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(54) Title: METHOD FOR COOLING CRYOGENIC LIQUIDS AND SYSTEM ASSOCIATED TO SAID METHOD

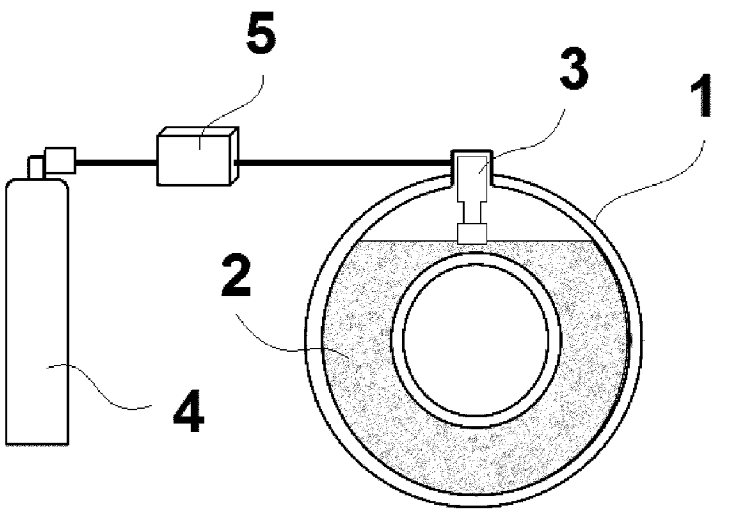

Fig. 3

(57) Abstract: The present invention relates to a method and a system for cooling liquid helium, that allows working without losses at temperatures under 2.5 K and at atmospheric pressure. The invention is preferably applicable to liquid helium baths for use in an NMR instrument, MRI instrument or instrument for measuring physical properties, and comprises: a cryostat (1) housing the cryogenic liquid which comprises inside thereof a superconducting device belonging to said instrument; a cryocooler (3) thermally connected to the cryostat; and an inlet source for cryogenic gas connected to the cryostat. Advantageously, the invention additionally comprises a subsystem (5) for regulating the pressure in the cryostat, operated by means for controlling the inlet of cryogenic gas into said cryostat.

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METHOD FOR COOLING CRYOGENIC LIQUIDS AND SYSTEM ASSOCIATED TO SAID METHOD

FIELD OF THE INVENTION

The present invention belongs to the field of systems and methods for cooling helium (He) and other cryogenic liquids, preferably for technical applications of nuclear magnetic resonance (NMR), magnetic resonance imaging (MRI), instruments for measuring physical properties or other equipment relying on the use of superconducting devices.

BACKGROUND OF THE INVENTION

Liquid helium is a cryogenic liquid used as a coolant to reach very low temperatures, preferably under the critical temperature (5.2 K) and critical pressure (220 kPa) thereof. Such temperatures are needed, for example, to cool superconducting devices. In known techniques for operating with such devices, liquid helium is previously stored in transport containers known as Dewar flasks at the boiling temperature at atmospheric pressure, typically about 4.2 K, and is transferred to the containers (known as cryostats) of the superconducting systems, also in liquid form at atmospheric pressure (about 100 kPa), that is, boiling. As the liquid helium is constantly boiling it tends to evaporate, such that to keep the cryostat at atmospheric temperature the vapor produced must exit the container, requiring the cryostat to be refilled periodically with more liquid helium.

In addition, advances in the field of superconductivity in recent decades have led to the possibility of generating high magnetic fields. For example, coils made with superconducting materials can create very strong DC magnetic fields without energy dissipation, and are used extensively in NMR, MRI or instruments for measuring physical properties. An example of these applications are superconducting coils made from Nb alloy cable, which have a much higher critical current and can create stronger magnetic fields when made to work at, for example, 2.5 K instead of 4.2 K. For this reason, in this type of systems it is always desirable to work at temperatures under 4.2 K.

To reach temperatures under 4.2 K state of the art technologies make use of the fact that the boiling temperature of liquid helium decreases when the pressure is reduced due to the characteristic properties of this element. To reduce said pressure, current techniques use, for example, vacuum pumps applied to the cryostat containing the helium. In this way the temperature corresponding to a specific pressure is set according to the liquid-vapor coexistence curve of the helium phase diagram (see, for example, Figure 1 of this document), allowing temperatures under 2 K to be obtained. In other known embodiments commonly used, this pressure regulation is applied only to a part of the liquid in a chamber insulated from the rest of the helium bath.

According to this description, known techniques start with a liquid helium bath at atmospheric pressure (100 kPa), at a temperature of 4.2 K (the boiling temperature for liquid helium at said atmospheric pressure at sea level, corresponding to point A in Figure 1). Using a vacuum pump to reduce the pressure inside the cryostat with negative pressure, a temperature of, for example, 2.5 K can be reached when the pressure in the cryostat has been reduced to 10 kPa, that is, point B in Figure 1. However, this pressure decrease has the undesirable effect of increasing the rate of evaporation of the liquid helium, leading to losses thereof and therefore the need for periodic refills. In addition, when the pressure in the cryostat is under atmospheric pressure, there is a high risk that air will enter the cryostat.

As described above, the methods based on using vacuum pumps have two main drawbacks. Firstly, the helium is lost at a much faster rate due to the pumping action, such that refilling frequency is increased. Secondly, when a negative pressure (vacuum) with respect to atmospheric pressure is introduced, air can leak into the cryostat, which can lead to several problems, such as the formation of ice inside the same.

The known systems for cooling superconductors with liquid helium include that described by patent US 5,220,800 (W.H. Müller). Said document relates to the cooling of liquid helium housed in a first lower chamber (using a cooler operating at a base temperature of 1.8-2.3 K). For this purpose, the patent proposes the use of a pumping system for evacuating liquid helium to a second upper chamber. However, the use of said pumping system is entirely inadequate since, as mentioned above, it results in a high evaporation rate due to the helium being pumped, as well as considerably increasing the risk of ice forming inside the cryostat of the system.

To solve the aforementioned drawbacks, the present invention proposes a novel method and a cooling system for liquid helium that allows working without losses at very low temperatures (for working temperatures of current cryocoolers, of about 2.5 K or less) and at a pressure equal to or greater than atmospheric pressure, thereby preventing the need to refill helium and negative pressures with the associated problems.

BRIEF DESCRIPTION OF THE INVENTION

According to the information discussed in the previous section, one object of the present invention is to obtain cryogenic cooling means for use in NMR or MRI equipment or in instruments for measuring physical properties (for example, devices comprising a superconducting coil inside them), which can operate at very low temperatures and atmospheric pressure, thereby preventing the appearance of helium losses or entry of air in the devices containing the cryogenic liquid.

This is achieved preferably by a method for cooling a bath of a cryogenic liquid (such as helium) housed in a cryostat that is thermally insulated from the outside, where said cryostat is thermally connected to:

- A cryocooler with a base refrigeration temperature;
- A source for introducing cryogenic gas in the cryostat.

Advantageously, said method comprises at least the following steps:

- Placing the cryocooler in thermal contact with the cryogenic liquid;
- Setting the pressure of the cryogenic liquid bath in the cryostat by regulating the inlet pressure of the cryogenic gas inside said cryostat.
- Cooling the cryogenic liquid, initially at boiling point and therefore consisting of liquid phase in equilibrium with vapor phase, to a single liquid phase until reaching the base temperature of the cryocooler, keeping the pressure inside the cryostat constant and slightly positive while the cryocooler is functioning.

In a preferred embodiment of the invention, the pressure of the cryogenic liquid bath in the cryostat is maintained at a value equal to or higher than atmospheric pressure. This completely prevents entry of air in the cryostat due to negative pressure differentials in the cooling system.

As regards the cryocooler of the invention, it preferably has a cooling power greater than zero at 4.2 K, and is equipped with one or more refrigeration stages, where at least one of said stages is in contact with the cryogenic liquid. This allows cooling the liquid bath directly in its exclusively liquid phase.

In another preferred embodiment of the invention, the cooling method comprises introducing cryogenic gas in the cryostat to compensate the change in density thereof when cooled, or to compensate possible leaks of this gas.

Another object of the invention relates to a cooling system for a cryogenic liquid bath used in an NMR instrument, MRI instrument or instrument for measuring physical properties, comprising:

- A cryostat for housing cryogenic liquid, thermally insulated from the outside, which includes inside it a superconducting device belonging to said instrument.
- A cryocooler thermally connected to the cryostat;
- A source for introducing cryogenic gas in the cryostat.

Advantageously, the system also comprises a subsystem for regulating the pressure in the cryostat, operated by means for controlling the inlet of cryogenic gas into said cryostat, where preferably said subsystem for regulating the pressure in the cryostat is a programmable automatic system. This allows ensuring that the pressure in the system remains constant at the desired value of atmospheric pressure or higher.

The present invention therefore provides the following main advantages:

(i) For a given cryogenic liquid, lower temperatures are obtained at atmospheric and higher pressures, thereby increasing the range of the minimum temperature for the instrument cooled by said liquid.

(ii) If the instrument has a superconducting magnet cooled by the cryogenic liquid, the value of the magnetic field thereof can be increased, since at a lower temperature the superconducting coil can withstand a higher current.

(iii) If it is necessary to remove the liquid helium from the instrument for maintenance or other reasons, high transfer efficiency is obtained by the use of a single liquid phase, without any boiling in the storage container (> 97%).

DESCRIPTION OF THE FIGURES

Figure 1 represents a phase diagram for helium, showing a path A-B in the liquid-vapor coexistence curve.

Figure 2 represents a phase diagram for helium, showing a path A-B in a single liquid phase.

Figure 3 shows a schematic representation of a preferred embodiment of the system of the invention.

Figure 4 shows the cooling process (helium inlet flow, temperature and pressure values) in a Dewar flask with 160 liters of liquid helium, from a temperature of 4.2 K to 2.5 K using the method of the invention.

DETAILED DESCRIPTION OF THE INVENTION

A detailed description of a preferred embodiment of the invention is provided below, based on the schematic representation of Figure 3 of this document. This preferred embodiment relates to a system and method for reducing the temperature of liquid helium in a cryostat (1) to a temperature of 2.5 K or less, while maintaining said cryostat (1) at atmospheric pressure or more. In addition, the method and system of the invention ensure negligible helium losses since no evaporation occurs, such that the need to refill the cryostat with more helium is prevented.

Unlike known techniques, the method and system of the invention propose, starting with a liquid helium bath (2) at atmospheric pressure (100 kPa) and a temperature of 4.2 K (point A of Figure 2), applying a cooling source to the helium bath (for example, using a cryocooler (3)) keeping the pressure constant during the process (for example, at atmospheric pressure). In this way it is possible to arrive from said point A of liquid-vapor coexistence to a point B' of only liquid phase, lowering the temperature of the helium bath (2) to temperatures on the order of 2 K. In this liquid phase the helium bath (2) has almost no losses, and if any exist they can be automatically compensated with very small amounts of additional gas, such as helium gas supplied by a source (4) of said gas using a pressure regulation and control subsystem (5), such that the desired pressure in the cryostat is maintained.

To execute the system and method of the invention at least one cryocooler (3) configured to generate base temperatures of 4.2 K or less is used. Said devices are known in the prior art, and, for example, can consist of commercially available cryocoolers with two cooling stages, which currently can supply 1.5 W of cooling power at 4.2 K, and have a base temperature under 2.5 K. In addition, as mentioned above, another essential part of the invention is the cryostat (1) that stores liquid helium, to which the stages of the cryocooler refrigeration stages are applied. In addition, to operate the helium gas supply to the cryostat an automatic pressure regulation system (5) is used such that the helium bath can be kept at a constant pressure programmed by the user. This pressure can be adjusted to atmospheric pressure (100 kPa) or higher, ensuring that no air enters the cryostat (1) in case of leaks.

As mentioned above, Figure 3 of this document represents the most simple embodiment of the invention. In this embodiment the coldhead of the cryocooler (3) (which comprises the two cooling stages) is located on the upper part of the cryostat (1), maintaining its second stage in direct thermal contact with the liquid helium bath (2). In this way, the cryocooler (3) cools the entire volume of liquid helium (2) which fills the cryostat (1) from its initial temperature (around 4.2 K) to its base temperature (for example, under 2.5 K for the best cryogenic cooling systems available today).

The helium gas will enter the cryostat during this process, as helium density increases when its temperature drops. This gas will also be liquefied by the cryocooler (3). The amount of gas entering the cryostat (1) will correspond to the necessary increase in mass to reach the required density for the liquid helium. Subsequently, the entry of helium gas into the cryostat (1) will immediately stop when the second stage of the cryocooler (3) reaches its base temperature. At this time the cooling power is compensated by the radiation and conduction heat entering the cryostat (1). After this the liquid helium (2) will remain at the base temperature of 2.5 K or less, with insignificant helium losses and at the pressure programmed by the user by the pressure regulation system (5). Figure 4 of the present document illustrates this cooling process over time (in hours) for a Dewar flask containing 160 liters of liquid helium, where the temperature falls from 4.2 K to 2.5 K by the cooling method of the invention. The Figure shows three graphs with the flow (in liters per minute) of helium gas into the Dewar, the temperature (in K) of the helium bath, and the pressure (in kPa) throughout the process which, as seen, remains constant during the cooling. It can also be seen that helium flow falls to zero at the end of the process once the base temperature is reached.

The present invention is preferably applicable in NMR and MRI instruments, and in general to any other instrument with superconducting devices inside that uses a cryocooler to cool a cryostat. In said instrument the coldhead of the cryocooler (3) preferably operates at full power in its first stage, to be able to cool the radiation shield of the cryostat (1), and its second stage is placed in contact with the helium bath (2) at full power. In addition, as mentioned in preceding paragraphs, the system of the invention also comprises a control subsystem (5) for controlling the pressure of the helium bath (2). The system will thus receive gas from a helium gas source (4) and the helium bath (2) of the NMR instrument will finally reach a temperature of 2.5 K or less at 1 psig (for the maximum power cryocoolers currently available) or any other positive working pressure desired depending on the equipment used.

By way of summary, it has been described how the present invention provides a method for obtaining monophasic cryogenic liquids, storing them and transferring them at temperatures near the triple point or the Lambda point (2.3 K in the case of helium), working at pressures of 100 kPa or higher. In this way it is possible to obtain monophasic cryogenic liquids that can be used at any point above the saturation or equilibrium line of the liquid-vapor phases, that is, in the liquid phase region of the phase diagram.

CLAIMS

1.- Method for cooling a cryogenic liquid bath (2) housed in a cryostat (1), for use in an NMR instrument, MRI instrument or in an instrument for measuring physical properties, said cryostat (1) housing a superconducting device of the aforementioned instrument, and thermally connected to:

a cryocooler (3) with a base refrigeration temperature; and to

a source (4) for introducing cryogenic gas in the cryostat (1);

where the method is characterized by comprising at least the following steps:

- placing the cryocooler (3) in thermal contact with the cryogenic liquid (2);
- setting the pressure of the cryogenic liquid bath (2) in the cryostat (1) by regulating the inlet pressure of the cryogenic gas inside said cryostat (1);
- cooling the cryogenic liquid (2) in a single liquid phase until reaching the base temperature of the cryocooler (3), keeping constant the pressure inside the cryostat (1) while the cryocooler (3) is operating.

2.- Method according to the previous claim, where the pressure of the cryogenic liquid bath (2) in the cryostat (1) is kept at a value equal to or greater than atmospheric pressure.

3.- Method according to any of the previous claims, where the cryogenic liquid and gas is helium.

4.- Method according to the previous claim, where the cryocooler (3) has a cooling power greater than zero at 4.2 K.

5.- Method according to any of the previous claims, where the cryocooler (3) has one or more cooling stages, where at least one of said stages is in contact with the cryogenic liquid (2).

6.- Method according to any of the previous claims, where cryogenic gas is introduced in the cryostat (1) to compensate the change in density thereof when cooled.

7.- Method according to any of the previous claims, where cryogenic gas is introduced in the cryostat (1) to compensate for leaks of said gas.

8.- Method according to any of the previous claims, used in a cryogenic liquid cryostat (1) that houses a superconducting device.

9.- Method according to the previous claim, where the superconducting device belongs to the NMR instrument, MRI instrument or instrument for measuring physical properties.

10.- System for cooling a cryogenic liquid bath (2) for use in an NMR instrument, MRI instrument or instrument for measuring physical properties, comprising:

- a cryostat (1) for housing cryogenic liquid (2) that comprises a superconducting device belonging to the aforementioned instrument;
- a cryocooler (3) thermally connected to the cryostat (1);
- a source (4) for introducing cryogenic gas connected to the cryostat (1);

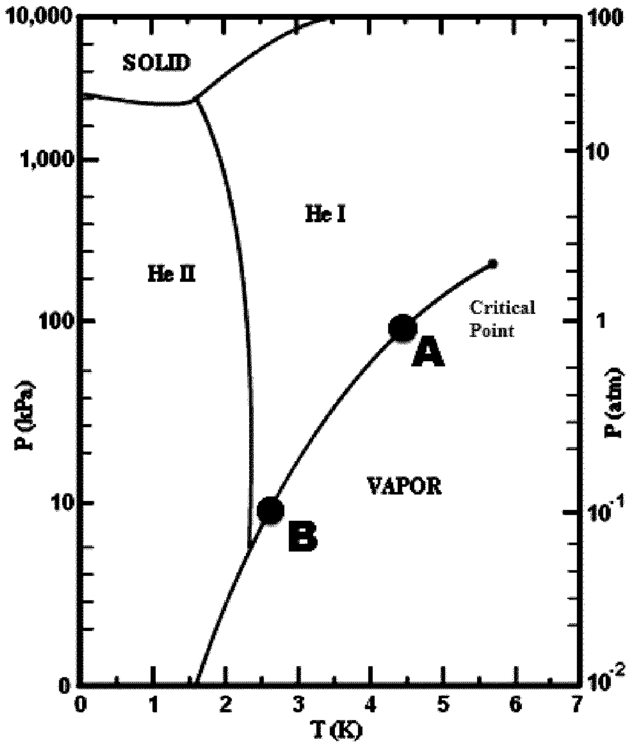
the system characterized in that it additionally comprises a subsystem (5) for regulating the pressure in the cryostat (1) operated by means for controlling the inlet of cryogenic gas into said cryostat (1).

11.- System according to the previous claim, where the cryogenic liquid and gas is helium.

12.- System according to the previous claim, where the cryocooler (3) has a cooling power greater than zero at 4.2 K.

13.- System according to any of claims 10-12, where the cryocooler (3) has one or more stages, where at least one of said stages is in thermal contact with the cryogenic liquid (2).

14.- System according to any of claims 10-13, where the subsystem (5) for regulating pressure in the cryostat (1) is a programmable automatic subsystem.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10
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10^-1
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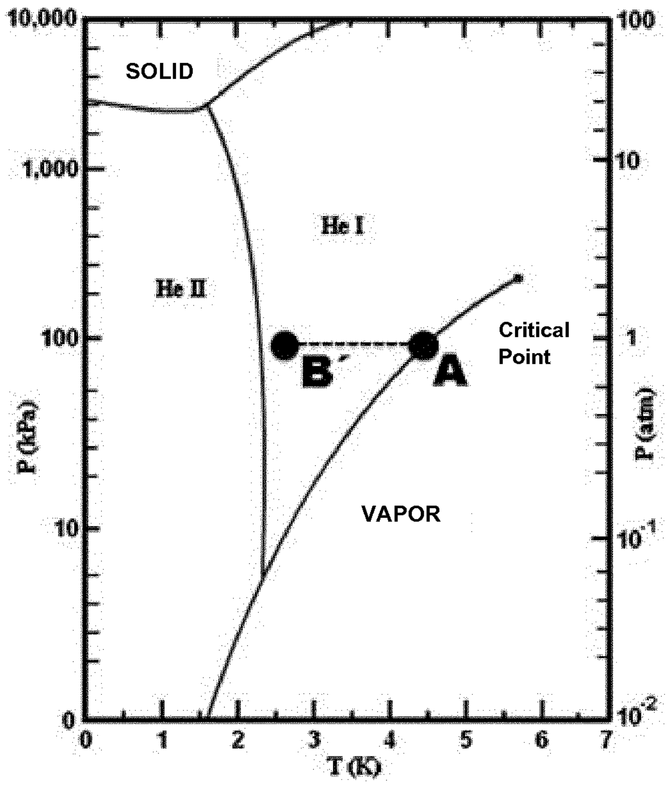
He II
Critical Point
A
B
VAPOR
0 1 2 3 4 5 6 7
T (K)

Fig. 1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10^-1
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He I
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Critical Point
B´
A
VAPOR
0 1 2 3 4 5 6 7
T (K)

Fig. 2

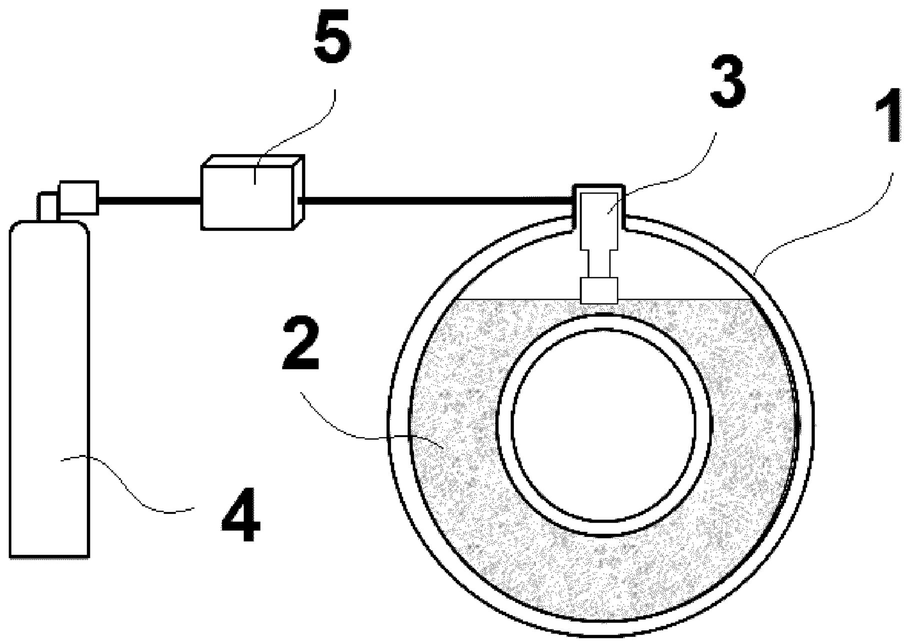
5
3
1
2
4

Fig. 3

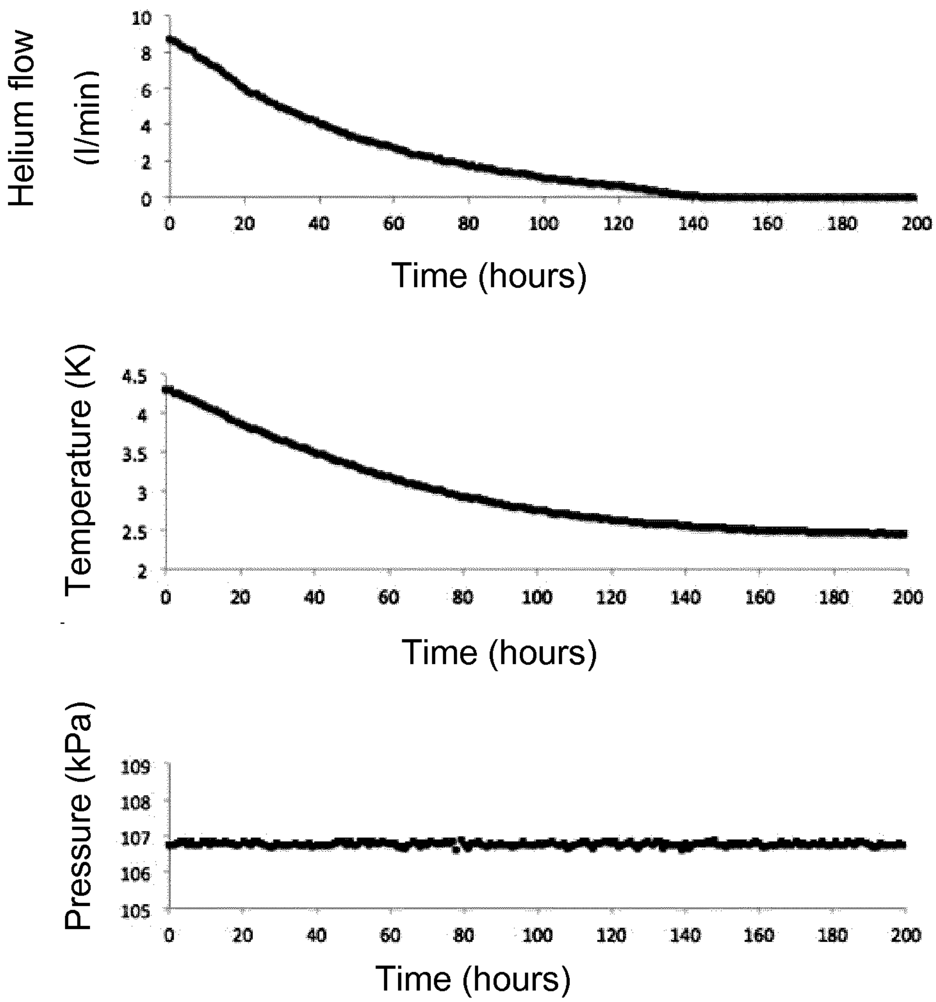
Helium flow (l/min)
10
8
6
4
2
0
0 20 40 60 80 100 120 140 160 180 200
Time (hours)
Temperature (K)
4.5
4
3.5
3
2.5
2
0 20 40 60 80 100 120 140 160 180 200
Time (hours)
Pressure (kPa)
109
108
107
106
105
0 20 40 60 80 100 120 140 160 180 200
Time (hours)

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/059076

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01R33/38 H01F6/04
ADD. G01R33/3815

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)
G01R H01F F25B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, BIOSIS, COMPENDEX, EMBASE, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2008 249201 A (TOSHIBA CORP) 16 October 2008 (2008-10-16) paragraphs [0008], [0021], [0024]; figures 1,2 -----	10-14
X	JP H11 304271 A (MITSUBISHI ELECTRIC CORP) 5 November 1999 (1999-11-05) paragraph [0014] - paragraph [0015] -----	10-14
A	US 5 220 800 A (MUELLER WOLFGANG H [DE] ET AL) 22 June 1993 (1993-06-22) cited in the application column 2, line 36 - column 4, line 29 -----	1-14
A	US 2001/013778 A1 (TSUDA MUNETAKA [JP]) 16 August 2001 (2001-08-16) paragraphs [0031], [0038]; claim 7 -----	1-14
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 June 2016	08/07/2016

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2

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 838 964 B1 (KNIGHT LARRY KEITH [US] ET AL) 4 January 2005 (2005-01-04) column 8, line 66 - column 10, line 7 column 11, line 20 - column 12, line 15 -----	1-14
A	GB 2 492 645 A (BRUKER BIOSPIN AG [CH]) 9 January 2013 (2013-01-09) page 12, paragraph 4 - page 14, paragraph 1 -----	1-14
A	EP 1 747 478 B1 (OXFORD INSTR SUPERCONDUCTIVITY [GB]) 3 February 2010 (2010-02-03) paragraph [0041] - paragraph [0043] -----	1-14
A	DE 20 2005 010892 U1 (BRUKER BIOSPIN GMBH [DE]) 6 October 2005 (2005-10-06) paragraph [0026]; figure 1 -----	10
A	US 2011/271694 A1 (STROBEL MARCO [DE] ET AL) 10 November 2011 (2011-11-10) paragraph [0022] - paragraph [0049] -----	1-14

2

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
JP 2008249201	A	16-10-2008	JP	4855990	B2	18-01-2012
			JP	2008249201	A	16-10-2008
JP H11304271	A	05-11-1999	NONE			
US 5220800	A	22-06-1993	GB	2254409	A	07-10-1992
			US	5220800	A	22-06-1993
US 2001013778	A1	16-08-2001	JP	3728167	B2	21-12-2005
			JP	2001218751	A	14-08-2001
			US	2001013778	A1	16-08-2001
US 6838964	B1	04-01-2005	NONE			
GB 2492645	A	09-01-2013	CH	705269	A2	15-01-2013
			DE	102011078608	A1	10-01-2013
			GB	2492645	A	09-01-2013
			US	2013008187	A1	10-01-2013
EP 1747478	B1	03-02-2010	AT	457068	T	15-02-2010
			EP	1747478	A1	31-01-2007
			JP	4340318	B2	07-10-2009
			JP	2007538244	A	27-12-2007
			US	2008290869	A1	27-11-2008
			WO	2005114244	A1	01-12-2005
DE 202005010892	U1	06-10-2005	NONE			
US 2011271694	A1	10-11-2011	DE	102010028750	A1	10-11-2011
			GB	2480154	A	09-11-2011
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