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(54) **LIQUID SUPPLY SYSTEM**

(57) There is provided a liquid supply system that can supply liquid efficiently with reduced time needed for precooling. The liquid supply system includes a first fluid channel through which cryogenic liquid flows from an inlet 130b to an outlet 130c via a first pump chamber P1 and a second fluid channel through which cryogenic liquid flows from the inlet 130b to the outlet 130c via a second pump chamber P2. The height of the location at which the direction of the first fluid channel changes from the vertically upward direction to the vertically downward direction and the location at which the direction of the second fluid channel changes from the vertically upward direction to the vertically downward direction are the same.

[Fig. 1]

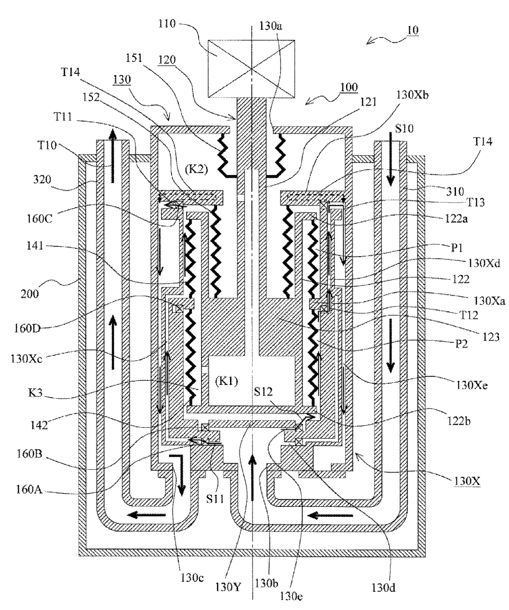

Fig.1

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Description

[Technical Field]

[0001] The present invention relates to a liquid supply system used to supply cryogenic liquid.

[Background Art]

[0002] It is known in prior art to use a liquid supply system having a pump chamber using a bellows to cause a cryogenic liquid such as liquid nitrogen or liquid helium to circulate in a circulation fluid passage (see Patent Literature 1 in the citation list below). In such a liquid supply system, the pump cannot operate satisfactorily if the fluid passage that passes through the pump chamber is not filled with liquid. Hence, when the system is started for the first time or when the system is started after maintenance, it is necessary to perform precooling so as to prevent vaporization of the cryogenic liquid in the fluid passage. To this end, before the liquid supply system is started, the cryogenic liquid is caused to flow in the fluid passage passing through the pump chamber to precool the fluid passage.

[0003] It is known in the art to provide two bellows arranged one above the other along the vertical direction in a liquid supply system to form two pump chambers located one above the other along the vertical direction (see Patent literature 1 in the citation list below). This system can discharge cryogenic liquid from the two pump chambers alternately when a shaft member that is moved vertically upward and downward by a driving source moves downward and upward. In conventional liquid supply systems of this type, the height of a location of an outlet of the liquid discharged from the vertically upper pump chamber and the height of a location of an outlet of the liquid discharged from the vertically lower pump chamber are different from each other. Specifically, the latter outlet is disposed lower than the former outlet. Hence, when the cryogenic liquid is caused to flow in the precooling process, the cryogenic liquid tends to be discharged from the latter outlet. For this reason, it takes a long time to lower the temperature of fluid passages in the upper region.

[Citation List]

[Patent Literature]

[0004] [PTL 1]
WO 2016/006648

[Summary of Invention]

[Technical Problem]

[0005] An object of the present invention is to provide a liquid supply system that can supply liquid efficiently with reduced time needed for precooling.

[Solution to Problem]

[0006] To achieve the above object, the following features are adopted.

[0007] An aspect of the present invention is a liquid supply system comprises:

a container having an inlet and an outlet for cryogenic liquid and provided with a pump chamber inside it;
a shaft member that moves vertically upward and downward in the container;
a first bellows and a second bellows disposed one above the other along the vertical direction in the container, each of which expands and contracts with upward and downward motion of the shaft member;
a first pump chamber formed by a space surrounding the outer circumference of the first bellows;
a second pump chamber formed by a space surrounding the outer circumference of the second bellows;
a first fluid channel through which cryogenic liquid flows from the inlet to the outlet via the first pump chamber; and
a second fluid channel through which the cryogenic liquid flows from the inlet to the outlet via the second pump chamber,
wherein the height of a location at which the direction of the first fluid channel changes from the vertically upward direction to the vertically downward direction and the height of a location at which the direction of second fluid channel changes from the vertically upward direction to the vertically downward direction are the same.

[0008] The liquid supply system is configured in such a way that the height of a location at which the direction of the first fluid channel changes from the vertically upward direction to the vertically downward direction and the height of a location at which the direction of second fluid channel changes from the vertically upward direction to the vertically downward direction are the same. Hence, when cryogenic liquid is caused to flow from the inlet to the outlet for the purpose of precooling, the level of the liquid flowing in the first flow passage and the level of the liquid flowing in the second fluid channel can be kept equal. This prevents situations in which liquid tends to be discharged from one of the fluid passage and not to flow in the other fluid passage from occurring. Therefore, the time needed for precooling can be shortened.

[0009] The first pump chamber may be formed by a space between a first valve that allows the cryogenic liquid entering through the inlet to flow into the interior of the container and a third valve that allows the cryogenic liquid to flow from the interior of the container to the outlet, the second pump chamber may be formed by a space between a second valve that allows the cryogenic liquid entering through the inlet to flow into the interior of the container and a fourth valve that allows the cryogenic liquid to flow from the interior of the container to the outlet, and the third valve and the fourth valve may be disposed in upper portions of the respective pump chambers.

[0010] This arrangement enables the pump chamber to be filled with liquid up to the height of the discharging valve. Thus, the most part of the interior of the pump chamber is filled with the liquid. This can make the time needed for precooling shorter. Moreover, since the interior of the pump chamber can be filled with liquid during precooling, gas which is compressible fluid hardly remains in the pump chamber. Therefore, supply of liquid by pumping can be carried out efficiently without being interfered with by the gas.

[Advantageous Effects of Invention]

[0011] The present invention enables a reduction in the time needed for precooling and efficient supply of liquid.

[Brief Description of Drawings]

[0012] [Fig. 1]

Fig. 1 a diagram illustrating the general configuration of a liquid supply system according to an embodiment.

[Description of Embodiments]

[0013] In the following, a mode for carrying out the present invention will be described specifically on the basis of a specific embodiment with reference to the drawing. The dimensions, materials, shapes, relative arrangements, and other features of the components that will be described in connection with the embodiment are not intended to limit the technical scope of the present invention only to them, unless particularly stated.

Embodiment

[0014] A liquid supply system in an embodiment will be described with reference to Fig. 1. The liquid supply system is suitably used for the purpose of, for example, maintaining a superconducting device in a ultra-low temperature state. Superconducting devices require perpetual cooling of components such as superconducting coils. Thus, a cooled device including a superconducting coil and other components is perpetually cooled by continuous supply of a cryogenic liquid (such as liquid nitrogen or liquid helium) to the cooled device. Specifically, a circulating fluid passage passing through the cooled device is provided, and the liquid supply system is connected to the circulating fluid passage to cause the cryogenic liquid to circulate, thereby enabling perpetual cooling of the cooled device.

<Overall Configuration of the Liquid Supply System>

[0015] Fig. 1 is a schematic diagram illustrating the overall configuration of the liquid supply system in the embodiment, where the overall configuration of the liquid supply system is illustrated in a cross section. Fig. 1 illustrates the overall configuration in cross sections in planes containing the center axis, where the left side and the right side of the center axis illustrate cross sections of different phases. More specifically, the left side of the center axis illustrates the cross sectional configuration at a location at which a first fluid channel that passes through a first pump chamber is clearly seen, and the right side of the center axis illustrates the cross sectional configuration at a location at which a second fluid channel that passes through a second pump chamber is clearly seen.

[0016] The liquid supply system 10 includes a main unit of the liquid supply system 100 (which will be referred to as the "main system unit 100" hereinafter), a vacuum container 200 in which the main system unit 100 is housed, and pipes (including an inlet pipe 310 and an outlet pipe 320). The inlet pipe 310 and the outlet pipe 320 both extend into the interior of the vacuum container 200 from outside the vacuum container 200 and are connected to the main system unit 100. The interior of the vacuum container 200 is a hermetically sealed space. The interior space of the vacuum container 200 outside the main system unit 100, the inlet pipe 310, and the outlet pipe 320 is kept in a vacuum state. Thus, this space provides heat insulation. The liquid supply system 10 is normally installed on a horizontal surface. In the installed state, the upward direction of the liquid supply system 10 in Fig. 1 is the vertically upward direction, and the downward direction in Fig. 1 is the vertically downward direction.

[0017] The main system unit 100 includes a linear actuator 110 serving as a driving source, a shaft member 120 that is moved in vertically upward and downward directions by the linear actuator 110, and a container 130. The linear actuator 110 is fixed on something suitable, which may be the container 130 or something that is not shown in the drawings. The shaft member 120 extends from outside the container 130 into the inside through an opening 130a provided in the ceiling portion of the container 130. The container 130 has an inlet 130b and an outlet 130c for liquid (cryogenic liquid) in its bottom portion (vertically lower portion). The aforementioned inlet pipe 310 is connected to the inlet 130b, and the outlet pipe 320 is connected to the outlet 130c.

[0018] Inside the container 130 are provided a plurality of structural components that compart the interior space into plurality of spaces, which constitute a plurality of pump chambers, passages for liquid, and vacuum chambers providing heat insulation. In the following, the structure inside the container 130 will be described in further detail.

[0019] The shaft member 120 has a main shaft portion

121 having a cavity in it, a cylindrical portion 122 surrounding the outer circumference of the main shaft portion 121, and a connecting portion 123 that connects the main shaft portion 121 and the cylindrical portion 122. The cylindrical portion 122 is provided with an upper outward flange 122a at its upper end and a lower outward flange 122b at its lower end.

[0020] The container 130 has a substantially cylindrical body portion 130X and a bottom plate 130Y. The body portion 130X has a first inward flange 130Xa provided near its vertical center and a second inward flange 130Xb provided on its upper portion.

[0021] Inside the body portion 130X, there are a plurality of first fluid passages 130Xc that extend in the axial direction below the first inward flange 130Xa and are spaced apart from one another along the circumferential direction. Inside the body portion 130X, furthermore, there are a plurality of second fluid passages 130Xd that extend in the axial direction above the first inward flange 130Xa and are spaced apart from one another along the circumferential direction. Inside the body portion 130X, there also is a third fluid passage 130Xe, which is an axially extending cylindrical space provided radially outside the region in which the first fluid passages 130Xc are provided. The bottom portion of the container 130 is provided with a fluid passage 130d that extends circumferentially and radially outwardly to join to the first fluid passages 130Xc. Furthermore, the bottom plate 130Y of the container 130 is provided with a fluid passage 130e that extends circumferentially and radially outwardly. These fluid passages 130d and 130e extend uniformly along the circumferential direction to allow liquid to flow radially outwardly in all directions, namely 360 degrees about the center axis.

[0022] Inside the container 130, there are provided a first bellows 141 and a second bellows 142, which expand and contract with the up and down motion of the shaft member 120. The first bellows 141 and the second bellows 142 are arranged one above the other along the vertical direction. The upper end of the first bellows 141 is fixedly attached to the upper outward flange 122a of the cylindrical portion 122 of the shaft member 120, and the lower end of the first bellows 141 is fixedly attached to the first inward flange 130Xa of the container 130. The upper end of the second bellows 142 is fixedly attached to the first inward flange 130Xa of the container 130, and the lower end of the second bellows 142 is fixedly attached to the lower outward flange 122b of the cylindrical portion 122 of the shaft member 120. The space surrounding the outer circumference of the first bellows 141 forms a first pump chamber P1, and the space surrounding the outer circumference of the second bellows 142 forms a second pump chamber P2.

[0023] Inside the container 130, there also are provided a third bellows 151 and a fourth bellows 152, which expand and contract with the up and down motion of the shaft member 120. The upper end of the third bellows 151 is fixedly attached to the ceiling portion of the container 130, and the lower end of the third bellows 151 is fixedly attached to the shaft member 120. Thus, the opening 130a of the container 130 is closed. The upper end of the fourth bellows 152 is fixedly attached to the second inward flange 130Xb provided on the container 130, and the lower end of the fourth bellows 152 is fixedly attached to the connecting portion 123 of the shaft member 120. A first space K1 is formed by the cavity in the main shaft portion 121 of the shaft member 120. A second space K2 is formed outside the third bellows 151 and inside the fourth bellows 152. A third space K3 is formed inside the first bellows 141 and the second bellows 142. The first space K1, the second space K2, and the third space K3 are in communication with each other. The space constituted by the first to third spaces K1, K2, and K3 is hermetically sealed. This space constituted by the first to third spaces K1, K2, and K3 is kept in a vacuum condition to provide heat insulation.

[0024] There are four check valves 160 including a first check valve 160A, a second check valve 160B, a third check valve 160C, and a fourth check valve 160D, which are provided at different locations inside the container 130. Each of these check valves 160 is an annular component provided coaxially with the shaft member 120. Each of the check valves 160 is configured to allow flow of liquid in radial directions from inside to outside and to block flow of liquid in radial directions from outside to inside.

[0025] The first check valve 160A and the third check valve 160C are provided in the fluid passage passing through the first pump chamber P1. The first check valve 160A and the third check valve 160C function to block backflow of liquid pumped by the pumping effect of the first pump chamber P1. Specifically, the first check valve 160A is provided on the upstream side of the first pump chamber P1, and the third check valve 160C is provided on the downstream side of the first pump chamber P1. More specifically, the first check valve 160A is provided in the fluid passage 130d provided in the bottom portion of the container 130. The third check valve 160C is provided in the fluid passage formed in the vicinity of the second inward flange 130Xb provided on the container 130. The third check valve 160C is provided in the upper portion of the first pump chamber P1. The upper portion of the pump chamber refers to the portion of the region that functions as the pump chamber that is higher than its vertical center. In other words, the third check valve 160C is provided at a position at which it allows gas in the first pump chamber P1 to be discharged from it and allows the first pump chamber P1 to be filled with liquid.

[0026] The second check valve 160B and the fourth check valve 160D are provided in the fluid passage passing through the second pump chamber P2. The second check valve 160B and the fourth check valve 160D function to block backflow of liquid pumped by the pumping effect of the second pump chamber P2. Specifically, the second check valve 160B is provided on the upstream side of the second pump chamber P2, and the fourth check valve 160D is provided on the downstream side of the second pump chamber P2. More specifically, the second check valve 160B is provided in the fluid passage 130e provided in the bottom plate 130Y of the container 130. The fourth check valve 160D is provided in the fluid passage that extends from the vicinity of the first inward flange 130Xa to the second fluid passages 130Xd. The fourth check valve 160D is provided in the upper portion of the second pump chamber P2. The upper portion of the pump chamber refers to the portion of the region that functions as the pump chamber that is higher than its vertical center. In other words, the fourth check valve 160D is provided at a position at which it allows gas in the second pump chamber P2 to be discharged from it and allows the second pump chamber P2 to be filled with liquid. The exit from the second fluid passages 130Xd is provided at a location of the same height as the location at which liquid flows out of the third check valve 160C.

<Description of the Overall Operation of the Liquid Supply System>

[0027] The overall operation of the liquid supply system will be described. When the shaft member 120 is lowered by the linear actuator 110, the first bellows 141 contracts, and the second bellows 142 expands. Consequently, the fluid pressure in the first pump chamber P1 decreases. Then, the first check valve 160A is opened, and the third check valve 160C is closed. In consequence, liquid supplied from outside the liquid supply system 10 through the inlet pipe 310 (indicated by arrow S10) is taken into the interior of the container 130 through the inlet 130b and passes through the first check valve 160A (indicated by arrow S11). Then, the liquid having passed through the first check valve 160A is pumped into the first pump chamber P1 through the first fluid passages 130Xc in the body portion 130X of the container 130. On the other hand, the fluid pressure in the second pump chamber P2 increases. Then, the second check valve 160B is closed, and the fourth check valve 160D is opened. In consequence, the liquid in the second pump chamber P2 passes through the fourth check valve 160D (indicated by arrow T12). The liquid having passed through the fourth check valve 160D is pumped into the third fluid passage 130Xe through the second fluid passages 130Xd provided in the body portion 130X (indicated by arrow T13). Then, the liquid passes through the outlet 130c and is brought to the outside of the liquid supply system 10 through the outlet pipe 320.

[0028] When the shaft member 120 is raised by the linear actuator 110, the first bellows 141 expands, and the second bellows 142 contracts. Consequently, the fluid pressure in the first pump chamber P1 increases. Then, the first check valve 160A is closed, and the third check valve 160C is opened. In consequence, the liquid in the first pump chamber P1 is pumped into the third fluid passage 130Xe provided in the body portion 130X through the third check valve 160C (indicated by arrow T11). Then, the liquid passes through the outlet 130c and is brought to the outside of the liquid supply system 10 through the outlet pipe 320. On the other hand, the fluid pressure in the second pump chamber P2 decreases. Then, the second check valve 160B is opened, and the fourth check valve 160D is closed. In consequence, liquid supplied from outside the liquid supply system 10 through the inlet pipe 310 (indicated by arrow S10) is taken into the interior of the container 130 through the inlet 130b and passes through the second check valve 160B (indicated by arrow S12). Then, the liquid having passed through the second check valve 160B is pumped into the second pump chamber P2.

[0029] As above, the liquid supply system 10 can cause liquid to flow from the inlet pipe 310 to the outlet pipe 320 both when the shaft member 120 moves downward and when the shaft member 120 moves upward. Hence, the phenomenon called pulsation can be reduced.

[0030] The fluid passage through which the cryogenic liquid flows from the inlet 130b to the outlet 130c via the first pump chamber P1 will be hereinafter referred to as a first fluid channel. The fluid passage through which the cryogenic liquid flows from the inlet 130b to the outlet 130c via the second pump chamber P2 will be hereinafter referred to as a second fluid channel. As will be apparent from the above description, the first fluid channel is the passage of the cryogenic liquid that enters from the inlet 130b, then flows in the direction indicated by arrow S11, then flows in the direction indicated by arrow T11, and then flows to the outlet 130c. The second fluid channel is the passage of the cryogenic liquid that enters from the inlet 130b, then flows in the direction indicated by arrow S12, then flows in the directions indicated by arrows T12 and T13, and then flows to the outlet 130c.

[0031] In the system, the height of the location at which the direction of the liquid flow in the first fluid channel changes from the vertically upward direction to the downward direction (see arrow T11) and the height of the location at which the direction of the liquid flow in the second fluid channel changes from the vertically upward direction to the downward direction (see arrow T13) are the same.

[0032] The flow of liquid in the liquid supply system 10 during its operation is summarized as below. When the shaft member 120 moves downward, the liquid flows in the first fluid channel upstream of the first pump chamber P1 but does not flow in the first fluid channel downstream of the first pump chamber P1. Moreover, the liquid flows in the second fluid channel downstream of the second pump chamber P2 but does not flow in the second fluid channel upstream of the second pump chamber P2. When the shaft member 120 moves upward, the liquid flows in the first fluid channel downstream of the first pump chamber P1 but does not flow in the first fluid channel upstream of the first pump chamber P1. Moreover, the liquid flows in the second fluid channel upstream of the second pump chamber P2 but does not flow in the second fluid channel downstream of the second pump chamber P2.

<Precooling>

[0033] Now, precooling will be described. As described in the description of the background art, in order to cause cryogenic liquid to circulate when the system is started for the first time or when the system is started after maintenance, it is necessary to precool the fluid passages so as to prevent the cryogenic liquid from evaporating in them. In the precooling process, cryogenic liquid is caused to flow in the aforementioned first and second flow passages using an external drive source. Then, the first check valve 160A, the second check valve 160B, the third check valve 160C, and the fourth check valve 16D are all opened. In consequence, the cryogenic liquid flows in the entirety of the first and second fluid channels including their upstream and downstream portions at the same time.

<Advantages of the Liquid Supply System According to the Embodiment

[0034] In the liquid supply system 10, the height of the location at which the direction of the liquid flow in the first fluid channel changes from the vertically upward direction to the downward direction (see arrow T11) and the height of the location at which the direction of the liquid flow in the second fluid channel changes from the vertically upward direction to the downward direction (see arrow T13) are the same. When the cryogenic liquid is caused to flow from the inlet 130b to the outlet 130c for the purpose of precooling, the level of the liquid flowing in the first fluid channel and the level of the liquid flowing in the second fluid channel can be kept equal. This prevents situations in which liquid tends to be discharged from one of the fluid passages and not to flow in the other fluid passage from occurring. Therefore, the time needed for precooling can be shortened.

Others

[0035] The configuration of the first and second fluid channels is not limited to the above-described configuration. For example, the first and second fluid channels in the above-described system may be provided with a detour passage of liquid (i.e. cryogenic liquid) provided in the second inward flange 130Xb of the container 130 (indicated by broken arrows T14 in Fig. 1) so that the second inward flange 130Xb can also be precooled in the precooling process. This can expedite cooling of the interior of the system.

[0036] In the above-described configuration, the flow of liquid (i.e. cryogenic liquid) may be reversed. Specifically, the outlet 130c may be used as an inlet, the outlet pipe 320 may be used as an inlet pipe, the inlet 130b may be used as an outlet, the inlet pipe 310 maybe used as an outlet pipe, and the flow of liquid in the first fluid channel and the second fluid channel may be reversed. In the above-described embodiment, all of the fourth check valves 160 are adapted to allow flow of liquid in radial directions from inside to outside and to block flow of liquid in radial directions from outside to inside. In the case where the flow of liquid is reversed, it is necessary for all of the fourth check valves 160 to be adapted to allow flow of liquid in radial directions from outside to inside and to block flow of liquid in radial directions from inside to outside. This configuration can also provide the advantageous effects same as the above-described embodiment.

[Reference Signs List]

[0037]

10: liquid supply system
100: main system unit
110: linear actuator
120: shaft member
121: main shaft portion
122: cylindrical portion
122a: upper outward flange
122b: lower outward flange
123: connecting portion
130: container
130a: opening
130b: inlet
130c: outlet
130d: fluid passage
130e: fluid passage
130Xa: first inward flange
130Xb: second inward flange
130Xc: first fluid passage
130Xd: second fluid passage
130Xe: third fluid passage
130Y: bottom portion
141: first bellows
142: second bellows
151: third bellows
152: fourth bellows
160: check valve
160A: first check valve
160B: second check valve
160C: third check valve
160D: fourth check valve
200: vacuum container
310: inlet pipe
320: outlet pipe
P1: first pump chamber
P2: second pump chamber

Claims

1. A liquid supply system comprising:

a container having an inlet and an outlet for cryogenic liquid and provided with a pump chamber inside it;

a shaft member that moves vertically upward and downward in the container;

a first bellows and a second bellows disposed one above the other along the vertical direction in the container, each of which expands and contracts with upward and downward motion of the shaft member;

a first pump chamber formed by a space surrounding the outer circumference of the first bellows;

a second pump chamber formed by a space surrounding the outer circumference of the second bellows;

a first fluid channel through which cryogenic liquid flows from the inlet to the outlet via the first pump chamber; and

a second fluid channel through which the cryogenic liquid flows from the inlet to the outlet via the second pump chamber,

wherein the height of a location at which the direction of the first fluid channel changes from the vertically upward direction to the vertically downward direction and the height of a location at which the direction of second fluid channel changes from the vertically upward direction to the vertically downward direction are the same.

2. A liquid supply system according to claim 1, wherein the first pump chamber is formed by a space between a first valve that allows the cryogenic liquid entering through the inlet to flow into the interior of the container and a third valve that allows the cryogenic liquid to flow from the interior of the container to the outlet, the second pump chamber is formed by a space between a second valve that allows the cryogenic liquid entering through the inlet to flow into the interior of the container and a fourth valve that allows the cryogenic liquid to flow from the interior of the container to the outlet, and the third valve and the fourth valve are disposed in upper portions of the respective pump chambers.

[Fig. 1]

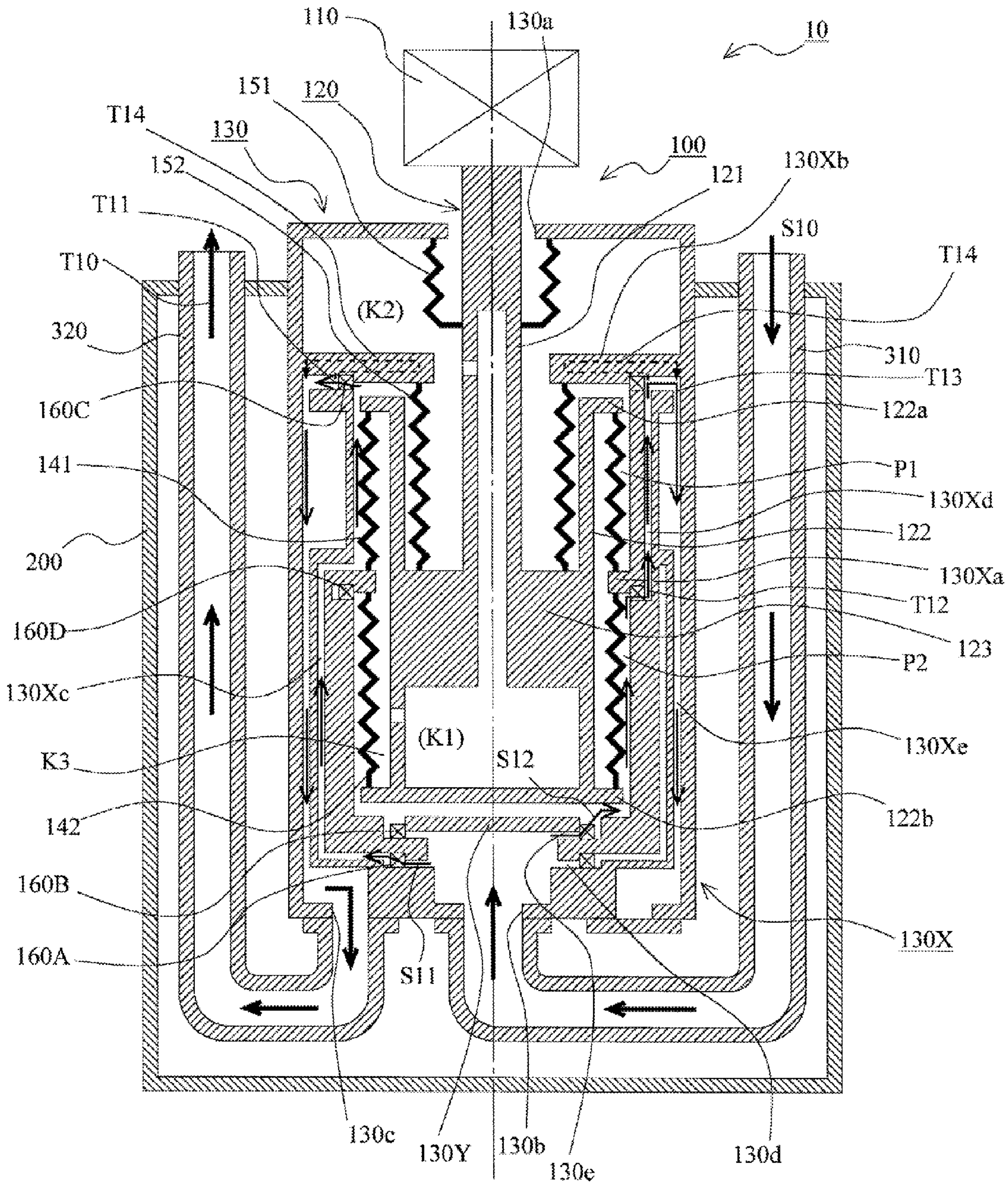
110
130a
10
151
120
T14
130
100
152
121
130Xb
T11
S10
T10
T14
(K2)
320
310
T13
160C
122a
141
P1
130Xd
200
122
130Xa
T12
160D
123
P2
130Xc
130Xe
(K1)
K3
S12
142
122b
160B
130X
160A
S11
130c
130Y
130b
130e
130d

Fig.1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/003635

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F04B15/08(2006.01)i, F04B43/08(2006.01)i, F25B9/00(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)
Int.Cl. F04B15/08, F04B43/08, F25B9/00

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

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 2016/047620 A1 (EAGLE INDUSTRY CO., LTD.) 31 March 2016, fig.7 & US 2017/0298914 A1, fig. 7 & EP 3199812 A1 & CN 106715906 A	1-2
A	JP 59-119075 A (TOYO SANSO CO., LTD.) 10 July 1984, fig. 2 (Family: none)	1-2
A	JP 48-54503 A (SIEMENS AG) 31 July 1973, drawing & US 3990816 A, fig. 1 & GB 1405655 A & DE 2155624 A1 & FR 2160104 B1 & CH 545916 A5	1-2

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 April 2018 (10.04.2018)	24 April 2018 (24.04.2018)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- WO 2016006648 A **[0004]**