



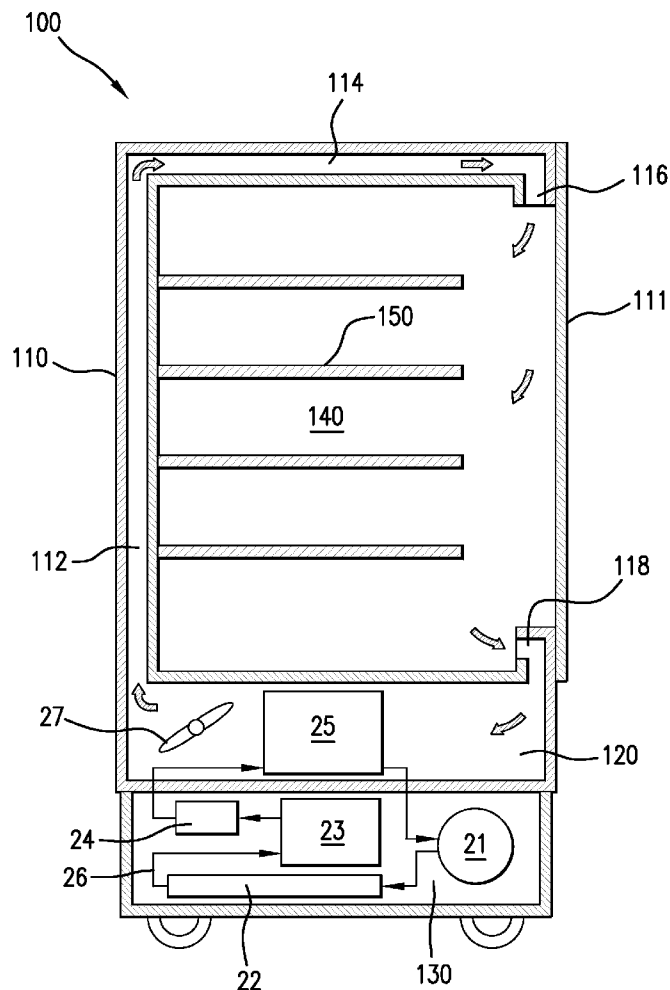
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(19) **United States**(12) **Patent Application Publication****Gu et al.**(10) **Pub. No.: US 2010/0300127 A1**(43) **Pub. Date: Dec. 2, 2010**(54) **REFRIGERATED CASE**(30) **Foreign Application Priority Data**(75) Inventors: **Zhong Gu**, Shanghai (CN); **LianFu Zhu**, Qingdao (CN); **Zhiwei He**, Shanghai (CN)

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F28D 5/00 (2006.01)(52) **U.S. Cl.** **62/115; 62/255; 62/498; 62/305**(57) **ABSTRACT**

In a self-contained plug-in display cabinet system (100), the evaporation temperature of the evaporator (25) is between -4° C. and 2° C., and with the adaption of constant pre-cooling means (22), the high-temperature and high-pressure refrigerant gas discharged by the compressor (21) is pre-cooled allowing use of a low system pressure ratio and, thus, a high temperature compressor (21). Furthermore, there may be no need for the evaporator to be defrosted, which overcomes the drawbacks of the currently available display cabinet systems that the refrigeration cycles have to be interrupted for defrosting the evaporator, thereby having further energy saving and being advantageous in keeping the temperature of the food stable.

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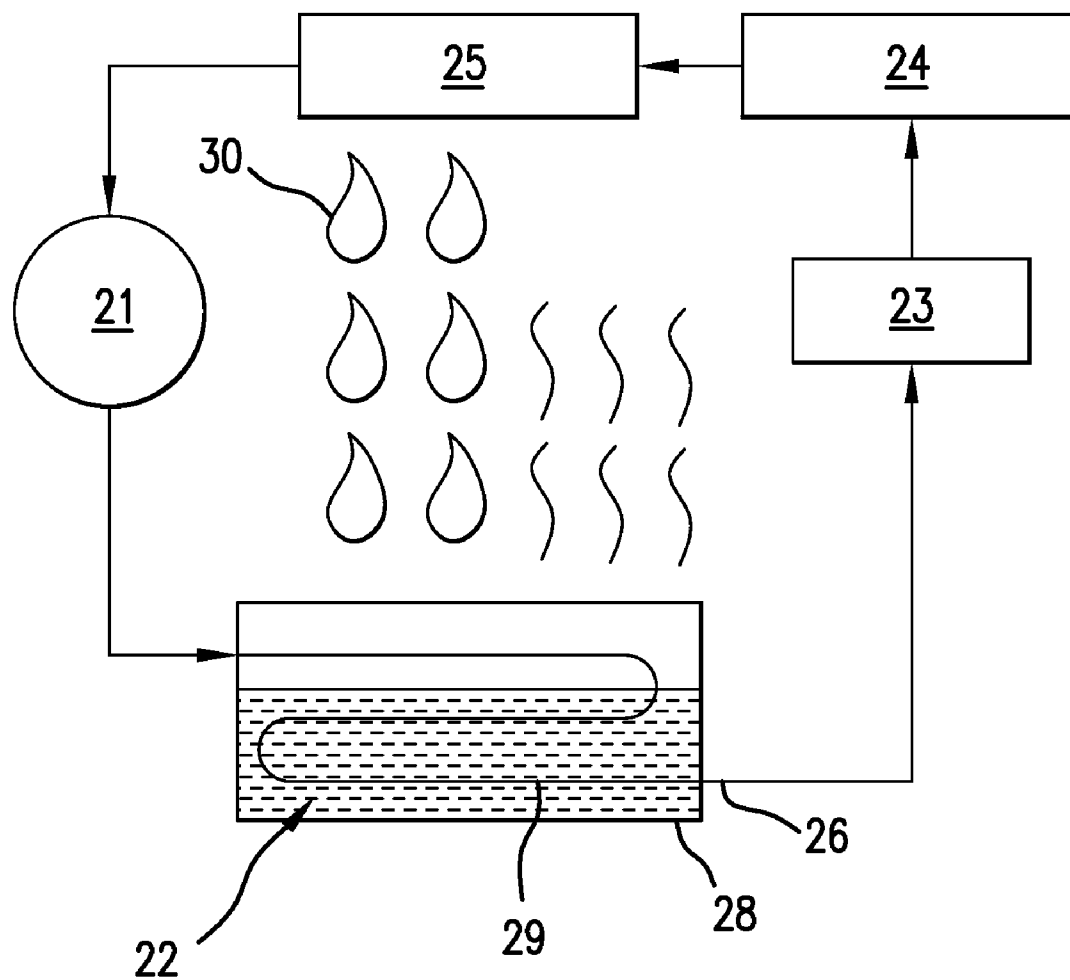


FIG. 1

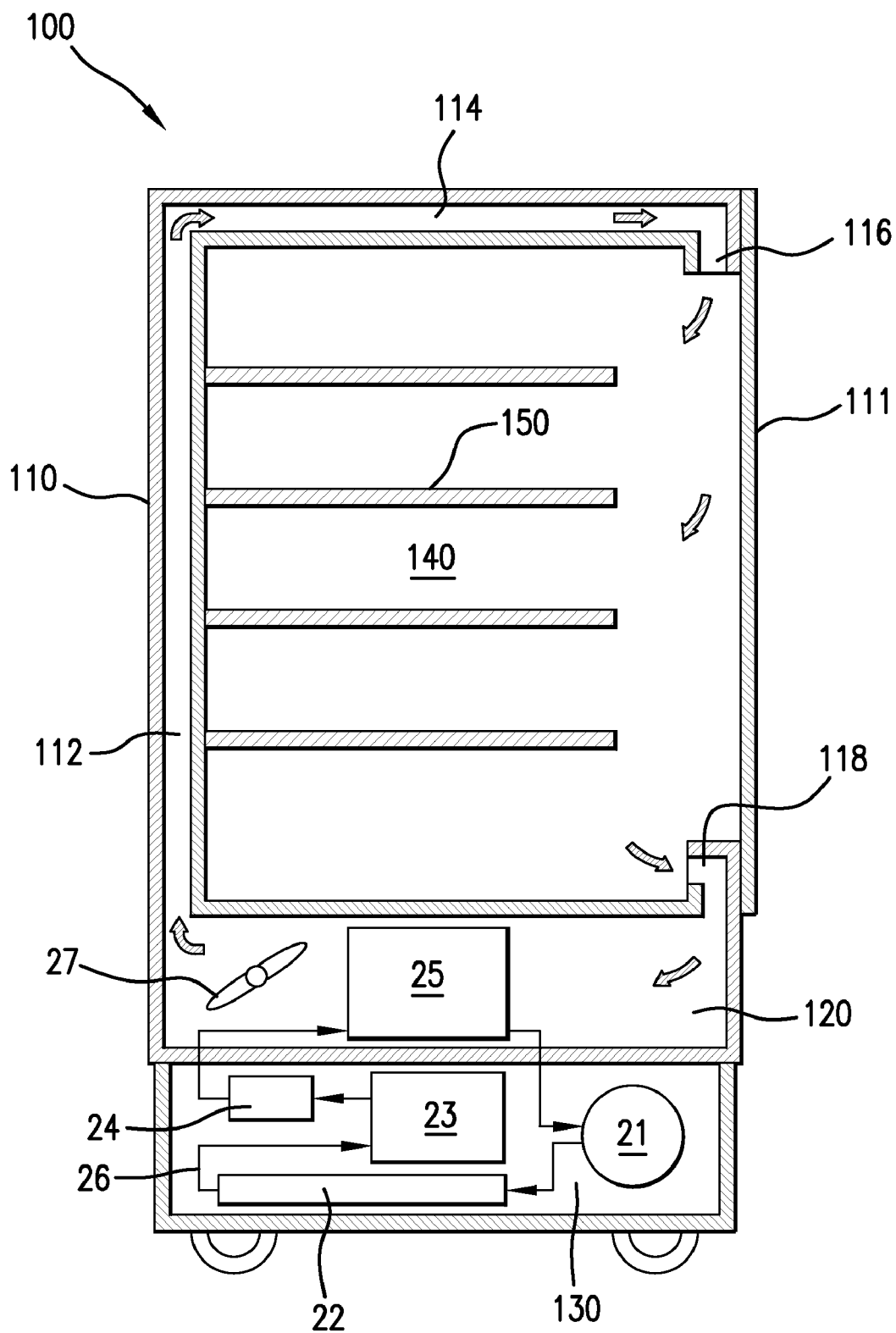


FIG. 2

REFRIGERATED CASE

[0001] BACKGROUND

[0002] The present disclosure relates to a complete display cabinet system, and in particular, to a self-contained plug-in product display cabinet system for preserving and refrigerating foods, beverages and fresh agricultural and livestock products.

[0003] Currently, self-contained plug-in product display cabinets for preserving and cooling (refrigerating) foods, beverages and fresh agricultural and livestock products are indispensable equipment for supermarkets and convenience stores. Such display cabinets can be of an open type or they can also be provided with doors for providing a cooling environment for goods, such as fresh foods, beverages, etc. to be displayed to customers.

[0004] Usually, in order to provide a suitable cooling environment, the refrigerating system of a display cabinet comprises at least the following parts: a compressor, a condenser, at least one evaporator incorporated in the display cabinet, a throttling mechanism, such as a float expansion valve, a thermal expansion valve or a throttle expansion valve (capillary), condenser, etc., and suitable refrigerant pipelines connecting these parts in a closed circulation loop. The refrigerant in the evaporator boils to gasify under the evaporation pressure, the compressor continuously sucks the gas generated in the evaporator and compresses the same to a condensing pressure, and then sends the high-temperature and high-pressure refrigerant to the condenser, the refrigerant is isobarically cooled and condensed into a liquid under the condensing pressure, and the heat released when the refrigerant is cooled and condensed is transferred to the cooling medium (usually this is water or air). The condensing temperature corresponding to the condensing pressure is above the temperature of the cooling medium. After the condensation, the liquid refrigerant enters the evaporator via the throttling mechanism, and when the refrigerant passes through the expansion valve, the pressure is reduced from the condensation pressure to the evaporation pressure, a part of the liquid is gasified and the temperature of the rest of the liquid is lowered to the evaporation temperature, thereby the refrigerant coming out of the expansion valve becomes a two-phase mixture whose temperature is the evaporation temperature. The liquid in the mixture evaporates in the evaporator, and during this process, the refrigerant absorbs latent heat it needs from the object being cooled or from the air, causing the temperature of the object being cooled or the air to be lowered to the required value. The gasified refrigerant is again sucked by the compressor, so as to start a next cycle.

[0005] According to the above cooling mechanism, in a product display cabinet, a freezing compressor is usually used as the core part of the system. Within the display cabinet, an air circulation system sends damp hot air returned from the display area to the evaporator, where the air exchanges heat with the refrigerant and becomes low-temperature, dry and cold air after having been cooled and dried, and then is injected into the product display area of the display cabinet via the cold air channel of the display cabinet to cool the displayed products; or, in an open type display cabinet, the low-temperature dry and cold air forms a cold air curtain between the product display area and the ambient air thereof, separating the products in the display area from the ambient.

[0006] In typical current product display cabinets, the required evaporating operational evaporation temperature of the refrigeration system with freezing compressors must be lower than -6°C ., (e.g., about -15°C .), and the actual evaporating temperature of ordinary evaporators used is about -10°C . to -8°C . However, because the performance of a refrigerating compressor varies with the changes of the evaporation temperature and the condensing temperature, in which the evaporation temperature has more influence on the performance of the refrigerating compressor and therefore, the system performance. The cooling capacity amount of refrigeration energy and the system efficiency of the refrigeration circuit drop significantly as the evaporation temperature lowers and therefore, in operation, as long as the temperature requirements by the objects to be cooled are met, the chiller should be kept at a relatively high evaporation temperature, so as to ensure a higher energy efficiency and a better energy economy.

SUMMARY

[0007] Therefore, in terms of a current product display cabinet, if the evaporation temperature of the evaporator can be increased to reduce the compression ratio of the system, which result in the improvement of the compressor working condition to enable the use of more cost-efficient, higher COP, and reliable air-conditioning compressor, not only the power consumption of the system can be reduced and the noise in the operation of the system can be decreased, but also the product display cabinet system can be more advantageously integrated to offer a self-contained plug-in structure. Therefore, to provide such a new self-contained plug-in display cabinet system is an innovation with great and positive significance to the art.

[0008] A self-contained plug-in display cabinet system may be provided, in which the evaporator's evaporation temperature can be increased by $6\text{--}12^{\circ}\text{C}$., so that the compression ratio of the compressor can be reduced to meet the requirements of an air-conditioning compressor, thus an air-conditioning compressor can be used to realize the refrigeration circulation, thereby resulting in significant reduction of energy consumption and noise as well as the reduction of the costs of the product.

[0009] A complete display cabinet system may comprise: a display cabinet containing a product display area and a compartment separated from the display area; an airflow circulation channel connecting the display area of the display cabinet to the airflow within the compartment; and a cooling system disposed in the compartment of the display cabinet and comprising an air-conditioning compressor, a condenser, a throttling mechanism, a condenser and pipelines connecting these parts, wherein the evaporation temperature of the evaporator is -4 to 2°C .

[0010] The saturated suction temperature (SST) of the cooling system with air-conditioning compressor may be above -5°C .

[0011] The cooling system may further comprise condensed water evaporating and cooling means for pre-cooling the high-temperature and high-pressure refrigerant flowing out of the outlet of the air-conditioning compressor.

[0012] The condensed water evaporating and cooling means may comprise a cooling water container and a coiled pipe before the condenser disposed within the cooling water container, and the cooling water container can constantly

collect and contain the water condensed on the surface of heat exchange fins of the evaporator for pre-cooling the refrigerant.

[0013] The display cabinet may contain a first compartment connected with the airflow circulation channel, and the evaporator may be disposed in the first compartment.

[0014] The display cabinet may further contain a second compartment, and the air-conditioning compressor, the condensed water evaporating and cooling means, the condenser and the throttling mechanism may be disposed in the second compartment.

[0015] A cooling system comprises an air-conditioning compressor, a condenser, a throttling mechanism, an evaporator and pipelines connecting these parts, in which the evaporation temperature of the evaporator is -4 to 2°C .

[0016] The saturated suction temperature of the cooling system with air-conditioning compressor may be above -5°C .

[0017] It may further comprise condensed water evaporating and cooling means for pre-cooling the high-temperature and high-pressure refrigerant flowing out of the outlet of the air-conditioning compressor.

[0018] The condensed water evaporating and cooling means may comprise a cooling water container and a pre-condenser coiled pipe disposed within the cooling water container, and the cooling water container can collect and contain the water condensed on the surface of heat exchange fins of the evaporator for pre-cooling the refrigerant.

[0019] In comparison with the prior art, in the product display cabinet system employing a high-performance evaporator, the evaporation temperature of the evaporator can be increased by 6 - 12°C . to between -4°C . and 2°C ., and by the adaptation of pre-cooling means, the condensate water from the evaporator pre-cools the refrigerant gas discharged by the compressor to decrease the condensing pressure, so as to make the working conditions of the core part of the system, i.e. the compressor, meet the requirements of an air-conditioning system and to realize the refrigeration circulation by an air-conditioning compressor. In comparison with currently available display cabinet systems, the display cabinet system, integrated by the above-mentioned parts may save energy by 49% and have better silencing effects and higher operational reliability. Furthermore, since the evaporation temperature of the system may be close to 0°C ., there is no need for the evaporator to be defrosted, which overcomes the drawback of the currently available display cabinet systems that the refrigeration circulation has to be interrupted for the evaporator to be defrosted, so as to save energy further and to be advantageous in keeping the temperature of the foods not being increased to protect displayed products.

[0020] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] FIG. 1 is a diagram of a cooling refrigeration system.

[0022] FIG. 2 is a schematic diagram of the structure of a self-contained plug-in display cabinet system.

[0023] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0024] It is easily understood that according to the technical solutions of the present disclosure, it would occur to those skilled in the art other embodiments of the display cabinet system of the present disclosure without departing from the essential spirit of the present disclosure. Therefore, the following particular embodiment and drawings are merely illustrative examples of the technical solutions of the present disclosure and are not to be deemed as the whole of the present disclosure or as limiting or defining the technical solutions of the present disclosure.

[0025] In an embodiment, as shown in FIG. 1, the refrigeration system 20 comprises an air-conditioning compressor 21, condensed water evaporating and cooling (refrigerant precooling) means 22, a heat rejection heat exchanger (e.g., condenser) 23, a throttling mechanism (expansion device) 24 and a high-performance evaporator 25, which parts of the system are connected sequentially by connecting pipelines 26. Among them, the saturated suction temperature (SST) of the air-conditioning compressor 21 is above -5°C ., the condensed water evaporating and cooling means 22 can employ an evaporating cooling coiled pipe with a condensed water container, and the condensed water container is used to collect and contain the water 30 condensed on and flowing off the surface of heat exchange fins of the evaporator 25. A float expansion valve, a thermal expansion valve or a throttle expansion valve can be selected as the throttling mechanism 24. The evaporation temperature of the high-performance evaporator 25 is -4 to 2°C ., and a high-performance evaporator which was developed by the present applicant and has been granted U.S. Pat. No. 6,460,372 B1 (the disclosure of which is incorporated by reference herein in its entirety as if set forth at length) can be selected as the high-performance evaporator 25.

[0026] The high-temperature and high-pressure refrigerant flowing out of the air-conditioning compressor 21 enters the condensed water evaporating and cooling means 22 via the pipeline 26, exchanges heat with the condensed water 30 discharged from the evaporator and is pre-cooled when passing through the coiled cooling pipe, and then enters the condenser 23 for cooling; the refrigerant becomes a low-temperature and low-pressure liquid or a two-phase liquid and gas mixture after having been throttled by the throttling mechanism 24, and then enters the evaporator 25. The refrigerant evaporates in the evaporator 5, and during this process the refrigerant absorbs heat from the air or the object being cooled, which are in contact with the heat exchange fins of the evaporator 25, so that the temperature of the air or the object being cooled which are in contact with the heat exchange fins of the evaporator 25 is lowered to the required value. Since the evaporation temperature of the evaporator 25 is close to 0°C ., the moisture in the air is constantly condensed to water on the surface of the heat exchange fins of the evaporator 25, but does not freeze/frost. The condensed water 21 flowing off the surface of the heat exchange fins of the evaporator 25 is collected and contained by using the condensed water container (e.g., tray or pan) 28 of the condensed water evaporating and cooling means 22 for pre-cooling the high-temperature and high-pressure refrigerant gas in the cooling coiled pipe 29 of the means 22 in the container.

[0027] The pre-cooling of the present disclosure differs, for example, from post-cooling (e.g., cooling between the condenser and the expansion device). For example, WO2006/101564 discloses post-cooling to maximize cooling upstream of the expansion device. However, that does not maximize cooling of compressor discharged conditions and, thereby, does not maximize compressor protection and minimize the compression ratio.

[0028] The high-temperature and high-pressure refrigerant flowing out of the outlet of the compressor 21 is better cooled by using the condensed water evaporating and cooling means 22. In comparison with the currently available product display cabinet systems, the evaporation temperature of the refrigerant flowing out of the outlet of the high-performance evaporator 25 can be increased by about 6-12° C. to between -4° C. and 2° C., so as to make the working conditions of the core part of the system, i.e. the compressor, meet the requirements of an air-conditioning system and to realize the above refrigeration circulation with the air-conditioning compressor. In comparison with the currently available display cabinet systems, the display cabinet system, integrated by the above-mentioned parts, may save more energy and shows better silencing effects and higher operational reliability. Furthermore, since the evaporation temperature of the system is close to 0° C., there is no need for the evaporator to be defrosted, which overcomes the drawbacks of the currently available display cabinet systems that the refrigeration circulation has to be interrupted for the evaporator to be defrosted, thereby saving more energy and being advantageous in keeping the temperature of the foods stable.

[0029] The constant/continuous nature of condensate collection and associated pre-cooling is distinguished from intermittent collection associated with collecting condensate melted from the evaporator during defrost. Whereas defrost condensate is collected only during a relatively small portion of the normal operating cycle, condensate may be collected and delivered to the cooling means 22 a much greater percentage of the time (e.g., 50-100% of the time, more narrowly, 90-100%). Additionally, if the means 26 is further integrated with the condenser, the identified pre-cooling may be defined as occurring generally before the traditional cooling associated with the condenser (e.g., at least 50% of the pre-cooling occurring before at least 50% of the traditional air cooling of refrigerant in the condenser).

[0030] FIG. 2 shows a schematic diagram of the structure of the new self-contained plug-in display cabinet system 100 incorporating the refrigerant system 20. The display cabinet system 100 comprises an upright front-open insulated cabinet 110 and a first compartment 120 and a second compartment 130 disposed below the insulated cabinet 110. The insulated cabinet 110 can also be provided with a door 111, with airflow channels 112, 114, 116 and 118 being disposed on the inside of walls, in which the airflow channels 112, 118 are connected respectively with the first compartment 120. The front-open area of the insulated cabinet 110 provides a product display area 140, in which several shelves 150 are disposed for displaying goods. The evaporator 25 is disposed within the first compartment 120 of the display cabinet 100, while the air-conditioning compressor 21, the condensed water evaporating and cooling means 22, the condenser 23 and the throttling mechanism 24 are disposed within the second compartment 130, and all of these parts are connected by the connecting pipes 26.

[0031] The returned damp and hot air in the display area 140 is sucked using air circulation mean, such as a fan 27, into the first compartment 120 from the airflow channel 118, passes through the evaporator 25, comes into contact with the surface of heat exchange fins of the evaporator 25, becomes low-temperature and dry air after exchanging heat with the refrigerant and being cooled, and is discharged into the airflow channel 112 and to the product display area 140 via the airflow channels 114, 116, thereby lowering the temperature of the foods. When the damp and hot air passes the evaporator 25, the moisture therein is condensed to water on the surface of the heat exchange fins of the evaporator 25 and flows off into the condensed water container of the condensed water evaporating and cooling means 22 below, to be used for pre-cooling the high-temperature and high-pressure refrigerant coming out of the outlet of the compressor 21. The refrigerant coming out of the outlet of the evaporator 25 returns again to the air-conditioning compressor 21 for compression, thus forming a refrigeration circulation.

[0032] In comparison with a more conventional currently available display cabinet, the above product display cabinet system employing the technical solution of the present disclosure saves energy by 49% and has the advantages of better silencing effects and higher operational reliability due to the integration of high COP and reliable air conditioning compressor used in cooling refrigeration system, high efficient evaporator to increase the evaporating pressure, and evaporator condensate pre-cooler to reduce condensing pressure to maximize the compression efficiency. An example is given in the context of ISO23953-1 and the associated 3M1, 3M2, and 3H1 case temperatures. 3 (ambient) M (MT)1 (product temperature)—ambient 25 C, Humidity 60% and product temperature -1 to 5 C. 3M2—ambient 25 C, Humidity 60% and product temperature -1 to 5 C. 3H1—ambient 25 C, Humidity 60% and product temperature -1 to 10 C. With the present system, an HT compressor may be used in an application normally requiring an MT compressor. An exemplary such substitution may reduce the system pressure ratio from that of one without the cooling means. For example, at 25 C ambient and 60% humidity, the baseline system may have a system pressure ratio of (about 3.4 to about 3.6) to (about 2.4 to about 2.8) using R22 refrigerant.

[0033] It is easily understood that the product display cabinet system 100 is not limited to the structure as described in the above embodiment, other alternative structures or embodiments can be proposed by a person skilled in the art. For example, the first and the second compartments 120, 130 can be disposed above the cabinet 110, or the positions of the first and the second compartments 120, 130 can be exchanged or there can be no division between them, or the positions of the airflow channels 112, 114, 116 and/or 118 can be varied, etc.

[0034] Although an embodiment is described above in detail, such description is not intended for limiting the scope of the present disclosure. It will be understood that various modifications may be made without departing from the spirit and scope of the disclosure. For example, when implemented in the reengineering of an existing container configuration, details of the existing configuration may influence or dictate details of any particular implementation. Accordingly, other embodiments are within the scope of the following claims.

1. A self contained plug in display cabinet system (100), characterized in that the system comprises:

a display cabinet (110) containing a product display area (140) and a compartment (120, 130) separated from the display area;

an airflow circulation channel (112, 114, 116) connecting the airflow between the display area and the compartment of the display cabinet; and

a refrigeration system (20) disposed in the compartment of the display cabinet and comprising an air-conditioning compressor (21), a condenser (23), a throttling mechanism (24), an evaporator (25), and pipelines (26) connecting these parts, wherein the evaporation temperature of the evaporator is -4°C. to 2°C.

2. The self-contained plug-in display cabinet system as claimed in claim 1, characterized in that the suction temperature (SST) of said air-conditioning compressor is above -5°C.

3. The self-contained plug-in display cabinet system as claimed in claim 1, characterized in that said refrigeration system further comprises condensed water evaporating and cooling means for pre-cooling the high-temperature and high-pressure refrigerant flowing out of the outlet of the air-conditioning compressor.

4. The self-contained plug-in display cabinet system as claimed in claim 3, characterized in that said condensed water evaporating and cooling means comprises a cooling water container and a coiled evaporation pipe disposed within the cooling water container, and said cooling water container can collect and contain the water condensed on the surface of heat exchange fins of the evaporator for pre-cooling the refrigerant.

5. The self-contained plug-in display cabinet system as claimed in claim 4, characterized in that said display cabinet contains a first compartment connected with the airflow circulation channel, and said evaporator is disposed in the first compartment of the display cabinet.

6. The self-contained plug-in complete display cabinet system as claimed in claim 5, characterized in that said display cabinet further contains a second compartment, and said air-conditioning compressor, condensed water evaporating and cooling means, condenser and throttling mechanism are disposed in the second compartment.

7. A refrigerating system, characterized in that it comprises an air-conditioning compressor, a condenser, a throttling mechanism, an evaporator and pipelines connecting the parts, wherein the evaporation temperature of the evaporator is -4 to 2°C.

8. The refrigerating system as claimed in claim 7, characterized in that the saturated suction temperature of said air-conditioning compressor is above -5°C.

9. The refrigerating system as claimed in claim 7, characterized in that it further comprises condensed water evaporating and cooling means for pre-cooling the high-temperature and high-pressure refrigerant flowing out of the outlet of the air-conditioning compressor.

10. The refrigerating system as claimed in claim 9, characterized in that said condensed water evaporating and cooling means comprises a cooling water container and an coiled evaporation pipe disposed within said cooling water container, and said cooling water container can collect and contain the water condensed on the surface of heat exchange fins of the evaporator for pre-cooling the refrigerant.

11. A method for operating a refrigerated display cabinet system, the system comprising:

a display cabinet (110) containing a product display area (140); and

a refrigeration system (20) comprising a compressor (21), a heat rejection heat exchanger (23), an expansion device (24), and an evaporator (25),

the method comprising:

pre-cooling refrigerant flowing from the compressor to the condenser via condensate collected from the evaporator, the pre-cooling effective to maintain an evaporation temperature of the evaporator of -4°C. to 2°C.

12. The method of claim 11 wherein:

at least 50% of the pre-cooling occurs before at least 50% of an air cooling of refrigerant in the condenser.

13. The method of claim 11 wherein:

the condensate is continuously collected over at least 90% of an operational cycle.

14. The method of claim 13 wherein:

there is no defrosting.

15. The method of claim 13 wherein:

a characteristic operational system pressure ratio is 2.4-2.8.

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