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(54) COMPRESSOR-FREE COOLING SYSTEM POWERED BY HEAT SOURCE

(57) A cooling system comprises a heat source (1), providing heat; a power generation device (2), heating a cooling medium (3) through the heat source (1) to increase the temperature and pressure of the cooling medium (3) and gasifying the same; a condenser (5), due to a pressure difference incurred in the power generation device (2), the liquid cooling medium (3) flowing from the power generation device (2) into the condenser (5), and the liquid cooling medium (3) decreasing; a throttle valve (7), making the liquid cooling medium (3) decrease the pressure thereof and absorb heat to be sprayed to an evaporator (8); the evaporator (8), the cooling medium (3) performing heat exchanges heat in the evaporator (8) with a refrigeration output (10); and a liquid medium reflux device (15), the liquid medium (3) accumulated at the bottom of the evaporator (8) flowing back freely to the power generation device (2) under the action of gravity. The evaporator (8), the liquid medium reflux device (15), and the power generation device (2) are arranged are vertically arranged in a descending order.

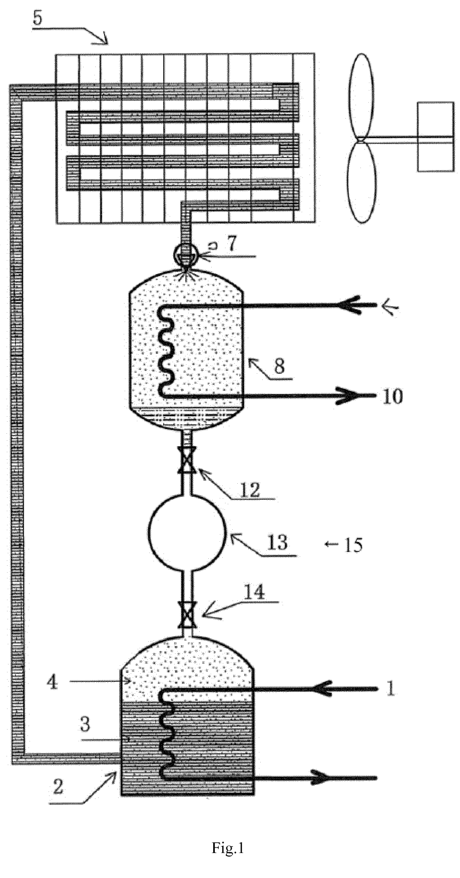

Fig.1

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Description

Field of the Invention

[0001] The present patent application relates to a refrigeration system, in particular to a compressor-free refrigeration system powered by a heat source.

Background of the Invention

[0002] A conventional compression refrigerator consists of four parts: a compressor, a condenser, an evaporator, and an expansion valve. The working process is as follows: a low-pressure gaseous heat exchange medium (e.g., Freon) vaporized in the evaporator is extracted by the compressor, compressed into high-pressure gas, and fed into the condenser; the high-pressure gas is refrigerated and condensed into high-pressure liquid in the condenser, throttled by the expansion valve into low-pressure liquid working medium, and fed back into the evaporator; the low-pressure liquid working medium at normal temperature in the evaporator absorbs heat from a refrigeration output; in that way, a refrigeration cycle is completed.

[0003] The compression refrigeration technique has some drawbacks, such as high cost, installation inconvenience, high power consumption, and high noise.

[0004] To overcome the drawbacks of compression refrigeration technique, for example, a solar air-conditioner is disclosed in Chinese Patent Application No. CN1710346. As shown in Figure 4, the solar air-conditioner comprises an energy accumulator 2, with a light-tube solar receiver 8 designed to convert light energy into heat energy arranged on one side of the energy accumulator 2, and a tubular heat exchanger 3 containing a low-boiling working medium arranged in the cavity of the energy accumulator 2. In the refrigeration process, the working medium is heated up and vaporized in the heat exchanger 3, forming high-temperature and high-pressure gas; the gas is outputted from the heat exchanger 3 to an outdoor condenser 10; the temperature and pressure of the gas are decreased in the condenser 10; then, the gas is throttled by a throttle valve 12. At this point, the working medium is in low-temperature liquid state, and it flows into an indoor evaporator 11 and absorbs heat there, and thereby the indoor temperature is decreased. Then, the working medium flows through a booster 7, a pressure valve 6, and a solenoid-operated four-way valve into the heat exchanger 3 in the energy accumulator; in that way, a cycle is completed.

[0005] Though no compressor is used in the circulation process of the heat exchange medium in the air conditioner disclosed in the patent application document, a booster 7 is used to drive the working medium in the evaporator to return to the heat exchanger, so as to accomplish working medium circulation. Such a structure is still similar to a compressor, and doesn't thoroughly solve the problem of power required for driving the working medium to return from the evaporator to the heat exchanger after heat exchange.

Summary of the Invention

[0006] To solve the problem described above, the present invention provides a refrigeration system that utilizes a heat source instead of a compressor to achieve refrigeration.

[0007] The present invention provides a refrigeration system, comprising: a heat source designed to provide heat energy; a power generator designed to heat up a refrigerating medium with the heat source arranged in the power generator, so that the temperature and pressure of the refrigerating medium are increased and the refrigerating medium is vaporized; a condenser into which the liquid refrigerating medium flows from the power generator under the action of the pressure difference resulted from the high temperature in the power generator, and in which the temperature of the liquid refrigerating medium is decreased; a throttle valve which controls the liquid refrigerating medium flowing through the condenser to jet out from it under the action of the pressure difference, so that the pressure of the liquid refrigerating medium is decreased under the jet action and the liquid refrigerating medium absorbs heat; an evaporator into which the low-temperature and low-pressure refrigerating medium is jetted from the throttle valve, and in which the low-temperature and low-pressure refrigerating medium exchanges heat with a refrigeration output in the evaporator and is accumulated in the form of liquid refrigerating medium on the bottom of the evaporator; and a liquid working medium return unit through which the liquid working medium accumulated on the bottom of the evaporator flows back freely to the power generator under gravity action, wherein the evaporator, liquid working medium return unit, and power generator are arranged from top to bottom in a vertical direction in turn.

[0008] In the present invention, a variety of common heat sources can be used to heat up the working medium, so that the working medium can flow from the power generator into the evaporator; in addition, gravity is used as the power for driving the working medium to flow back from the evaporator into the power generator. Under gravity action, the upper valve and lower valve open in alternate, so that the pressure difference between the power generator and the evaporator is balanced twice with the reservoir, and thereby the liquid working medium is returned from the evaporator to the power generator after heat exchange and circulates. In that way, the difficulty in the return of the working medium as a result of the pressure difference between the power generator and the evaporator is solved reasonably.

Brief Description of the Drawings

[0009]

Figure 1 is a schematic diagram of a first embodiment of the refrigeration system in the present invention.

Figure 2 is a schematic diagram of a working state of the liquid working medium, in which the upper valve is open.

Figure 3 is a schematic diagram of a second embodiment of the refrigeration system in the present invention.

Figure 4 is a schematic diagram of a refrigeration system in the prior art.

Detailed Description of the Embodiments

[0010] As shown in Figure 1, the refrigeration system in the present invention comprises: a heat source 1 that is designed to provide heat energy; a power generator 2 that contains a liquid working medium 3 and a gaseous working medium 4, a condenser 5, a throttle valve 7, an evaporator 8, a refrigeration output 10, and a liquid working medium return unit 15. The power generator 2 utilizes the heat source 1 arranged in it to heat up the refrigerating medium comprising the liquid working medium 3 and gaseous working medium 4, so that the temperature and pressure of the refrigerating medium are increased and the refrigerating medium is vaporized. Under the action of the pressure difference resulted from the high temperature in the power generator 2, the liquid refrigerating medium 3 flows from the power generator 2 into the condenser, and the temperature of the liquid refrigerating medium is decreased in the condenser 5. The throttle valve 7 controls the liquid refrigerating medium flowing through the condenser to jet out from it under the action of the pressure difference, so that the pressure of the liquid refrigerating medium is decreased under the jet action and the liquid refrigerating medium absorbs heat. The low-temperature and low-pressure refrigerating medium is jetted from the throttle valve 7 into the evaporator 8, exchanges heat with the refrigeration output 10 in the evaporator, and is accumulated in a form of liquid refrigerating medium on the bottom of the evaporator 8. The liquid working medium accumulated on the bottom of the evaporator 8 flows back freely to the power generator under gravity action via the liquid working medium return unit 15.

[0011] The liquid working medium return unit 15 comprises an upper valve 12, a reservoir 13, and a lower valve 14, wherein, the upper end of the reservoir 13 is connected to the evaporator 8 via the upper valve 12, the lower end of the reservoir 13 is connected to the power generator 2 via the lower valve 14, and the upper valve 12 and lower valve 14 open sequentially, but don't open at the same time. Especially, the evaporator 8, liquid working medium return unit 15, and power generator 2 are arranged from top to bottom in a vertical direction in turn.

[0012] The working process of the entire system is as follows: the liquid working medium 3 is heated up in the power generator 2, so that the temperature and pressure of the liquid working medium 3 are increased and the liquid working medium 3 is vaporized. In the entire system, the evaporator side is in low-temperature and low-pressure state, while the power generator side is in high-temperature and high-pressure state. For example, the temperature is 20°C at the evaporator side and 60°C at the power generator side. It is seen from the following table: in the case of refrigerant F-12, the pressure at 20°C is 0.4689MPa and 1.427MPa at 60°C, which is to say, the pressure difference between the evaporator side and the power generator side is 0.958MPa.

[0013] Under the action of the pressure difference between the evaporator side and the power generator side, the liquid working medium that is not vaporized in the lower part of the power generator flows out of the power generator 2 into the condenser 5 through a pipe outlet below the gas-liquid interface in the power generator 2. At the condenser 5, the temperature of the liquid working medium drops, but the liquid working medium is still in high-pressure state. The high-pressure liquid working medium is jetted out through a throttle valve into the evaporator 8. At this point, the pressure of the liquid working medium drops, and the liquid working medium is vaporized and absorbs the heat from the refrigeration output in the evaporator; thus, heat exchange is accomplished.

Table 1. Pressure vs. Temperature of Refrigerating Media

Temperature/°C	Pressure/MPa	
	F-12	F-22
0	0.2104	0.399
10	0.325	0.582
20	0.4689	0.811
30	0.6464	1.093
40	0.8620	1.434
50	1.1205	1.842
60	1.427	2.327

[0014] To prevent reduction of pressure difference between the power generator and the evaporator and ensure the working medium can flow back to the power generator and circulates, a liquid working medium return unit 15 is arranged between the power generator and the evaporator.

[0015] The liquid working medium return unit 15 comprises an upper valve 12 (e.g., in the form of an electronic switch), a reservoir 13, and a lower valve 14 (e.g., in the form of an electronic switch). The upper end of the reservoir 13 is connected to the evaporator 8 via the upper valve 12, and the lower end of the reservoir 13 is connected to the power generator 2 via the lower valve 14.

[0016] Especially, the evaporator 8, liquid working medium return unit 15, and power generator 2 are arranged from top to bottom in a vertical direction in turn.

[0017] After heat exchange with the refrigeration output 10, the gaseous working medium in the evaporator becomes low-temperature and low-pressure liquid working medium. The liquid working medium is accumulated on the bottom of the evaporator. The upper valve 12 connected to the bottom of the evaporator 8 opens at a specific time interval. Within a preset time after the upper valve is opened, the pressure between the reservoir 13 and the evaporator 8 will be balanced, and the liquid working medium on the bottom of the reservoir 13 will flow back freely into the reservoir 13 under gravity action, as shown in Figure 2. Then, the upper valve 12 is closed. Next, the lower valve 14 is opened; within a preset time after the lower valve 14 is opened, the pressure between the reservoir 13 and the power generator 2 will be balanced, and the liquid working medium in the reservoir 13 will flow back freely into the power generator 2 under gravity action in the same way. Then, the lower valve 14 is closed. As the upper valve and lower valve are opened in alternate, pressure isolation is achieved between the power generator and the evaporator. With the liquid working medium return unit 15, the pressure difference between the power generator and the evaporator is maintained so that the system operation can continue, and the liquid working medium can flow back. A refrigeration cycle is accomplished through the above process.

[0018] Thus, in the present invention, the working medium can flow back from the evaporator to the power generator solely under gravity action, and a preset pressure difference is maintained between the power generator and the evaporator by means of the upper valve and lower valve, so that the entire system can continue its operation.

[0019] The time interval at which the valves are opened can be controlled by means of a controller.

[0020] Preferably, water cooling or air cooling is used in the present invention. As shown in Figure 3, in the present invention, two condensers connected in series are employed for duplex cooling, i.e., a heat storage water tank 20, followed by an air-cooled condenser.

[0021] The refrigerating medium can be ammonia, F12, F22, F502, liquid nitrogen, or 134A, etc.

[0022] As described above, a variety of common heat sources can be used as the power source for heating up the working medium, so that the working medium can flow from the power generator into the evaporator; in addition, gravity is used as the power source for driving the working medium to flow back from the evaporator into the power generator. Thus, the complex process of electrical energy-mechanical energy conversion involved in the compressor in conventional refrigeration systems is eliminated thoroughly. In addition, the compressor-free refrigeration system in the present invention has simple structure and lower cost, and is applicable to a variety of application scenarios.

[0023] Therefore, the refrigeration system disclosed in the present invention can save energy. It can utilize a variety of common heat sources, such as water heaters and waste heat of boilers, etc., and doesn't consume electrical energy heavily when compared with compression refrigeration systems. In addition, the refrigeration system disclosed in the present invention doesn't have noise produced by compressor, and has low cost and wide applicability. The implementers can employ different heat sources, such as solar heat source, electric heat source, or waste heat of boiler, etc., according to the local conditions.

Claims

1. A refrigeration system, comprising:

    a heat source designed to provide heat energy;
    a power generator designed to heat up a refrigerating medium with the heat source arranged in the power generator, so that the temperature and pressure of the refrigerating medium are increased and the refrigerating medium is vaporized;
    a condenser into which the liquid refrigerating medium flows from the power generator under the action of the pressure difference resulted from the high temperature in the power generator, and in which the temperature of the liquid refrigerating medium is decreased;
    a throttle valve which controls the liquid refrigerating medium flowing through the condenser to jet out from the throttle valve under the action of the pressure difference, so that the pressure of the liquid refrigerating medium is decreased under the jet action and the liquid refrigerating medium absorbs heat;
    an evaporator into which the low-temperature and low-pressure refrigerating medium is jetted from the throttle valve, and in which the low-temperature and low-pressure refrigerating medium exchanges heat with a refrigeration output in the evaporator and is accumulated in the form of liquid refrigerating medium on the bottom of the evaporator; and
    a liquid working medium return unit through which the liquid working medium accumulated on the bottom of the evaporator flows back freely to the power generator under gravity action,
    wherein the evaporator, liquid working medium return unit, and power generator are arranged from top to bottom in a vertical direction in turn.

2. The refrigeration system as set forth in claim 1, wherein the liquid working medium return unit comprises an upper valve, a reservoir, and a lower valve, the upper end of the reservoir is connected to the evaporator via the upper valve, the lower end of the reservoir is connected to the power generator via the

lower valve, and the upper valve and lower valve open sequentially, but don't open at the same time.

3. The refrigeration system as set forth in claim 1, wherein the liquid working medium flows out of the power generator through a pipe outlet arranged blow the gas-liquid interface in the power generator.

4. The refrigeration system as set forth in claim 1, wherein the condenser is a water-cooled condenser or an air-cooled condenser, or comprises a water-cooled condenser and an air-cooled condenser connected in series.

5. The refrigeration system as set forth in claim 1, wherein the refrigerating medium is any gas-liquid phase change refrigerant.

6. The refrigeration system as set forth in claim 5, wherein the refrigerating medium is ammonia, F12, F22, F502, liquid nitrogen, or 134A.

7. The refrigeration system as set forth in claim 1, wherein the liquid working medium return unit opens at a specific time interval.

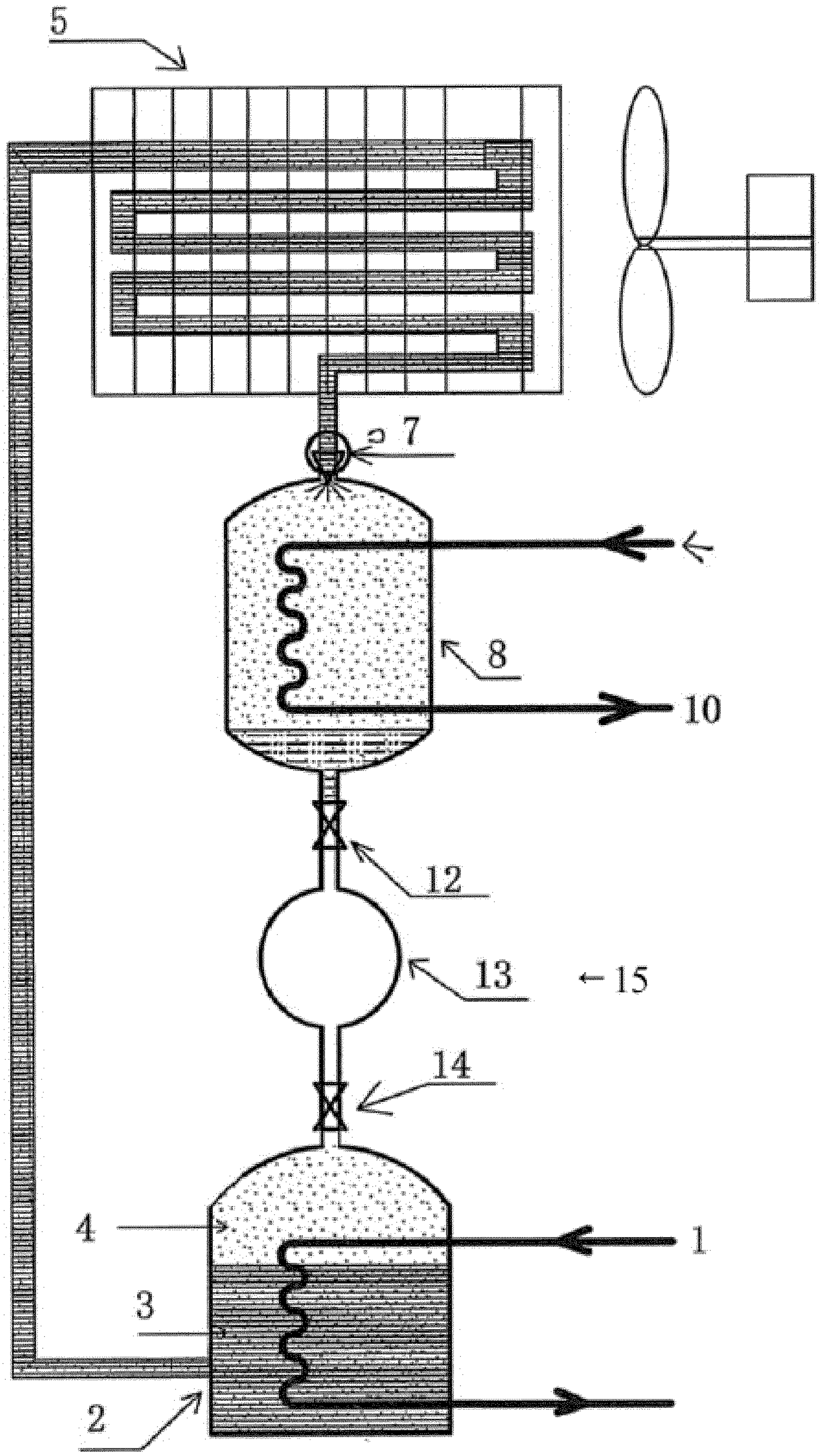

Fig.1

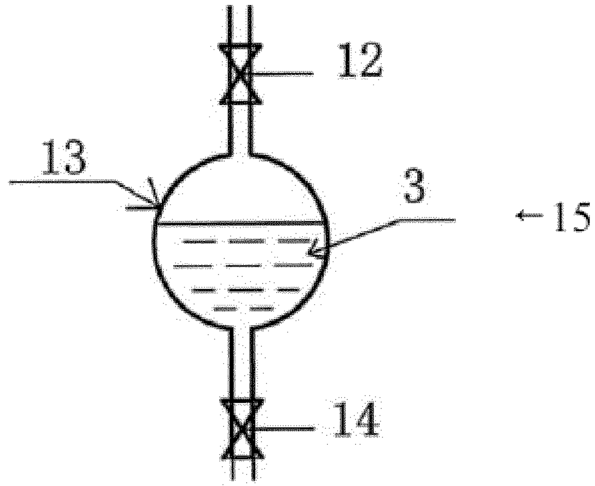

Fig.2

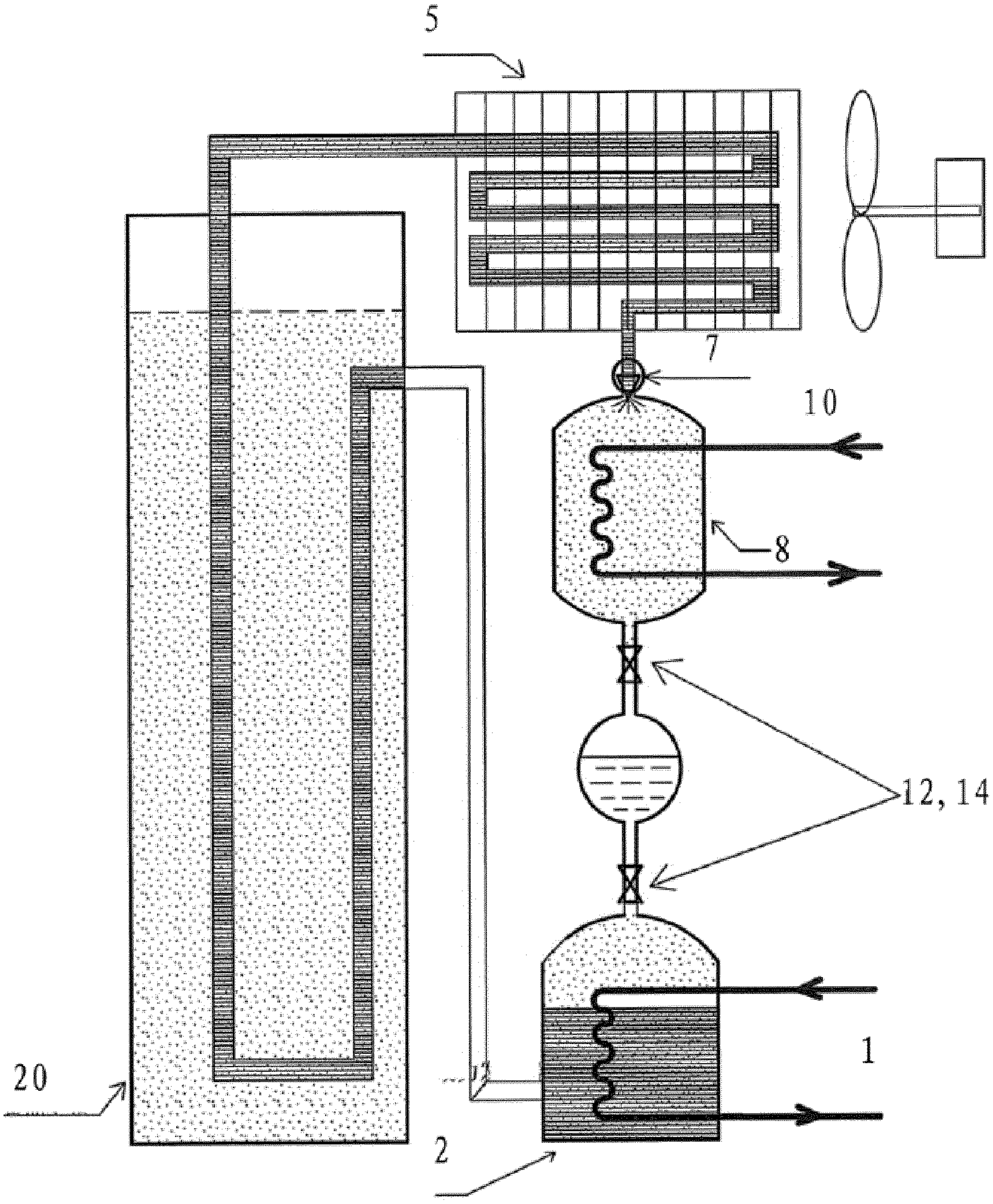

Fig.3

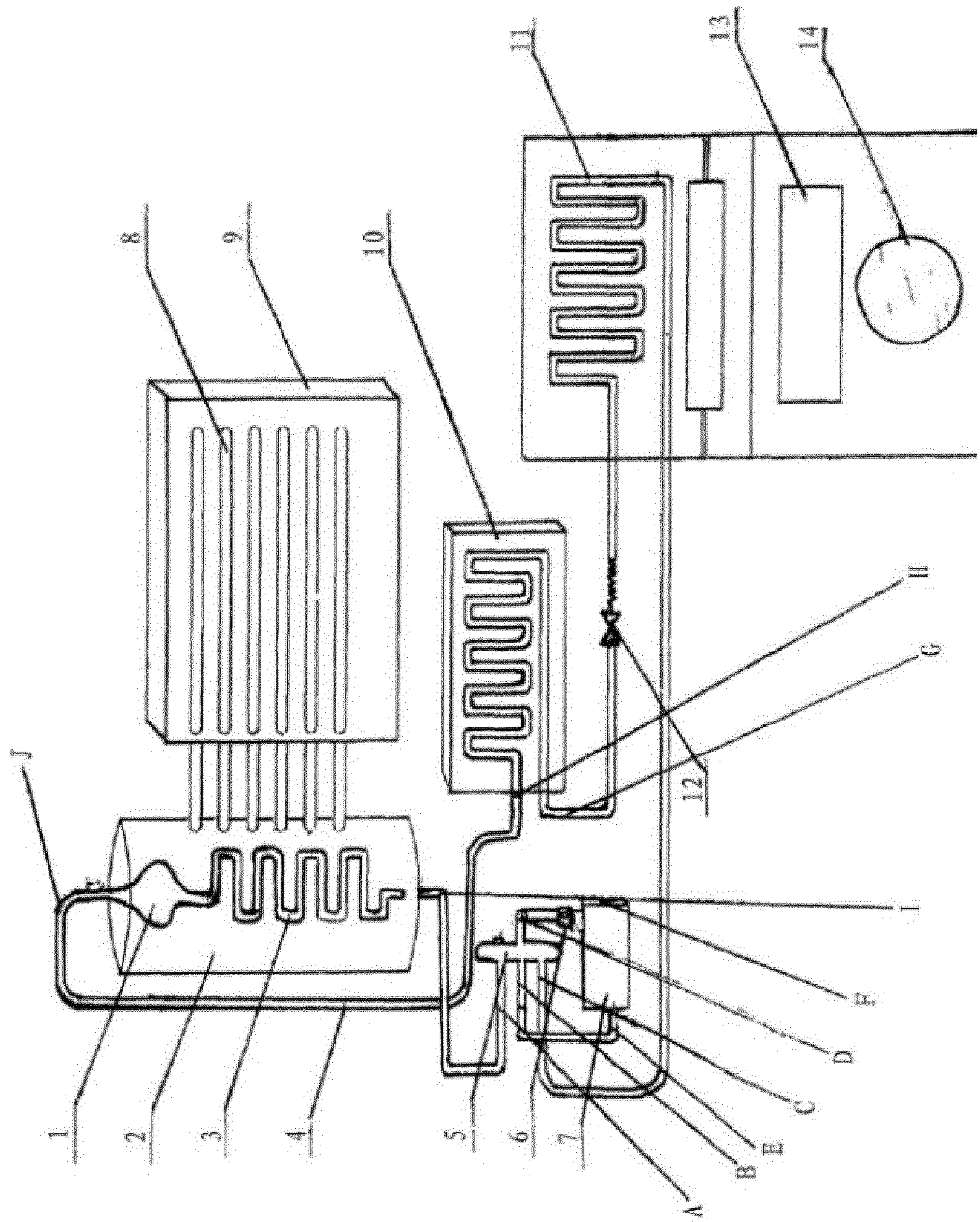

Fig.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/081806

A. CLASSIFICATION OF SUBJECT MATTER

F25B 23/00 (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)

IPC: F25B F24F F24J2

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)

Data bases: EPODOC, WPI, CPRS, CNKI;
Search terms: heat driv+ dynamic+ evaporator condenser valve generator producer gravit+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 1710346 A (ZHANG, Yong) 21 Dec. 2005 (21.12.2005) description, page 3, paragraph 4, page 4, paragraph 2 and figure 1	1-7
A	CN 101706175 A (JIN, Qihai) 12 May 2010 (12.05.2010) the whole document	1-7
A	CN 1235261 A (CAO, Yiwen) 17 Nov. 1999 (17.11.1999) the whole document	1-7
A	US 2005068734 A1 (ERNST D M et al.) 31 Mar. 2005 (31.03.2005) the whole document	1-7
A	US 2004237546 A1 (BUTSCH O R et al.) 02 Dec. 2004 (02.12.2004) the whole document	1-7

☐ 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

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"O" document referring to an oral disclosure, use, exhibition or other means

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 Jun. 2012 (27.06.2012)	16 Aug. 2012 (16.08.2012)

Name and mailing address of the ISA	Authorized officer
State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10)62019451	ZHOU, Yanhong Telephone No. (86-10)62084150

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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Form PCT/ISA /210 (patent family annex) (July 2009)

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- CN 1710346 **[0004]**