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(71) Applicants:
- **Dairei Co., Ltd.**
  Bunkyo-ku
  Tokyo 113-0034 (JP)
- **Nihon Freezer Co., Ltd.**
  Bunkyo-ku,
  Tokyo 113-0034 (JP)

(72) Inventors:
- **KURITA, Susumu**
  Tokyo 113-0034 (JP)
- **KURITA, Nobuyoshi**
  Tokyo 113-0034 (JP)

(74) Representative: **Röthinger, Rainer**
Wuesthoff & Wuesthoff
Patent- und Rechtsanwälte
Schweigerstrasse 2
81541 München (DE)

(54) CONTROL SYSTEM FOR REFRIGERATING MACHINE EMPLOYING NON-AZEOTROPIC REFRIGERANT

(57) Issues to be solved

On a refrigerator using non-azeotropic refrigerants, its cooling-capability is improved at starting up and/or at going up interior room temperature.

Means as solution

On a single-stage type refrigerating system using non-azeotropic refrigerant, composing with a compressor (1), a condenser (2), and an evaporator (10), heat exchanging between returned-refrigerant from evaporator and high-pressure refrigerant toward evaporator, electromagnetic valves (5-1 to 5-4) of capillary tubes (6-1 to 6-4) as expansion valves of evaporator are fully open, at moments of large load needed such as at starting up, the system is controlled flux of refrigerant gas and pressure of it by closing them one by the other corresponding to going down of interior room temperature.

As the state of interior room temperature is high and low boiling point constituent is not condensed, cooling capability of high boiling point refrigerant performs in maximum.

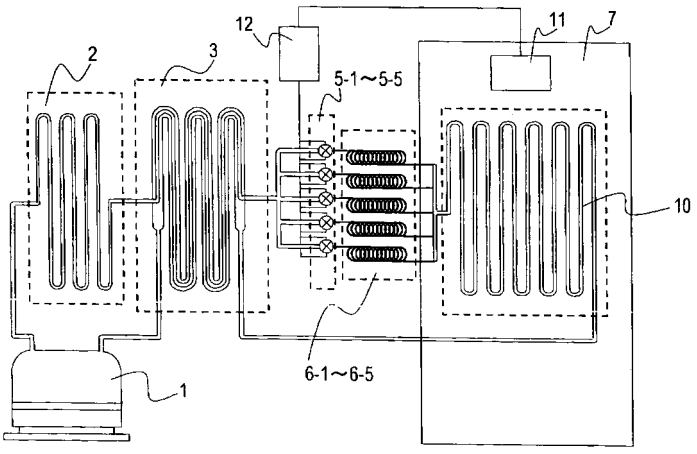

Fig. 1: Configuration of refrigerating system of the present invention

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to refrigerators using non-azeotropic refrigerant, wherein especially, like a large interior storage room at scale, they are necessary to have big performance to reach a set interior temperature at starting up stage, moreover they have large change of the interior temperature because of broadly open doors for storing and taking out of storage goods.

BACKGROUND OF THE ART

[0002] As refrigerators for relatively longer period to keep freshness of such as meat, fish and shellfish, wherein they are attainable ultra low temperature less than -50°C, has been used at fishery ports and material handling bases, Currently as refrigerating systems to realize such ultra low temperature, it has been conventionally used double-stage refrigerators which have 2 compressors and 2 condensers with combination of low boiling point refrigerant which has the boiling point is in the range of these low temperature zone and high boiling point refrigerant which works in room temperature.
Inventors of this present invention had proposed the single-stage compressor type refrigerator to realize such ultra low temperature using non-azeotropic refrigerant with combination of low boiling point refrigerant and high boiling point refrigerant, which is condensable at room temperature. (Japanese Patent Application No. H 11-99498)

[0003] By the invented ultra low temperature refrigerating system, it has been realized such ultra low temperature. The refrigerating system is a simple single-stage refrigerator, which is assembled with single compressor and a condenser. The system exchanges heat between returned refrigerant gas exhausted from the evaporator in low temperature and high-pressure refrigerant gas toward the evaporator. The system condenses low boiling point refrigerant in high-pressure refrigerant by vaporization heat of high boiling point refrigerant in returned refrigerant gas. The system establishes condition of vaporization and condensation cycle of non-azeotropic refrigerant at backward and at forward of the single evaporator.
In the case of applying the above mentioned system to stoker which has relatively smaller capacity, it is possible to keep relatively stable driving state because of small heat capacity, few amount of ventilation of interior cool air during stock and take out materials by horizontally open and close door type structure on the top face of refrigerator in general, and small change of interior temperature.

[0004] However in the case of large interior storage room larger than several thousand liters of interior capacity, like for use of storage whole body of tuna without cutting as business use, it is necessary to enter and work for workers, because of space for working zone and storage, vertical open and close door type is required and not only it is necessary to enhance performance at starting up stage accompanied with enlarged capacity but also it is necessary to enhance pull-down performance for keeping interior temperature and quick recovery to storage temperature from rising temperature, because of big amount of ventilated air of these opening and closing doors, and/or during stocking and taking out storage materials operation work.
While coping with this enhancing performance by enlarging capacity of individual elements of refrigerator such as a compressor and a condenser, not only it becomes to bear higher cost accompanied with increase of capacity, but also it becomes unnecessary exceed performance comparing with usual operating condition.
Moreover coping with enlarging output of compressor for temporal increase of load, subordinating ability and catch up ability are not good to change of temperature; it is not realized cooling ability coping with output.
Especially in the case of frequent works of storage and take out storage materials and large change of interior temperature, it is difficult to keep stable interior temperature and to get back usual state of temperature speedily.
Inventors of the present invention considered cause of this problem and traced following specific characteristics of non-azeotropic refrigerant.
Namely, it is necessary to exercise full cooling ability of refrigerator, in the case of starting up stage, and large rising change of interior temperature.
In such situation, temperature of returned refrigerant at heat exchangers is high while under condition of high interior temperature until stable operating condition and it is not enough to get cooling down though evaporated high boiling point constituent in the non-azeotropic refrigerant cools high-pressure side refrigerant, low boiling point constituent as state of not condensed circulates in the system. Hence, though spouted out pressure from compressor does rise, low boiling point constituent does not reach to condensation, since flux of it is restrained by resistance of decompress like capillary tube, and heat radiation is also restrained.
Thus low boiling point constituent in the non-azeotropic refrigerant is not condensed, as it circulates in the refrigerating system as gaseous state, though it is compressed to high-pressure by a compressor, low boiling point constituent is kept as gaseous state to an evaporator from a condenser through a heat exchanger, the working load of compressor is large, since pressure raises by such over load of compressor, heat radiation above mentioned is not increased, whole

cooling ability is not increased, and interior temperature would not get cooling down easily. Namely, since effect of cooling is mainly based on condensation and evaporation of high boiling point constituent in transition state, after all, so cooling ability is not kept and is not worked.
As low boiling point constituent is not cooled down enough in transition state, the super low temperature ability of refrigerant does not work, also it is not condensed, though pressure of it is raised by a compressor, therefore whole circulation of refrigerant is restrained, increase of cooling ability and recovery to usual operating state are restrained.

DISCLOSURE OF INVENTION

Problems To Be Solved By The Present Invention

[0005] On a single-stage type refrigerating system using non-azeotropic refrigerant, at starting up and/or at interior temperature rising stage, while low boiling point constituent does not reach to condensation, or, while interior temperature is getting cooling down, it should be solved to be possible stable operation by restraining load fluctuation, increasing amount of flux of refrigerant in order to enhance cooling performance.

How The Problems Are Solved

[0006] The present invention provides a single-stage type refrigerating system using non-azeotropic refrigerant, wherein having a compressor, a condenser, an evaporator, wherein said system exchange heat between returned refrigerant from the evaporator, and high-pressure refrigerant toward the evaporator in a path from the condenser, comprising; open degree of controllable expansion valves of the evaporator against pressure and flux of refrigerant gas, at starting up stage and/or at state of not progressing condensation of low boiling point constituent at high temperature of the interior storage room, enhancing cooling performance by high temperature boiling point constituent, keeping pressure according to condensation condition of high temperature boiling point constituent by the opening expansion valves of evaporator, getting lower temperature of the interior storage room according to progressing condensation of low boiling point constituent, closing the said expansion valves of evaporator one by the other adjusting pressure to meet to condensation condition of low boiling point constituent as usual operating state, and a system, wherein the said expansion valves of evaporator, having plural parallel capillaries, the system is featured in controlling amount of flux by number of opening valves and by number of closing valves.

Advantages Of The Present Invention

[0007] According to the present invention, on a single-stage type refrigerating system using non-azeotropic refrigerant, during higher operating temperature of the system like at starting up and/or at rising stage of interior temperature, wherein low boiling point-constituent in non-azeotropic refrigerant does not reach to condensation, it is possible to get smoothly stable operation cooling down interior temperature, exercising maximum cooling ability, moreover, it is possible to decrease load of compressor of refrigeration system..

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1: Configuration of refrigerating system of the present invention
Fig. 2: Cooling Speed Curves showing relationship between number of capillary tubes and cooling rate

Description of Reference Symbols

[0009]

1 :	compressor
2:	condensor
3: heat	exchanger
5-1 to 5-5:	electromagnetic valves
6-1 to 6-5:	capillary
7:	refrigerator
10:	evaporator
11:	sensor of temperature

12; controller

Description Of The Best Mode

[0010] Refrigerant using for the present invention is a mixture of non-azeotropic refrigerants, especially in order to reach to lower than -50°C, wherein comprising of combination of low boiling point-constituent with standard boiling point of lower than -50 °C and high boiling point constituent which has high boiling point and high vapor pressure enabling heat radiation from a condenser and condensation at room temperature, wherein it exchanges heat between high temperature - high-pressure refrigerant from condenser toward compressor and low temperature - low-pressure refrigerant from an evaporator toward a compressor, wherein it is driven under condition as it cools high-pressure refrigerant toward an evaporator under boiling point, it heats inhaling gas to a compressor higher than dew point at the pressure.
Composing refrigerator, in order to attain above mentioned conditions, it is composed with a compressor, a condenser, a throttle valve and an evaporator, it is set a heat exchanger between a condenser - a throttle valve and an evaporator - a compressor for meeting to above mentioned condition, it is designed to be possible to adjust open degree of a throttle valve, it is designed control mechanism to be possible to adjust open degree of a throttle valve depending on the sensed temperature by a sensor to measure interior temperature of storage room. As starting up of the refrigerator, or interior temperature is going up over a certain temperature during stock and take out storage goods, the open degree of the throttle valve is controlled as the maximum, corresponding to cooling of interior temperature, decreasing flux of refrigerant by closing the open degree of the throttle valve gradually, as interior temperature reach to a set temperature, it is controlled to be minimum open degree of the throttle valve.
As a throttle valve for non-azeotropic refrigerants, more preferable, it is set plural parallel capillary tubes, corresponding to interior temperature, it is controlled flux of refrigerant by using electromagnetic valves one after the other, opening and closing these capillary tubes.

Embodiment Of The Present Invention

[0011] Hereinafter, the outline of embodiment of the present invention, and its parameters are described. A conceptual configuration of refrigerating system of the present invention is shown in Fig.1. Compressed refrigerant gas by a compressor (1) radiates heat to the air at a condenser (2), is branched to four paths via a heat exchanger (3), and it is expanding by guided capillary tubes with electromagnetic valve (5-1 to 5-5), it is vaporized in an evaporator (10), and it cools the interior storage room (7).
In an evaporator, corresponding to interior temperature and pressure, a part of high boiling point constituent sends itself to heat exchanger with returned gas as state of condensation, cools high temperature and high-pressure refrigerant by evaporation of itself mainly, condenses low boiling point constituent.
Temperature of the interior storage room is detected by a sensor of temperature (11), number of capillary tubes passing refrigerant are controlled corresponding to preset temperature by controller (12), by opening and/or closing electromagnetic valves (5-1 to 5-5)..
At a phase of starting up and/or a stage of higher temperature more than certain temperature in the interior storage room, all electromagnetic valves are open, and refrigerant goes through every capillary tube.
Temperature of interior storage room goes up more than higher over preset temperature, electromagnetic valves are close one by the other, amount of circulation of refrigerant corresponding to the temperature of interior storage room and exhaling pressure of compressor are controlled.
When temperature of interior storage room reaches to stable condition at preset temperature, the system is driven using only one capillary tube. Parameters of embodiment are shown below:

Structure of storage room: prefabricated structure with double doors
Capacity of interior storage room: 4,275 liters
Operating temperature: lower than -50 °C, -60 °C maximum
Refrigerant: Used refrigerant was enclosed 4,400 grams of EP-53P. Parameters of non-azeotropic refrigerants are shown in Table 1. Composition of non-azeotropic refrigerants EP-53P is HFC-23: 40 weight %, HFC-134a: 60 weight % was used.

[0012]

[Table- 1]

Composition of non-azeoiropic refrigerants and its physical characteristics				
	Chemical formula	Boiling point (°C 1 atm)	Critical Temperature (°C)	Critical pressure (abs) (MPa)
HFC-23	CHF_3	-82.03	25.9	4.83
HFC-134a	CH_2FCF_3	-26.18	101.5	4.065

[0013] In the case of using one capillary tube under configured structure shown in Fig. 1, the interior storage room temperature change from starting up is shown in Table 2. The interior temperature was measured at upper position of interior storage room. The required time was about 5 hours from room temperature of 34°C to reach the set temperature of -50°C.

[0014]

Table 2

Operating Condition In The Case Of One Capillary Tube(Room Temperature : 31-34°C)							
Hours of operation	Interior room Temperature (° C)	Exhaling pressure of compressor (MPa)	Inhaling pressure of compressor (MPa)	Exhaling temperature of compressor (°C)	Inhaling temperature of compressor (°C)	Inlet temperature of heat exchanger (°C)	Outlet temperature of heat exchanger (°C)
0:00	-	-	-	-	-	-	
0:30	5.7	2.35	0.025	122.8	33.3	108.0	
1:00	-8.4	2.42	0.050	134.2	32.8	116.0	
1:30	-27.0	2.30	0.070	136.0	24.9	114.0	-30.7
2:00	-35.5	2.25	0.070	133.0	24.9	111.9	-37.9
2:30		2.23	0.070	-			
3:00	-44.6	2.20	0.060	120.0	9.6	107.0	-42.0
3:30	-47.2	1.95	0.050	118.0	5.8	107.0	-43.6
4:00	-48.5	1.95	0.040	119.0	5.1	103.0	-44.4
4:30	-49.1	1.90	0.040	118.0	5.0	104.0	-44.1
5:00	-50.2	1.95	0.040	118.0	5.1	104.0	-44.4

[0015] Hereinafter, change of interior room temperature of the embodiment in the case of using four capillary tubes is shown in Table 3.
Interior temperature was measured at upper point of interior storage room. The electromagnetic valves were closed one by the other at each switching temperature for four capillary tubes was 0°C, -10°C, -25°C, under such temperature, one capillary tube was always open. The result is shown in Table 3. The required time to reach set temperature of - 50°C was about 4 hours.

[0016]

Table 3

Operating condition in the case of four capillary tubes(Room temperature : 31-33°C)							
Hours of operation	Interior room Temperature (°C)	Exhaling pressure of compressor (MPa)	Inhaling pressure of compressor (MPu)	Exhaling temperature of compressor (°C)	Inhaling temperature of compressor (°C)	Inlet temperature of heat exchanger (°C)	Outlet temperature of heat exchanger (°C)
0:00							
0:30	-15.3	2.20	0.25	101.0	-3.8	78.4	-21.0
1:00	-30.6	2.40	0.070	114.0	15.6	98.0	-33.8
1:30	-38.2	2.20	0.060	122.1	10.9	105.0	-38.6
2:00	-41.8	2.20	0.060	122.0	10.5	10.4	-39.5
2:30	-45.1	20.5	0.060	122.0	10.0	104.0	-41.4
3:00	-47.9	20.0	0.050	125.0	10.7	104.0	-42.0
3:30	-48.5	19.0	0.050	123.0	10.2	105.0	-43.3
4:00	-50.2	19.0	0.050	119.0	10.6	105.0	-43.2
4:30	-50.0	19.0	0.040	125.0	9.0	111.0	-44.0
5:00	-50.2	19.0	0.040	120.0	6.2	101.0	-45.1

[0017] The above results as change of interior room temperature for hours of operation is shown in Fig.2. As shown in Fig. 2, in the case of using four capillary tubes closing one by the other corresponding to interior room temperature in order to control amount of refrigerant and pressure, it is recognized that interior room temperature from room temperature rapidly falls and starting up is very large.
What starting up is very large does mean required operation hours are less to reach - 50°C of usual operating temperature, and it also means that response against temperature change is rapid.
To temperature change from set temperature by input and output of goods under usual operating condition, interior storage room wall and inside cooled goods in advance are at set temperature, greatly rising interior atmosphere by effect of ventilation of air by open doors and new storage goods become object for cooling. Consequently, it relates that load on cooling from the aspect of heat capacity relatively small, but range of cooling temperature is large. The present invention of refrigerating system has quick response for interior storage room temperature change. It is possible to recover to usual operating condition temperature rapidly and it is also preferable for conventional usage of refrigerator.

Claims

1. A single-stage type refrigerating system using non-azeotropic refrigerant, wherein having a compressor, a condenser, an evaporator, wherein the said system exchanges heat between returned refrigerant from the evaporator, and high-pressure refrigerant toward the evaporator in a path from the condenser, wherein the said system is composed of the open degree of controllable expansion valves of the evaporator against pressure and flux of refrigerant gas, at starting up stage and/or at state of not progressing condensation of low boiling point constituent at high temperature of the interior storage room, in order to enhance cooling performance by high temperature boiling point constituent, keeping pressure according to condensation condition of high temperature boiling point constituent by the opening expansion valves of evaporator, getting lower temperature of the interior storage room according to progressing condensation of low boiling point constituent, closing the said expansion valves of evaporator one by the other adjusting pressure to meet to condensation condition of low boiling point constituent as usual operating state.

2. A system, according to claim 1, wherein the said expansion valves of evaporator, having plural parallel capillaries, is featured in controlling amount of flux by number of opening valves and by number of closing valves.

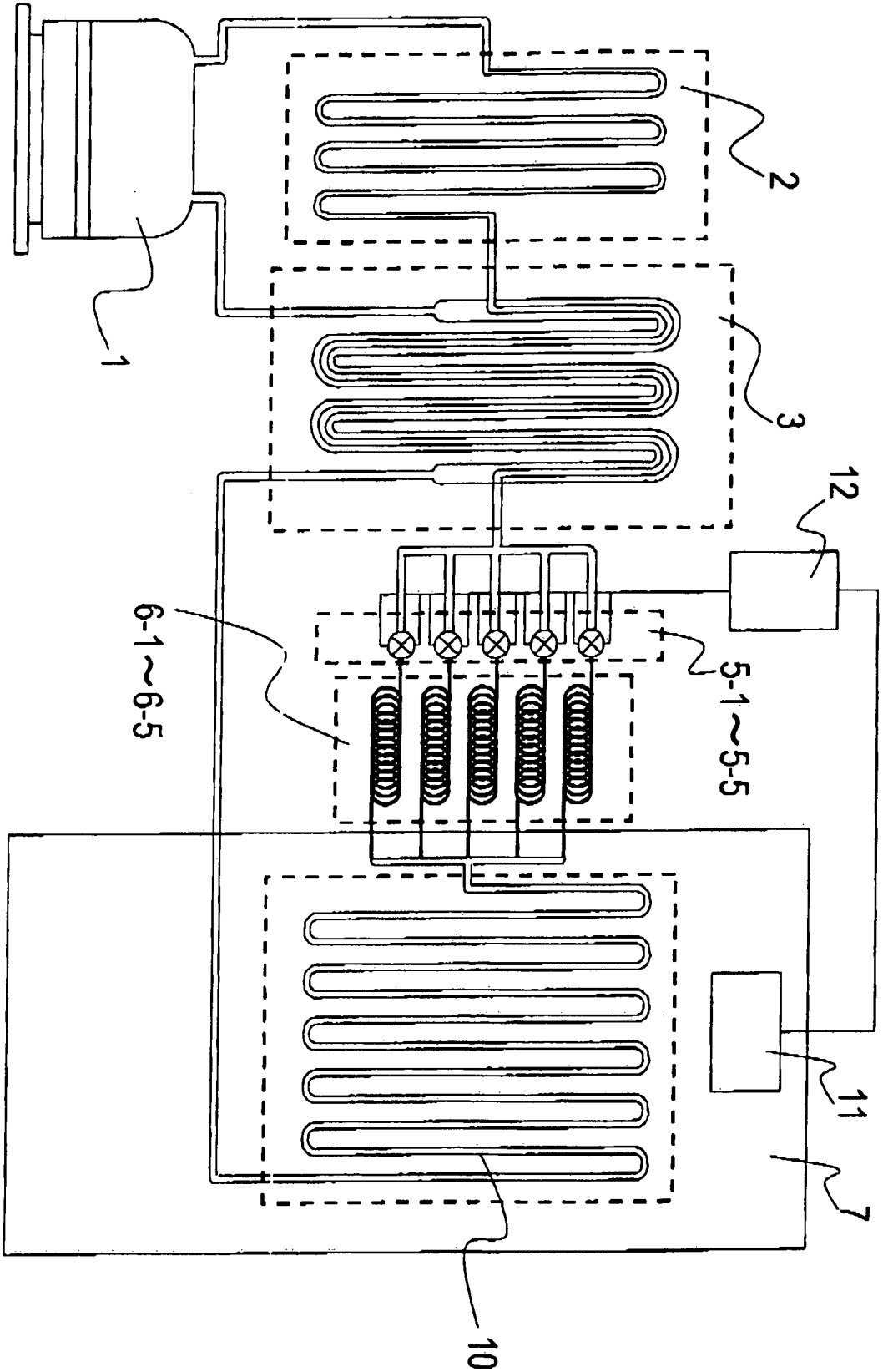

Fig. 1: Configuration of refrigerating system of the present invention

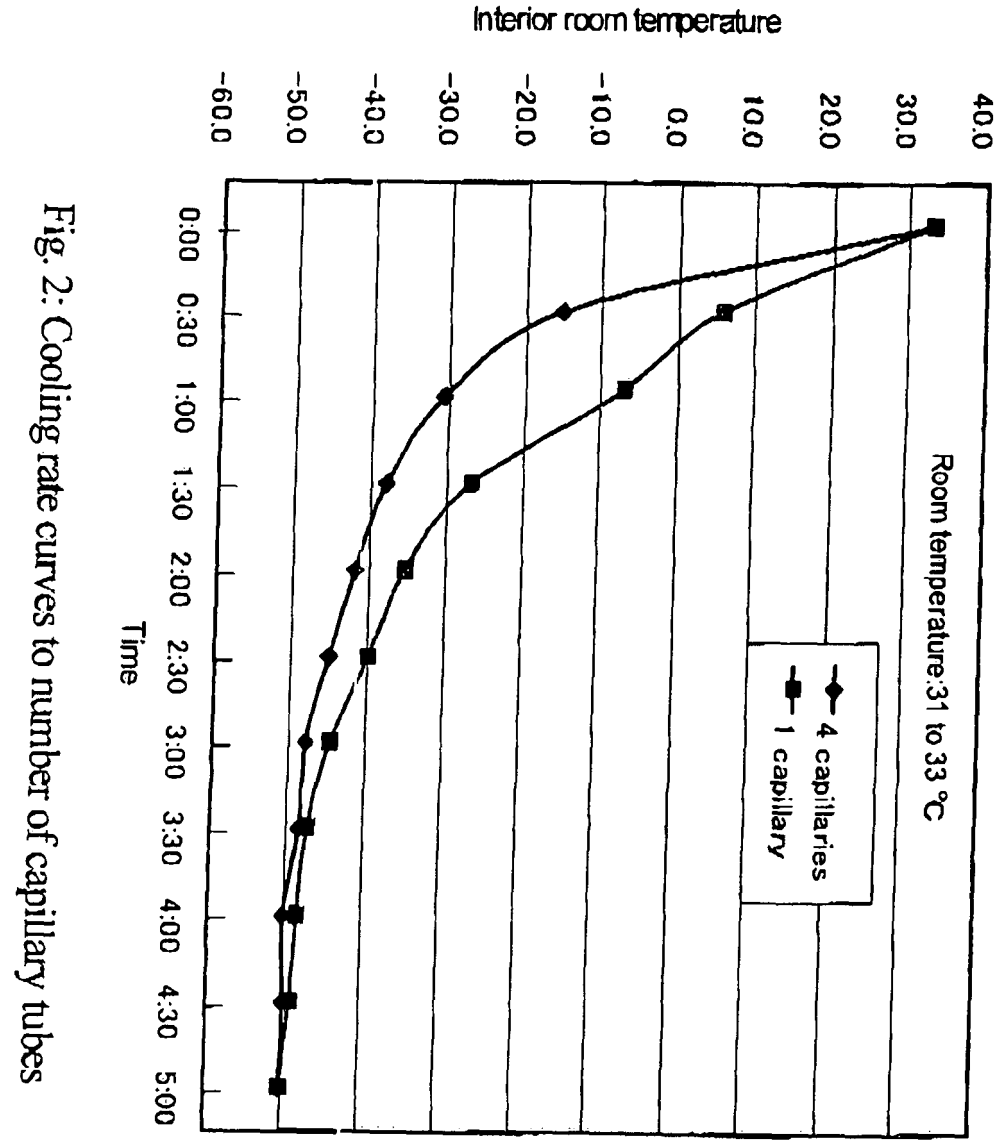

Fig. 2: Cooling rate curves to number of capillary tubes

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/311961

A. CLASSIFICATION OF SUBJECT MATTER
F25B1/00(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)
F25B1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2006
Kokai Jitsuyo Shinan Koho 1971-2006 Toroku Jitsuyo Shinan Koho 1994-2006

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.
Y	JP 59-84052 A (Mitsubishi Heavy Industries, Ltd.), 15 May, 1984 (15.05.84), Page 2, upper left column, line 14 to lower left column, line 12; Fig. 3 (Family: none)	1,2
Y	JP 2003-21473 A (Nihon Furiza Kabushiki Kaisha), 24 January, 2003 (24.01.03), Par. Nos. [0003] to [0004]; Fig. 4 (Family: none)	1,2

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

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Date of the actual completion of the international search	Date of mailing of the international search report
01 September, 2006 (01.09.06)	12 September, 2006 (12.09.06)
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/311961

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 1-200155 A (Yazaki Corp.), 11 August, 1989 (11.08.89), Page 3, upper right column, line 1 to lower right column, line 10; Fig. 1 (Family: none)	2
A	JP 2002-39637 A (ShinMaywa Industries, Ltd.), 06 February, 2002 (06.02.02), Full text; Figs. 1 to 6 (Family: none)	1,2

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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