peak of a hydrogen gas concentration in an exhaust fluid at the purge gas receiving port **52** of the exhaust line **50**, that is, the exhaust fluid flowing into the treatment device **60**. In addition, the flow rate of the downstream purge may be great compared to a total flow rate of the body purge and the upstream purge. Even in this manner, the peak of the hydrogen gas concentration in the exhaust fluid flowing into the treatment device **60** can be suppressed.

[0068] As is known, in a case where a hydrogen gas concentration is 4% or less, a hydrogen gas does not combust. Accordingly, it is beneficial in terms of safety to suppress a hydrogen gas concentration peak at the purge gas receiving port **52** to be 4% or less.

[0069] Thus when exemplary conditions in which a hydrogen gas concentration peak is set to 4% or less are considered, for example, under the conditions of FIG. **3**B (the cryopump volume is set to 30 L, the buffer volume is set to 3 L, the hydrogen gas initial concentration is set to 60%, and the flow rates of body purge and upstream purge are set to 20 L/min, respectively), the hydrogen gas concentration peak at the purge gas receiving port **52** can be set to 3.9% when a flow rate ratio of the body purge, the upstream purge, and the downstream purge is set to 1:1:11 (that is, the downstream purge is 220 L/min).

[0070] An increase in the amount of a hydrogen gas stored in the cryopump **10** is suppressed, so that a hydrogen gas concentration peak at the time of regeneration can be suppressed. For example, when a hydrogen gas initial concentration is set to 13% (when a hydrogen gas storage capacity of the cryopump **10** is set to a maximum value of 22% (=13/60*100)) under the conditions of FIG. **3**B, a flow rate ratio of body purge, upstream purge, and downstream purge is set to 1:1:1, so that the hydrogen gas concentration peak at the purge gas receiving port **52** can be set to 3.7%. In addition, under the conditions of FIG. **3**C (the cryopump volume is 30 L, the buffer volume is 30 L, the hydrogen gas initial concentration is 60%, and the flow rates of body purge and upstream purge are 20 L/min, respectively), when a flow rate ratio of body purge, upstream purge, and downstream purge is set to 1:1:6 (that is, the downstream purge is 120 L/min), a hydrogen gas concentration peak at the purge gas receiving port **52** can be set to 3.8%. In this case, when the hydrogen gas initial concentration is set to 23%, the flow rate ratio of the body purge, the upstream purge, and the downstream purge is set to 1:1:1, so that the hydrogen gas concentration peak at the purge gas receiving port **52** can be set to 3.8%.

[0071] Therefore, in a case where the buffer volume **56** is relatively small (less than 10 L, for example, 3 L), the flow rate of downstream purge may be selected from a range of 1 time to 11 times the flow rate of body purge (or upstream purge). On the other hand, in a case where the buffer volume **56** is relatively large (for example, 10 L or more and 30 L or less), the flow rate of the downstream purge may be selected from a range of 1 time to 6 times the flow rate of the body purge (or the upstream purge). In this manner, it is expected that a hydrogen gas concentration peak at the purge gas receiving port **52** can be suppressed to approximately 4% or less.

[0072] As described above, according to the embodiment, as the exhaust line **50** has the buffer volume **56**, a hazardous gas that is exhausted from the cryopump **10** and that flows into the treatment device **60** can be efficiently diluted, and a concentration peak of the hazardous gas can be suppressed. In addition, according to the embodiment, as downstream purge is applied to the exhaust line **50**, the hazardous gas that flows into the treatment device **60** can be efficiently diluted, and the concentration peak of the hazardous gas can be suppressed. The consumption of a purge gas can be suppressed compared to a case where only body purge (or upstream purge) is used.

[0073] In the above description, a hydrogen gas is given as an example, but the hazardous gas is typically a type **2** gas or a type **3** gas, and a concentration change in the exhaust line **50** is the same as that of the hydrogen gas. Therefore, the buffer volume **56** and the downstream purge are also effective for other hazardous gases in efficiently diluting the hazardous gases flowing into the treatment device **60** and suppressing concentration peaks of the hazardous gases.

[0074] FIG. **5** schematically shows a cryopump system according to the other embodiment. A cryopump system shown in FIG. **5** is different from the cryopump system shown in FIGS. **1** and **2** and includes a plurality of (three, in this example) cryopumps **10**. The plurality of cryopumps **10** are connected to the common treatment device **60** by the exhaust line **50**. In the following description, when it is necessary to distinguish the plurality of cryopumps **10**, the cryopumps **10** are referred to as cryopumps **10***a*, **10***b*, and **10***c* in some cases.

[0075] Each of the cryopumps **10** includes the rough valve **18**, the body purge valve **20**, the exhaust valve **22**, and the exhaust purge valve **24**, and these are provided at the cryopump container **16** of each cryopump. The cryopump system is provided with the controller **46** that controls the plurality of cryopumps **10**, and the controller **46** can operate as a regeneration controller that controls each of the valves described above of each cryopump **10** during regeneration of the plurality of cryopumps **10**. The configuration of the cryopump **10** shown in FIG. **5** may be the same as that of the cryopump **10** shown in FIGS. **1** and **2**, and description of the same components will be omitted to avoid redundancy.

[0076] The exhaust line **50** is provided in order to exhaust an exhaust fluid from the plurality of cryopumps **10** to the treatment device **60**. The exhaust line **50** includes a plurality of branch lines **50***a* and a merging line **50***b* that connects the plurality of branch lines **50***a* to the treatment device **60**. Each of the branch lines **50***a* is connected to the exhaust valve **22** and the exhaust purge valve of the corresponding cryopump **10** at the upstream end and is connected to the merging line **50***b* at the downstream end.

[0077] Each of the branch lines **50***a* includes the buffer volume **56** that connects the exhaust valve **22** of the corresponding cryopump **10** to the merging line **50***b*. The buffer volume **56** of each branch line **50***a* may be in a range of 1 liter to 30 liters as described above. The exhaust purge valve **24** of each cryopump **10** is connected to the branch line **50***a* on the upstream side (exhaust valve **22** side) with respect to the buffer volume **56**. An exhaust fluid from the cryopump container **16** of each of the cryopumps **10** merges in the merging line **50***b* by passing through the buffer volume **56** of each of the branch lines **50***a* of the exhaust line **50** from the exhaust valve **22** of each of the cryopumps **10** and flows into the treatment device **60**.

[0078] The body purge valve **20** of each cryopump **10** enables body purge of the cryopump **10**. The exhaust purge valve **24** of each cryopump **10** supplies a purge gas to the upstream side of the exhaust line **50** with respect to the buffer volume **56** and enables upstream purge of the cryopump **10**. In addition, the body purge from the body purge valve **20** can also be used as the upstream purge by opening the exhaust valve **22**.

[0079] The merging line **50***b* of the exhaust line **50** corresponds to the purge gas receiving port **52** in the embodiment described above. In addition, for a certain cryopump **10** (for example, a first cryopump **10***a*), the exhaust valve **22** or the exhaust purge valve **24** of another cryopump **10** (for example, a second cryopump **10***b* or a third cryopump **10***c*) corresponds to the additional exhaust purge valve **54** in the embodiment described above. Accordingly, downstream purge of the certain cryopump **10** (for example, the first cryopump **10***a*) is enabled by receiving body purge or upstream purge of another cryopump **10** (for example, the second cryopump **10***b* or the third cryopump **10***c*) from the merging line **50***b* to the branch line **50***a* of the certain cryopump **10** (for example, the first cryopump **10***a*).

[0080] The cryopump system is provided with a roughing line **58** separately from the exhaust line **50**. The roughing line **58** connects the rough valve **18** of each cryopump **10** to a common roughing pump **59**. The plurality of cryopumps

10 are roughed by the roughing pump **59** through the rough valve **18** of each cryopump **10** and the roughing line **58**.

[0081] According to this configuration, while depending on the number of cryopumps **10** included in the cryopump system, it is easy to realize the great flow rate of downstream purge. For example, a total purge gas flow rate from the second cryopump **10***b* and the third cryopump **10***c* can be used for the downstream purge of the first cryopump **10***a*.

[0082] However, in this case, it is not desirable that a gas flowing into a certain cryopump **10** (for example, the first cryopump **10***a*) from another cryopump (for example, the second cryopump **10***b* or the third cryopump **10***c*) as downstream purge contains a hazardous gas exhausted from another cryopump.

[0083] Thus, in a case where the plurality of cryopumps **10** are regenerated simultaneously, regeneration start of a certain cryopump **10** may be prioritized over the remaining cryopumps **10**. In other words, regeneration start of the remaining cryopumps **10** may be delayed with respect to the cryopump **10** that starts the regeneration first. The delay time may be, for example, several minutes (for example, 2 minutes to 10 minutes).

[0084] Therefore, the controller **46** may be configured to control a certain cryopump **10** so that an exhaust fluid is exhausted from the certain cryopump **10** to the treatment device **60** and to control another cryopump **10** so that a purge gas is supplied from another cryopump **10** to the merging line **50***b* of the exhaust line **50**. The controller **46** may be configured to open the body purge valve **20** of the certain cryopump **10** in order to exhaust the exhaust fluid from the certain cryopump **10** to the treatment device **60**. The controller **46** may be configured to open the exhaust purge valve **24** of the other cryopump **10** in order to supply the purge gas from another cryopump **10** to the merging line **50***b* of the exhaust line **50**.

[0085] In this manner, first, regeneration (temperature raising process) of the first cryopump **10***a* is started, and an exhaust fluid is exhausted from the first cryopump **10***a* to the exhaust line **50** by using body purge of the first cryopump **10***a*. The exhaust purge valves **24** of the remaining second cryopump **10***b* and the third cryopump **10***c* are opened, and the first cryopump **10***a* can efficiently dilute the exhaust fluid flowing into the treatment device **60** using a purge gas from the two cryopumps **10***b* and **10***c* as downstream purge.

[0086] After a hazardous gas is exhausted from the first cryopump **10***a* in this manner, regeneration (temperature raising process) of any one (for example, the second cryopump **10***b*) of the remaining cryopumps **10** is started. Body purge and upstream purge of the first cryopump **10***a* can be used as downstream purge for the second cryopump **10***b*. The upstream purge of the third cryopump **10***c* can also be continuously used as the downstream purge for the second cryopump **10***b*.

[0087] Then, after a hazardous gas is exhausted from the second cryopump **10***b*, regeneration (temperature raising process) of the third cryopump **10***c* is started. Body purge and upstream purge of the first cryopump **10***a* and the second cryopump **10***b* can be used as downstream purge for the third cryopump **10***c*.

[0088] The controller **46** may be configured to open both the body purge valve **20** and the exhaust purge valve **24** of a certain cryopump **10** in order to exhaust an exhaust fluid from the certain cryopump **10** to the treatment device **60**. In this manner, the exhaust fluid can be efficiently exhausted from the cryopump **10** to the exhaust line **50** by using body purge and upstream purge.

[0089] The controller **46** may be configured to control the cryocooler **14** so that another cryopump **10** is cooled to prevent generation of an exhaust fluid in the cryopump container **16** of another cryopump **10**, and to open the exhaust purge valve **24** of another cryopump **10**. In this manner, when regeneration (temperature raising process) of the first cryopump **10***a* is started, the remaining second cryopump **10***b* and third cryopump **10***c* can be maintained in a cooling state, and exhaust from the remaining cryopumps **10***b* and **10***c* can be reliably blocked. At the same time, the first cryopump **10***a* can efficiently dilute the exhaust fluid flowing into the treatment device **60** using a purge gas from the two cryopumps **10***b* and **10***c* as downstream purge.

[0090] The controller **46** may be configured to control a certain cryopump **10** and another cryopump **10** so that the flow rate of a purge gas from another cryopump **10** to the merging line **50***b* is increased compared to the flow rate of the purge gas from the certain cryopump **10** to the merging line **50***b*. In this manner, the flow rate of downstream purge can be increased compared to the flow rate of body purge (or upstream purge), which is effective in suppressing a peak of a hazardous gas concentration in an exhaust fluid flowing into the treatment device **60**.

[0091] Considering exemplary conditions in which a concentration peak of a hydrogen gas is set to 4% or less, for example, when the cryopump volume is set to 30 L, the buffer volume **56** of each of the branch lines **50***a* of the exhaust line **50** is set to 10 L, the hydrogen gas initial concentration is set to 60%, and the flow rates of body purge and upstream purge of each cryopump **10** are set to 20 L/min and 60 L/min, respectively (in this case, downstream purge corresponds to 160 L/min), a hydrogen gas concentration peak in the merging line **50***b* of the exhaust line **50** can be set to 4.0%.

[0092] In addition, in this example, in a case where a hydrogen gas initial concentration is decreased to 25%, a hydrogen gas concentration peak in the merging line **50***b* of the exhaust line **50** can be set to less than 4.0% even when the buffer volume **56** of each of the branch lines **50***a* of the exhaust line **50** is reduced to 3 L and the flow rates of the body purge and the upstream purge of each cryopump **10** are decreased to 20 L/min.

[0093] The present invention has been described hereinbefore based on the examples. It is clear for those skilled in the art that the present invention is not limited to the embodiments, various design changes are possible, various modification examples are possible, and such modification examples are also within the scope of the present invention.

INDUSTRIAL APPLICABILITY

[0094] The present invention can be used in the field of cryopump systems and regeneration controllers for cryopump systems.

[0095] It should be understood that the invention is not limited to the above-described embodiment, but may be modified into various forms on the basis of the spirit of the invention. Additionally, the modifications are included in the scope of the invention.

What is claimed is:

1. A cryopump system comprising:

a plurality of cryopumps each of which includes a cryopump container, an exhaust valve that exhausts an exhaust fluid from the cryopump container, and an exhaust purge valve that supplies a purge gas to the exhaust valve or downstream thereof; and

an exhaust line through which the exhaust fluid is exhausted from the plurality of cryopumps to a treatment device, the exhaust line including a plurality of branch lines and a merging line, the plurality of branch lines each connected to the exhaust valve and the exhaust purge valve of a corresponding cryopump, the merging line connecting the plurality of branch lines to the treatment device.

2. The cryopump system according to claim 1,

wherein each of the branch lines includes a buffer volume that connects the exhaust valve of the corresponding cryopump to the merging line, and the exhaust purge valve of the corresponding cryopump is connected to that branch line on an exhaust valve side with respect to the buffer volume.

3. The cryopump system according to claim 2,

wherein the buffer volume is in a range of 1 liter to 30 liters.

4. The cryopump system according to claim 1,

wherein the plurality of cryopumps include a first cryopump and a second cryopump, and

the cryopump system further comprises:

a regeneration controller that controls regeneration of the cryopump system, the regeneration controller being configured to control the first cryopump so that the exhaust fluid is exhausted from the first cryopump to the treatment device and concurrently to control the second cryopump so that the purge gas is supplied from the second cryopump to the merging line of the exhaust line.

5. The cryopump system according to claim 4,

wherein the plurality of cryopumps further include a third cryopump, and

the regeneration controller is configured to control the first cryopump so that the exhaust fluid is exhausted from the first cryopump to the treatment device and concurrently to control the second cryopump and the third cryopump so that the purge gas is supplied from the second cryopump and the third cryopump to the merging line of the exhaust line.

6. The cryopump system according to claim 4,

wherein each of the plurality of cryopumps includes a body purge valve that supplies the purge gas to the cryopump container, and

the regeneration controller is configured to open both the body purge valve and the exhaust purge valve of the first cryopump in order to exhaust the exhaust fluid from the first cryopump to the treatment device.

7. The cryopump system according to claim 4,

wherein each of the plurality of cryopumps includes a cryocooler that cools the cryopump, and

the regeneration controller is configured to control the cryocooler so that the second cryopump is cooled to prevent generation of the exhaust fluid in the cryopump container of the second cryopump and to open the exhaust purge valve of the second cryopump.

8. The cryopump system according to claim 4,

wherein the regeneration controller is configured to control the first cryopump and the second cryopump so that a flow rate of the purge gas from the second cryopump to the merging line is increased compared to a flow rate of the purge gas from the first cryopump to the merging line.

9. A regeneration controller for a cryopump system,

wherein the cryopump system includes:

a plurality of cryopumps, each of which includes a cryopump container, an exhaust valve that exhausts an exhaust fluid from the cryopump container, and an exhaust purge valve that supplies a purge gas to the exhaust valve or downstream thereof, and

an exhaust line through which the exhaust fluid is exhausted from the plurality of cryopumps to a treatment device, the exhaust line including a plurality of branch lines and a merging line, the plurality of branch lines each connected to the exhaust valve and the exhaust purge valve of a corresponding cryopump, the merging line connecting the plurality of branch lines to the treatment device,

the plurality of cryopumps include a first cryopump and a second cryopump, and

the regeneration controller is configured to control the first cryopump so that the exhaust fluid is exhausted from the first cryopump to the treatment device and concurrently to control the second cryopump so that the purge gas is supplied from the second cryopump to the merging line of the exhaust line.

10. A cryopump system comprising:

a cryopump that includes a cryopump container, an exhaust valve which exhausts an exhaust fluid from the cryopump container, and a first exhaust purge valve which supplies a purge gas to the exhaust valve or downstream thereof; and

an additional exhaust purge valve that is connected to the exhaust valve and the exhaust purge valve, that is provided at an exhaust line through which the exhaust fluid is exhausted from the cryopump to a treatment device, and that supplies the purge gas to a treatment device side with respect to the first exhaust purge valve.

11. The cryopump system according to claim 10,

wherein the exhaust line includes a buffer volume connected between the first exhaust purge valve and the additional exhaust purge valve.

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