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(54) **REFRIGERANT COOLING SYSTEM FOR AN ELECTRONIC APPARATUS AND THE METHOD THEREOF**

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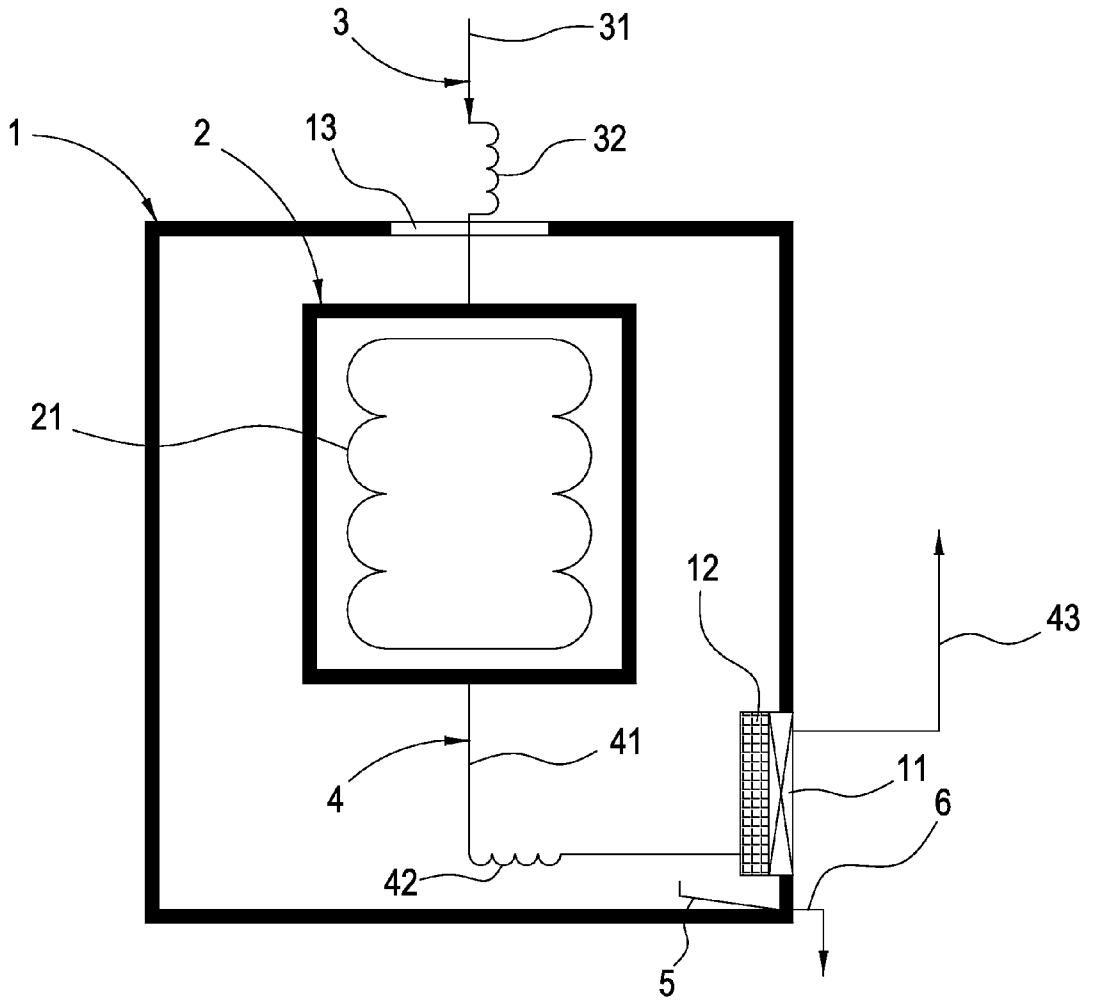
(57) **ABSTRACT**

A refrigerant cooling system for an electronic apparatus and the method thereof are provided. An enclosure is set with a fan on one side thereof; the enclosure is set with an opening on one side thereof. The enclosure is set with an electronic substrate inside with other electronic devices. The electronic substrate is set with a middle-temperature evaporator with an input end and an output end, in which the refrigerant is filled into the input end. The input end is set with a throttling device. The output end is set with a throttling device connecting to a low-temperature evaporator. The low-temperature evaporator is set with a condensed water drain-pan at a bottom side thereof and the condensation water drain-pan is connected to a drain pipe. The pipe of the output end of low-temperature evaporator is connected to a receiver or a compressor of a refrigerating system for a compression cycle.



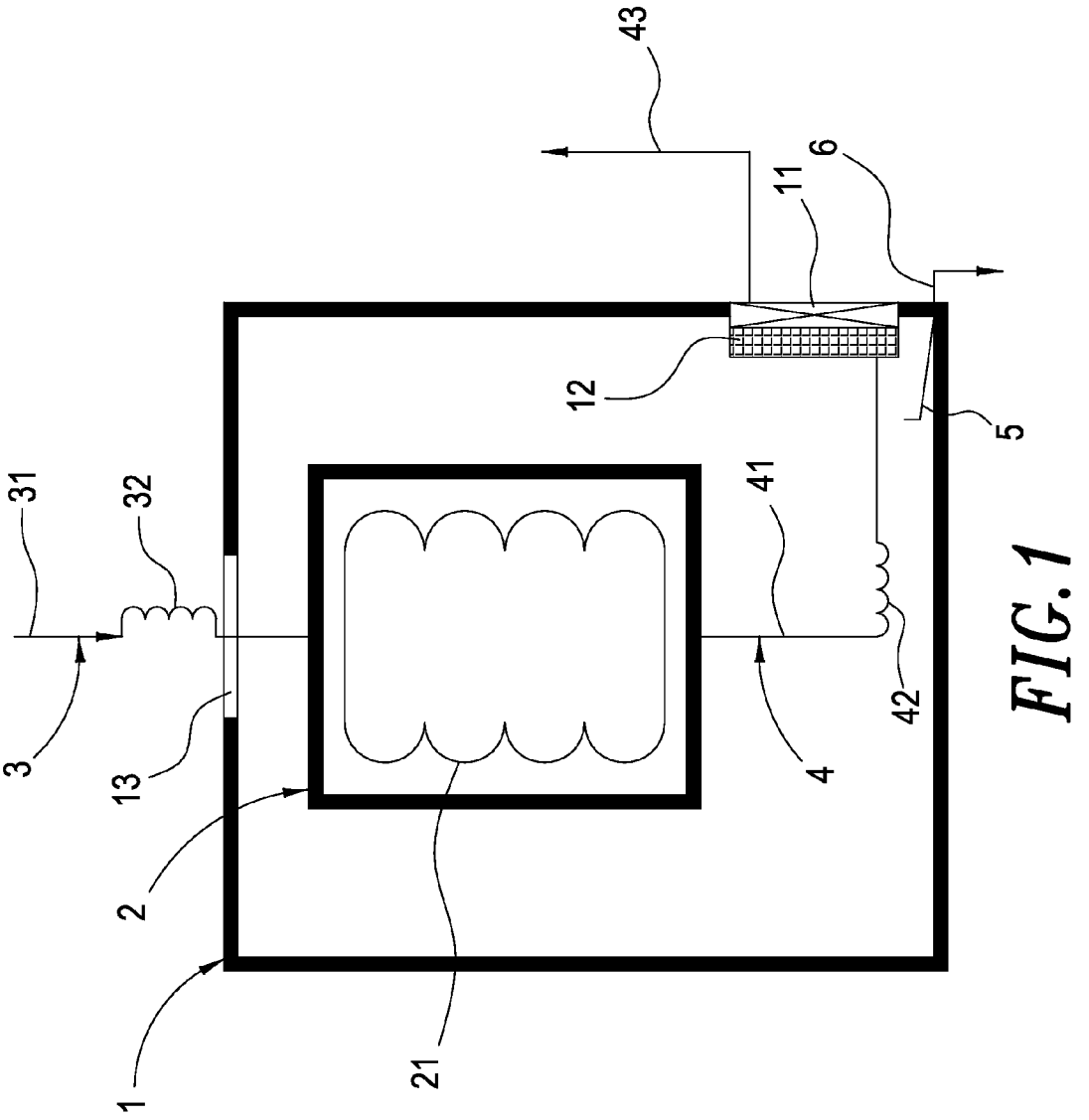


FIG. 1

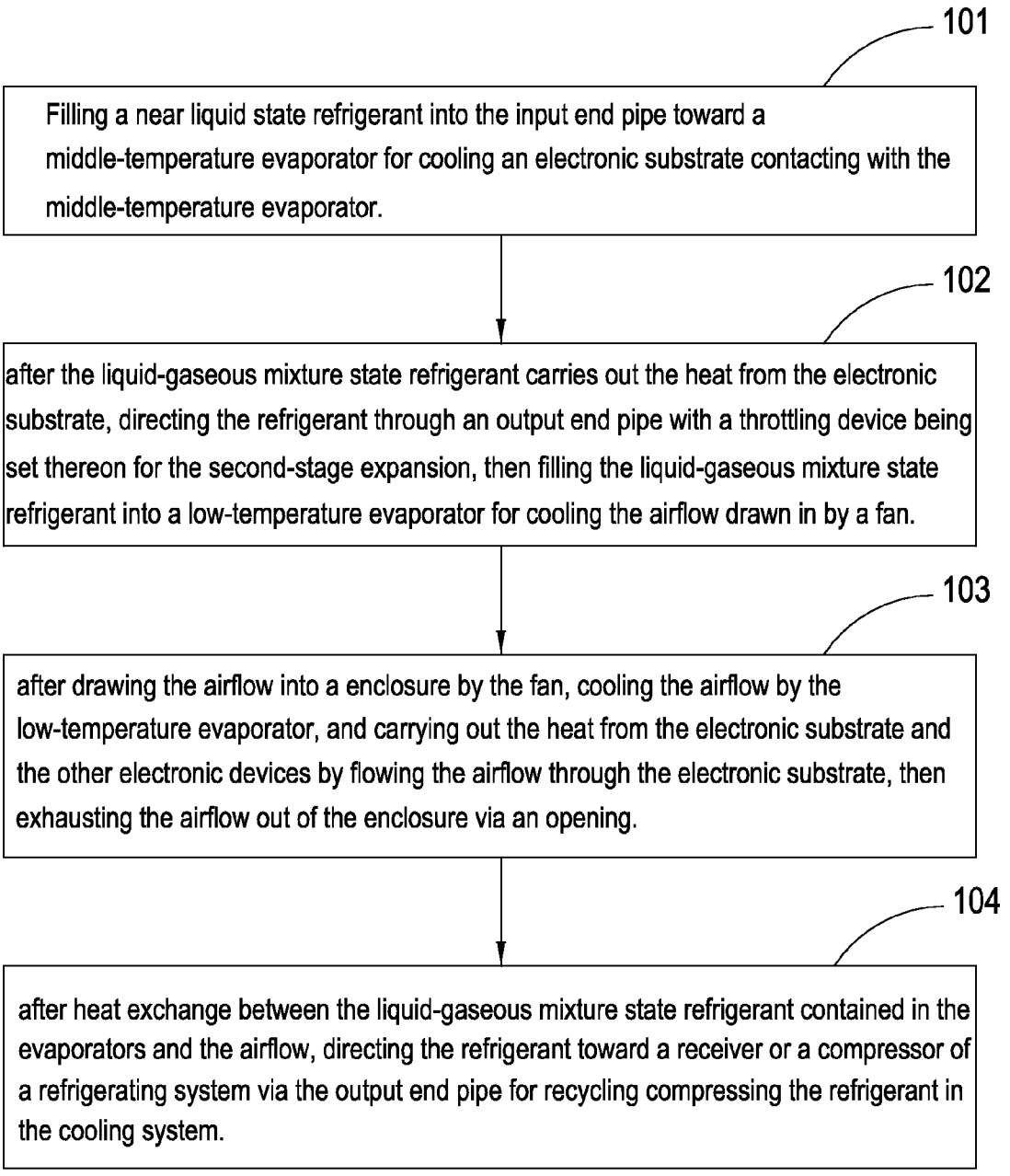

101
Filling a near liquid state refrigerant into the input end pipe toward a middle-temperature evaporator for cooling an electronic substrate contacting with the middle-temperature evaporator.
102
after the liquid-gaseous mixture state refrigerant carries out the heat from the electronic substrate, directing the refrigerant through an output end pipe with a throttling device being set thereon for the second-stage expansion, then filling the liquid-gaseous mixture state refrigerant into a low-temperature evaporator for cooling the airflow drawn in by a fan.
103
after drawing the airflow into a enclosure by the fan, cooling the airflow by the low-temperature evaporator, and carrying out the heat from the electronic substrate and the other electronic devices by flowing the airflow through the electronic substrate, then exhausting the airflow out of the enclosure via an opening.
104
after heat exchange between the liquid-gaseous mixture state refrigerant contained in the evaporators and the airflow, directing the refrigerant toward a receiver or a compressor of a refrigerating system via the output end pipe for recycling compressing the refrigerant in the cooling system.

FIG.2

REFRIGERANT COOLING SYSTEM FOR AN ELECTRONIC APPARATUS AND THE METHOD THEREOF

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a refrigerant cooling system for an electronic apparatus and the method thereof. More particularly, the present invention relates to refrigerant cooling system for an electronic apparatus and the method thereof that applies a low-temperature refrigerant loop of a simple refrigerating system for cooling electronic devices; thus the operation temperature of the electronic devices is much lower than that achieved by conventional air-cooling methods, and formation of moisture condensation on surfaces of the electronic devices is prevented.

[0003] 2. Description of the Prior Art

[0004] Conventional cooling systems for electronic devices are widely applied with high-temperature air-cooling or high-temperature liquid-cooling methods to prevent the electronic devices from forming moisture condensation. The conventional cooling systems however are inefficient in terms of cooling and occupy a large amount of space. Development of other conventional cooling systems using low-temperature liquid refrigerant focus on how to design a precise system to prevent the formation of moisture condensation on the electronic devices. Eventually, the system has become an independent mechanism and its controlling processes and sensor devices are complex and expensive.

[0005] Moreover, due to the poor heat conductivity of the air, an air-cooling method requires a large space for heat dissipation both inside the enclosure of the electronic device and surrounding of the electronic device. Heat dissipation determines the operation efficiency and the size of the electronic devices. For example, a frequency converter has a fin structure that occupies more than fifty percent of the total size of the frequency converter. Conventionally, heat dissipation technologies and environmentally controlled air conditioning for a Data Center adopts air-cooling technologies. Since heat generated by the computer server is extremely high, a lot of space is needed for cooling the computer server. For ensuring proper distribution and flow of the air, a design of a Data Center has to adopt a high racked floor and preserves enough path space and air circulation space.

[0006] As a result, the aforementioned prior art of cooling systems still have flaws in many aspects and are not sound designs and therefore the technology in this field needs to be improved.

[0007] In order to address the flaws derived from the aforementioned cooling systems prior art, the inventor of the present invention was inclined to improve it. After years of research, the inventor finally succeeded in developing an electronic apparatus and the method for the refrigerant cooling system.

SUMMARY OF THE INVENTION

[0008] The primary objective of the present invention is to provide a refrigerant cooling system for an electronic apparatus and the method thereof. The cooling system is configured to efficiently carry out the heat generated by the electronic devices with a low-temperature refrigerant, and to ensure the operational temperature of the electronic devices at a level lower than that achieved by conventional air-cooling methods in order to prevent moisture condensation from forming on the surfaces of the electronic devices.

[0009] Another objective of the present invention is to provide a refrigerant cooling system for an electronic apparatus and the method thereof that ensures safety during operation of the electronic devices, improves efficiency, and decreases hardware requirements. The present invention also decreases the size of electronic devices and saves energy.

[0010] The refrigerant cooling system for an electronic apparatus and the method thereof for achieving the aforementioned objectives is described as follows. The enclosure of the cooling system has at least one fan on one side. The fan is configured to draw air into the enclosure and cool off the interior of the enclosure. The enclosure is also set with at least one opening on one side. The opening is to exhaust high-temperature air out of the interior of the enclosure. Inside the enclosure, there is an electronic substrate which has other electronic devices that would generate heat. The electronic substrate is set with a middle-temperature evaporator with an input end and an output end, in which the refrigerant flows into the input end for cooling the heat generated by the electronic substrate.

[0011] The input end is set with a throttling device, and the output end is set with a throttling device connecting to a low-temperature evaporator. The low-temperature evaporator is set with a condensation water drain-pan on a bottom side thereof for collecting condensed water from airflow cooled by the low-temperature evaporator. The condensed water is then drained out of the enclosure via a drain pipe. The low-temperature evaporator is connected to an output end, and the liquid-gaseous mixture state refrigerant flowing through the low-temperature evaporator is redirected to a refrigerant receiver or a compressor of a refrigerating system for compression cycles. The aforementioned devices are connected together via pipes to form a cooling system using the refrigerant and the airflow to process heat exchange with the electronic substrate. By applying the cooling system, it is able to carry away the heat generated by the electronic devices with the low-temperature refrigerant and to ensure the operational temperature of the electronic devices at a much lower level than that achieved by conventional air-cooling methods and to prevent formation of moisture condensation on the surfaces of the electronic devices.

[0012] These features and advantages of the present invention will be fully understood and appreciated from the following detailed description of the accompanying Drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** illustrates the refrigerant cooling system for an electronic apparatus and the method thereof of the present invention; and

[0014] FIG. **2** illustrates a flowchart of the refrigerant cooling system for an electronic apparatus and the method thereof.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] FIG. **1** shows a block diagram of the present invention of a refrigerant cooling system for an electronic apparatus and the method thereof, mainly comprises devices as follows.

[0016] An enclosure **1**, in which is set with at least one fan **11** on one side thereof. The fan **11** is configured to take air into

the enclosure **1**. The fan **11** is set with a low-temperature evaporator **12**. The enclosure **1** is set with at least one opening **13** at one side thereof. The opening **13** is adapted to exhaust the air out of the enclosure **1**. The number and the locations of the fans **11** are variable to ensure the airflow being driven into the low-temperature evaporator **12** and drawn toward the middle-temperature evaporator **21**. The low-temperature evaporator **12** is set with a condensation water drain-pan **5** on the bottom side thereof for collecting condensed water resulting from air cooled by the low-temperature evaporator **12**. The condensed water is drained out of the enclosure **1** via a drain pipe **6**. The number and the locations of the openings **13** are variable to ensure the airflow being introduced into the low-temperature evaporator **12** and drawn toward the middle-temperature evaporator **21**.

[0017] An electronic substrate **2** is set with a middle-temperature evaporator **21** and other electronic devices.

[0018] An input end **3** is connected to one side of the electronic substrate **2** by a pipe **31**, and the pipe **31** is set with a throttling device **32**. The input end **3** is configured to input the near liquid state refrigerant. The throttling device **32** is any device being configured to expand and cool the near liquid state refrigerant, such as an expansion valve, a capillary, or an orifice plate. The near liquid state refrigerant is provided by an external refrigerating system or a liquid refrigerant pump. The near liquid state refrigerant is at high temperature and under high pressure.

[0019] An output end **4** is connected to another side of the electronic substrate **2** by a pipe **41**, and the pipe **41** is set with a throttling device **42** that is connected to the low-temperature evaporator **12** and an output end **43**. The output end **43** of the low-temperature evaporator is connected to a receiver or a compressor (not shown) of a refrigerating system for forming a compression cycle in a cooling system.

[0020] The refrigerant cooling system for an electronic apparatus and the method thereof is formed by the aforementioned configuration.

[0021] FIG. **2** shows a flowchart of the refrigerant cooling system for an electronic apparatus and the method thereof. To assist in further understanding the technologies applied in the present invention, the main steps are illustrated as follows.

[0022] Step 1 as shown in **101**, filling a near liquid state refrigerant into the input end pipe toward a middle-temperature evaporator for cooling an electronic substrate contacting with the middle-temperature evaporator.

[0023] Step 2 as shown in **102**, after the liquid-gaseous mixture state refrigerant carries out the heat from the electronic substrate, directing the refrigerant through an output end pipe with a throttling device being set thereon for the second-stage expansion, then filling the liquid-gaseous mixture state refrigerant into a low-temperature evaporator for cooling the airflow drawn in by a fan.

[0024] Step 3 as shown in **103**, after a fan introduces the airflow into an enclosure, the low-temperature evaporator cools off the airflow. The electronic substrate and the other electronic devices then will carry away the heat by flowing the airflow through the electronic substrate and then exhausting the airflow out of the enclosure via an opening.

[0025] Step 4 as shown in **104**, after the heat exchanges between the liquid-gaseous mixture state refrigerant contained in the evaporators and the airflow, the refrigerant is directed toward a receiver or a compressor of a refrigerating system via the output end pipe for a compression cycle in the cooling system.

[0026] According to the principles of thermodynamics, when the near liquid state refrigerant flows through each throttling device, the liquid state refrigerant expands. In other words, when the liquid state refrigerant flows through each throttling device, the temperature of the refrigerant is lowered compared to the temperature of the refrigerant flowing through previous throttling devices. And the low-temperature evaporator can drop the dewpoint temperature of the air flow and therefore the temperature of the airflow is lower than the temperature of the surface of the electronic substrate. According to the principles of psychrometrics, when the temperature at the surface of an electronic device is higher than the dewpoint temperature of the ambient air, condensation of moisture does not occur on the surface of the electronic devices.

[0027] Compared with other conventional technologies, the refrigerant cooling system for an electronic apparatus and the method thereof of the present invention has the following advantages.

[0028] 1. The present invention provides a cooling system that can efficiently carry away the heat generated by electronic devices with low-temperature refrigerant, and keep the operation temperature of the electronic devices much lower than that achieved by conventional air-cooled methods. In addition, moisture condensation is prevented from forming on the surfaces of the electronic devices.

[0029] 2. The present invention provides a refrigerant cooling system for an electronic apparatus and the method thereof for ensuring safety during operation of the electronic devices, improving efficiency, and decreasing need for auxiliary equipment. The present invention is also applied to decrease the size of electronic devices and save energy.

[0030] Many changes and modifications in the above described embodiment of the invention can, of course, be carried out without departing from the scope thereof. Accordingly, to promote the progress in science and the useful arts, the invention is disclosed and is intended to be limited only by the scope of the appended claims.

What is claimed is:

1. A refrigerant cooling system for an electronic apparatus, comprising:

an enclosure, in which the enclosure is set with at least one fan on one side thereof, the fan is configured to draw air into the enclosure, the enclosure is set with a low-temperature evaporator, the enclosure is set with at least one opening on one side thereof, and the opening is adapted to exhaust the airflow out of the enclosure;

an electronic substrate, being set with a middle-temperature evaporator;

an input end, in which the input end is connected to one side of the electronic substrate by a pipe, and the pipe is set with a throttling device;

an output end, in which the output end is connected to another side of the electronic substrate by a pipe, a throttling device is connected to the pipe, the output end is then connected to an output end of the low-temperature evaporator via the pipe, a liquid-gaseous mixture state refrigerant flowing through the low-temperature evaporator is redirected to a receiver or a compressor of a refrigerating system to form a recycling cooling system; thereby the refrigerant cooling system for an electronic apparatus is formed by the aforementioned configuration.

2. The refrigerant cooling system for an electronic apparatus as claimed in claim **1**, wherein the low-temperature evapo-

rator is set with a condensation water drain-pan at a bottom side thereof for collecting condensed water from airflow cooled by the low-temperature evaporator, and the condensed water is drained out of the enclosure via a drain pipe.

3. The refrigerant cooling system for an electronic apparatus as claimed in claim **1**, wherein the electronic substrate is set with other electronic devices.

4. The refrigerant cooling system for an electronic apparatus as claimed in claim **1**, wherein the input end is configured to input the near liquid state refrigerant

5. The refrigerant cooling system for an electronic apparatus as claimed in claim **1**, wherein the throttling device is any device being configured to cool the expanding liquid state refrigerant, such as an expansion valve, a capillary, or an orifice plate.

6. The refrigerant cooling system for an electronic apparatus as claimed in claim **1**, wherein the near liquid state refrigerant is provided by an external refrigerating system or a liquid refrigerant pump.

7. The refrigerant cooling system for an electronic apparatus as claimed in claim **1**, wherein the state of the refrigerant contained in the middle-temperature evaporator is at high temperature and under high pressure, and is in near liquid state.

8. The refrigerant cooling system for an electronic apparatus as claimed in claim **1**, wherein the number and the locations of the fans are variable to ensure flowing directions of the airflow is drawn into the low-temperature evaporator and drawn toward the middle-temperature evaporator.

9. The refrigerant cooling system for an electronic apparatus as claimed in claim **1**, wherein the number and the locations of the openings are variable to ensure flowing directions of the airflow is drawn into the low-temperature evaporator and drawn toward the middle-temperature evaporator.

10. A refrigerant cooling method for an electronic apparatus, comprising the steps of:

Step 1: Filling a near liquid state refrigerant into the input end pipe toward a middle-temperature evaporator for cooling an electronic substrate contacting with the middle-temperature evaporator;

Step 2: after the liquid-gaseous mixture state refrigerant carries away the heat from the electronic substrate, directing the refrigerant through an output end pipe with a throttling device being set thereon for second-stage expansion, then filling the liquid-gaseous mixture state refrigerant into a low-temperature evaporator for cooling the airflow drawn by a fan;

Step 3, after drawing the airflow into a enclosure by the fan, cooling the airflow by the low-temperature evaporator, and carrying out the heat from the electronic substrate and the other electronic devices by directing the airflow through the electronic substrate, then exhausting the airflow out of the enclosure via an opening;

Step 4, after heat exchange between the liquid-gaseous mixture state refrigerant contained in the evaporator and the airflow, flowing the refrigerant toward a receiver or a compressor of a refrigerating system via the output end pipe for a compression cycle in the cooling system.

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