

REFRIGERATED STORAGE CABINET

5 This invention relates to a refrigerated storage cabinet with a humidifying mechanism for preventing the stored merchandise from desiccation.

Generally, a refrigerated cabinet is provided with a refrigeration unit which comprises an
10 evaporator for cooling down the storage, or storage and display compartment of the cabinet, a compressor and a condenser both of which are disposed in a working chamber of the cabinet. The merchandise storage space is, generally, cooled down by natural
15 convection or forced convection; the air in the storage compartment is passed through the evaporator, disposed at an upper and/or lower portion of the storage compartment, by natural air flow or fan movement. The operation of the refrigeration unit is
20 controlled by a temperature control device, for example a thermostat, to maintain the predetermined temperature in the storage compartment.

Humidity in the storage compartment changes in dependence on the operative condition of the
25 refrigeration unit, i.e., during the operation of the refrigeration unit, the vapour contained in the air in the storage compartment is condensed and frosts on fins of the evaporator. As a result of this condensation, the air passing through the evaporator
30 of the unit is dried, and, therefore, the relative humidity in the storage compartment is reduced. Conversely, if operation of the refrigeration unit is stopped, the frost on the evaporator is melted and finally becomes water which is evaporated again and
35 rehumidifies the air. The storage compartment is thus returned to a condition of high humidity. However, these changes in humidity may damage

(12)

merchandise stored in the refrigerated cabinet. Various techniques have been used in the prior art to resolve the desiccation problems. One such technique involves supplying a predetermined amount of water to the storage compartment continuously to humidify the space. However, this technique requires piping for supplying the water into the compartment, and the cabinet should be located near a water source. Location of the cabinet is thus limited and further cost is involved to establish the required humidity. Another technique to maintain adequate humidity involves introducing foreign matter into the cabinet but the air in the storage compartment may become contaminated. Still another technique involves the introduction of fresh air from outside the cabinet into the compartment. However, this raises the heat load in the compartment.

In accordance with the invention, in a refrigerated storage cabinet having an storage compartment for merchandise, and provided with a refrigeration unit for cooling the compartment, the unit comprising a compressor, a condenser and two evaporators, the two evaporators being connected in parallel so that refrigerant selectively flows into one or the other of the evaporators, one of the two evaporators being disposed in the compartment for cooling the air in the compartment, and other evaporator being disposed in an air duct which can be connected to the exterior of the cabinet for condensing water vapour from ambient air or to the compartment for circulation into the compartment of air which has been humidified by previously condensed water.

This construction, involving a simple modification to a conventional refrigeration unit, provides adequate humidification of the storage compartment with minimum extra space requirements.

Some examples of a refrigerated cabinet constructed in accordance with the invention are illustrated in the accompanying drawings, in which:-

Figure 1 is a vertical sectional view of one cabinet;

Figure 2 is a schematic diagram of a refrigeration circuit;

Figure 3 is a time chart graph for illustrating the operating process of the refrigerating circuit in Figure 2;

Figure 4 is a partly enlarged sectional view of a second cabinet;

Figure 5 is a partly enlarged sectional view of a third cabinet;

Figure 6 is a partly enlarged sectional view of a fourth cabinet taken on the line A-A in Figure 7;

Figure 7 is a sectional view of the fourth cabinet;

Figure 8 is a section taken on the line B-B in Figure 7;

Figure 9 is a section taken on the line C-C in Figure 7; and,

Figure 10 is a schematic view to illustrate the air duct utilized in the fourth example of cabinet.

Referring to Figure 1, a refrigerated cabinet 1 comprises an upper storage/display compartment 11 and a lower mechanical compartment 12 for working parts. The compartment 11 is defined by an upper insulating wall panel 111, a lower insulating wall panel 112, side panels (not shown) extending between the upper panel 111 and the lower panel 112, a front glass window 113, and a rear glass door 114 which is slidably mounted to open and close a rear opening of the cabinet 1. A plurality of shelves 13 are horizontal disposed in the storage/display compartment 11 to divide the

compartment into a plurality of display spaces.

5 A first evaporator 14 is supported on the inner surface of the upper panel 111 in the compartment 11 to cool down the compartment 11. The air in the compartment 11 is force circulated for heat exchange with the first evaporator 14 by a first blower fan 15 on the suction side of the first evaporator 14. A drain pan is located beneath the first evaporator 14 for collecting water dropping from the evaporator 14. The storage/display compartment 11 is thus refrigerated by the first evaporator 14.

10 A second evaporator 17 is disposed in a lower portion of the compartment 11 in a duct formed by an air passageway 18 which is defined between an inner surface of the lower panel 112 and a bottom plate 19 extending within the compartment 11 to cover a bottom portion thereof. The bottom plate 19 defines a front air gap 181 and a rear air gap 182, whereby air in the compartment 11 can be passed through the air passageway 18 via the front and rear air gaps 181, 182. The air passed through the second evaporator 17 is forced by a second blower fan 20 on the discharge side of the second evaporator 17.

20 A connecting inlet hole 21 is formed through the lower panel 112 to interconnect the outside of the display cabinet 1 and the suction end of the air passageway 18, and controlled by a damper plate 22. The damper plate 22 is located at the air passageway 18 to close the communication with the interior of the compartment 11 when the damper plate 22 opens the hole 21. Outside air is thus introduced into the air passageway 18 via the hole 21 and passed through the second evaporator 17.

30 As shown in Figure 2, a refrigeration unit 23 for use in the cabinet 1 comprises a compressor 231, a condenser 232, the two evaporators 14, 17 and an accumulator 233. The compressor 231, condenser 232

and accumulator 233 are generally disposed in the lower working compartment 12. The first and second evaporators 14 and 17 are connected in parallel with one another and a connecting portion at the suction side of both evaporators 14, 17 is fitted with a selection valve 24 communicating with the condenser 232. A reducing device 234 and check valve 235 are disposed on the suction sides and discharge sides, respectively, of each evaporator 14, 17. Therefore, during the operation of the refrigerating unit 23, the refrigerant is passed through either evaporator by operation of the selection valve 24.

The operation of this refrigerating unit and humidifying mechanism will be explained with reference to the Figures 1-3. When an electro driving circuit (not shown) is energized, the compressor 231 and first blower fan 15 are driven, and continue to operate until the driving circuit is deenergized. (This time point is indicated by t_0 in Figure 3.) At that time, the temperature in the storage/display compartment 11 normally exceeds a predetermined temperature, and therefore, the refrigerant flows into the first evaporator 14 by operation of the selection valve 24 and the damper plate 22 closes the hole 21. Control of the selection valve 24 and damper plate 22 are by a thermostat (not shown).

The second blower fan 20 is also driven at that time, so that air in the compartment 11 is circulated within the compartment 11 and passes through the first and second evaporators 14, 17 (this circulation is indicated by arrow A in Figure 1). On the other hand, the refrigerant is compressed by compressor 231 and discharged into the condenser 232, and passed through the first evaporator 14 and accumulator 233 back to the suction side of the compressor 231. Thus, the compartment 11 is refrigerated by the air

passed through the first evaporator 14.

During the refrigerating operation, if the temperature in the compartment 11 is below the predetermined temperature (as indicated by t_1 in Figure 3), the selection valve 24 is moved to change the flow way of the refrigerant and the damper plate 22 opens the hole 21 to provide communication between the outside and the air passageway 18. The movement of the second blower fan 20 is also stopped, as indicated in Figure 3. At that time, the damper plate 22 blocks communication between the interior of the compartment 11 and the suction end of the air passageway 18. Thus, the air in the compartment 11 is only passed through the first evaporator 14 by operation of the first blower fan 15 the refrigerant of the refrigeration unit 23 flows through the second evaporator 17. In this condition, since flow of the refrigerant in the first evaporator is intercepted, the vapour in the compartment 11 which has been condensed by the first evaporator 14 is evaporated again, and as a result of this evaporation, the humidity in the compartment 11 is increased. On the other hand, since the refrigerant flows through the second evaporator 17, the air in the air passageway 18 is refrigerated by heat exchange with the second evaporator 17, and, as a result of the refrigeration, the partial vapour pressure of the air is reduced by condensation of vapour. The vapour pressure of the outside air is relatively higher than that air in the air passageway, and outside air flows into the air passageway 18 through the hole 21 (this flow of air is indicated by dotted line arrow B). The vapour in the air is thus condensed and frosts on the second evaporator 17.

When the operation of the refrigerating unit stops, the temperature in the compartment 11 is

gradually raised and finally exceeds the predetermined temperature, (this time is indicated by t_2 in Figure 3). At that time, the air circulation in the compartment 11 and the refrigerant flow way returns to the initial stage as at time t_0 and the refrigerating operation starts again. However, since frost on the second evaporator 17 is melted, the air passing through the second evaporator 17 is humidified, even if the air passing through the first evaporator 14 is dried by condensation of vapour in the air.

As shown in Figure 3, the above operating cycle is repeated in dependence on the temperature in the compartment 11, and continued until the driving circuit is deenergized. Therefore, the humidity of air circulated in the compartment 11 is maintained by operation of the second evaporator 17.

In the above example, forced convection is used. However, natural convection is an alternative.

Figure 4 illustrates another refrigerated display cabinet wherein parts of the apparatus, which are similar to the parts of the apparatus shown in Figure 1, are indicated by the same reference numeral. In this example the air passageway defined between the bottom plate 19 and the inner surface of the lower panel 112 is horizontally divided by a separating plate 29 to form a first air passageway 30 and a second air passageway 31. Each of the passageways 30, 31 communicates with the storage/display compartment 11 through front air gaps 32a, 32b, respectively, and rear air gaps 33a, 33b, respectively, formed at the front and rear of the bottom plate 19.

A first evaporator 14' and a first blower fan 15' are located in the first air passageway 30, and a second evaporator 17' and a second blower fan 20' are located in the second air passageway 31.

Furthermore, the suction end of the second air passageway 31 is connected with the outside of the cabinet 1 through an inlet hole 21, and a damper plate 27 is located in the passageway 31 to control opening and closing of the hole 21. When the damper plate 27 is positioned to open the hole 21, communication between the interior of the compartment 11 and the suction end of the second air passageway 31 is blocked by the damper plate 27. A dust protective filter 35 may be disposed in the hole 22 to prevent the ingress of air-entrained dust. The operation of the refrigerating unit, and of the blower fans and damper plate are as in the first example.

Thus, upon the operation of the first blower fan 15', air in the storage/display compartment 11 is withdrawn into the first air passageway 30 through the front air gap 32a be cooled by heat exchange with the first evaporator 14', and refrigerated air is returned into the compartment 11 through the rear air gap 33a. The second blower fan 20', causes the air in the storage/display compartment 11 to be withdrawn into the second air passageway 31 through the front air gap 32b, passed through the second evaporator 17' and returned into the compartment 11 through the rear air gap 32b. Thus, the storage/display compartment 11 is refrigerated by the first evaporator 14'.

When the temperature in the compartment 11 is below the predetermined temperature, the refrigerant flows into the second evaporator 17' and the damper plate 27 is moved to open the hole 21 to allow outside air into the suction end of the second air passageway 31. The second blower fan 20' is stopped and the first blower fan 15' is still driven. Therefore, the air in the compartment 11 is withdrawn into the first air passageway 31, and passed through the first evaporator 14', air being prevented from circulating through the second air passageway 32 from

the compartment by the damper plate 27..

At that time, since flow of refrigerant through the first evaporator 14' is interrupted, frost on the first evaporator 14' is melted and humidifies the air passing through the first evaporator 14'. Therefore, humidity in the storage/display compartment 11 is increased. On the other hand, since the second evaporator 17' is refrigerated, vapour in the outside air, entering the suction end of the second air passageway 32 through the hole 21, is condensed and frosts on the second evaporator 17'.

If the temperature in the storage/display compartment 11 exceeds the predetermined temperature, the air circulation within the storage/display compartment 11 and the flow of the refrigerant are returned to the initial stage, and again, the refrigeration unit restarts the refrigerating operation in the compartment 11. At that time, the air passing through the second evaporator 17' is humidified by water melting off the second evaporator 17'. A humidifying operation from frost on either evaporator is thus continued throughout operation of the refrigerating unit.

Figure 5 shows a modification of the example shown in Figure 4, wherein a further outlet hole 36 is formed through the lower panel 12 to connect the outside of the display cabinet 1 and the discharge end of the second air passageway 31, and a second damper plate 37 disposed in the passageway 31 controls the opening and closing of the second hole 36. When the damper plate 37 is positioned away from hole 36, communication between the discharge end of the second air passageway 31 and the interior of the storage/display compartment 11 is blocked by the damper plate 37 to allow outside air to circulate. The movement of both damper plates 27 and 36 is synchronized with one another, and drive of the second

blower fan 20' is independent of the movement of the damper plates 27, 36. That is, when one of the damper plates closes its hole; the other damper plate also closes its hole, and even if the holes are closed, the second blower fan 20' is still driven to cause air circulation through the second evaporator 17'. Upon opening of both holes 21 and 26, the ambient air is introduced into the second air passageway 31 and discharged to the outside of the cabinet 1 owing to operation of the second blower fan 20'. During the circulation of ambient air, vapour contained in the ambient air is condensed and frosts on the evaporator 17'. Therefore, the condensating efficiency of the second evaporator is improved.

Figures 6-10 shows a further example which relates to a modification in the location of the second evaporator to improve space factors. As clearly shown in Figure 10, the lower panel 112 has a extended space 40 which is covered by an insulating wall element 401 extending into the working compartment 12. The first evaporator 14" and first blower fan 15" are located in the first air passageway 30' to enable circulation of the air in the storage/display compartment 11 through the front opening 32a and the rear opening 33a. Since, the extended space 40 is formed integrally with the lower panel 112 and separated from the compartment 11, the second air passageway 31' which is divided from the first air passageway 30' by the separating plate 29 and comprises a front opening 32b, a suction duct 311 interconnecting the front opening 32b and a suction hole 311a of the extended space 40, a discharge duct 312 interconnecting a discharge hole 312a of the extended space 40 and the compartment 11, and a rear opening 33b, provides communication between the extended space 40 and the compartment 11. The second evaporator 17" is disposed in the extended space 40 vertically across the air flow. The second blower

fan 20" may be disposed in the extended space 40 to accomplish the forced convection. The interior of the extended space 40, particularly the suction end of the extended space 40, is connected to the exterior of the cabinet 1 through the hole 21, passage through which is controlled by a damper plate 27, as above described with reference to Figures 1, 4 or 5.

In operation, when the refrigerating unit is started up, the refrigerant flows into the first evaporator 14", and the first and second blower fans 15", 20" are driven. Therefore, air in the compartment 11 is drawn into the first air passageway 301 for heat exchange with the first evaporator 14". Thus, the air in the compartment 11 is refrigerated by the first evaporator 14". As that time, the air passed through the first evaporator 14" is dried owing to condensation of vapour in the air. On the other hand, the second blower fan 20" is also driven, so that air in compartment 11 passes through second air passageway 31' and extended space 40.

When the temperature in the storage/display compartment 11 is cooled down below the predetermined temperature, the flow of refrigerant is changed to flow into the second evaporator 17" and the second blower fan 20" is stopped. However, the first blower fan 15" continues to operate and air in the compartment 11 is passed through the first evaporator 14" via the first air passageway 30'. Since, frost on the evaporator is melted to become water, the air passed through the first evaporator 14" is humidified. On the other hand, the hole 21 is opened by the operation of damper plate 27, thus during the cooling of air in the extended space 40, the outside air flows into the space 40 and vapour in the air frosts on the second evaporator 17".

If the temperature in the storage/display

28

compartment 11 exceeds the predetermined temperature, the cycle recommences. At that time, the frost on the second evaporator is melted, and air passed through the second evaporator 17" is humidified by the melted frost. Therefore, humidity of the air in storage/display compartment 11 is kept to the required degree.

5
10

15

20

25

30

35

29



- 13 -

CLAIMS

1. A refrigerated storage cabinet having a storage compartment for merchandise, and provided with a refrigeration unit for cooling the compartment, the unit comprising a compressor, a condenser and two evaporators, wherein the two evaporators are connected in parallel so that refrigerant selectively flows into one or the other of the evaporators, one of the two evaporators being disposed in the compartment for cooling the air in the compartment, and other evaporator being disposed in an air duct which can be connected to the exterior of the cabinet for condensing water vapour from ambient air or to the compartment for circulation into the compartment of air which has been humidified by previously condensed water.

2. A cabinet according to claim 1, wherein the connection between the air duct and the exterior of the cabinet is controlled by a damper plate.

3. A cabinet according to claim 1 or claim 2, wherein a dust protective filter is disposed in an ambient air inlet to the air duct.

4. A cabinet according to any one of the preceding claims, wherein the air duct can be connected to the exterior of the cabinet via an inlet at one end of the duct and an outlet at the other end of the duct, both the inlet and outlet being closable by damper plates.

5. A cabinet according to any one of the preceding claims, wherein the one evaporator is disposed at a top portion of the compartment and the other



evaporator is disposed at a bottom portion of the compartment.

5 6. A cabinet according to any one of claims 1 to 4, wherein the two evaporators are disposed at a bottom portion of the compartment, air flow through the evaporators being divided by a separator plate.

10 7. A cabinet according to any one of claims 1 to 4, wherein the one evaporator is disposed at a bottom portion of the storage compartment and the other evaporator is disposed in another compartment below the storage compartment.

15 8. A refrigerated storage cabinet, substantially as described with reference to the any one of the examples illustrated in the accompanying drawings.

20

25

30

35