Providing a flow of low-temperature air saturated with water and utilising same in a refrigerating device

The present invention relates to providing a flow of low temperature air saturated with water and utilising same in a refrigerating device.

In a refrigerator or refrigerated showcase of the type wherein the substances being refrigerated are placed on holding shelves in the refrigerator, or on display racks in the showcase, and a refrigerant gas is made to circulate in direct contact with these substances being refrigerated, low temperature air obtained by a refrigerating device whereto a refrigeration cycle, for instance, is applied is often used for refrigerating substances in the refrigerator or showcase.

In these cases, the low-temperature air has low relative humidity, i.e. it is dry air; since it is obtained by cooling air from outside or the air in the refrigerator or showcase. Therefore, a phenomenon occurs in which moisture is evaporated from the substances being refrigerated when the air circulated through the refrigerator or showcase.

This phenomenon causes a serious deterioration of the quality of the substances being refrigerated such as cakes, perishable foods, or the like, and even when the refrigeration itself is made satisfactorily, the perishable foods or the like dry out and thereby lose their values as commodities.

According to one aspect of the present invention there is provided a method of providing a flow of low-temperature air saturated with water, comprising the steps of flowing air upwardly through a heat exchanger, positioning said heat exchanger generally vertical, providing an evaporator coil of a refrigerating machine inside said heat exchanger, providing a supply of water at the lower

end of said heat exchanger, spraying water from said supply of water inside said heat exchanger onto said evaporator coil, flowing air to be saturated with said water through the inside of said heat exchanger in contact with said coil and with said sprayed water therein, providing an amount of water in said step of spraying water larger than the amount of water said flow of air is capable of carrying, and constricting the flow of water saturated air exiting the upper end of said heat exchanger to thereby cause a jetting effect thereof, whereby to ensure removal of the larger droplets of water from said saturated flow for automatic return of said larger droplets to said supply of water by falling downwardly through said heat exchanger.

According to another aspect of the invention there is provided a refrigerating device wherein a flow of water saturated low-temperature air is brought into direct contact with goods in the device, said device being oriented generally vertically, said device being divided into a main goods space, a generally horizontal machinery and water storage space below said main space, and a generally vertical return space at the back of said main space, access door means at the front of said main space, a vertically disposed heat exchanger positioned at the back of said main space and interconnecting said main and water storage spaces, an evaporator coil means forming part of a refrigerating machine, means to position said evaporator coil means on the inside of said heat exchanger, pump means for pumping water from said water supply into said heat exchanger, nozzle means, said pump means pumping said water from said water supply through said nozzle means and into the inside of said heat exchanger, fan means, said fan means comprising means to pump air from said return space into said heat exchanger, whereby said air from said fan means flows through said heat exchanger in contact with said evaporator means and said sprayed water therein

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to thereby become saturated with water, means to flow said air through said heat exchanger from the lower end to the upper end thereof, restrictor means at the upper end of said heat exchanger, whereby a jet effect of the water saturated air exiting said heat exchanger is achieved, whereby to ensure removal of the larger droplets of water from said saturated flow for automatic return of said larger droplets to water supply by falling downwardly through said heat exchanger, means to flow the water saturated air exiting from said heat exchanger into said main space, and means to return the air flow from said main space to a suction side of said fan via said return space.

By means of the present invention, the possibility of the evaporation of moisture from the perishable foods is eliminated completely even when the cooling gas is in direct contact with the foods, since saturated low-temperature air containing tiny water droplets is used as the cooling gas for cooling the perishable foods and keeping them at low temperature, in direct contact therewith. Thus, the present invention furnishes a refrigerator or a refrigerated showcase enabling an excellent maintenance of the freshness and quality of perishable foods for a long time.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a section of part of a refrigerated showcase offered by the present invention;

Figure 2 is a section taken along the line A-A of Fig. 1;

Figure 3 is a section taken along the line B-B of Fig. 1; and

Figure 4 is a section of part near the upper-end of the display section.

An explanation will now be made regarding the refrigerating device, such as a refrigerated showcase, to which the above method of heat exchange is applied, with reference to Figures 1 to 4.

The showcase 1 is formed of a display section 2 in the upper part and a machinery chamber 3 in the lower. The front and both sides of the display section 2 are formed of transparent glass plates 4 and 5, while the back thereof is formed of a back plate 6 made of a steel plate or the like. A heat insulating material 7 is stuck onto the rear surface of the back plate 6. The front glass plate also serves as a door for the display section 2, and has a hinge 8.

A display chamber 10 is formed inside the display section 2 partitioned from the other sections by a ceiling plate 22 and a bottom plate 31, and a number of shelf plates 9 for holding the displayed substances are provided in the display chamber 10 fixed at appropriate intervals. Partition plates 11 are provided in the display section 2 in positions comparatively near to, but with a prescribed spacing from, the back plate 6. The partition plates 11 extend to the machinery chamber 3 located below and are fixed so that a passage 12 of a predetermined size is defined between the plates 11 and the back plate (formed by extending the back plate 6 of the display section 2) of the machinery chamber 3. A plurality of small holes 13 communicating the passage 12 with the display chamber 10 are made in the parts of said partition plates 11 corresponding to the display chamber 10, while an opening 15 communicating with a suction port of a fan 14 is formed in the part of the plate 11 corresponding to the machinery chamber 3.

A water pipe 16 having a length which extends nearly the full height of the showcase 1, and which introduces cold water, is erected in such a manner that it is positioned in the central part between the partit

plates 11. The water pipe 16 is connected, at the lower end, to the discharge port of a pump 17 which is installed in a cold water tank positioned in the lowermost part of the showcase 1, and it has a plurality of water injection nozzles 18 around its periphery in the area inside the display chamber 10. A cylindrical body 20 is arranged around the outer periphery of the water pipe 16 at the prescribed spacing (serving as a passage 26) therefrom, the lower end of the cylindrical body 20 extends to the machinery chamber 3 and has a tangential air inlet 21 communicating with the exhaust pipe of the fan 14 therein.

The upper end of the body 20 passes through the ceiling plate 22 of the display chamber 10, and opens with a restricted opening 25, into a space 24 formed between said ceiling plate 22 and the ceiling plate 23 of the showcase. In addition, part 27 of the evaporator coil of a refrigerating cycle mentioned later is positioned in the passage 26 formed between the water pipe 16 and the cylindrical body 20.

A semi-cylindrical duct 28 is provided around the cylindrical body 20 at a prescribed spacing (forming a space 30) from the body 20. This duct 28 extends only within the display chamber 10 and is provided with a plurality of small holes 29 communicating the passage 30 with the inside of the display chamber. The lower end of the duct 28 is in close contact with the bottom plate 31 of the display chamber, while the upper end thereof opens into the space 24.

A cold water tank 32 is formed in the lower part of the machinery chamber 3, the pump 17 is arranged inside this tank 32 to suck up the cold water in the tank. A part 33 of the evaporator of the refrigerating device is arranged inside said tank to cool the water in the tank. The refrigerating device mentioned here is of a conventional type wherein a refrigerating cycle in which a high temperature refrigerant rated at $1^{\circ}c$ to $-5^{\circ}c$ is used, and the

members thereof apart from the evaporator are not shown in the figures.

Regarding the operation of the device of this embodiment, water in the cold water tank 32 is cooled by the operation of the refrigerating device, and the water thus cooled is sucked up into the water pipe 16 by the pump 17. The water sprayed from or atomized by the water injection nozzles 18 provided on the peripheral wall of the water pipe 16 is blown against the evaporator coil 27. Meanwhile, air is made to flow inside the passage 26 from below by the fan 14, and the cooled water injected into the passage 26 is mixed with this air flow. The air is cooled by this cooled water to become supersaturated low-temperature air containing a large quantity of moisture, and is jetted from the restricted opening 25 into the space 24 above. During this jetting from the restricted opening 25, large water droplets contained in the air are removed and drop along the cylindrical body 20. Accordingly, the low-temperature air flowing into the space 24 is placed in a saturated state containing only tiny water droplets, it flows into the space 30 and then into the display chamber 10 therefrom via the small holes 29 made in the duct 28.

The display chamber 10 communicates with the passage 12 through the plurality of holes 13 in the partition plates 11 forming at the back thereof, while the bottom of the passage 12 communicates with the suction port of the fan 14. Therefore, the cooled air from the space 24 flows through the display chamber 10, cooling the substances being refrigerated in the display chamber, and then is sucked into the fan 14, and thus the above flow is continued. In the course of this flow, the mixture of air and cooled water is further cooled down by the evaporator coil 27 provided in the passage 26, as it flows through the passage 26. As a result, the temperature of the mixture (of water and air) becomes even lower, combined with the heat of vaporizati

of water generated when the cooled water from the water injection nozzles 18 was mixed with the air from the fan 14.

In this way, the cooled air in a saturated state containing low-temperature, tiny water droplets are made to circulate through the display chamber and thereby perishable foods placed on the shelves in the display chamber are refrigerated in the showcase of the present invention. Accordingly, in the refrigeration of the perishable foods, for instance, the foods can be refrigerated and maintained at a low temperature, while the possibility that the foods, the substances being refrigerated, could be dried by the vaporization of moisture therefrom is prevented completely. Therefore, the freshness of perishable foods can be maintained for a long time.

In order to make the cooled air flow uniformly into the display chamber in the showcase, attention must be given to the design of the form, position, number, etc. of the small holes 29 made in the duct 28, and also to make a similar decision with respect to the small holes 13 bored in the partition plates 11. It is also needless to say that such a design is required for the uniform refrigeration of substances being refrigerated when the refrigeration load of each shelf is different.

As described above, the method of heat exchange according to the present invention is free from the freezing of moisture onto the evaporator pipe through which the refrigerant is circulating and, accordingly, the heat exchange is achieved thereby under optimum conditions constantly. Moreover, since low-temperature air in a saturated state containing tiny water droplets is used as the cooling air in the refrigerating device such as a refrigerated showcase or refrigerator whereto the method of heat exchange according to the present invention is applied, the vaporization of moisture from the substances

being refrigerated is completely prevented even when the refrigeration is conducted by making circulated cooled air contact the substances directly, and, in addition, the passing air can be purified by the atomized water. Therefore, the above refrigerating device and the refrigerator enable an especially excellent maintenance of the quality of perishable, foods, the substances being refrigerated, and the values thereof as commodities for a long time, when these foods are preserved and displayed at low temperature for a long time. Moreover, since the commodities can be displayed without being wrapped, the state thereof can be confirmed from outside very accurately. Thus, the present invention is very useful in a refrigerated showcase or a refrigerator and displays many advantages therefor.

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CLAIMS

1. A method of providing a flow of low-temperature air saturated with water, comprising the steps of flowing air upwardly through a heat exchanger, positioning said heat exchanger generally vertically, providing an evaporator coil of a refrigerating machine inside said heat exchanger, providing a supply of water at the lower end of said heat exchanger, spraying water from said supply of water inside said heat exchanger onto said evaporator coil, flowing air to be saturated with said water through the inside of said heat exchanger in contact with said coil and with said sprayed water therein, providing an amount of water in said step of spraying water larger than the amount of water said flow of air is capable of carrying and constricting the flow of water saturated air exiting the upper end of said heat exchanger to thereby cause a jetting effect thereof, whereby to ensure removal of the larger droplets of water from said saturated flow for automatic return of said larger droplets to said supply of water by falling downwardly through said heat exchanger.

2. A method according to claim 1, comprising filtering the water taken from said supply of water prior to said spraying of water to thereby purify the air and the water in the flow of water saturated air.

3. A method according to claim 1 or 2, comprising providing a portion of said evaporator coil in said water supply, whereby the water is precooled before it is sprayed.

4. A method according to claim 1, 2 or 3, comprising a relatively high temperature refrigerant in said refrigerating machine.

5. A method according to claim 4, wherein said refrigerant rates from $1^{o}C$ to $-5^{o}C$.

6. A refrigerating device wherein a flow of water saturated low-temperature air is brought into direct con-

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tact with goods in the device, said device being oriented generally vertically, said device being divided into a main goods space, a generally horizontal machinery and water storage space below said main space, and a generally vertical return space at the back of said main space, access door means at the front of said main space, a vertically disposed heat exchanger positioned at the back of said main space and interconnecting said main and water storage spaces, an evaporator coil means forming part of a refrigerating machine, means to position said evaporator coil means on the inside of said heat exchanger, pump means for pumping water from said water supply into said heat exchanger, spray nozzle means, said pump means pumping said water from said water supply through said spray nozzle means and onto the inside of said heat exchanger, fan means, said fan means comprising means to pump air from said return space into said heat exchanger, whereby said air from said fan means flows through said heat exchanger in contact with said evaporator means and said sprayed water therein to thereby become saturated with water, means to flow said air through said heat exchanger from the lower end to the upper end thereof, restrictor means at the upper end of said heat exchanger whereby a jet effect of the water saturated air exiting said heat exchanger is achieved whereby to ensure removal of the larger droplets of water from said saturated flow for automatic return of said larger droplets to water supply by falling downwardly through said heat exchanger, means to flow the water saturated air exiting from said heat exchanger into said main space, and means to return the air flow from said main space to a suction side of said fan via said return space.

7. A device according to claim 6, wherein the means to flow said water saturated air from said heat exchanger into said main space comprises a first wall means surrounding a portion of said heat exchanger, and the means to

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return the air flow from said main space to said return space comprises second wall means, the first and second wall means each being formed with a plurality of openings sized, positioned and provided in numbers such that the flow of water saturated air through said main space is uniform throughout said main space.

8. A device according to claim 6 or 7, comprising means to position a portion of said evaporator means in said water supply, whereby the water is pre-cooled before it is pumped through said nozzle means.

9. A device according to claim 6, 7 or 8, wherein a relatively high temperature refrigerant is provided in said refrigerating machine.

10. A device according to any one of claim 6 to 9, wherein said refrigerant is rated about 1°C to about -5°C.

11. A device according to any one of claims 6 to 10, comprising water filter means located in said machinery and water storage space, said filter means being operative to filter the water from said water storage means before it is pumped to said nozzles by said pump means, whereby the air and the water in the flow of water saturated air exiting said heat exchanger are purified.

12. A method of providing a flow of low-temperature air saturated with water, substantially as hereinbefore described with reference to the accompanying drawings.

13. A refrigerated showcase substantially as hereinbefore described with reference to the accompanying drawings.

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