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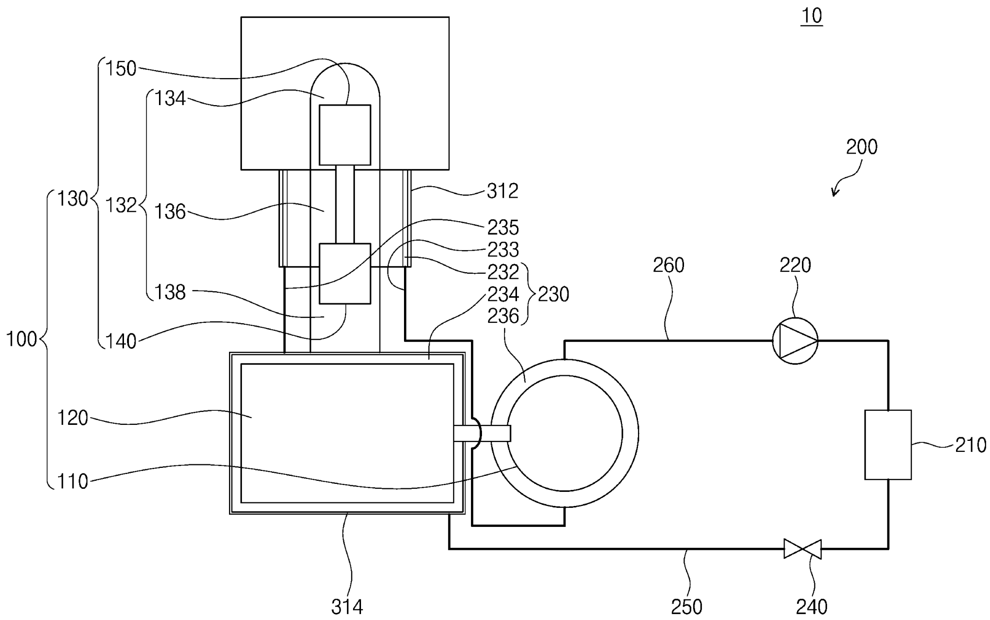
(54) **CRYOGENIC REFRIGERATION SYSTEM**

(57) Provided is a cryogenic refrigeration system. The cryogenic refrigeration system includes a cryogenic refrigerator, and a heat dissipation module configured to cool the cryogenic refrigerator. Here, the heat dissipation module includes a condenser configured to condense a refrigerant that cools the cryogenic refrigerator, and a heat exchanger connected to the cryogenic refrigerator to circulate the refrigerant between the cryogenic refrigerator and the condenser, thereby cooling the cryogenic refrigerator.

FIG. 1



EP 3 136 021 A1

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This U.S. non-provisional patent application claims priority under 35 U.S.C. § 119 of Korean Patent Application No. PCT/KR2015/004044, filed April 23, 2015, the entire contents of which are hereby incorporated by reference.

TECHNICAL FIELD

[0002] The present invention disclosed herein relates to a cryogenic refrigeration system, and more particularly, to a cryogenic refrigeration system capable of improving a coefficient of performance thereof

BACKGROUND ART

[0003] In general, a cryogenic refrigerator may be used to cool a superconductor or a small-sized electronic component. For example, the cryogenic refrigerator may include a stirling refrigerator, a GM refrigerator, and a Joule-Thomson refrigerator. The above-described cryogenic refrigerator may generate refrigeration output through an expansion process of working fluid such as helium or hydrogen. The expansion process may accompany heat generation of a compression process. Accordingly, the cryogenic refrigerator may be cooled by a heat dissipater. The typical cryogenic refrigerator may be cooled by a dual heat dissipater. The dual heat dissipater may include a water-cooling type heat dissipater and a vapor compression refrigerator. The water-cooling type radiator may cool the cryogenic refrigerator. The water-cooling type heat dissipater may be cooled by the vapor compression refrigerator However, since the water-cooling type heat dissipater uses water that has a low cooling efficiency of performance, a coefficient of performance of the cryogenic refrigerator may be reduced. In addition, the water-cooling type heat dissipater and the vapor compression refrigerator may increase costs for operating the cryogenic refrigerator to reduce productivity.

DISCLOSURE OF THE INVENTION

TECHNICAL PROBLEM

[0004] The present invention provides a cryogenic refrigeration system capable of increasing a radiant efficiency due to a coefficient of performance of refrigerant.

[0005] The present invention also provides a cryogenic refrigeration system capable of minimizing costs for operating a cryogenic refrigerator.

TECHNICAL SOLUTION

[0006] Embodiments of the present invention provide a cryogenic refrigeration system including: a cryogenic refrigerator; and a heat dissipation module configured to cool the cryogenic refrigerator. Here, the heat dissipation module includes: a condenser spaced apart from the cryogenic refrigerator to condense a refrigerant that cools the cryogenic refrigerator; and a heat exchanger connected to the cryogenic refrigerator to circulate the refrigerant between the cryogenic refrigerator and the condenser, thereby cooling the cryogenic refrigerator.

[0007] In other embodiments of the present invention, cryogenic refrigeration systems include: a cryogenic refrigerator comprising a power generation part, a power conversion part configured to convert power generated in the power generation part, and a gas cooling part configured to cool a gas by using the power converted in the power conversion part; and a heat dissipation module configured to circulate a refrigerant that cools the cryogenic refrigerator into the power generation part, the power conversion part, and the gas cooling part.

ADVANTAGEOUS EFFECTS

[0008] As described above, the cryogenic refrigeration system according to the embodiments of the present invention may use refrigerant having a coefficient of performance and/or a heat absorption efficiency greater than that of the water to increase a radiant efficiency of the cryogenic refrigerator. The cryogenic refrigerator may be directly cooled by the heat dissipation module to minimize the operational costs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1 is a diagram illustrating an example of a cryogenic refrigeration system according to the present invention.

FIG. 2 is a diagram illustrating a cryogenic refrigerator in FIG. 1.

FIG. 3 is a diagram illustrating another example of the cryogenic refrigeration system in FIG. 1.

FIG. 4 is a diagram illustrating still another example of the cryogenic refrigeration system in FIG. 1.

BEST MODE FOR CARRYING OUT THE INVENTION

[0010] Exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings. Advantages and features of the present invention, and implementation methods thereof will be clarified through following embodiments described with reference to the accompanying drawings. The present invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this invention will be thorough and complete, and will fully convey the scope of the present invention to those skilled in the art. Further, the present invention is only defined by scopes of claims. Like reference numerals refer to like elements throughout.

[0011] In the specification, the technical terms are used only for explaining a specific exemplary embodiment while not limiting the present invention. In the specification, the terms of a singular form may include plural forms unless referred to the contrary. The meaning of 'comprises' and/or 'comprising' specifies a component, a step, an operation and/or an element does not exclude other components, steps, operations and/or elements. Also, it will be understood that the terms such as chambers, units, arms, links, blades, motors, pulleys, rotational shafts, and belts are used as general mechanical terms in the specification. Since preferred embodiments are provided below, the order of the reference numerals given in the description is not limited thereto.

[0012] FIG. 1 is a diagram illustrating an example of a cryogenic refrigeration system 10 according to the present invention. FIG. 2 is a diagram illustrating a cryogenic refrigerator 100 in FIG. 1.

[0013] Referring to FIGS. 1 and 2, the cryogenic refrigeration system 10 according to the present invention may include the cryogenic refrigerator 100 and a heat dissipation module 200. The cryogenic refrigerator 100 may be cooled to a cryogenic temperature. The heat dissipation module 200 may dissipate heat from the cryogenic refrigerator 100.

[0014] The cryogenic refrigerator 100 may include a stirling cryogenic refrigerator. According to an embodiment, the cryogenic refrigerator 100 may include a power generation part 110, a power conversion part 120, and a gas cooling part 130.

[0015] The power generation part 110 may generate rotational power by external power. For example, the power generation part 110 may include a motor. The power generation part 110 may be connected to the power conversion part 120. The power generation part 110 may be heated to a temperature greater than a room temperature. The power generation part 110 may be heated to a temperature equal to or greater than about 30°C.

[0016] The power conversion part 120 may convert the rotational power to reciprocating linear power. The power conversion part 120 may include a shaft 122, a cam 125, a plurality of connecting rods 126, and a housing 128. The shaft 122 may be connected to the power generation part 110. The cam 124 may be connected between the shaft 122 and the connecting rods 126. The connecting rods 126 may extend to the gas cooling part 130. The housing 128 may surround the cam 124. The housing 128 may be connected to the gas cooling part 130.

[0017] The housing 121 may be provided in the housing 128. Oil 121 may be heated by operation of the shaft 122, the cam 124, and the connecting rods 126.

[0018] The gas cooling part 130 may be disposed on the power conversion part 120. The gas cooling part 130 may cool gas 131 at the cryogenic temperature. The gas 131 may include helium gas. According to an example, the gas cooling part 130 may include a cylinder 132, a displacer 140, and a piston 150. The cylinder 132 may be connected onto the power conversion part 120. The gas 131 may be provided into the cylinder 132. The displacer 140 and the piston 150 may be connected to the connecting rods 126 to move up and down in the cylinder 132. The displacer 140 may be disposed above the piston 150. One of the connecting rods 126 may pass through the piston 150.

[0019] The cylinder 132 may include a gas expansion region 134, a gas compression region 136, and a piston movement region 138. The gas expansion region 134 may be disposed above the gas compression region 136. The displacer 140 may be connected to one of the connecting rods 126 to move up and down in the gas expansion region 134 and the gas compression region 136. The displacer 140 may expand and cool the gas 131 in the gas expansion region 134. Accordingly, the gas expansion region 134 may be a cooling region. The gas compression region 136 may be connected to the rest of the connecting rods 126 and disposed between the gas expansion region 134 and the piston movement region 138. The piston 150 may move up and down in the piston movement region 138. Alternatively, the piston movement region 138 may be a region through which one of the connecting rods 126 passes. The displacer 140 and the piston 150 may compress the gas 131 in the gas compression region 136. The compressed gas 131 may heat the cylinder 132 in the gas compression region 136. Thus, the gas compression region 136 may be a heating region.

[0020] The heat dissipation module 200 may circulate to supply refrigerant to the power generation part 110, the power conversion part 120, and the gas cooling part 130 to directly cool the cryogenic refrigerator 100. The direct cooling method may have a size smaller than that of the typical dual heat dissipater and reduce maintenance costs. Accordingly, the cryogenic refrigeration system 10 according to the present invention may reduce the operational costs.

[0021] According to an example, the heat dissipation module 200 may include a condenser 210, a compressor 220, heat exchangers 230, a refrigerant expander 240, a refrigerant supply line 250, and a refrigerant collecting line 260. The condenser 210 may condense the refrigerant. The compressor 220 may be connected to the condenser 210. The condenser 220 may compress the refrigerant. According to an example, the refrigerant may include R22, R123, R134a, HFC-407C, HFC-407A, or R-123yf. The refrigerant may have a freezing point and an evaporation point, which are lower than those of water. For example, when water at a temperature of about 15 °C is heat-exchanged to about 30 °C with respect to the cryogenic refrigerator 100 at a temperature of about 63K, the water may have a coefficient of performance (COP) of about 0.2625. Meanwhile, the refrigerant of the R22 may have the coefficient of performance greater than that of the water. When the R22 at a temperature of about -30 °C is heat-exchanged to about -15 °C, the R22 may have the coefficient of performance of about 0.323. The heat exchangers 230 may be connected to the power generation part 110, the power conversion part 120, and the gas cooling part 130. The refrigerant supply line 250 may be connected between the condenser 210 and the heat exchangers 230. A radiant efficiency of the cryogenic refrigerator 100 may be increased. The refrigerant expander 240 may be connected to the refrigerant supply line 250. The refrigerant collecting line 260 may be connected between the compressor 220 and the heat exchangers 230.

[0022] The condenser 210 may liquefy the refrigerant. The condenser 210 may include a water-cooling type condenser and an air-cooling type condenser.

[0023] The refrigerant expander 240 may be disposed between the condenser 210 and the heat exchangers 230. The refrigerant expander 240 may vaporize and cool the refrigerant. The cooled refrigerant may be supplied to the heat exchangers 230 through the refrigerant supply line 250. The refrigerant may be heated in the heat exchangers 230.

[0024] The compressor 220 may supply the heated refrigerant to the condenser 210 with a predetermined pressure. The refrigerant in a gas state may be supplied to the condenser 210. The refrigerant may be circulated between the heat exchangers 230 and the condenser 210.

[0025] The heat exchangers 230 may cool the power generation part 110, the power conversion part 120, and the gas cooling part 130. According to an example, the heat exchangers 230 may include a gas heat exchanger 232, an oil heat exchanger 234, and a motor heat exchanger 236.

[0026] The gas heat exchanger 232 may be disposed in the compression region 136. The gas heat exchanger 232 may cool the cylinder 132 in the compression region 136. The heat exchange supply line 233 may connect the gas heat exchanger 232 to the oil heat exchanger 234. The heat exchange collecting line 235 may connect the gas heat exchanger 232 to the motor heat exchanger 236. The refrigerant may be sequentially supplied to the oil heat exchanger 234, the gas heat exchanger 232, and the motor heat exchanger 236. A first protection cover 312 may be disposed to surround the gas heat exchanger 232. The first protection cover 312 may protect the gas heat exchanger 232. On the other hand, the first protection cover 312 may prevent dew formation caused by cooling of the gas heat exchanger 232.

[0027] The power generation part 234 may be disposed on the power conversion part 120. The oil heat exchanger 234 may cool the oil in the power conversion part 120. The oil heat exchanger 234 may be connected to the refrigerant supply line 250. A second protection cover 314 may be disposed to surround the heat exchanger 234. The second protection cover 314 may protect the oil heat exchanger 234.

[0028] The motor heat exchanger 236 may be disposed on the power generation part 110. The motor heat exchanger 236 may cool the power generation part 110. The motor heat exchanger 236 may be connected to the refrigerant collecting line 260.

MODE FOR CARRYING OUT THE INVENTION

[0029] FIG. 3 is a diagram illustrating another example of the cryogenic refrigeration system 10 in FIG. 1.

[0030] Referring to FIG. 3, the heat dissipation module 200 may include a first pressure transducer 272, a first temperature sensor 274, and a circulation flow rate controller 276.

[0031] The first pressure transducer 272 may be disposed in the refrigerant collecting line 260 between the heat exchangers 230 and the compressor 220. The first pressure transducer 272 may detect a pressure of the refrigerant.

[0032] The first temperature sensor 274 may be disposed in the refrigerant collecting line 260 disposed adjacent to the first pressure transducer 272. The first temperature sensor 274 may detect a temperature of the refrigerant.

[0033] The circulation flow rate controller 276 may be connected to the first pressure transducer 272, the first temperature sensor 274, and the refrigerant expander 240. Also, the circulation flow rate controller 276 may receive a detection signal of the temperature and the pressure of the first pressure transducer 272 and the first temperature sensor 274. The circulation flow rate of the refrigerant may be controlled on the basis of the temperature and the pressure. The refrigerant expander 240 may control the circulation flow rate of the refrigerant according to the control signal of the circulation flow rate controller 276.

[0034] The cryogenic refrigerator 100 and the condenser 210, the compressor 220, the heat exchangers 230, the refrigerant expander 240, the refrigerant supply line 250, and the refrigerant collecting line 260 of the heat dissipation module 200 may be the same as those in FIGS. 1 and 2.

[0035] FIG. 4 is a diagram illustrating still another example of the cryogenic refrigeration system 10 in FIG. 1.

[0036] Referring to FIG. 4, the heat dissipation module 200 may include a second temper sensor 282, a second pressure transducer 284, a bypass valve 286, a bypass controller 288, a bypass line 290, and a sensitive heat tube 292.

[0037] The second temperature sensor 282 may be disposed in the refrigerant collecting line 260. The second temperature sensor 282 may detect the temperature of the refrigerant.

[0038] The second pressure transducer 284 may be disposed in the refrigerant collecting line 260. The second pressure transducer 284 may detect the pressure of the refrigerant.

[0039] The bypass valve 286 may be disposed in the refrigerant collecting line 260 between the condenser 210 and the compressor 220. The bypass valve 286 may be connected to the bypass line 290. The bypass valve 286 may include a three-way valve.

[0040] The bypass controller 288 may control the bypass valve 286. The bypass controller 288 may receive temperature and pressure signals of the second temperature sensor 282 and the second pressure transducer 284.

[0041] The bypass line 290 may detour the condenser 210 to connect the refrigerant collecting line 260 to the refrigerant supply line 250. According to an example, the bypass line 290 may be branched from the bypass valve 286. The bypass line 290 may be connected to the refrigerant supply line 250 between the heat exchangers 230 and the refrigerant expander 240. For example, when the temperature of the refrigerant of the refrigerant collecting line 260 is low, the bypass controller 288 may allow the refrigerant to detour from the refrigerant collecting line 260 to the refrigerant supply line 250 through the bypass line 290. Also, when the pressure of the refrigerant of the refrigerant collecting line 260 is high, the bypass controller 288 may allow the refrigerant to detour from the refrigerant collecting line 260 to the refrigerant supply line 250

[0042] The sensitive heat tube 292 may be disposed in the refrigerant collecting line 260. The sensitive heat tube 292 may be connected to the refrigerant expander 240. The sensitive heat tube 292 may detect the temperature of the refrigerant in the refrigerant collecting line 260. The sensitive heat tube 292 regulates the refrigerant expander 240 on the basis of the temperature of the refrigerant. The sensitive heat tube 292 may output a turn-on signal and a turn-off signal of the refrigerant expander 240. When the temperature of the refrigerant is high, the sensitive heat tube 292 may output the turn-on signal. When the temperature of the refrigerant is low, the sensitive heat tube 292 may output the turn-off signal.

[0043] The cryogenic refrigerator 100 and the condenser 210, the compressor 220, the heat exchangers 230, the refrigerant expander 240, the refrigerant supply line 250, and the refrigerant collecting line 260 of the heat dissipation module 200 may be the same as those in FIGS. 1 and 2.

[0044] Although the exemplary embodiments of the present invention have been described, it is understood that the present invention should not be limited to these exemplary embodiments but various changes and modifications can be made by one ordinary skilled in the art within the spirit and scope of the present invention as hereinafter claimed. Thus, the above-disclosed embodiments are to be considered illustrative and not restrictive.

INDUSTRIAL APPLICABILITY

[0045] According to the embodiment of the present invention, the cryogenic refrigerator may increase the radiant efficiency thereof to minimize the operational costs. In addition, the cryogenic refrigerator may effectively cool the low temperature superconductor or high temperature superconductor. The superconductor may be used as a source material for a power plant, a substation, a magnetic resonance device, a magnetic levitation train, a superconductor research center. The cryogenic refrigerator may be widely used in the field of superconductor technology. Furthermore, the cryogenic refrigerator may be mounted on a tensile tester for cryogenic metal.

Claims

1. A cryogenic refrigeration system comprising:

a cryogenic refrigerator; and
a heat dissipation module configured to cool the cryogenic refrigerator,

wherein the heat dissipation module comprises:

a condenser spaced apart from the cryogenic refrigerator to condense a refrigerant that cools the cryogenic refrigerator; and
a heat exchanger connected to the cryogenic refrigerator to circulate the refrigerant between the cryogenic refrigerator and the condenser, thereby cooling the cryogenic refrigerator.

2. The cryogenic refrigeration system of claim 1, wherein the cryogenic refrigerator comprises a gas cooling part configured to expand a gas, thereby cooling the gas, and
the heat exchanger comprises a first heat exchanger configured to cool the gas cooling part.

3. The cryogenic refrigeration system of claim 2, wherein the gas cooling part comprises:

a cylinder comprising an expansion region in which the gas is expanded and a compression region defined below the expansion region;
a displacer disposed in the cylinder to move between the expansion region and the compression region; and
a piston disposed below the displacer to move in the compression region,
wherein the first heat exchanger is disposed in the compression region.

4. The cryogenic refrigeration system of claim 3, wherein the cryogenic refrigerator further comprises a power generation part configured to generate power provided to the displacer and the piston, and
the heat exchanger further comprises a second heat exchanger configured to cool the power generation part.

5. The cryogenic refrigeration system of claim 4, wherein the cryogenic refrigerator further comprises a pow-

er conversion part disposed below the cylinder to convert the power generated in the power generation part, and
the heat exchanger further comprises a third heat exchanger configured to cool the power conversion part.

6. The cryogenic refrigeration system of claim 5, wherein the heat dissipation module further comprises:

a heat exchange collecting line configured to connect the first heat exchanger to the second heat exchanger; and
a heat exchange supply line configured to connect the first heat exchanger to the third heat exchanger.

7. The cryogenic refrigeration system of claim 5, wherein the heat dissipation module comprises:

a refrigerant collecting line connected between the second heat exchanger and the condenser to collect the refrigerant; and
a refrigerant supply line connected between the third heat exchanger and the condenser to supply the refrigerant.

8. The cryogenic refrigeration system of claim 7, further comprising:

a compressor disposed in the refrigerant collecting line to compress the refrigerant; and
an expander disposed in the refrigerant supply line to expand the refrigerant.

9. The cryogenic refrigeration system of claim 8, wherein the heat dissipation module further comprises:

a first pressure transducer disposed in the refrigerant collecting line between the condenser and the second heat exchanger to detect a pressure of the refrigerant;
a first temperature sensor disposed in the refrigerant collecting line disposed adjacent to the first pressure transducer to detect a temperature of the refrigerant; and
a circulation flow rate controller configured to receive a pressure detection signal and a temperature detection signal of the first pressure transducer and the first temperature sensor to control the expander.

10. The cryogenic refrigeration system of claim 8, wherein the heat dissipation module further comprises:

a bypass valve disposed in the refrigerant collecting line between the condenser and the compressor; and
a bypass line branched from the bypass valve and connected to the refrigerant supply line between the expander and the third heat exchanger by bypassing the condenser.

11. The cryogenic refrigeration system of claim 10, wherein the heat dissipation module further comprises:

a second pressure transducer disposed in the refrigerant collecting line between the compressor and the second heat exchanger to detect a pressure of the refrigerant;
a second temperature sensor disposed in the refrigerant collecting line disposed adjacent to the second pressure transducer to detect a temperature of the refrigerant; and
a bypass controller configured to receive a pressure detection signal and a temperature detection signal of the second pressure transducer and the second temperature sensor to control the bypass valve.

12. The cryogenic refrigeration system of claim 10, wherein the heat dissipation module further comprises a sensitive heat tube disposed in the refrigerant collecting line between the compressor and the second heat exchanger to detect a temperature of the refrigerant, thereby outputting turn-on and turn-off signals of the expander.

13. A cryogenic refrigeration system comprising:

a cryogenic refrigerator comprising a power generation part, a power conversion part configured to convert power generated in the power generation part, and a gas cooling part configured to cool a gas by using the power converted in the power conversion part; and
a heat dissipation module configured to circulate a refrigerant that cools the cryogenic refrigerator into the power generation part, the power conversion part, and the gas cooling part.

14. The cryogenic refrigeration system of claim 13, wherein the heat dissipation module comprises:

a condenser configured to condense the refrigerant; and
a heat exchanger configured to provide the refrigerant condensed in the condenser to the power generation part, the power conversion part, and the gas cooling part.

15. The cryogenic refrigeration system of claim 14, wherein the heat dissipation module further comprises:

a refrigerant collecting line configured to collect the refrigerant between the condenser and the heat exchanger; and
a refrigerant supply line configured to supply the refrigerant between the condenser and the heat exchanger.

16. The cryogenic refrigeration system of claim 15, wherein the heat exchanger comprises:

a first heat exchanger configured to cool the gas cooling part;
a second heat exchanger configured to cool the power generation part; and
a first heat exchanger configured to cool the power conversion part.

17. The cryogenic refrigeration system of claim 16, wherein the heat dissipation module further comprises:

a heat exchange refrigerant collecting line configured to collect the refrigerant between the first heat exchanger and the second heat exchanger; and
a heat exchange refrigerant supply line configured to supply the refrigerant between the first heat exchanger and the third heat exchanger.

18. The cryogenic refrigeration system of claim 16, wherein the gas cooling part comprises a cylinder having an expansion region in which the gas is expanded and a compression region in which the gas is compressed, and
the first heat exchanger is disposed in the compression region.

19. The cryogenic refrigeration system of claim 15, wherein the heat dissipation module further comprises:

a compressor disposed in the refrigerant collecting line to compress the refrigerant;
a pressure transducer disposed between the compressor and the heat exchanger to detect a pressure of the refrigerant;
an expander disposed in the refrigerant supply line to expand the refrigerant; and
a circulation flow rate controller configured to receive a pressure detection signal of the pressure transducer to control the expander.

20. The cryogenic refrigeration system of claim 15, wherein the heat dissipation module further comprises:

a bypass valve disposed in the refrigerant collecting line; and
a bypass line connected to the bypass valve and connected to the refrigerant supply line by bypassing the condenser.

FIG. 1

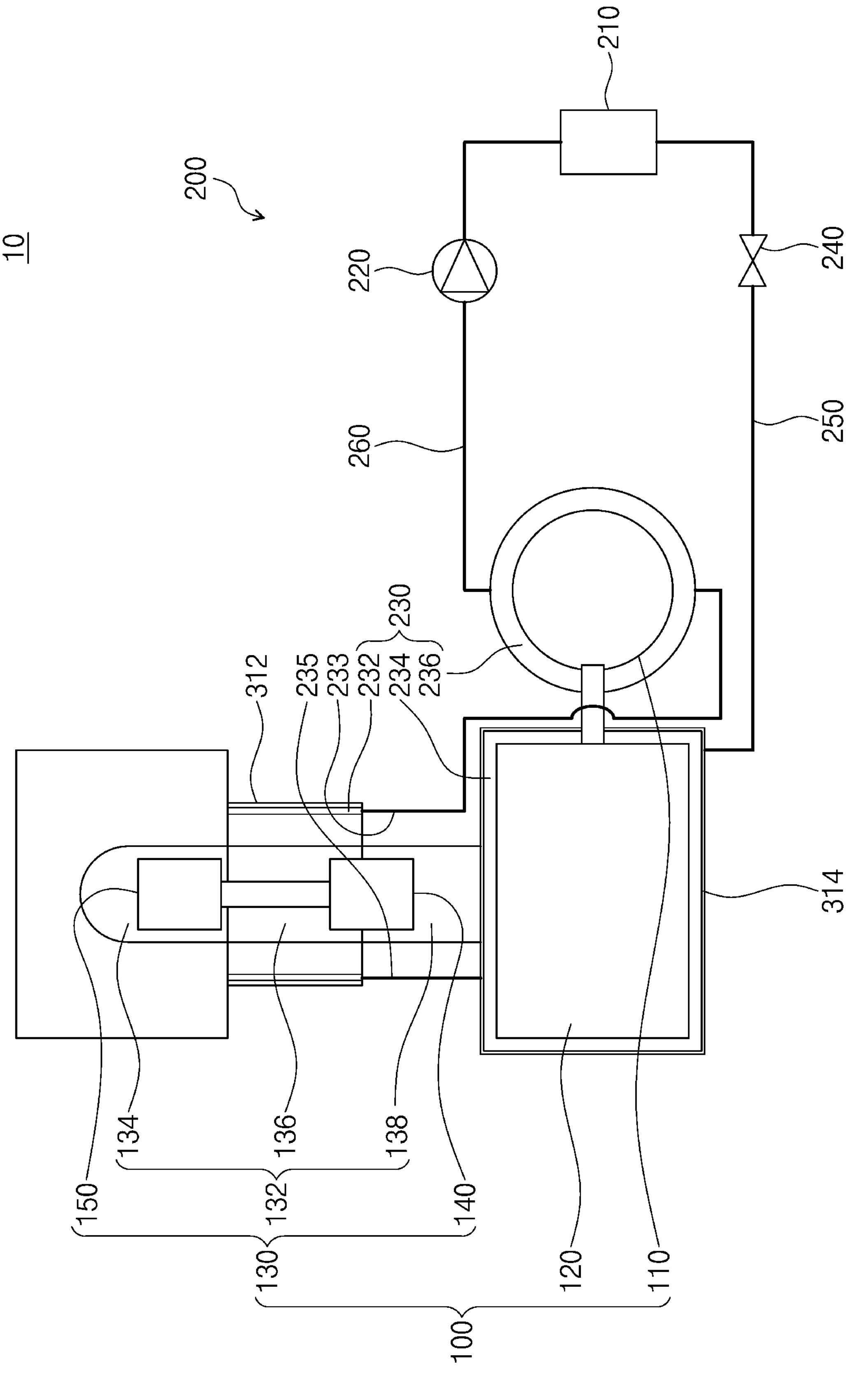

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FIG. 2

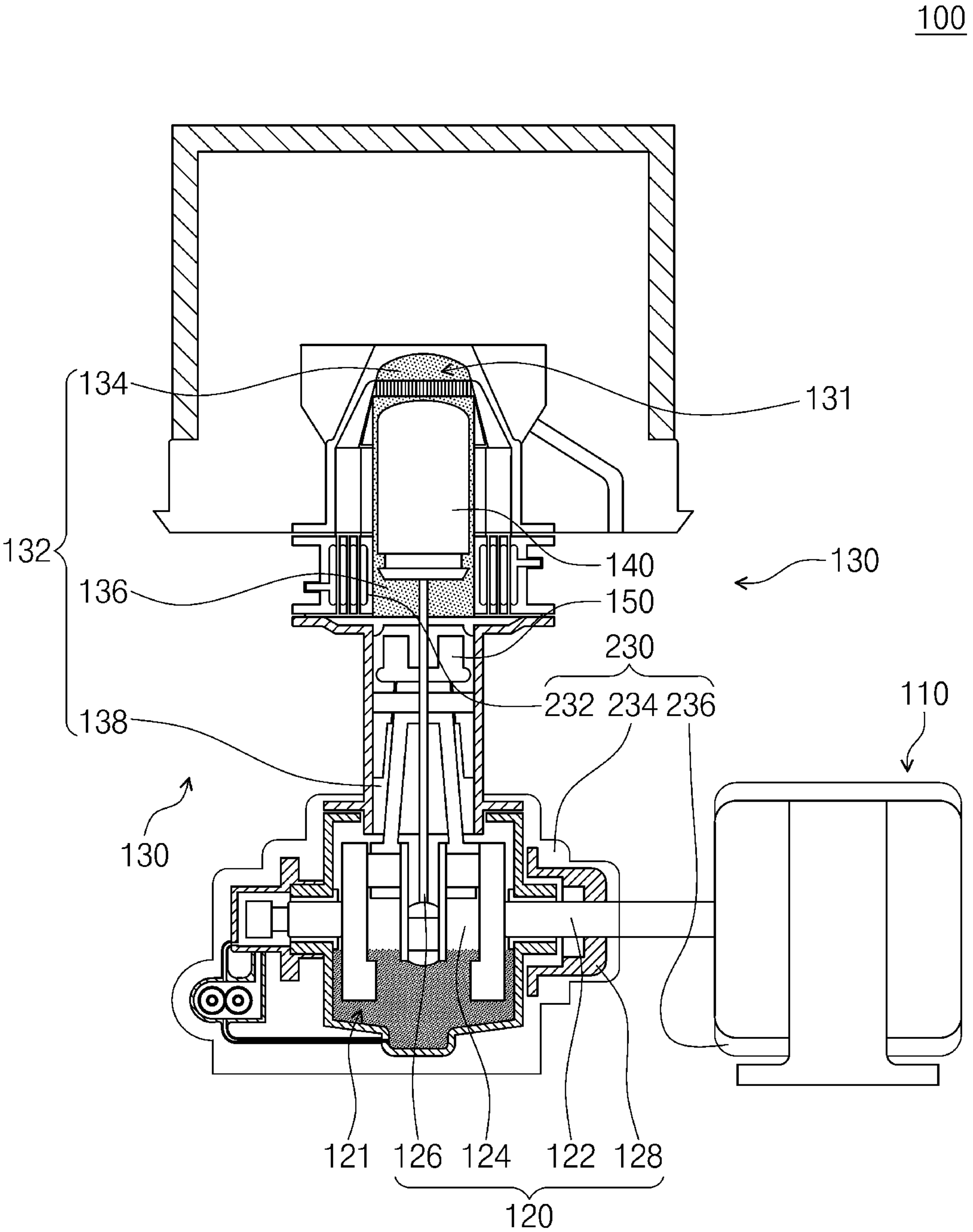
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FIG. 3

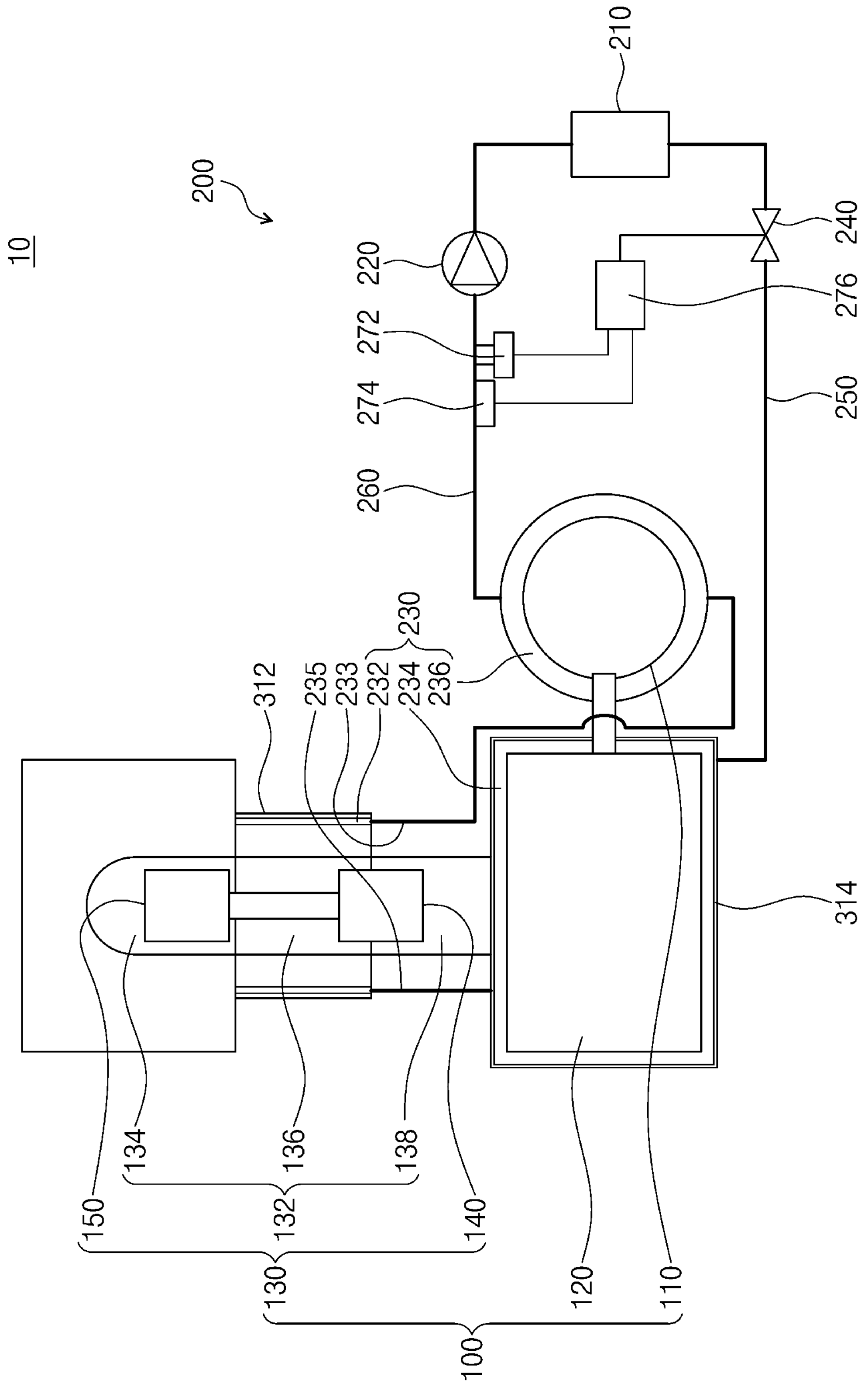
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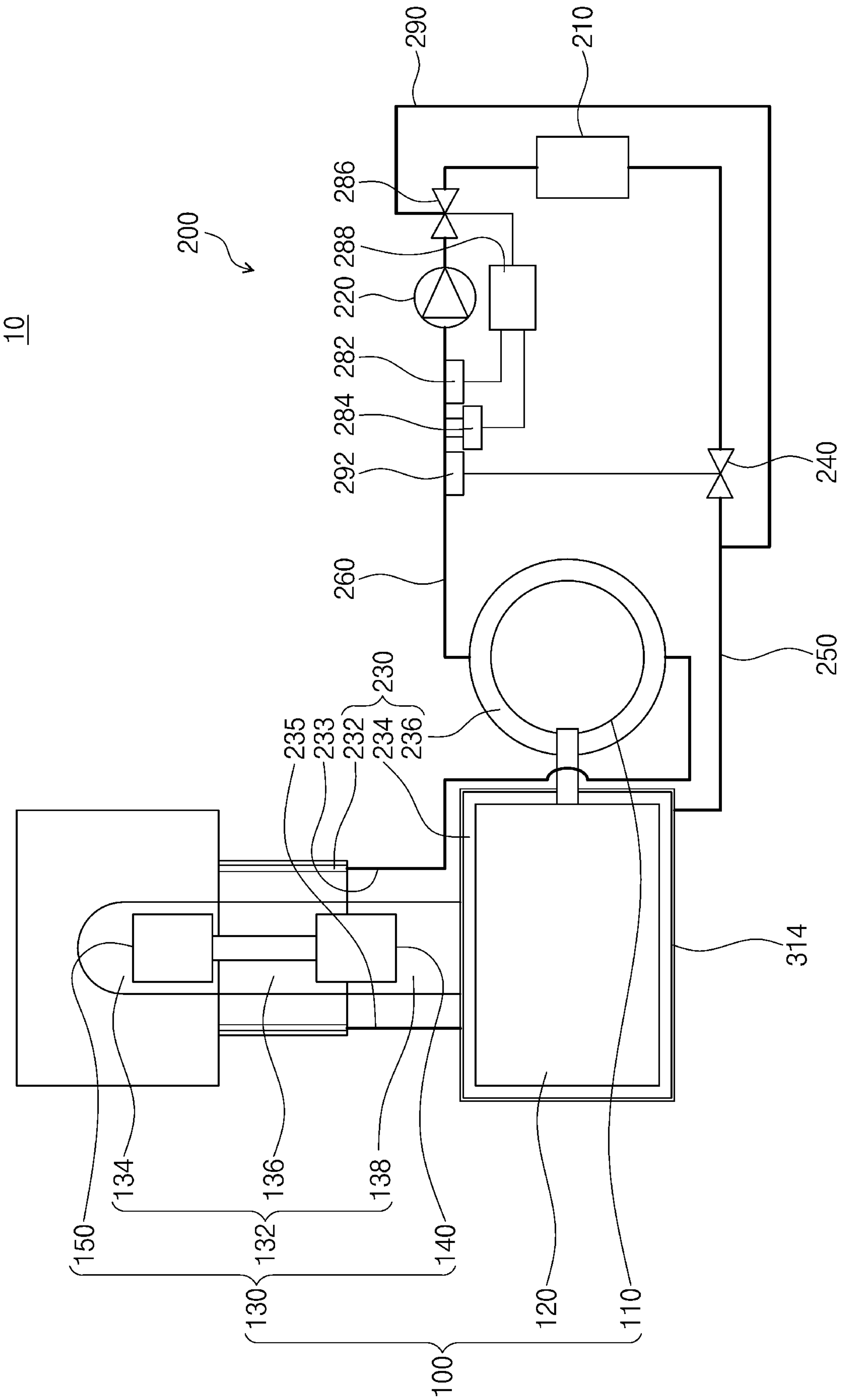
FIG. 4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INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2015/004044

A. CLASSIFICATION OF SUBJECT MATTER

F25B 9/00(2006.01)i, F25B 9/14(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)

F25B 9/00; F25B 9/14; F24F 11/02; F04B 17/04; F25B 41/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: cryocooler, condenser, heat radiant module, heat exchanger, expansion, piston, power, transducer, controller

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	KR 10-2000-0052196 A (LG ELECTRONICS INC.) 16 August 2000 See page 3, line 36 - page 4, line 26 and figure 3.	1-8,10-11,13-18,20 9,12,19
Y	JP 07-332736A (HITACHI LTD.) 22 December 1995 See paragraph [0024] and figure 1.	9,19
Y	JP 2008-249157 A (SAGINOMIYA SEISAKUSHO INC.) 16 October 2008 See paragraph [0018] and figure 1.	12
A	US 2013-0067936 A1 (XU et al.) 21 March 2013 See paragraphs [0017]-[0028] and figure 1.	1-20
A	JP 2008-224062 A (TOSHIBA CORP.) 25 September 2008 See paragraphs [0012]-[0022] and figure 1.	1-20

☐ 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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search	Date of mailing of the international search report
03 AUGUST 2015 (03.08.2015)	**04 AUGUST 2015 (04.08.2015)**

Name and mailing address of the ISA/**KR**
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Authorized officer

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2015/004044

Patent document cited in search report	Publication date	Patent family member	Publication date
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Form PCT/ISA/210 (patent family annex) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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