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(57) **ABSTRACT**

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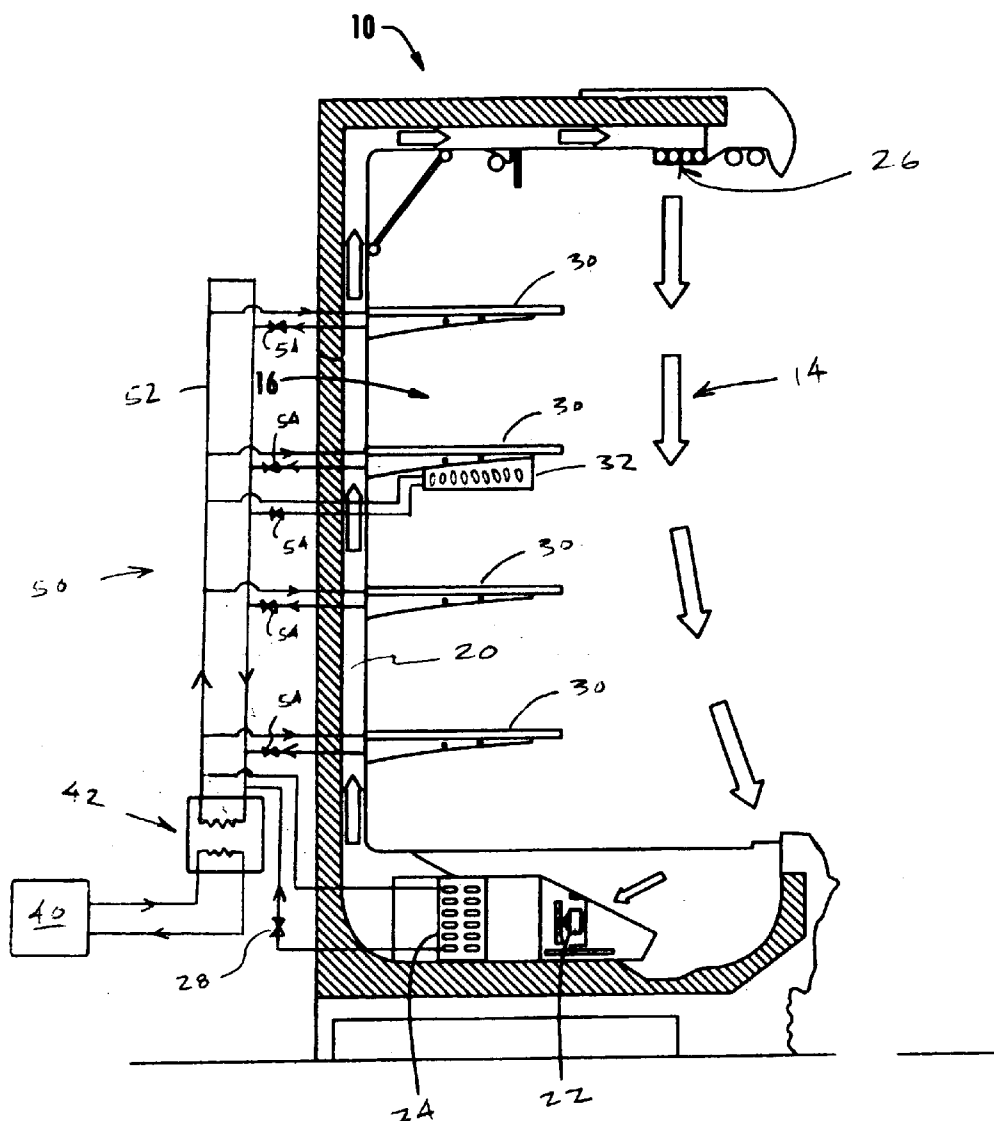
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An open-front refrigerated case with reduced frost operation includes a housing having an open front and defining a product storage space therein. An air flow device is operatively coupled to an air flow path to direct a flow of air over a dehumidification coil for discharge as a dehumidified air curtain over the open front. The dehumidification coil operates substantially frost-free at a temperature of greater than 32° F. A contact cooling device and/or a gravity cooling device is disposed within the space and arranged to receive a coolant from a coolant system, where the dehumidified air curtain operates as a humidity tempering boundary to minimize the humidity within the storage space, so that the case operates in a substantially frost-free manner.



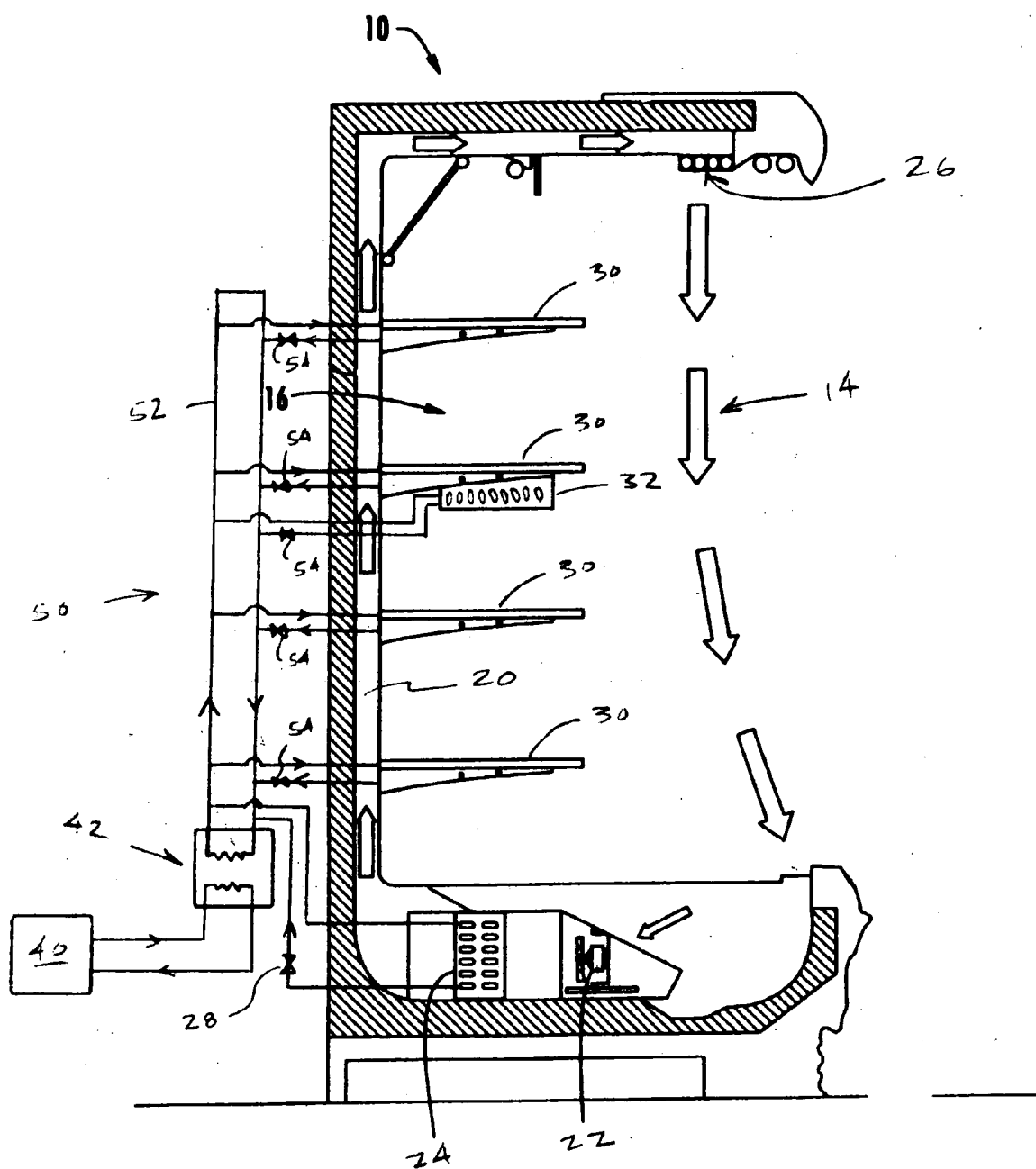


FIG. 1

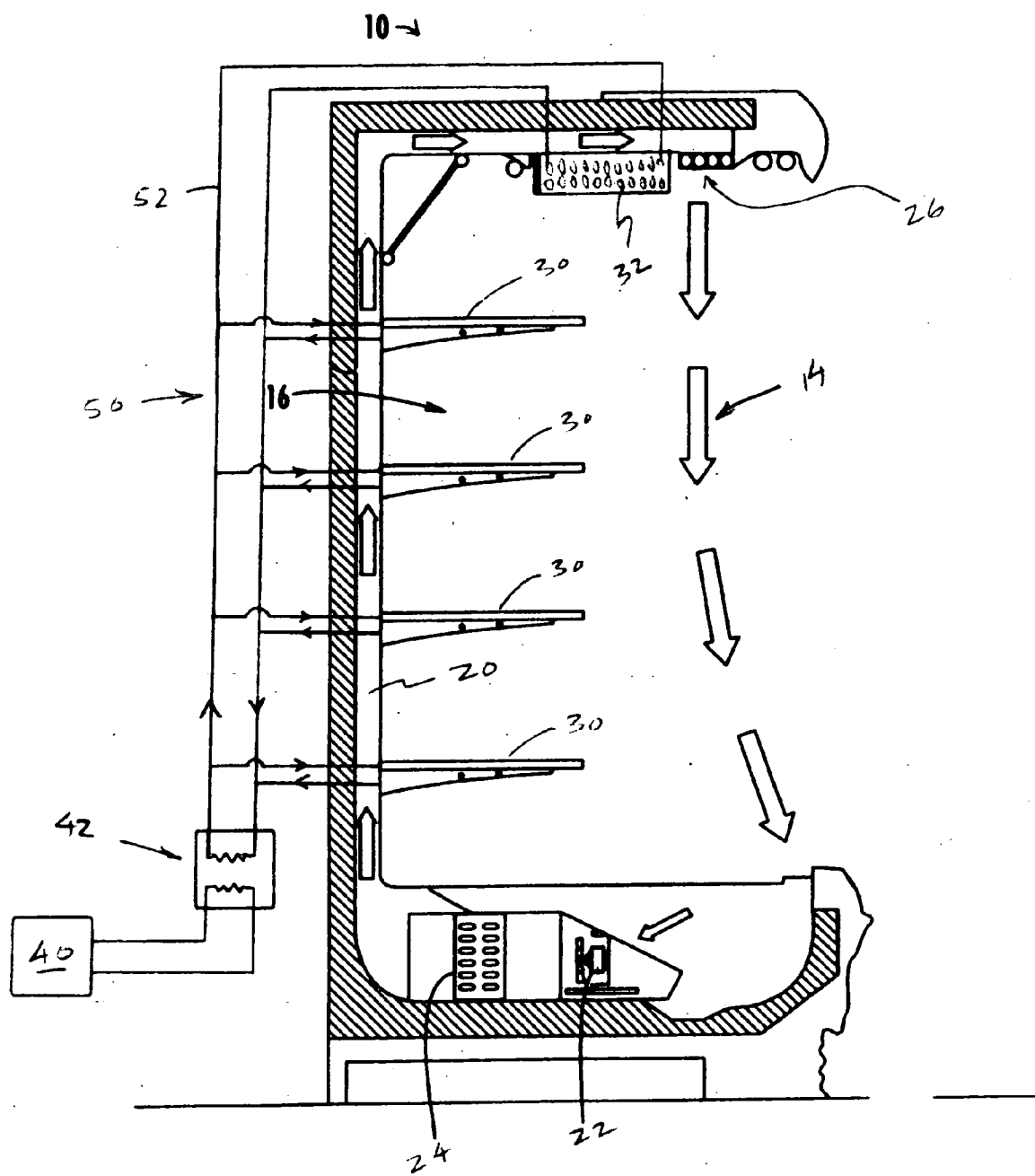


FIG. 3

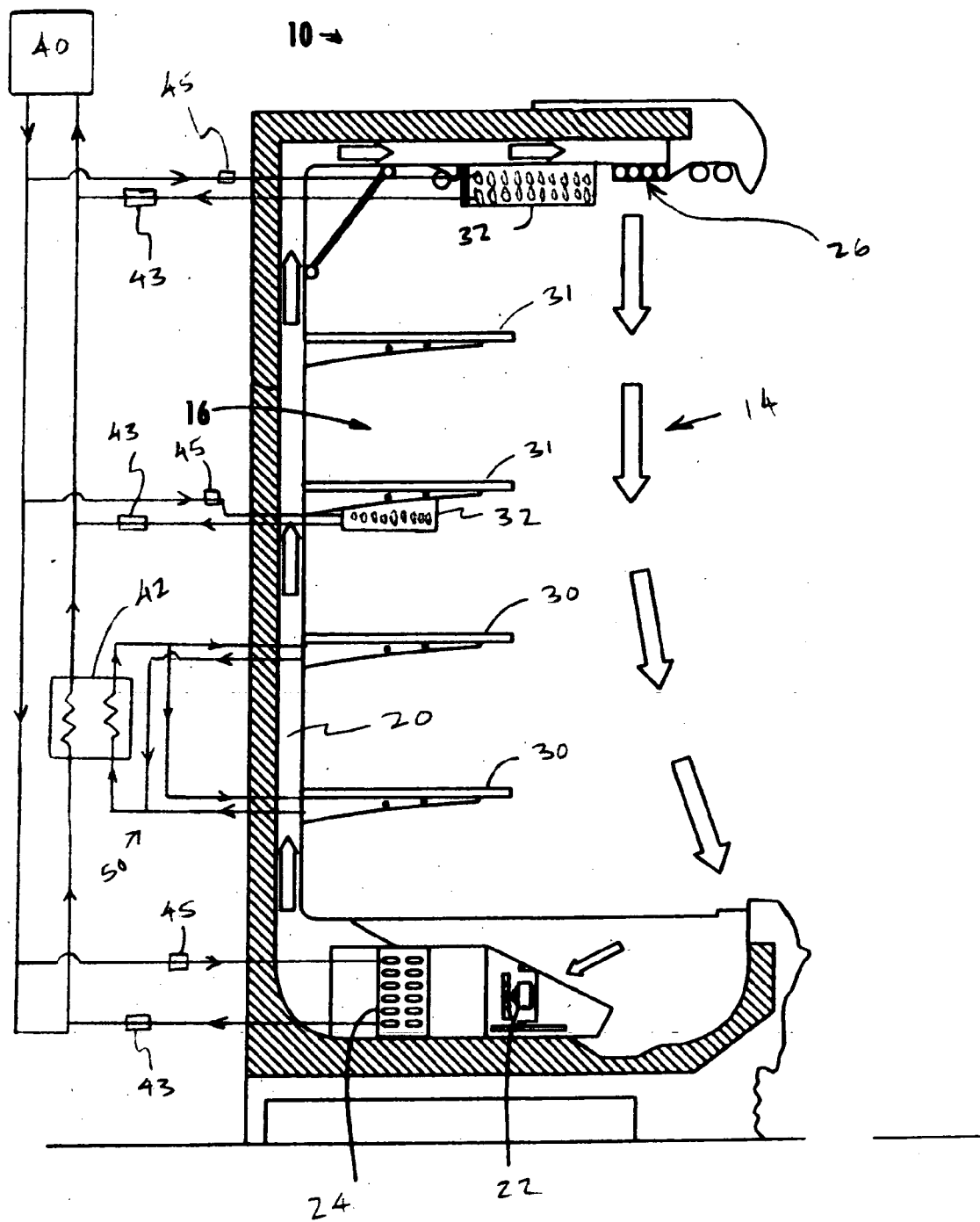


FIG. 4

REFRIGERATED CASE WITH LOW FROST OPERATION

BACKGROUND

[0001] The present invention relates to an open-front refrigerated case. The present invention more specifically relates to an open-front refrigerated display case having chilled shelves and/or a gravity cooling coil. The present invention more specifically relates to an open-front refrigerated display case having chilled shelves and/or a gravity cooling coil, and an air curtain dehumidified by a dehumidifying coil operating above 32° F. that prevents frost formation on the dehumidifying coil and provides a low humidity boundary to minimize frost formation on the chilled shelves and/or gravity cooling coil.

[0002] It is known to provide for a refrigerated case for storage and presentation of food products (such as perishable meat, dairy, seafood, produce, etc.). Such known refrigerated cases may include those of a type typically having an open front to permit consumers to reach in and select products from shelves within the case (e.g. "self service" type cases, etc.). Open-front refrigerated cases often have a main cooling coil operating at a temperature below 32° F. to chill air that is distributed by a fan through ducts. The chilled air is blown into the product storage space of the case for cooling the products, and downwardly from a discharge along a top front portion of the case to provide an "air curtain" extending across the front of the case. The air curtain is intended to form an "invisible thermal boundary" between the chilled product storage space within the case and the warmer ambient air surrounding a front of the case. The invisible thermal boundary of the air curtain is intended to minimize "mixing" of surrounding ambient-temperature air with the chilled air within the storage space of the case and behind the air-curtain. However, the operation of the main cooling coil at a temperature below 32° F. tends to result in frost buildup on the cooling coil over time as moisture in the air condenses and freezes on the surfaces of the cooling coil, resulting in diminished performance of the coil and increased energy consumption.

[0003] It is also known to provide refrigerated cases with chilled shelves or pans to provide contact cooling for food products stored and displayed on the shelves. Such cases are typically service-type cases that are normally "closed" and provide access through doors or the like to minimize the amount of moisture accumulation within the storage space. However, such chilled pans also tend to accumulate frost over time as moisture in the air space within the case (and from the ambient air when doors to the case are opened) and from the food products condenses and freezes on the chilled shelves.

[0004] It is also known to provide refrigerated cases with gravity-type cooling coils located in a top portion of the case. Such cases are also typically service-type cases that are normally "closed" and provide access through doors or the like to minimize the amount of moisture accumulation within the storage space, and to permit a natural circulation of air within the space as cooled air from the gravity coil falls and warm air from the products rises. However, such gravity type cooling coils also tend to accumulate frost over time as moisture in the air space within the case (and from the ambient air when doors to the case are opened) and from the food products condenses and freezes on the surfaces of the cooling coils.

[0005] Accordingly, it would be desirable to provide a refrigerated display case of the open-front type that combines the advantages of contact cooling of food products provided by chilled shelves and the advantages of the humidity control provided by an air curtain, in a way that minimizes or eliminates the accumulation of frost on the chilled surfaces (e.g. shelves, air curtain dehumidifying coil, etc.) of the refrigerated case. It would be desirable to provide a refrigerated display case of the open-front type that combines the advantages of cooling of food products provided by gravity-type cooling coils and the advantages of the humidity control provided by an air curtain, in a way that minimizes or eliminates the accumulation of frost on the chilled surfaces (e.g. gravity cooling coil, air curtain dehumidifying coil, etc.) of the refrigerated case. It would also be desirable to provide a refrigerated display case having a gravity coil and refrigerated shelves operating below 32° F. for cooling the products in the storage area and an air curtain dehumidified by an air curtain dehumidifying coil operating at above 32° F., so that the air curtain cooling coil does not accumulate frost and the air curtain is sufficiently cool and dry to temper or maintain a low humidity environment within the storage space to minimize or eliminate frost accumulation on the chilled shelves or the gravity coil.

[0006] Accordingly, it would be desirable to provide a refrigerated display case having any one or more of these or other advantageous features.

SUMMARY

[0007] The present invention relates to an open-front refrigerated case with reduced frost operation. The case includes a product storage space and at least one chilled shelf within the storage space. A cooling system provides a coolant for circulation through the chilled shelf. An air curtain dehumidifying coil operating at a temperature above 32° F. is provided to dehumidify a flow of air that is discharged downwardly in the form of an air curtain across a front opening of the case to minimize a humidity level within the storage space.

[0008] The present invention also relates to an open-front refrigerated display case with reduced frost operation. The case includes a product storage space and a gravity cooling coil disposed in a top portion of the storage space. A cooling system provides a coolant for circulation through the gravity cooling coil. An air curtain dehumidifying coil operating at a temperature above 32° F. is provided to dehumidify a flow of air that is discharged downwardly in the form of an air curtain across a front opening of the case to minimize a humidity level within the storage space.

[0009] The present invention further relates to an open-front refrigerated case with reduced frost operation. The case includes a product storage space and at least one chilled shelf within the storage space and a gravity cooling coil disposed within a top portion of the storage space. A cooling system provides a coolant for circulation through the chilled shelf and the gravity cooling coil. An air curtain dehumidifying coil operating at a temperature above 32° F. is provided to dehumidify a flow of air that is discharged down-

wardly in the form of an air curtain across a front opening of the case to minimize a humidity level within the storage space.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a schematic representation of a side elevation view of a refrigerated case having chilled shelves within a storage space and an air curtain dehumidified by an air curtain dehumidifying coil operating above 32° F. according to one exemplary embodiment.

[0011] FIG. 2 is a schematic representation of a side elevation view of a refrigerated case having a gravity cooling coil disposed within a top portion of a storage space and an air curtain dehumidified by an air curtain dehumidifying coil operating above 32° F. according to another exemplary embodiment.

[0012] FIG. 3 is a schematic representation of a side elevation view of a refrigerated case having chilled shelves within a storage space, and a gravity cooling coil disposed within a top portion of the storage space, and an air curtain dehumidified by an air curtain dehumidifying coil operating above 32° F. according to another exemplary embodiment.

[0013] FIG. 4 is a schematic representation of a side elevation view of a refrigerated case having chilled shelves within a storage space, and a gravity cooling coil disposed within a top portion of the storage space, and an air curtain dehumidified by an air curtain dehumidifying coil operating above 32° F. according to a further exemplary embodiment.

DETAILED DESCRIPTION

[0014] Referring to the FIGURES, a front-loading refrigerated case 10 of the open-front type having a storage space 16 for display of chilled (e.g. refrigerated, frozen, etc.) products is shown according to an exemplary embodiment. The case 10 is shown to include an air curtain 14 (e.g. air stream, etc.) formed from a flow of air that is dehumidified by an air curtain dehumidifying coil 24. Unlike conventional air curtains that function to provide primarily a thermal boundary to separate the low temperature interior product storage space of the case from a warmer external ambient environment surrounding the case (e.g. supermarket atmosphere, etc.), the air curtain of the illustrated embodiments is operated at an increased temperature and functions primarily as a humidity tempering device to maintain a low humidity level within the storage space. The dehumidified air curtain may also provide a secondary benefit of serving, at least to some degree, as a thermal boundary too. The low temperature of the food products within the storage space is maintained primarily by contact cooling from chilled shelves and/or the cooling effects from the circulation of air from a gravity cooling coil disposed above the shelves. The operation of the air curtain at an increased temperature (in relation to conventional open-front refrigerated case air curtains) is intended to prevent frost accumulation on the air curtain dehumidifying coil, while also providing sufficient dehumidification to the air curtain to maintain the product storage space at low humidity to minimize or eliminate frost accumulation on the chilled shelves and/or gravity cooling coil(s). The combination of the dehumidification provided by the relatively “warmer” air curtain and air curtain dehumidifying coil, with the chilled shelves and/or gravity cooling coil to maintain the temperature of the products in the

storage space, is believed to provide a relatively “frost-free” or reduced-frost refrigerated case of the open-front type.

[0015] Referring to FIGS. 1-4, the operation of the humidity-tempering air curtain 14 is shown according to an exemplary embodiment. The case 10 is shown to include an air curtain flow path 20 having an airflow device (shown as a fan 22) and a dehumidification device 24 (shown as the air curtain dehumidifying coil, but may also be a desiccant wheel or other dehumidification device) for dehumidifying a flow of air that is drawn in through a front portion of the case, and discharged from an exit opening 26 shown along a top front portion of the case. The air curtain dehumidifying coil 24 is shown located in a bottom portion of the case adjacent to fan 22 and receives a source of coolant from either a primary cooling system 40 (as shown for example in FIG. 4) or a secondary cooling system 50 (shown for example in FIG. 1). According to an alternative embodiment, the dehumidifying device may be located at another suitable location, such as within a rear portion of the case housing, including for example, within air flow passage 20).

[0016] Unlike conventional open-front refrigerated cases that use a common cooling coil to chill an air curtain (to provide a thermal boundary across the open front) and to provide chilled air for cooling the storage space and the products stored therein, the dehumidified air curtain 14 operates primarily as a humidity boundary and not as the primary source of cooling for the storage space 16 and the products contained therein. Thus, the temperature of the air curtain may be operated at a temperature that is higher than the air curtains of conventional open-front cases. For the embodiments where the dehumidification device is provided as a coil, the dehumidifying coil 24 may receive a supply of coolant from any suitable source.

[0017] As shown for example in the embodiment of FIG. 1, the coil 24 receives a supply of a liquid coolant from a secondary liquid coolant system 50, where the temperature of the coolant may be controlled by a chiller 42 that interfaces with the primary refrigeration system 40. The chiller may be controlled for operation of one case, or for a plurality of cases having similar operating temperature requirements. According to the embodiment shown in FIG. 1, the flow of liquid coolant through the coil 24 may be controlled (e.g. “pulsed” on an open-closed manner or modulated in a variable position manner) by a flow regulating device 28 (e.g. valve, etc.) to adjust the rate of liquid coolant flow through the coil 24. The operation and position of valve 28 may be controlled by any suitable control system in response to suitable parameters, such as a signal representative of the temperature of the coil 24, a signal representative of the humidity of the air curtain 14, a signal representative of the humidity within the storage space 16, etc. Suitable instrumentation of a conventional type for providing such signals (e.g. thermocouples, RTDs, humidity sensors, etc.) may be provided at appropriate location and arranged to provide a signal to a programmable control device such as a microprocessor to provide the appropriate output signal to the valve 28. All such operating and control schemes are intended to be within the scope of the embodiments described herein.

[0018] As shown by way of example in FIG. 4, the coil may alternatively receive a supply of refrigerant coolant from the primary refrigeration system 40, which may also include an electronic pressure regulator 45 or a superheat control valve 43 of a conventional type to control the

temperature of the refrigerant coolant within the coil 24. The primary refrigeration system 40 and the secondary liquid coolant system 50 may be configured in any suitable arrangement to provide the desired dehumidification performance for the air curtain and the desired temperature control for the shelves and gravity cooling coils. As shown by way of example in FIG. 4, the primary refrigeration system may be configured to supply a refrigerant coolant to the gravity cooling coils 32 and to the dehumidification coil 24, while the secondary liquid coolant system may be configured to provide cooling to shelves 30. All suitable combinations of the coils, shelves and coolant supply systems are intended to be within the scope of the embodiments.

[0019] According to the present embodiments, the temperature and flow rate of the coolant through the air curtain dehumidifying coil 24 is regulated so that the dehumidifying coil 24 operates at a temperature above freezing (i.e. 32° F.) so that moisture from the flow of air that condenses on the coil 24 remains in a liquid state and is routed to a suitable receptacle (e.g. drip pan, etc.) or drain (not shown), and does not freeze on the surface of the dehumidifying coil 24. Operation of the dehumidifying coil 24 at a temperature above freezing is intended to prevent frost accumulation on the surface of the air curtain dehumidifying coil 24. The dehumidification of the air curtain 14 is intended to maintain a low humidity level within the storage space 16 by tempering the surrounding ambient air and humidity with a dehumidified layer of air. The air curtain dehumidifying coil 24 dehumidifies the flow of air used in the air curtain 14 to maintain a low humidity level within the storage space 16. The low humidity level within the space 16 permits the use of low temperature cooling devices such as (for example) chilled shelves and/or gravity coil(s) to cool the food products, in a manner intended to minimize or eliminate the accumulation of frost on the surfaces of the shelves or gravity coil(s).

[0020] According to another embodiment, the dehumidification device may be non-coolant based and provided as a liquid desiccant, desiccant wheel, or the like, where the dehumidification coil and the supply of a coolant thereto are omitted. The dehumidification device (such as a desiccant wheel) may be arranged within a bottom or rear portion or top portion of the case housing for simple and convenient replacement.

[0021] Referring to FIG. 1, case 10 is also shown to include chilled (refrigerated, cooled, etc.) shelves 30 mounted within the space 16 and arranged to receive chilled products for storage and display. The chilled shelves 30 receive a supply of coolant for chilling the shelves. The coolant may be circulated through channels or passages formed within the shelves, or may be circulated through tubing or coils contacting (or integrated with) an underside of the shelf. As shown in the illustrated embodiment of FIG. 1, the coolant may be a chilled liquid coolant, such as a glycol-based fluid, provided by a secondary liquid cooling system 50 that circulates the coolant in a secondary cooling loop 52 to the shelves 30 and to a heat exchange device shown as a chiller 42. Chiller 42 is shown to interface with a "primary" cooling system 40, such as a refrigeration system (e.g. a direct expansion or vapor-compression type refrigeration system, etc.) that operates to chill the coolant circulating in the secondary cooling loop 52. The primary cooling system and the secondary cooling system may be provided in any one of multiple combinations for use with

the case (or multiple cases) in a facility. For example, the secondary cooling system may be a local system provided at the particular case location and interfaces with a centrally located primary refrigeration system configured to interface with multiple cases. Also, the secondary cooling system may be provided as a centralized system that supplies coolant to multiple cases within a facility (such as a supermarket, etc.) and is chilled by a single, remotely located primary refrigeration system. According to an alternative embodiment, the coolant may be provided directly by a single refrigeration system and a "secondary" cooling system may be omitted.

[0022] The coolant is provided at a temperature sufficient to permit the chilled shelves 30 to provide a desired amount of contact cooling to food products (or the like) disposed on the shelves. According to one embodiment, the temperature range of the coolant provided to the shelves 30 is below freezing, for example, within a range of approximately 20° F.-32° F. Alternatively, the temperature range of the coolant provided to the shelves may be above freezing, for example, within a range of approximately 32° F.-38° F. However, the coolant may be provided at any suitable temperature that is appropriate to maintain the desired temperature of the products disposed on the shelves within the storage space. The relatively low humidity level in the case is intended to allow the shelves to operate below freezing without accumulating excessive amounts of frost on the surfaces of the shelves.

[0023] Referring to FIG. 2, case 10 is also shown to include a gravity cooling coil 32 disposed within a top portion of the storage space 16 and arranged to receive a supply of coolant to provide cooling to the products on conventional shelves 31 located beneath the gravity coil 32. A single gravity coil 32 may be provided at a top portion of the storage space (as shown) or multiple gravity coils may be provided (e.g. one mounted beneath each shelf, etc.). As shown in the illustrated embodiment of FIG. 2, the coolant may be a chilled liquid coolant, such as a glycol-based fluid, provided by the secondary cooling system 50 that circulates the coolant in secondary cooling loop 52 to the gravity coil(s) 32 and to the chiller 42. According to an alternative embodiment, the coolant for the gravity coil(s) may be provided directly by a refrigeration system and a secondary cooling system may be omitted.

[0024] The coolant is provided at a temperature sufficient to permit the gravity coil(s) 32 to provide a desired amount of cooling to the food products (or the like) disposed on the shelves 31. According to one embodiment, the temperature range of the coolant provided to the gravity coil(s) 32 is below freezing, for example, within a range of approximately 20° F.-32° F. Alternatively, the temperature range of the coolant provided to the gravity coil(s) may be above freezing, for example, within a range of approximately 32° F.-38° F. However, the coolant may be provided at any suitable temperature that is appropriate to maintain the desired temperature of the products within the storage space. The relatively low humidity level in the case is intended to allow the gravity coils 32 to operate below freezing without accumulating excessive amounts of frost.

[0025] Referring to FIG. 3, case 10 is shown to include both chilled shelves 30 and a gravity cooling coil 32 disposed within a top portion of the storage space 16, where the shelves 30 and the gravity coil(s) 32 are arranged to receive a supply of coolant to provide cooling to the products on the shelves 30 located beneath the gravity coil(s) 32. As shown in the illustrated embodiment of FIG. 3, the

coolant may be a chilled liquid coolant, such as a glycol-based fluid, provided by the secondary cooling system 50 that circulates the coolant in a secondary cooling loop 52 to the chilled shelves 30 and the gravity coil(s) 32 and to the chiller 42. According to an alternative embodiment, the coolant for the chilled shelves and the gravity coil(s) may be provided directly by a refrigeration system and a secondary cooling system may be omitted.

[0026] Referring further to FIG. 1 by way of example, the coolant is provided at a temperature sufficient to permit the combination of the chilled shelves 30 and the gravity coil(s) 32 to provide a desired amount of cooling to the food products (or the like) disposed on the shelves. The shelves and the gravity coils may have separate flow regulation or temperature control devices (shown schematically as valves 54) intended to permit the shelves and the gravity coil(s) to operate at different temperatures or coolant flow rates, so that a product cooling profile within the storage space of the case can be customized to suit products having different temperature storage requirements. The coolant may be provided at any suitable temperature and flow rate that is appropriate to maintain the desired temperature of the products within the storage space. The relatively low humidity level in the case is intended to allow the chilled shelves and the gravity coil(s) to operate below freezing without accumulating excessive amounts of frost. The valves 54 may be operated in any suitable manner, such as "open-closed" or "variable position modulation" to maintain a desired temperature on each shelf and/or cooling coil. The operation and control of valves 54 and thus temperature of the shelves 30 and coils 32, may be provided by any suitable control system, such as temperature sensors on the shelves and/or coils providing signals representative of temperature to a programmable control device operable to provide output signals to control position of the valves 54 to maintain a desired temperature at each shelf and/or gravity cooling coil.

[0027] According to any exemplary embodiment, an open-front type refrigerated display case is provided that is intended to operate in a relatively frost-free manner in comparison to conventional open-front refrigerated cases. The case of the illustrated embodiments uses a dehumidification device such as a coil operating at a temperature above freezing (to prevent frosting of the coil) to dehumidify a flow of air for use in an air curtain, where the air curtain functions as a humidity tempering device to maintain a relatively low humidity level within the storage space, while chilled shelves and/or gravity cooling coil(s) are provided within the storage space to maintain the desired temperature of food products stored within the space. The dehumidified air curtain is intended to permit operation of the chilled shelves and/or gravity cooling coil(s) in a relatively frost-free manner, by providing a humidity boundary that minimizes the level of moisture in the air space proximate the shelves and/or gravity cooling coil(s). Accordingly, the unique combination of an air curtain dehumidified by a coil operating at a temperature above freezing, and contact or gravity cooling elements within the storage space to cool the products has resulted in an open-front type refrigerated display case that is believed to operate in a manner that substantially reduces the need for defrosting of the cooling surfaces of the case.

[0028] According to any alternative embodiment, other types cooling or dehumidifying devices or technology may be used to permit operation of the case in a manner that reduces the humidity in the vicinity of cooling surfaces that

operate at a temperature below freezing. Accordingly all such types of cooling and/or dehumidification technology is intended to be within the scope of the disclosure.

[0029] It is also important to note that the construction and arrangement of the elements of the refrigerated case with reduced frost operation as shown in the preferred and other exemplary embodiments is illustrative only. Although only a few embodiments of the present inventions have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited. For example, elements shown as integrally formed may be constructed of multiple parts or elements, the plenum and its inlets, outlets, and airflow devices may be arranged in any suitable manner or otherwise varied to take advantage of the dehumidified air curtain and the cooling elements within the storage space. The length or width of the structures and/or members or connectors or other elements of the case may be varied. It should be noted that the elements and/or assemblies of the refrigerated case may be constructed from any of a wide variety of materials that provide sufficient strength or durability, in any of a wide variety of colors, textures and combinations. Accordingly, all such modifications are intended to be included within the scope of the appended claims. Other substitutions, modifications, changes and omissions may be made in the design, operating conditions and arrangement of the preferred and other exemplary embodiments without departing from the spirit of the appended claims.

[0030] The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. Any means-plus-function clause is intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Other substitutions, modifications, changes and omissions may be made in the design, operating configuration and arrangement of the preferred and other exemplary embodiments without departing from the spirit of the appended claims.

What is claimed is:

1. An open-front refrigerated case with reduced frost operation, comprising:

a housing having an open front and defining a product storage space therein;

an air flow device operatively coupled to an air flow path to direct a flow of air over a dehumidification coil for discharge as a dehumidified air curtain over the open front, the dehumidification coil operating substantially frost-free at a temperature of greater than 32° F.;

at least one of a contact cooling device and a gravity cooling device disposed within the space and arranged to receive a coolant from a coolant system;

wherein the dehumidified air curtain operates as a humidity tempering boundary to minimize the humidity within the storage space.

2. The case of claim 1 wherein the coolant system comprises a refrigeration system and the coolant is a refrigerant.

3. The case of claim 1 wherein the coolant system comprises a secondary liquid coolant system.

4. The case of claim 3 wherein the secondary liquid coolant system interfaces with a primary refrigeration system through a chiller.

5. The case of claim 4 wherein the chiller is contained within the housing.

6. The case of claim 1 wherein the chiller is a centrally located chiller operable for use with a plurality of cases in a facility.

7. A refrigerated display case comprising:

a housing having an open front and defining a space adapted to receive products;

a dehumidification device operating at a temperature greater than 32° F.;

an air flow device operable to direct a flow of air over the dehumidification device and for discharge over the open front as a dehumidified air curtain;

at least one shelf arranged to receive a flow of a coolant to provide contact cooling to the products;

a cooling system providing coolant to the shelf;

wherein the dehumidification device operates above freezing in a substantially frost-free manner and the dehumidified air curtain maintains a low humidity environment proximate the shelf so that the shelf operates in a substantially frost-free manner.

8. The refrigerated display case of claim 7 wherein the air flow device comprises a fan, and the fan and dehumidification coil are located in a plenum formed by the housing.

9. The refrigerated display case of claim 7 wherein the coolant comprises a refrigerant.

10. The refrigerated display case of claim 7 wherein the shelf comprises a plurality of shelves oriented in a vertically stacked arrangement.

11. The refrigerated display case of claim 10 wherein the coolant comprises a liquid coolant provided by a secondary cooling system that interfaces with a primary cooling system through a heat exchanger.

12. The refrigerated display case of claim 11 wherein the secondary coolant system comprises at least one flow regulation device operable to maintain a first shelf at a first temperature and a second shelf at a second temperature.

13. The refrigerated display case of claim 7 further comprising a gravity cooling coil disposed in a top portion of the space.

14. The refrigerated display case of claim 7 further comprising a gravity cooling coil disposed directly beneath the shelf.

15. The refrigerated display case of claim 7 wherein the dehumidification device comprises a coil configured to receive a supply of at least one of the coolant or a refrigerant.

16. The refrigerated display case of claim 7 wherein the dehumidification device comprises a desiccant wheel.

17. A refrigerated display case comprising:

a housing having an open front and defining a space adapted to receive products;

a first coil operating at a temperature greater than 32° F.;

an air flow device operable to direct a flow of air over the first coil and for discharge over the open front as a dehumidified air curtain;

a second coil operating at a temperature below 32° F., the second coil disposed within the space to cool the products;

a cooling system providing coolant to the second coil;

wherein the first coil operates above freezing in a substantially frost-free manner and the dehumidified air curtain maintains a low humidity environment proximate the second coil so that the second coil operates in a substantially frost-free manner.

18. The refrigerated display case of claim 17 wherein the first coil comprises a dehumidification coil disposed external to the space and adjacent to the air flow device.

19. The refrigerated display case of claim 17 wherein the second coil comprises a gravity cooling coil disposed in a top portion of the space.

20. The refrigerated display case of claim 17 further comprising a shelf disposed within the space and the low humidity environment and configured to receive the products.

21. The refrigerated display case of claim 20 wherein the shelf is configured to receive a supply of the coolant to provide contact cooling to the products and.

22. The refrigerated display case of claim 21 wherein the shelf operates in a substantially frost-free manner in the low humidity environment.

23. The refrigerated display case of claim 22 further comprising a third coil disposed beneath the shelf and configured to receive a supply of the coolant, the third shelf arranged as a gravity cooling coil and operating in a substantially frost-free in the low humidity environment.

24. A method of operating a refrigerated display case for low frost performance, comprising:

providing a housing defining a storage space for products, the storage space having an open front, and an air flow passage communicating with the open front;

providing a dehumidification coil communicating with the air flow passage;

providing an air flow device operable to direct a flow of air over the dehumidification coil for discharge as a dehumidified air curtain over the open front;

providing a cooling device comprising at least one of a contact-cooling shelf and a gravity cooling coil within the space for cooling products;

circulating a coolant to the cooling device; and

operating the dehumidification coil at a temperature above 32° F.

25. The method of claim 24, further comprising the step of circulating a refrigerant through the dehumidification coil.

26. The method of claim 24 wherein the cooling device comprises a contact cooling shelf and a gravity cooling coil, and the coolant circulated to the contact cooling shelf comprises a liquid coolant and the coolant circulated to the gravity cooling coil comprises a refrigerant.

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