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(54) **LIQUID SUPPLY SYSTEM**

(57) There is provided a liquid supply system that enables a reduction in time required for precooling to reduce the time taken to make a pump operable. A container 130 includes a first casing 131 in which fluid passages passing through a first pump chamber P1 and a second pump chamber P2 are provided and a second casing 132 that surrounds the outer wall of the first casing 131. A space (fourth space K4) between the first casing 131 and the second casing 132 is configured to allow a cryogenic liquid for precooling to flow through it.

[Fig. 1]

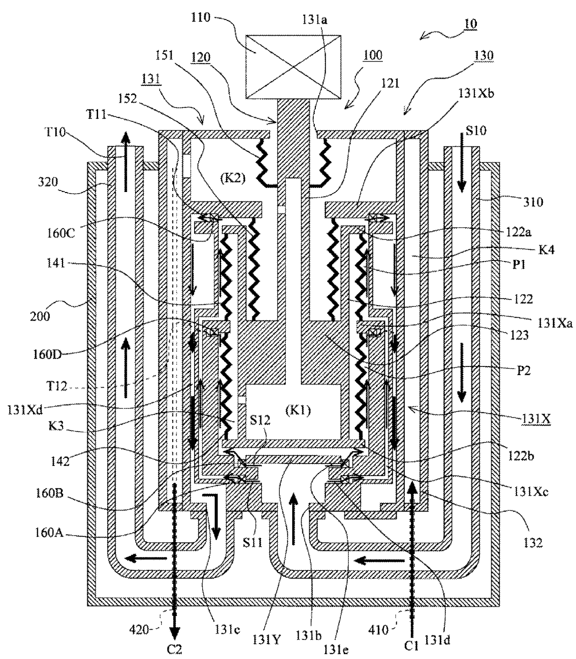

Fig.1

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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 Literatures 1 and 2 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] In conventional systems, the cryogenic liquid is caused to flow directly in the fluid passage passing through the pump chamber. It takes a long time to cool the fluid passage to make the pump operable by this process.

[Citation List]

[Patent Literature]

[0004]

[PTL 1]
WO 2016/006648
[PTL 2]
WO 2006/003871

[Summary of Invention]

[Technical Problem]

[0005] An object of the present invention is to provide a liquid supply system that enables a reduction in time required for precooling to reduce the time taken to make a pump operable.

[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; and
a bellows that expands and contracts with upward and downward motion of the shaft member;
wherein the pump chamber is formed by a space surrounding the outer circumference of the bellows, the container includes a first casing in which a fluid passage passing through the pump chamber is provided and a second casing configured in such a way as to surround the outer wall of the first casing, and a space between the first casing and the second casing is configured to allow cryogenic liquid for precooling to flow through it.

[0008] The fluid passage provided in the first casing can be precooled by causing cryogenic liquid for precooling to flow in the space between the first casing and the second casing. Thereafter, the fluid passage can be cooled in a short time by causing cryogenic liquid to flow in the fluid passage. This can reduce the time taken to make the pump operable.

[0009] The space between the first casing and the second casing may be kept in a vacuum state with the cryogenic liquid having been removed from the space between the first casing and the second casing after precooling.

[0010] With this feature, the space between the first casing and the second casing can provide heat insulation.

[0011] A hermetically sealed space other than the liquid supply passage passing through the pump chamber may be provided in the interior of the first casing, and the hermetically sealed space and the space between the first casing and the second casing may be in communication with each other.

[0012] The system may further comprise a third casing that surrounds the second casing and that a hermetically sealed space kept in a vacuum state may be formed between the second casing and the third casing.

[0013] With this feature, the hermetically sealed space between the second casing and the third casing can provide heat insulation.

[0014] This enables efficient cooling to be achieved when cryogenic liquid flows in the space between the first casing and the second casing.

[Advantageous Effects of Invention]

[0015] According to the present invention, precooling can be performed in a reduced time, and the time taken to make the pump operable can be shortened.

[Brief Description of Drawings]

[0016]

[Fig. 1]

Fig. 1 is a diagram illustrating the general configuration of a liquid supply system in a first embodiment.
[Fig. 2]
Fig. 2 is a diagram illustrating the general configuration of a liquid supply system in a second embodiment.

[Description of Embodiment]

[0017] In the following, modes for carrying out the present invention will be described specifically on the basis of specific embodiments with reference to the drawings. The dimensions, materials, shapes, relative arrangements, and other features of the components that will be described in connection with the embodiments are not intended to limit the technical scope of the present invention only to them, unless particularly stated.

First Embodiment

[0018] A liquid supply system in a first 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>

[0019] Fig. 1 is a schematic diagram illustrating the overall configuration of the liquid supply system, where the overall configuration of the liquid supply system is illustrated in a cross section. Fig. 1 illustrates the overall configuration in a cross section in a plane containing the center axis.

[0020] 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.

[0021] 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 container 130 includes a first casing 131 and a second casing 132 that is provided in such a way as to surround the outer wall of the first casing 131.

[0022] The shaft member 120 extends from outside the container 130 into the inside through an opening 131a provided in the ceiling portion of the first casing 131. The first casing 131 has an inlet 131b and an outlet 131c for liquid (cryogenic liquid) on its bottom. The aforementioned inlet pipe 310 is connected to the inlet 131b and the outlet pipe 320 is connected to the outlet 131c.

[0023] Inside the first casing 131 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 first casing 131 will be described in further detail.

[0024] 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.

[0025] The first casing 131 has a substantially cylindrical body portion 131X and a bottom plate 131Y. The body portion 131X has a first inward flange 131Xa provided near its vertical center and a second inward flange 131Xb provided on its upper portion.

[0026] Inside the body portion 131X, there are a plurality of first fluid passages 131Xc that extend in the axial direction below the first inward flange 131Xa and are spaced apart from one another along the circumferential direction. Inside the body portion 131X, there also is a second fluid passage 131Xd, which is an axially extending cylindrical space provided radially outside the region in which the first fluid passages 131Xc are provided. The bottom portion of the first casing 131 is provided with a fluid passage 131d that extends circumferentially and radially outwardly to join to the first fluid passages 131Xc. Furthermore, the bottom plate 131Y of the first casing 131 is provided with a fluid passage 131e that extends circumferentially and radially outwardly. These fluid passages 131d and 131e extend uniformly all along the circumferential direction to allow liquid to flow radially outwardly in all directions, namely 360 degrees about the center axis.

[0027] 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 131Xa of the first casing 131. The upper end of the second bellows 142 is fixedly attached to the first inward flange 131Xa of the first casing 131, 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.

[0028] 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 first casing 131, and the lower end of the third bellows 151 is fixedly attached to the shaft member 120. Thus, the opening 131a of the first casing 131 is closed. The upper end of the fourth bellows 152 is fixedly attached to the second inward flange 131Xb provided on the first casing 131, and the lower end of the fourth bellows 152 is fixedly attached to the connecting portion 123 of the shaft member 120.

[0029] 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.

[0030] Inside the first casing 131, there are a fluid passage passing through the first pump chamber P1 and a fluid passage passing through the second pump chamber P2. The second casing 132 is configured to surround the outer wall of the first casing 131. An annular fourth space K4 is formed between the first casing 131 and the second casing 132. The fourth space K4 may also be in communication with the first space K1, the second space K2, and the third space K3. The space constituted by the first to fourth spaces K1, K2, K3, and K4 is configured to be capable of being hermetically sealed.

[0031] 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.

[0032] 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 131d provided in the bottom portion of the first casing 131. The third check valve 160C is provided in the fluid passage formed in the vicinity of the second inward flange 131Xb provided on the first casing 131.

[0033] 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 131e provided in the bottom plate 131Y of the first casing 131. The fourth check valve 160D is provided in the fluid passage formed in the vicinity of the first inward flange 131Xa of the first casing 131.

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

[0034] 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 131b 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 passage 131Xc in the body portion 131X of the first casing 131. 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 is pumped into the second fluid passage 131Xd provided in the body portion 131X through the fourth check valve 160D (see arrow T12). Then, the liquid passes through the outlet 131c and is brought to the outside of the liquid supply system 10 through the outlet pipe 320.

[0035] 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 second fluid passage 131Xd provided in the body portion 131X through the third check valve 160C (indicated by arrow T11). Then, the liquid passes through the outlet 131c 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 131b 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.

[0036] 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.

<Precooling>

[0037] 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 container entirely so as to prevent the cryogenic liquid from evaporating in the fluid passage. In this embodiment, cryogenic liquid is caused to flow in the fourth space K4 formed between the first casing 131 and the second casing 132 before cryogenic liquid is supplied to the fluid passages passing through the pump chambers (the first pump chamber P1 and the second pump chamber P2). In the following, the process of precooling will be specifically described.

[0038] To the fourth space K4 are connected a first pipe 410 for delivering liquid for precooling and a second pipe 420 for discharging the liquid for precooling. The first pipe 410 and the second pipe 420 are indicated by broken lines in Fig. 1, because they are provided at locations outside the cross section shown in Fig. 1. When precooling is performed, the fourth space K4, the vacuum container 200, and the fluid passage from the inlet pipe 310 to the outlet pipe 320 are evacuated firstly, and then a gas having a boiling point lower than the temperature of the cryogenic liquid for precooling is supplied into the fourth space K4 and the fluid passage from the inlet pipe 310 to the outlet pipe 320. After the fourth space K4 and the fluid passage from the inlet pipe 310 to the outlet pipe 320 are filled with the gas, the cryogenic liquid is supplied into the fourth space K4 through the first pipe 410. At that time, the second pipe 420 is opened to discharge the gas from the fourth space K4.

[0039] After the container 130 is cooled, the cryogenic liquid is discharged through the second pipe 420 by a discharging pump (e.g. dry-sealed vacuum pump), which is not illustrated in the drawings. The cryogenic liquid is discharged to the atmosphere after vaporized and passing through a heat exchanger, where it is heated to a temperature near room temperature. A chamber capable of storing the cryogenic liquid may be provided in the discharging fluid passage downstream of the heat exchanger to prevent the cryogenic liquid from being discharged to the atmosphere in the liquid state. A pressure relief valve may be provided to prevent the fluid pressure in the discharging fluid passage from becoming excessively high.

[0040] As above, after the fourth space K4 is cooled, the cryogenic liquid is discharged, and hence the fourth space K4 is in a vacuum state. The first space K1, the second space K2, and the third space K3 may be in communication with the fourth space K4, as described above. If this is the case, the first space K1, the second space K2, and the third space K3 are also in a vacuum state after cooled by the above-described precooling process.

[0041] By cooling the fourth space K4 (and the first space K1, the second space K2, and the third space K3 also in this embodiment), the fluid passage passing through the first pump chamber P1 and the fluid passage passing through the second pump chamber P2 are cooled. In consequence, when cryogenic liquid is supplied to these fluid passages, vaporization of the cryogenic liquid is prevented from occurring. As the cryogenic liquid flows in these fluid passages, they are cooled in a short time. Thus, the time taken until the pump is started to operate can be shortened. The cryogenic liquid in the fourth space K4 may be discharged from it to evacuate the fourth space K4 after the operation of the pump is started (in other words, after the up and down motion of the shaft member caused by the linear actuator 110 is started).

<Advantages of the Liquid Supply System According to This Embodiment

[0042] The liquid supply system 10 can cool the fluid passages in the first casing 131 beforehand by causing cryogenic liquid for precooling to flow in the space (the fourth space K4) between the first casing 131 and the second casing 132. Thereafter, the fluid passages can be cooled in a short time by supplying cryogenic liquid to them. Therefore, the time taken until the pump is started to operate can be shortened.

[0043] The liquid supply system is configured to remove cryogenic liquid from the fourth space K4 after precooling to keep the fourth space K4 in a vacuum state. Therefore, the fourth space K4 can provide heat insulation.

[0044] The liquid supply system has hermetically sealed spaces (the first, second, and third spaces K1, K2, K3) in the first casing 131 that are separated from the fluid passages passing through the first pump chamber P1 and the second pump chamber P2. These hermetically sealed spaces are in communication with the fourth space K4. Hence, the first space K1, the second space K2, and the third space K3 are also cooled by the precooling process. This improves the reliability of cooling of the fluid passages passing through the first pump chamber P1 and the second pump chamber P2. Moreover, the first space K1, the second space K2, and the third space K3 can also provide heat insulation.

Second Embodiment

[0045] Fig. 2 illustrates a liquid supply system in a second embodiment. The system in the first embodiment has a second casing that surrounds the outer wall of the first casing. The system has a third casing that surrounds the second casing. The structure and the operation of the system are the same as those of the system in the first embodiment except for the third casing, and the same components will be denoted by the same reference signs and will not be described further for the sake of convenience.

[0046] Fig. 2 is a schematic diagram illustrating the overall configuration of the liquid supply system, where the overall configuration of the liquid supply system is illustrated in a cross section. Fig. 2 illustrates the overall configuration in a cross section in a plane containing the center axis. The liquid supply system 10 differs from the system in the first embodiment only in the features relating to the third casing 133. The other features are the same as those in the liquid supply system 10 in the first embodiment, and the same features will not be described further for the sake of convenience.

[0047] The container 130 includes the first casing 131, the second casing 132 that surrounds the outer wall of the first casing 131, and the third casing 133 that surrounds the second casing 132. As in the first embodiment, a fluid passage passing through the first pump chamber P1 and a fluid passage passing through the second pump chamber P2 are provided in the first casing 131. The second casing 132 surrounds the outer wall of the first casing 131. Between the first casing 131 and the second casing 132 is the annular fourth space K4. The fourth space K4 may be in communication with the first space K1, the second space K2, and the third space K3. The space constituted by the first space K1, the second space K2, the third space K3, and the fourth space K4 can be hermetically sealed.

[0048] The third casing 133 surrounds the outer wall of the second casing 132. The ceiling portion of the third casing 133 covers the ceiling portion of the first casing 131 and the ceiling portion of the second casing 132 with a gap between. The ceiling portion of the third casing 133 has an opening 133a. The shaft member 120 extends into the interior of the container 130 from outside through the opening 133a. A fifth bellows 153 is provided on the upper portion of the third casing 133. The fifth bellows 153 extends and contracts with the up and down motion of the shaft member 120. The upper end of the fifth bellows 153 is fixedly attached to the shaft member 120, and the lower end of the fifth bellows 153 is fixedly attached to the third casing 133. Thus, the opening 133a is closed.

[0049] The third casing 133 configured as above forms a hermetically sealed space (i.e. the fifth space K5) between the second casing 132 and the third casing 133. The fifth space K5 is configured to be kept in a vacuum state. Hence, the fifth space K5 provides heat insulation.

[0050] The overall operation of the liquid supply system and the process of precooling are the same as those in the first embodiment and will not be described.

[0051] The liquid supply system 10 can also provide advantageous effects the same as the system in the first embodiment. The fifth space K5 provides heat insulation. This improves the efficiency of cooling of the fourth space K4 etc. in the precooling process. Moreover, this can prevent freezing from occurring due to thermal contact of the space used for precooling with something of high temperature (e.g. atmosphere). Specifically, since the top of the ceiling portion of the first casing 131 and the ceiling portion of the second casing 132 is covered with the fifth space K5, which provide heat insulation, freezing can be prevented from occurring near the ceiling portion of the first casing 131 and the ceiling portion of the second casing 132 during precooling.

Others

[0052] In the systems in the first and second embodiments, the second pipe 420 used for precooling may extend into the interior of the fourth space K4 and the orifice of the second pipe 420 may be located in the upper portion of the fourth space K4. This can eliminate difficulties in filling the fourth space K4 with cryogenic liquid that may be involved in the precooling process due to residence of gas in the upper portion of the fourth space K4.

[Reference Signs List]

[0053]

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
131: first casing
131a: opening
131b: inlet
131c: outlet
131d: fluid passage
131e: fluid passage
131X: body portion
131Xa: first inward flange
131Xb: second inward flange
131Xc: first fluid passage
131Xd: second fluid passage
132: second casing
133: third casing
133a: opening
141: first bellows
142: second bellows
151: third bellows
152: fourth bellows
153: fifth 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
410: first pipe
420: second pipe
P1: first pump chamber
P2: second pump chamber

Claims

1. A liquid supply system comprising:

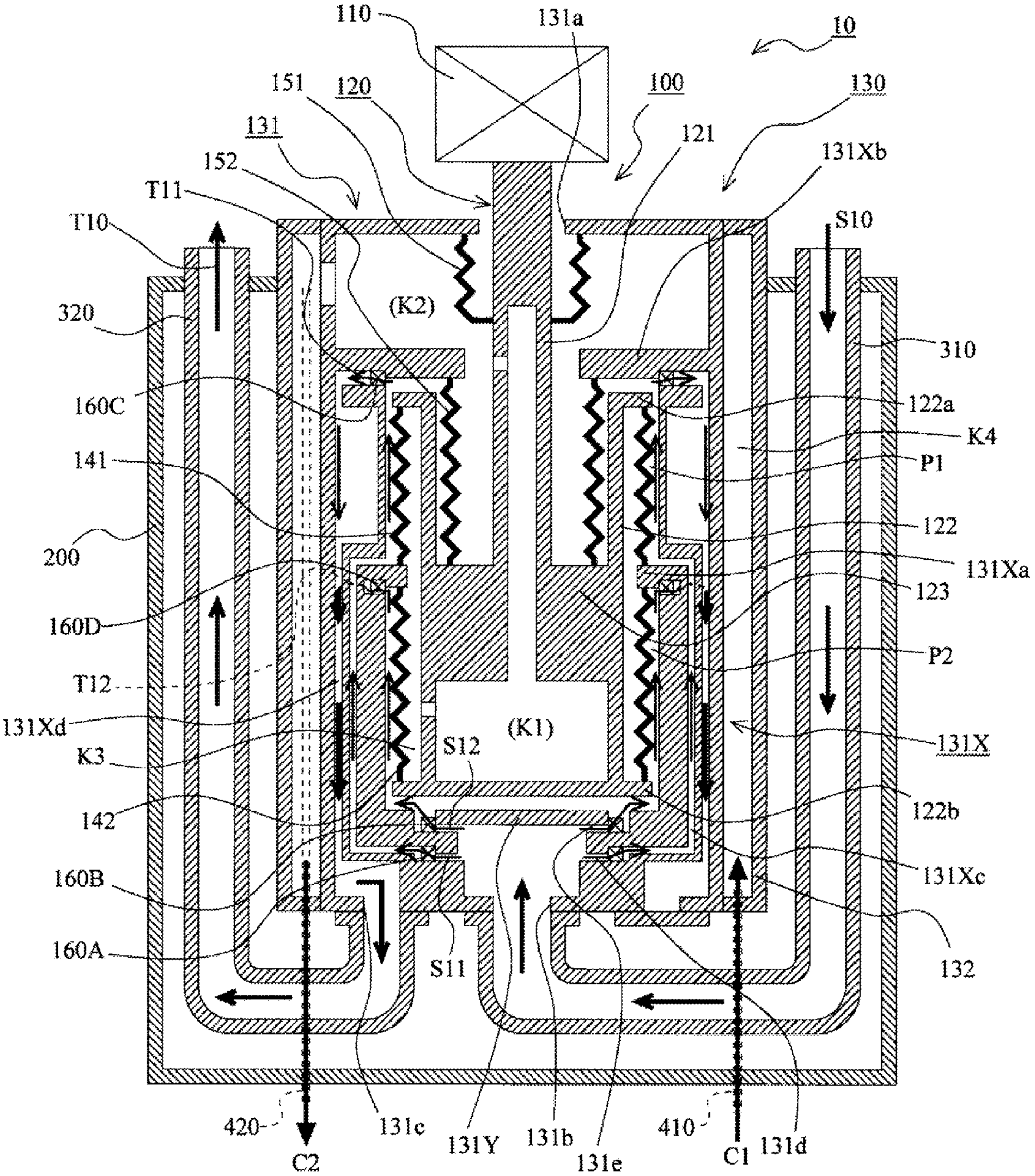
a container having an inlet and an outlet for cryogenic liquid and provided with a pump chamber inside it;
a shaft member that moves vertically upward and downward in the container; and
a bellows that expands and contracts with upward and downward motion of the shaft member;
wherein the pump chamber is formed by a space surrounding the outer circumference of the bellows, the container includes a first casing in which a fluid passage passing through the pump chamber is provided and a second casing configured in such a way as to surround the outer wall of the first casing, and a space between the first casing and the second casing is configured to allow cryogenic liquid for precooling to flow through it.

2. A liquid supply system according to claim 1, wherein the space between the first casing and the second casing is kept in a vacuum state with the cryogenic liquid having been removed from the space between the first casing and the second casing after precooling.

3. A liquid supply system according to claim 1 or 2, wherein a hermetically sealed space other than the passage passing through the pump chamber is provided in the interior of the first casing, and the hermetically sealed space and the space between the first casing and the second casing are in communication with each other.

4. A liquid supply system according to claim 1, 2, or 3, further comprising a third casing that surrounds the second casing, wherein a hermetically sealed space kept in a vacuum state is formed between the second casing and the third casing.

[Fig. 1]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122a
K4
141
P1
122
200
131Xa
123
160D
P2
T12
131Xd
(K1)
131X
K3
S12
142
122b
131Xc
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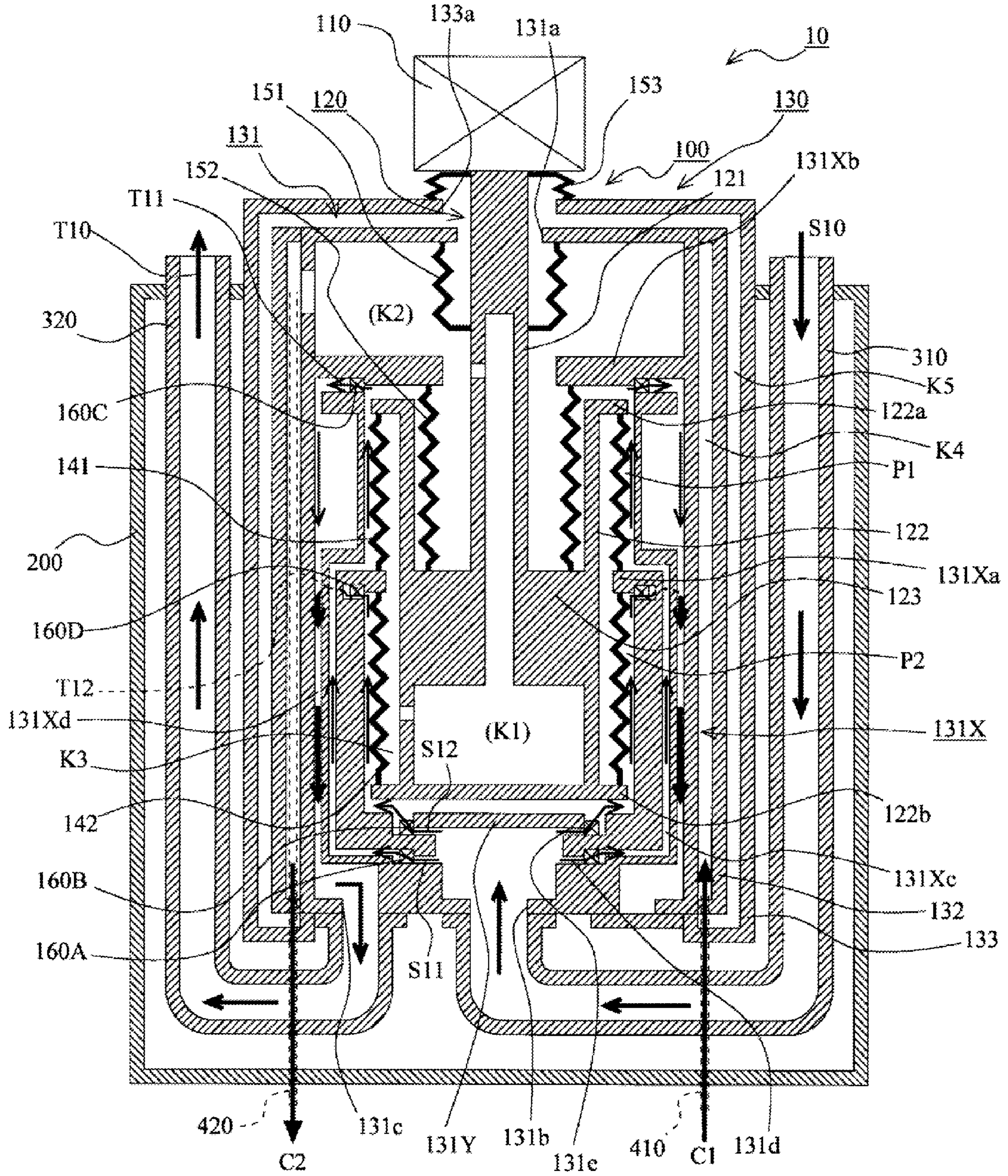
C1
131d
C2

Fig.1

[Fig. 2]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P1
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131Xa
123
160D
P2
T12
131Xd
(K1)
131X
K3
S12
142
122b
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131c
131Y
131b
131e
410
C1
131d
C2

Fig.2

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2018/003630

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.
X A	WO 2006/003871 A1 (MITSUBISHI HEAVY INDUSTRIES, LTD.) 12 January 2006, paragraphs [0106], [0121]-[0123], fig. 18 & US 2009/0165640 A1, paragraphs [0311]-[0313], fig. 18 & EP 1767783 A1 & EP 2071190 A1	1, 3-4 2
A	JP 2000-230478 A (ASAHI ENGINEERING CO., LTD.) 22 August 2000, paragraphs [0012]-[0013], fig. 1 (Family: none)	1-4
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10 April 2018 (10.04.2018)	24 April 2018 (24.04.2018)

Name and mailing address of the ISA/	Authorized officer
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