

Nov. 13, 1962

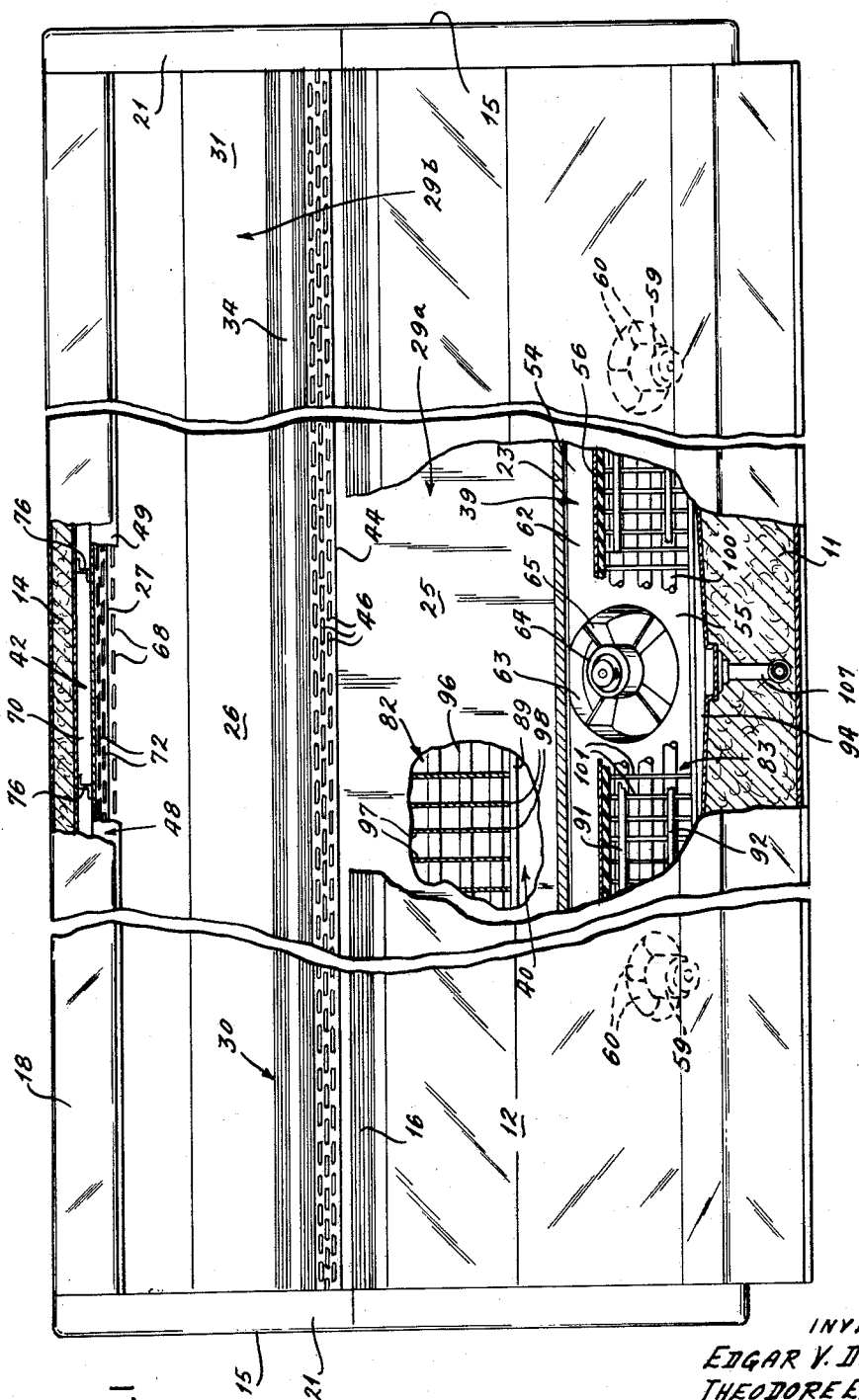
E. V. DICKSON ET AL

3,063,253

LOW TEMPERATURE REFRIGERATED CASE

Filed April 11, 1960

4 Sheets-Sheet 1



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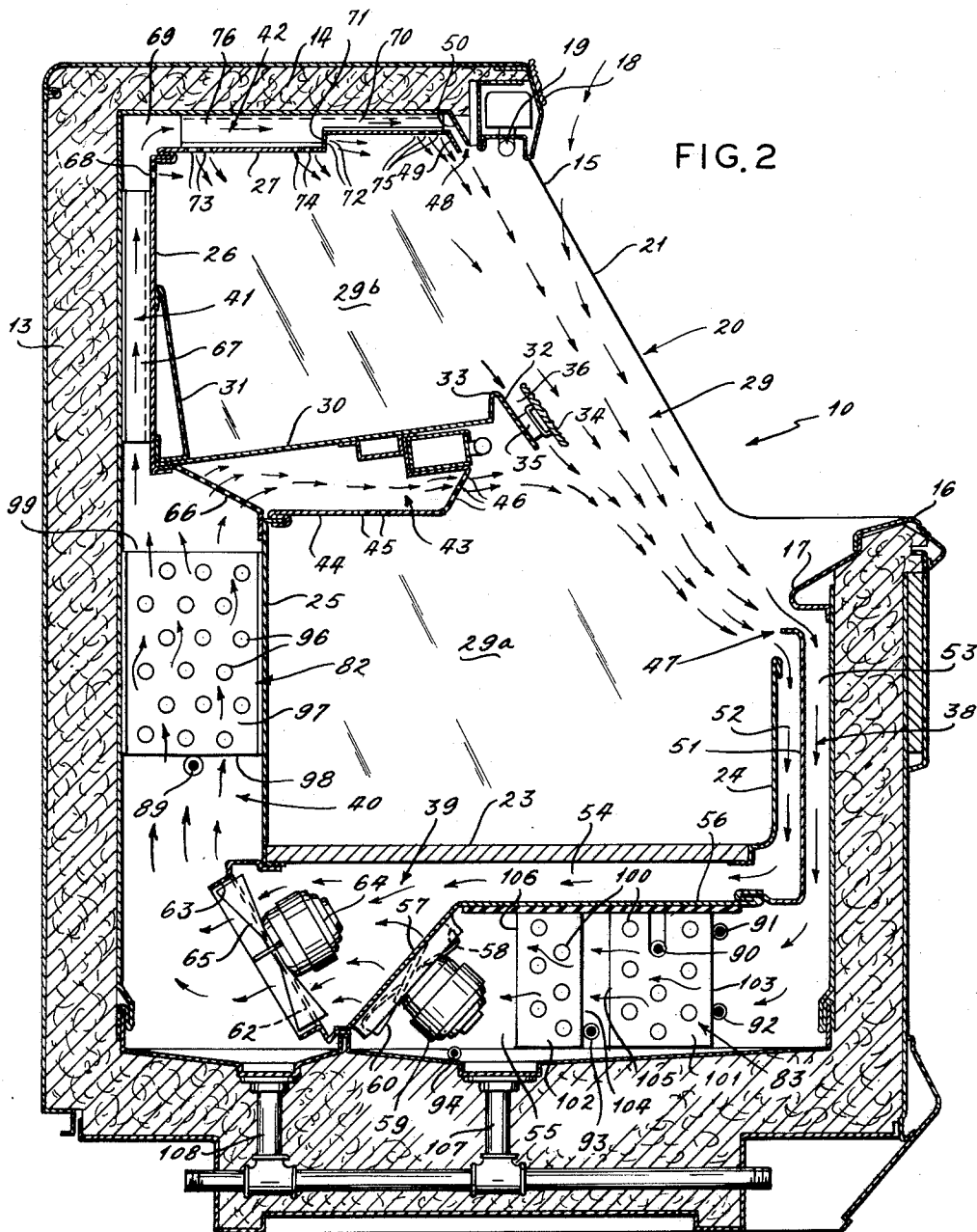
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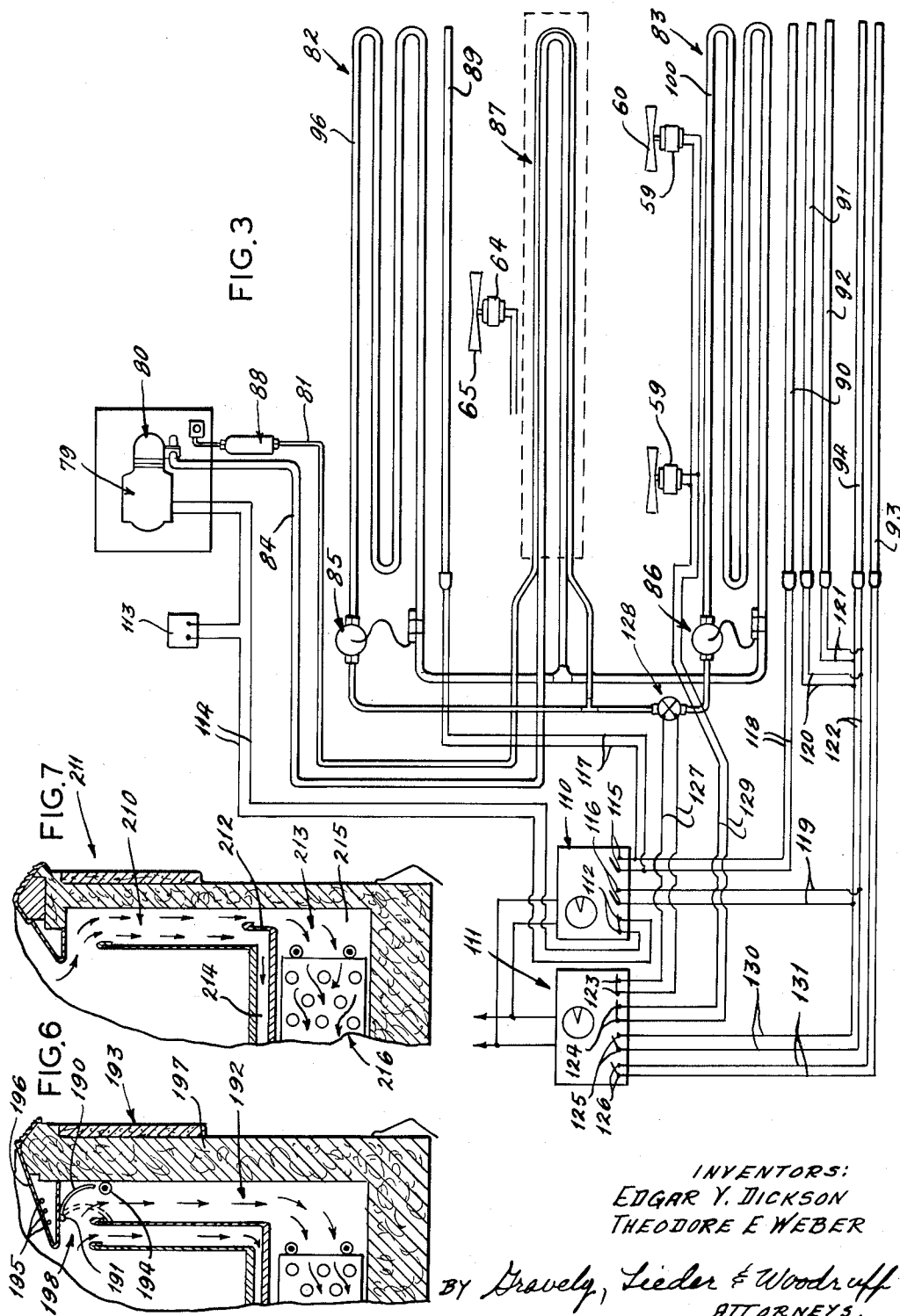
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FIG. 5

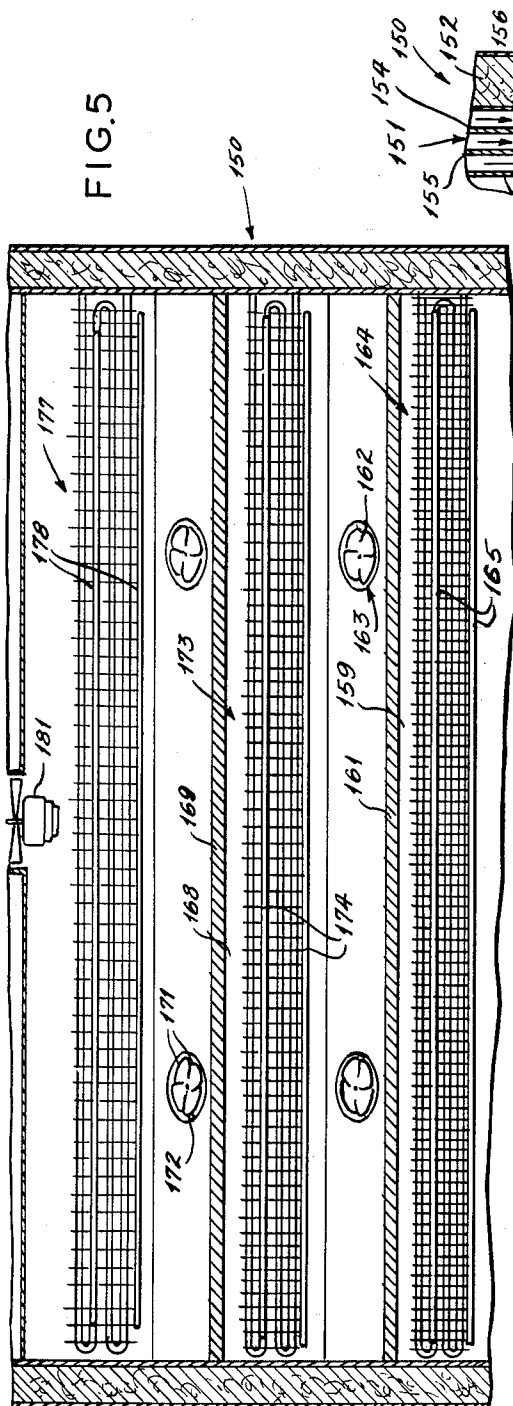
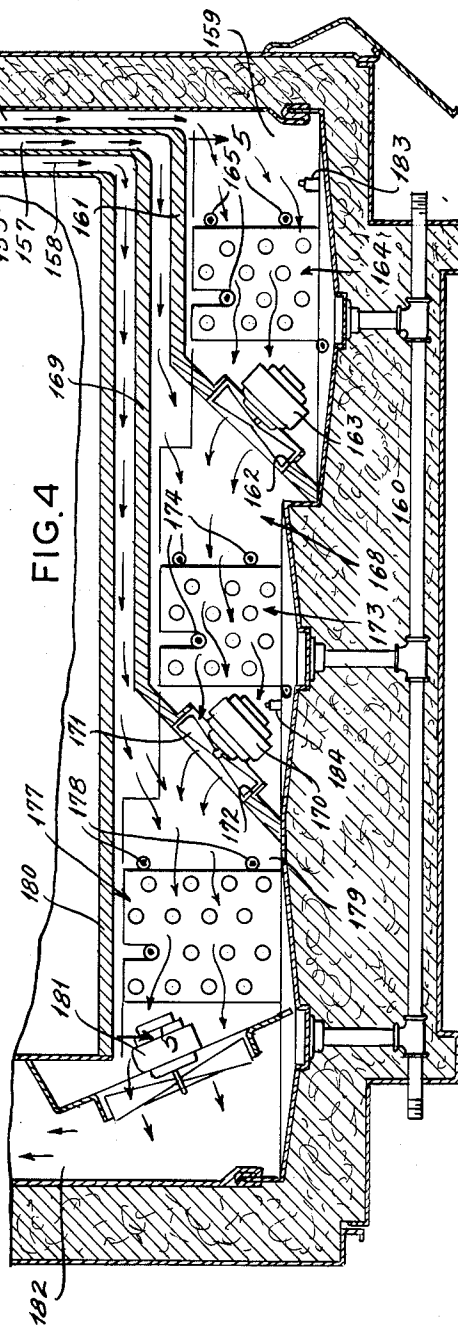


FIG. 4



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3,063,253

LOW TEMPERATURE REFRIGERATED CASE

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Filed Apr. 11, 1960, Ser. No. 21,457
19 Claims. (Cl. 62-256)

This invention relates generally to the refrigeration art, and more particularly to a refrigerated display case for low temperature refrigeration of frozen food products.

In the past many refrigerated cases have been provided for cooling food products at high, standard and low refrigeration temperatures. In the refrigeration industry, "high temperature refrigeration" refers to equipment which maintains a product or display area temperature at about 40° F. to 50° F.; "normal" or "standard" is a term used to designate equipment for cooling products in the display area to a refrigerated temperature of about 30° F. to 40° F.; and "low refrigeration temperature" is a range of product temperatures of about -10° F. or below to 10° F. produced by frozen food equipment. However, for purposes of disclosure the term "high temperature refrigeration" used herein refers to temperatures at and above the freezing point of water in a range of about 25° F. to 45° F. and preferably about 38° F. "Low temperature refrigeration" will be used herein as referring to refrigeration of food products and other products at temperatures below the freezing point of water and generally in the zone of -10° F. or colder to about 10° F. or preferably about 0° F.

Until a few years ago, the usual refrigeration equipment for merchandising food products included closed display area cabinets having hinged doors or sliding panels operating at either high or low refrigeration temperatures, open top single shelf display equipment operating at higher refrigeration temperatures for produce, multiple shelf equipment having well-type shelves with glass barriers each individually cooled and operating at high refrigeration temperatures for dairy products, and open top single well cabinets in which frozen foods were marketed. No equipment having an open front or open side display area including shelves without barriers and being cooled by a single air distributing system was available for products to be maintained at either high or low refrigeration temperatures until recently.

The display case disclosed in Dickson et al. Patent No. 2,822,672, issued February 11, 1958 was the first multi-deck, open front case manufactured for the display of products that did not require glass barriers or the like to hold cold air in the case. The air flow controlling means therein is disclosed in association with a high temperature refrigeration system that can effect efficient operation in a wide range of ambient temperatures and there is no insurmountable problem created by differences in humidity contained in this ambient air inasmuch as high temperature cooling coils operate at temperatures near freezing so that accumulation of frost is removed relatively easily with a negligible rise in product temperature during this period. However, a high temperature refrigeration system is not suitable for low refrigeration temperature operation because of moisture problems. Cases closed by doors or having open tops have been

In low temperature equipment moisture is the largest problem since the presence of moisture may cause freezing of mechanical moving parts as well as rapid frost accumulation on cooling coils with the result that the equipment rapidly becomes inoperative inasmuch as all of the air to be discharged from the cooling chamber into the case must pass over the cooling coils and be refrigerated substantially evenly for effective cooling of the display area. The moisture problem in low tem-

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perature equipment has also been pronounced in other ways such as by the formation of frost or ice on food packages, shelves, walls, molding strips and the like in the display area and by the blocking of air discharge or return passages or openings. In the past low temperature cases closed by doors or having open tops have been fairly satisfactory, but cold air hangs or stays in these cases by reason of the enclosed condition or by the inherent property of cold air to settle so that a minimum of warm moist ambient air enters these cases. Even so, moisture migration into the case from the ambient air by reason of the vapor pressure differential therebetween still causes frost or ice to form in the case in undesirable quantities, which, together with the inconveniences associated with reaching into open top cases or opening doors in order to select frozen products, makes these cases less desirable than an open front case having reach-on shelves. In the past attempts to provide open front, low temperature display cases principally have been directed toward preventing intermixture or entrainment of ambient room air with cold air of the case, but the various means therefor have not been operative. It has been discovered that a minimum amount of entrained ambient air will not prevent the efficient operation of low temperature refrigeration equipment if means for controlling or materially reducing the degree of moisture migration into the case is provided. Heretofore moisture in proposed low temperature open front cases has resulted in rapid frosting of the cooling coils, which required a total or complete defrost period every 3 to 4 hours with each defrost period lasting approximately 35 to 45 minutes because of time interval required to raise the temperature of the coil mass to a defrosting temperature. The solution to the problem is to provide a low temperature, open front case which will require defrosting at sufficiently infrequent intervals to maintain an even product temperature during these defrost cycles. Another problem related to the moisture migration problem has been to improve air flow through the case and across an open front to reduce or eliminate turbulence and minimize intermixture of warm, humid ambient air with the refrigerated air of the case so that it is possible to cool the air to predetermined low temperatures and to reduce the amount of moisture circulated through the low temperature evaporator coils. Some of these problems have been approached successfully as disclosed in Dickson et al. co-pending continuation application Serial No. 68,308 (original application Serial No. 714,374, filed February 10, 1958 and entitled "Food Merchandiser," now abandoned), but this display case utilizes two separate air cooling and distributing systems and no low temperature, open front refrigeration equipment having a single air distributing system has been successfully produced heretofore.

The principal object of the present invention is to provide a greatly improved display case for low temperature refrigeration of frozen food products.

More specifically, it is an object to provide a novel system for cooling an open front or open sided display area to low refrigeration temperatures and for preventing condensation and frost accumulation in the display area.

Another object is to provide a refrigeration system for circulating relatively dry low temperature air through a display case, and for dehumidifying said air at preselected locations within the case to maintain an operative condition for maximum time periods without total defrosting to assure substantially uniform product temperatures.

Another object is to provide a refrigeration system having cyclic defrosting for providing relatively long operating intervals and low product temperatures.

Another object is to provide a non-turbulent air wall for an open front case.

It is also an object to return substantially all cooled air for dehumidifying and cooling to low refrigeration temperatures.

A still further object of this invention is to provide an open front case having a directly accessible display area unrestricted by barriers or glass panels and cooled to low refrigeration temperatures.

These and still other objects and advantages will become more apparent hereinafter.

Briefly, the invention comprises a display case having an open front display area, and refrigeration means for cooling the display area to low refrigeration temperatures and forming an air wall of low temperature air across the front opening, the refrigeration means including cyclic defrosting means providing extended operating periods for maintaining low refrigeration temperatures of products in the display area.

The invention also consists in the parts and in the combinations and arrangements of parts and conditions thereof hereinafter described and claimed. In the accompanying drawings which form a part of this specification and wherein like numerals refer to like parts wherever they occur:

FIG. 1 is a front elevational view, partly broken away of a refrigerated case embodying the present invention,

FIG. 2 is a vertical transverse sectional view of the refrigerated case,

FIG. 3 is a schematic diagram showing a refrigeration system for a case embodying the invention,

FIG. 4 is a fragmentary cross-sectional view of a refrigerated case having a modified refrigeration system therein,

FIG. 5 is a sectional view taken along line 5—5 of FIG. 4 showing the coil arrangement of the modified refrigeration system,

FIG. 6 is a fragmentary sectional view of mechanical damper means for controlling return air flow, and

FIG. 7 is a fragmentary sectional view of another modified return air flow arrangement.

This application has subject matter in common with co-pending Dickson et al. continuation application Serial No. 68,308 (original application Serial No. 714,374, filed February 10, 1958 for "Food Merchandiser," now abandoned).

Referring now to FIGS. 1 and 2 of the drawings in detail, a display case 10 embodying the present invention includes an insulated outer cabinet structure including a base 11, a low front wall 12, a relatively high rear wall 13, a top wall 14 extending forwardly from the rear wall 13, and end walls 15. The upper margin of the front wall 12 is unrestricted by glass panels or other air retaining barriers for direct visibility and accessibility to the interior of the cabinet, and a rail or molding 16 of stainless material is provided over the top of the front wall and has a portion 17 forming a rearwardly projecting shield. The forward margin of the top wall 14 is capped by a decorative or advertising molding 18 of suitable stainless or finished material defining a typical housing for illuminating means 19 behind it. The forward margin or molding 18 of the upper wall 14 is positioned rearwardly from the front wall 12 and a substantial distance above the upper margin or molding 16 thereof to provide a front opening, shown generally at 20, defining the upper portion of the front side of the cabinet. The end walls 15 have front margins 21 sloping downwardly and forwardly from the front of the top wall 14 to the top of the front wall 12 and generally define the front opening 20.

Positioned within the outer cabinet and extending longitudinally between the end walls 15 thereof is an inner cabinet which includes a bottom plate or wall 23, a front panel 24, lower and upper rear panels 25 and 26, and a top wall or panel 27. The walls and panels of the inner cabinet are spaced from the respective walls of the outer cabinet to define therebetween portions of an air distribution and recirculation system and a housing for elements of a refrigeration system, which function to maintain low refrigeration temperatures in the display case 10.

The inner cabinet defines a display area 29 having a lower well portion 29a and an upper shelf portion 29b extending vertically above the front wall 12, and which is directly accessible through the front opening 20. At least one shelf 30 is provided in the display area 29, the shelf being mounted on the rear panel 26 above the well portion 29a and preferably sloping upwardly therefrom toward the front opening 20. If desired, an angular backplate 31 may be provided to support products against the rear panel 26 and, if desired, the shelf 30 may be adjustably mounted on the rear panel as taught in co-pending application Serial No. 714,374. The front of the shelf 30 is provided with an angularly positioned planar panel 32 positioned in a plane directed toward a point behind the upper edge of the front panel 24, and a small product abutment 33 is formed above the shelf 30 and defines the front edge thereof. A vane 34, which may also function as a price tag molding, is secured in predetermined spaced relation with the panel 32 by suitable spacers 35 and extends in a substantially parallel plane therewith toward a point behind the upper edge of the front panel 24. An elongated flue or air passage 36 is formed between the panel 32 and vane 34 which forms a portion of the air circulation system of the display case 10, as will appear. Referring again to the abutment 33 serving to retain products on the shelf 30, it will be noted that the front edge of the shelf 30 is virtually unrestricted so that products on the shelf are directly accessible through the front opening 20. As used herein, the terms "directly accessible" or "unrestricted" with regard to the front wall 12, display area 29 or shelf 30 are words of limitation restricted in meaning to specifically exclude the use of barriers or glass panels and like objects extending above the front wall or shelf obstructing vision or facility of purchasers.

The case cooling means embodying the present invention comprises the air distribution and recirculation system and the refrigeration system, shown diagrammatically in FIG. 3. Still referring to FIGS. 1 and 2, the air distribution system shown for purposes of illustration includes a vertical front air duct or return flue 38 between the front wall 12 and front panel 24, a lower chamber 39 between the bottom wall 11 and bottom panel 23, a side chamber 40 at the lower rear portion of the base between the rear wall 13 and the lower rear panel 25, a vertical air delivery duct 41 between the upper portion of the rear wall 13 and the upper rear panel 26, a horizontal air delivery duct or discharge flue 42 between the top wall 14 and the top panel 27, and another horizontal discharge duct 43 beneath the shelf 30 and formed by a panel 44. The panel 44 extends from the rear panel 25 to adjacent the front of the shelf 30 and has air discharge openings 45 for distributing air into the well 29a and air discharge openings 46 in the front vertical wall thereof through which air is discharged in a substantially horizontal path as will be described hereinafter. The ducts and chamber are in communication and the air distribution system also includes a return opening 47 to the return flue 38 and a discharge opening 48 from the duct 42 adjacent to the front of the top wall 14 formed by substantially parallel walls 49 and 50 in planes directed toward points behind the top of the front panel 24. In the operation of the display case 10, an air wall or curtain is formed across the open front 20 between the discharge and return openings 48 and 47, respectively. The front flue 38 may be divided by a vertical partition or panel 51 to form inner and outer return passages 52 and 53, and the opening 47 thereto being protected against the entrance of foreign matter by the overhanging shield 17. The lower chamber 39 is divided into an upper or primary air passage 54 and a lower or secondary air passage 55 by a horizontal partition 56, which is insulated to prevent heat

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transfer between the passages 54 and 55. The partition 56 is connected to the partition 51 in the return flue 38 and also is connected to an angular partition 57 having spaced openings 58 in which a pair of similar fans or like air moving means 59 are positioned. The fan blades 60 are positioned to deliver air from the lower passage 55 upwardly and merge it with air from the upper passage 54, and the blades 60 substantially cover the openings 58 and serve to block air flow therethrough when the fans 59 are inoperative, as will appear.

The lower chamber 39 and main or side chamber 40 are divided by a partition 62 having a single opening 63 centrally positioned in the display case 10 and a fan or like air moving means 64 is mounted with its blades 65 in a downwardly angled position toward the lower end of the side chamber 40. It will be readily apparent that the entire volume of air circulated through the display case 10 is moved by the fan 64 through the side chamber 40, and that the volume of air moved by the fans 59 through the passage 55 is added to the volume of air from the passage 54 to make up the total air volume handled by the fan 64. Accordingly, the fan 64 and chamber 40 are referred to as the main fan and main chamber, and the fans 59 and passage 55 is called the intermediate or secondary fans and intermediate or secondary passage. The fans 59 and 64, of course, comprise the circulating means of the air distributing system, and additional fan units may be added to increase the air moving capacity.

The main chamber 40 is in direct vertical communication with the rear flue or delivery passage 41, and the horizontal air duct 43 is in communication with the main chamber 40 through a perforated baffle 66 for proportioning the volume of air distributed to the flue 41 and duct 43. The rear flue 41 may include therein transverse structural members 67, which in addition to mounting the rear panel 26 on the rear wall 13 also function to maintain the air flow in straight vertical paths through the rear flue. Air openings 68 are formed in the rear panel 26 adjacent to the upper end thereof to eliminate or reduce condensation in the form of frost on the under surface of the top panel 27 and on the top of products in the upper display area 29b. The top panel 27 of the inner cabinet is stepped to provide enlarged rear and reduced front portions 69 and 70 of the top flue 42 and form a vertical wall portion 71 having openings 72 through which air is dispelled in a substantially horizontal path toward the discharge opening 48. The top panel also includes air openings 73 adjacent to the rear panel 26 and openings 74 adjacent to the vertical wall portion 71 through which air is discharged into the display area. Air openings 75 are formed in the top panel 27 immediately adjacent to the discharge flue 48 for assisting in the support of the air curtain. The restriction in the size of the flue 70 relative to the flue portion 69 and the size of openings 72, 73 and 74 is predetermined to prevent any appreciable decrease in the pressure of air delivered to and discharged from the delivery flue 48 from the rear flue 41. Structural members 76 are provided in the upper flue 42 which also assist in providing a straight path of air flow toward the discharge opening 48.

It is apparent that the secondary fans 59 draw a predetermined volume of air into the return air opening 47 and through the outer and secondary passages 53 and 55 of the return flue 38 and lower chamber 39. The main fan 64 draws a greater volume of air, most of which is delivered by the secondary fans 59 and the remainder of its capacity drawing air through the inner and upper passages 52 and 54 of the front return flue 38 and lower chamber 39. The capacity of the secondary fans 59 must not exceed the total capacity of the main fan 64 or else air will be discharged from the inner flue 52 through the opening 47. The total volume of air from the main fan 64 is discharged downwardly to produce turbulence and create a plenum effect and

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the air then passes upwardly in the main chamber 40 and is divided between the rear flue 41 and the horizontal flue 43 under the shelf 30. The air in the rear flue 41 is discharged into the upper horizontal delivery flue 42 and a portion is expelled through air openings 68 and 73 into the upper display area 29b. The remainder of the air flows forwardly in the upper duct 42, a portion being discharged downwardly and forwardly through openings 74 and 72 and the remainder being discharged through openings 75 and through the discharge flue 48 to form an air curtain across the open front 20 of the display area 29. The air discharged into the upper display area 29b flows forwardly over products on the shelf 30 and passes downwardly through the flue 36 at the front of the shelf and assists in maintaining a non-turbulent air curtain. The air discharged forwardly through the openings 46 from the duct 43 below the shelf assists in supporting the air curtain and in moving it toward the return flue opening 47 in a curve. The distribution of air will become more apparent hereinafter.

Referring to FIG. 3, a typical refrigeration system for the present display case 10 comprises a compressor 79, condensing unit 80, a liquid line 81, evaporator means 82, 83 and a gas return conduit or suction line 84 connected in series-flow relationship. The liquid line 81 is connected through expansion valves 85, 86 to the evaporator means 82, 83 to maintain a substantial pressure differential between the condenser 80 and evaporator means 82, 83 so that refrigerant is condensed by the condenser 80 and is maintained in liquid form to the expansion valves 85, 86 and vaporizes in the evaporator means for the absorption of heat from the surrounding air. A portion of the liquid line 81 and the suction line 84, in which gaseous refrigerant is returned to the compressor 79, are in heat exchange relationship, at 87, whereby heat is absorbed from the liquid line by the still expanding gaseous refrigerant in the suction line 84. The refrigeration system may also include a dehydrator 88 in the liquid line 81 and other conventional components.

In order for the refrigeration system to induce low refrigeration temperatures in the display area 29 for maintaining a product temperature near 0° F., it is necessary to produce sub-zero refrigerant temperatures in the evaporator means 82, 83, near -40° F. It is apparent that at these temperatures, frost or ice accumulations on the evaporators will occur by reason of the presence of moisture in the display case or in the ambient air. Accordingly, the refrigeration system of the display case 10 also includes at least one main defrost heater 89 and a plurality of secondary defrost heaters 90-94, the heaters having controlled cyclic defrost periods for the evaporator means 82, 83 to melt ice or frost from the evaporators and obtain continued operation of the case for extended periods of time. Control means for the operation of the display case refrigeration system will be described hereinafter.

Referring again to FIGS. 1 and 2, it will be seen that evaporator means 82 comprises a main or primary coil mounted in the main chamber 40 between the rear wall 13 and the lower rear panel 25 and extending longitudinally between the end walls 15. The main coil 82 includes a continuous serpentine coil 96 and a plurality of transversely and vertically extending fins 97, which are spaced apart longitudinally a predetermined relatively wide distance, as will appear. The fins 97 are each secured on the longitudinal coil portions and have a lower leading edge 98 and an upper trailing edge 99, the fins presenting a large cooling surface area for contact by the total volume of air moved into the main chamber 40 by the main fan 64 and, in addition, the fins 97 straighten air flow into non-turbulent vertical paths. The main defrost heater 89 is positioned below the main coil 82 in contact with the leading edge 98 of each of the fins 97 and centrally located between the side margins thereof.

The evaporator means 83 comprises a secondary or intermediate coil mounted in the secondary passage 55 of the lower chamber 39 between the bottom wall 11 and the insulated partition 56. The intermediate coil 83 is in direct communication with the outer return flue 53 and is in communication with the primary passage 54 and main fan 64 through the partition openings 58 in which the blades 60 of the intermediate fans 59 are positioned. The intermediate coil 83 includes a serpentine coil 100 and a plurality of transversely and vertically spaced fins 101 and 102, which are spaced apart longitudinally of the case 10 predetermined narrow distances relative to the spacing of the fins 97 of the main evaporator coil 82. The intermediate evaporator coil 83 is shown to have the divided fins 101 and 102 having leading edges 103 and 104, respectively, and trailing edges 105 and 106, respectively. However, a single fin arrangement may be desired in some applications of the teachings hereof, and in other uses a further division of fins may be desirable. The fins 101 and 102 are secured on the longitudinal portions of the coil 100 and present a large cooling surface area for contact by the portion of air moved through the secondary chamber portion 55.

In the preferred arrangement shown in FIG. 2, the heater 90 is in contact with each of the front fins 101 intermediate of the leading and trailing edges 103 and 105 and adjacent to the upper margins of the fins. The heaters 91 and 92 are positioned above and below in contact with the leading edges 103 of the front fins 101, and the heater 93 is secured adjacent to the lower margins of the fins 102 on the leading edges 104 thereof. The heater 94 is positioned adjacent to a drain 107 for the lower chamber 39 on the bottom wall 11 and extends longitudinally of the case 10. Another drain 108 is provided in the bottom wall 11 for the main chamber 40.

Referring again to FIG. 3, the control means for operating the display case 10 include an electrical circuit including main and secondary timing units 110 and 111, although the function of dual timing may be provided by a single device (not shown). The main timer 110 operates a relay (not shown) having normally closed contacts 112 to which the compressor 79 is connected in series with a pressure or temperature responsive switch 113 by leads 114, the switch 113 controlling the cycling of the compressor 79. The relay of the main timer 110 also includes pairs of normally open contacts 115 and 116, the former being connected by parallel leads 117 and 118 to the heaters 89 and 90 and the latter being connected by leads 119 to leads 120, 121 and 122 connecting the heaters 91, 92 and 94 in parallel.

The secondary or intermediate timer 111 operates a relay (not shown) having pairs of normally closed contacts 123 and 124 and pairs of normally open contacts 125 and 126. The contacts 123 are connected by leads 127 to a solenoid valve 128 positioned in the liquid line 81 to the intermediate coil 83 and maintained in an open position in the line by energization of its solenoid (not shown) through the timer 111. The valve 128 is spring loaded or the like to a normally closed position. The normally closed contacts 124 of the timer 111 are connected by leads 129 to the intermediate fans 59. The normally open contacts 125 are connected by leads 130 to the parallel leads 120, 121 and 122 to the heaters 91, 92 and 94. The normally open contacts 126 are connected by leads 131 to the defrost heater 93.

In the operation of the display case 10, the air distribution system and the refrigeration system cooperate to move relatively dry low temperature air through the display area 29 and across the open front 20 in substantially non-turbulent flow thereby minimizing the intermixture or entrainment of ambient air and the migration of moisture from the ambient air into the display area. The present case 10 functions to maintain more nearly uniform or constant product temperatures (at or near 0° F.), and the rise in product temperature during a main

defrost is also minimized as will be described presently.

According to the invention, air from the display area 29 and from the air curtain across the open front 20 is drawn into the return opening 47 to the front flue 38. This air may include a thin layer of ambient air which will tend to move along the outer side of the air curtain. In the initial operation of the display case, such as when the case goes into operation following a main defrost, the major portion of return air is pulled into the outer front flue 53 by the fans 59 inasmuch as the fans 59 have an air handling capacity almost as great as that of the fan 64 and the path of air flow through the intermediate refrigeration chamber 55 through the intermediate expansion coil 83 is substantially unrestricted. The air drawn into the inner return flue 52 by the fan 64 comes from the inner side of the air curtain or from the display area 29 and is relatively dry. The moisture is removed from the air in the intermediate refrigeration chamber as it passes over the intermediate coil 83 and is condensed on the fins 101 and 102 in the form of frost or ice. This dehumidified air is then discharged by the fans 59 and merged with the air in the passage 54, and is then drawn by the fan 64 into the main refrigeration chamber 40 in a direction away from the main evaporator coil 82. The air handled by the fan 64 constitutes the entire volume of air distributed into the display area 29 and across the open front 20 of the display case 10. The main and intermediate coils 82 and 83 are connected in parallel in the same refrigeration system, FIG. 3, and operate at substantially the same temperature. Accordingly, the air discharged by the fan 64 and circulated upwardly in the main refrigeration chamber 40 through the main coil 82 during initial operation of the case is relatively dry and cooled to the desired low temperature for distribution into the case 10.

During the operation of the case and as the intermediate coils build up frost accumulations on the fins 101 and 102 thereof, the air passage through the intermediate refrigeration chamber 55 becomes restricted whereby the fans 59 draw a smaller volume of air. Therefore, the air flow into the return opening 47 shifts downwardly and a larger volume of air is pulled into the inner return flue 52 by the main fan 64. It is apparent that the volume of air drawn into the inner return flue will continue to increase during the continued operation of the intermediate fans 59, and that this air will have an increasing amount of moisture contained therein. The moisture contained in the air passed over the main coil 82 will be dehumidified so that a balance is effected between the main and intermediate coils 82 and 83 providing relatively dry low temperature air for the refrigeration of products in the display area and for forming a dry air curtain moving at a predetermined velocity across the open front 20 and thereby absorbing moisture from the ambient air and carrying it into the return flue 38 before any appreciable migration of moisture into the display area 29 can take place.

The air wall or curtain is formed primarily by low temperature air discharged through the discharge flue 48, which is elongated and in a plane directed toward a point behind the return flue opening 47. The air curtain is supported against turbulence at its discharge by air flowing through the openings 75 in the top panel 27 and by the forwardly directed air stream discharged through the opening 72 from the top flue 42. The upper display area 29b and products therein are cooled by air discharged through the openings 68, 73 and 74, and this air also produces a scrubbing action tending to eliminate frost accumulation on the top panel 27 and products on the shelf 30. In order to prevent turbulence below and around a price tag molding 34 on the front of shelf 30 caused by the flow of display area air outwardly over the shelf and molding, a flue 36 is provided between the molding and the planar surface 32 at the front of the shelf whereby the molding constitutes a vane positioned

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in a predetermined location and having planar surfaces which direct the flow of air toward a point behind the return flue opening 47. The non-turbulent flow of the air curtain is also produced by the substantially horizontal discharge of low temperature air from the flue 43 beneath the shelf 30 in a forward direction toward the air curtain. Products in the lower well portion 29a of the display area are also scrubbed by the air discharged from the flue 43 through the openings 45 and 46. It will be seen from FIG. 2 that the air curtain moves in a substantially rectilinear path from the discharge opening 48 to a point inwardly of the return opening 47 and below the flue 36, the air curtain then curving in an arcuate path toward the return opening and the variable pressure differential in the inner and outer return flues 52 and 53 adjusting the return of case air during the operation.

A minimum of frost accumulates on the main coil 82 during the first operational period of the display case 10 after a main defrost period whereas the intermediate coil 83 becomes coated with ice or frost so that its efficiency is materially reduced in a period of 3 to 5 hours. Accordingly, after a predetermined interval of full operation for which the intermediate or secondary timer 111 is set, the timer operates the relay to close normally open contacts 125 and 126 and to open normally closed contacts 123 and 124 and thereby effect an intermediate defrost cycle. The opened contacts 123 break the circuit to the solenoid (not shown) of the valve 128 to close the liquid line 81 through the coil 100, and simultaneously therewith the circuit to the fans 59 is opened by the contacts 124 and the circuits to the heaters 91, 92, 93 and 94 are closed through the contacts 125 and 126. The defrost heaters rapidly induce heat into the lower chamber 55 to raise the temperature of the coil mass above freezing and melt the frost accumulation from the coil 100 and from the fins 101 and 102. The heater 94 is provided to heat the bottom surface of the bottom wall 11 in which the drain 107 is provided to carry off the water during defrost. The fan blades 60 substantially close off the openings 58 in the partition 57 during this defrost cycle whereby virtually no air movement occurs and the defrost heat remains in the static chamber to facilitate rapid defrost of the intermediate coil 83.

During the intermediate defrost cycle, the main fan 64 continues to operate and all of the return air is pulled through the primary passage 54 in by-pass relation with the intermediate coil 83 and is cooled to low refrigeration temperatures by the main coil 82. Accordingly, moisture carried by the air stream is deposited on the fins 97 of the main coil 82, but the intermediate defrost time is kept at a minimum, generally less than 25 to 30 minutes. It should be noted that the operation of the case 10 between the main defrost and the first intermediate defrost extends for a period between 3 to 5 hours, and that no appreciable rise in product temperature occurs during this time. Furthermore, when the intermediate defrost occurs the entire capacity of the condensing unit 80 is diverted to the main coil 82 thereby producing a further drop in temperature tending to lower the product temperature further, and the over-all rise of product temperature during intermediate defrost is negligible.

At the end of an intermediate defrost period, the secondary timer 111 operates the relay to return the contacts 123, 124, 125 and 126 in successive steps to place the intermediate cooling system back into operation after a time delay. The contacts 123 are closed and the contacts 125 and 126 are opened simultaneously to circulate refrigerant in the liquid line 81 to the coil 100 and to shut off the heaters 91-94. However, the fans 59 are not made operative for a period in which the temperature of the intermediate coil 83 is dropped to its low temperature and moisture in the air of the chamber 55 and remaining on the fins 101 and 102 are redeposited on the fins as frost. The contacts are then closed following this time delay and the intermediate portion of the refrigera-

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tion system again draws nearly all of the air therethrough for cooling and dehumidification. The product temperature is lowered to a point below its normal low temperature. A negligible ice or frost accumulation will occur on the main coil 82 for an extended period in the operation of the case 10 following the first intermediate defrost, and further intermediate defrost cycles may be provided before the main coil 82 will need to be defrosted.

A main defrost occurs at predetermined intervals, such as every 12 hours, by the operation of the main timer 110 of the control means. The timer 110 operates a relay or the like (not shown) to open normally closed contacts 112 and close pairs of normally open contacts 115 and 116 to effect a total defrost of the display case refrigeration system. The opened contacts 112 opens the circuit to the compressor-condenser unit 79, 80 and simultaneously the closed pairs of contacts 115 and 116 complete circuits to the main defrost heater 89 and to the intermediate defrost heaters 90, 91, 92 and 94. The heaters produce heat in the main and lower chambers 40 and 55, and the fans 59 and 64 continue to operate to circulate air through the distribution system during the entire period of the main defrost. During the initial period of defrost the air passing through the coils 83 and 82 will be cooled by the ice melting on the fins 101, 102 and 97, and the air is in heat exchange relation therewith so that the fins and coils 100 and 96 will be heated more rapidly to melt the ice accumulation. Accordingly, the main defrost cycle is shortened and it has been discovered that the product temperature rise is less when the fans operate than when the fans are shut off. The fans also continue to operate during the pull-down period following the main defrost when the main timer 110 has returned the contacts 112, 115 and 116 to the normally closed and open conditions thereof and the coil temperature is being lowered to its normal operating temperature. The refrigeration system goes back into operation substantially free from frost.

It will be apparent that the present open front display case 10 has a greatly improved single refrigeration system and air distribution system effecting efficient low temperature operation for long periods of continuous operation or with a minimum of defrosts to prevent the rise of product temperature so high that there is a risk of product loss through spoilage. The air distribution system provides a smooth flow of dry low temperature air through the case whereby layers of air are provided in the air curtain across the open front 20 and, because of a lack of turbulence, these layers remain separated with the inner drier layer being moved directly over the main coil 82 and the outer layers of warmer air containing the greatest amount of moisture being moved over the intermediate coil 83. During the intermediate defrost cycles, the main coil 82 and fan 64 continue to operate and maintain the air circulated through the case at a low refrigeration temperature, and heat in the intermediate coil chamber 55 is effectively retained therein during this intermediate defrost. A time delay at the end of the intermediate defrost during the period in which the intermediate coil temperature is lowered to near its operating temperature facilitates the collection of excess moisture in that area to keep the main coil 82 free of ice for longer periods. During the main defrost cycles, case air is continuously circulated over the main and secondary coils 82 and 83 to materially shorten the time required for total defrost to take place whereby the refrigeration system is returned to full operation before an appreciable rise of product temperature occurs.

It will be noted that the relatively wide spacing of the main coil fins 97 facilitates longer operation before frost accumulations materially reduce the efficiency thereof whereas the intermediate coil fins 101 and 102 are spaced closer together to more effectively remove moisture from the return air stream.

Referring to FIGS. 4 and 5, it will be seen that the

invention may be embodied in a refrigeration system having additional intermediate coils. In the drawings only the intermediate coil portion is shown and the case 10 may be similar in other details to FIG. 2. The display case 150 in FIGS. 4 and 5 has a front return flue 151 between its front wall 152 and front panel 153, the flue 151 being divided by vertical partitions 154 and 155 to form outer, central and inner passages 156, 157 and 158, respectively. A first intermediate refrigeration chamber 159 is formed between the bottom wall 160 and an insulated panel 161 having spaced openings 162 for fans 163. A first intermediate coil 164 is positioned in the first chamber 159 and has defrost heaters 165, and the chamber 159 is connected with the outer passage 156 for the most moist return air from the display area and air curtain. A drain 166 is provided in the bottom wall 160 for the chamber 159.

A second intermediate refrigeration chamber 168 is formed between the bottom wall 160 and a second insulated panel 169 connected to the partition 155 and having fans 170 with blades 171 positioned in openings 172 of the panel 169. The second chamber 168 houses a second intermediate coil 173 having heaters 174, and a drain 175 is formed in the bottom wall 160 for the second chamber 168.

Another coil 177 having heaters 178 is shown positioned in a chamber 179 between the bottom wall 160 and the insulated bottom panel 180 defining the bottom of the display area of the case 150. The chamber 179 is in direct communication with the inner passage 158 through which the driest air is returned for re-cooling to low refrigeration temperatures and recirculation through the case 150. However, the coil 177 may be a master dehumidifier for the entire air flow to be moved by the main fan 181 into the main chamber 182 through a main coil (not shown). The operation of the coils 164 and 173 would be on defrost cycles similar to that already described, the coil 164 being defrosted at least one time between each defrost cycle of both of the intermediate coils. It will be seen in FIG. 5 that the fins of the coil 173 are spaced wider than the fins of the coil 164 to permit the longer operation with defrosting. Similarly, the fins of the master dehumidifier coil 177 are even wider spaced than either of the intermediate coils 164 and 173 or the main coil (not shown) inasmuch as the coil 177 will be defrosted with each main defrost only and therefore must accommodate a larger frost load than the main coil which is kept relatively free of frost by the coil 177.

The fins of the evaporator coils disclosed herein may have offset or staggered leading edges to accommodate a larger ice load since it is known that ice builds up on the leading edge more rapidly than on the surfaces of the fins. Therefore, by staggering the leading edges the tendency of frost to build up and rapidly bridge across the leading side of the fins is reduced to obtain longer effective operation. It is apparent that the panels above the intermediate coils may be removable for service.

Referring again to FIG. 4, the coils 164 and 173 may be automatically put on an intermediate defrost cycle by pressure or temperature responsive elements 183, 184 which sense the reduced flow of air through the coils or temperature rise therein due to the accumulated frost load. It is within the scope of the present invention to use various combinations of time, temperature and pressure responsive means to initiate or terminate defrost periods and these means may be responsive to increases or decreases in air pressure or refrigerant pressure, and increases or decreases in air temperature or refrigerant temperature. To this end it may be desirable to utilize separate refrigerant systems for different coils or combinations of coils.

If desired, the capacity of the intermediate and main fans may be balanced to effect a predetermined initial proportion of air in each portion of the distribution system.

Referring now to FIG. 6, it will be seen that a damper 190 may be pivotally mounted at 191 to close off the front return flue 192 of a display case 193. A heater 194 may be positioned in the front flue 192 to remove frost therefrom, or small heaters 195 within the molding strip 196 of the front wall 197 to prevent condensation thereon may keep the damper 190 in operative condition for closing off the air inlet 198 to the intermediate system. If desired, the damper 190 may be operated by a solenoid (not shown) for positive action rather than being responsive merely to air pressure moved into the return flue 192.

In FIG. 7 no partition is provided in the front flue 210 of a display case 211, but a splitter member 212 is provided at the lower chamber 213 to facilitate the division of air into the upper passage 214 to the main fan (not shown) and into the intermediate refrigeration chamber 215 housing a coil 216. The non-turbulent air flow in the display area and through the return flue 210 may permit this arrangement.

It is to be understood that the foregoing description and accompanying drawings have been given only by way of illustration and example of a novel open front, low temperature display case having controlled cyclic defrost to obtain dehumidification of re-circulated air and extended periods of operation with substantially constant product temperatures. Changes and modifications in the present disclosure will be readily apparent to all skilled in the art and are contemplated as being within the scope of the present invention, which is limited only by the claims which follow.

What is claimed is:

1. In a low temperature display case having a display area, first air cooling and circulating means for distributing low temperature air to the display area, means returning and dividing the air from said display area into a relatively dry cold inner portion and a relatively moist warm outer portion, and second air cooling and circulating means for dehumidifying and cooling to low refrigeration temperatures the outer portion of air and discharging it to said first air cooling and circulating means for distribution thereby of all of the return air to said display area.

2. In a low temperature display case having a display area having an open front side, first air cooling and circulating means for distributing low temperature air in the display area and forming a wall across said open front side, air return duct means for receiving the total amount of air from said display area and wall and having parallel air flow passage portions both of which are in communication with said first air circulating means, and second air cooling and circulating means in one of said passage portions for dehumidifying and cooling to low refrigeration temperatures the portion of return air circulated therethrough in advance of delivery of said portion to said first air cooling and circulating means.

3. A refrigeration system for a low temperature open sided display cabinet in which a low temperature air curtain is formed across the open side thereof and is returned and recirculated by air moving and cooling means, comprising a main cooling coil and a main air moving means positioned to pass therethrough all of the return air to be cooled for forming the air curtain, a secondary cooling coil and secondary air moving means adapted to pass therethrough only a portion of the return air, means for distributing the coolest and least humid portion of return air directly to said main coil and for distributing the warmest and most humid portion of return air to the main coil through said secondary coil, and means for periodically defrosting said secondary coil and continuing to operate said main coil.

4. A refrigeration system for a low temperature open sided display cabinet in which a low temperature air curtain is formed across the open side thereof and is returned and recirculated by air moving and cooling means, comprising a main cooling coil and a main air moving means positioned to pass therethrough all of the return

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air to be cooled for forming the air curtain, a secondary cooling coil and secondary air moving means adapted to pass therethrough only a portion of the return air, means for feeding the coolest and least humid portion of return air directly to said main coil and for feeding the warmest and most humid portion of return air to the main coil through said secondary coil, means for periodically defrosting said secondary coil and creating a static air chamber around said secondary coil, and means for continuing to operate said main coil during a period of defrost of said secondary coil.

5. A refrigeration system for a low temperature open sided display cabinet in which a low temperature air curtain is formed across the open side thereof and is returned and recirculated by air moving and cooling means, comprising a main cooling coil and a main air moving means positioned to pass therethrough all of the return air to be cooled for forming the air curtain, a secondary cooling coil and secondary air moving means adapted to pass therethrough only a portion of the return air, means for feeding the coolest and least humid portion of return air directly to said main coil and for feeding the warmest and most humid portion of return air to the main coil through said secondary coil, means for periodically defrosting only said secondary coil and retaining heat in a static chamber around said secondary coil, and means for periodically defrosting both of said main and secondary coils and circulating air therethrough during said defrost.

6. A refrigeration system for the low temperature refrigeration of an air stream having a decreasing heat and moisture gradient from the outer side to the inner side thereof, comprising first and second passages having adjacent inlet ends receiving said air stream, a main low temperature cooling coil and a main air moving means connected to the outlet ends of said first and second passages, a secondary cooling coil and secondary air moving means in said first passage receiving the warmest and most humid portion of the air stream, said first and second air moving means having predetermined air moving capacities adapted to create differential negative pressures in said first and second passages whereby said air stream is divided between said passages in a proportion dependent upon the negative pressures therein.

7. A refrigeration system for the low temperature refrigeration of an air stream having a decreasing heat and moisture gradient from the outer side to the inner side thereof, comprising first and second passages receiving said air stream, a main low temperature cooling coil and a main air moving means connected to said first and second passages, a secondary low temperature cooling coil and secondary air moving means in said first passage receiving the warmest and most humid portion of the air stream, said air stream being divided between said first and second passages in a proportion dependent upon the negative pressure differential therebetween, and means for inducing heat into said secondary coil and rendering said first passage substantially static whereby the air stream will be circulated through said second passage by said main air moving means.

8. A refrigeration system for the low temperature refrigeration of an air stream having a decreasing heat and moisture gradient from the outer side to the inner side thereof, comprising first and second passages receiving said air stream, a main low temperature cooling coil and a main air moving means connected to said first and second passages, a secondary low temperature cooling coil and secondary air moving means in said first passage receiving the warmest and most humid portion of the air stream, said air stream being divided between said first and second passages in a proportion dependent upon the negative pressures therein, said cooling coils having fins thereon extending substantially parallel to the direction of air flow therethrough, the fins on said secondary coil being closer together than the fins on said main coil.

9. The method of refrigerating frozen food products

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in the display area of an open front display case including circulating low temperature air through the display area and forming a wall of low temperature air across the open front, returning substantially all of said low temperature air into said display case, circulating the most humid portion of said return air over first refrigerating means operating at low refrigeration temperatures to effect dehumidification, circulating the least humid portion of return air in by-pass relation with said first refrigerating means, and passing said least humid portion of return air and said rehumidified air over second refrigerating means operating at low temperatures for distribution to said display area and across the open front of said display case.

10. The method of refrigerating frozen food products in the display area of an open front display case including circulating low temperature air through the display area and forming a wall of low temperature air across the open front, returning substantially all of said low temperature air into said display case, circulating the most humid portion of said return air over first refrigerating means operating at low refrigeration temperatures to effect dehumidification, circulating the least humid portion of return air in by-pass relation with said first refrigerating means, passing said least humid portion of return air and said dehumidified air over second refrigerating means operating at low temperatures for distribution to said display area and open front, and removing frost accumulations from said first refrigeration means more frequently than from said second refrigeration means.

11. The method of refrigerating frozen food products in the display area of an open front display case including forming a wall of low temperature air across the open front, circulating low temperature air through the display area in supporting relationship with said wall of air to reduce turbulence thereof, returning substantially all of said low temperature air into said display case, circulating only the most humid portion of said return air over first refrigerating means operating at low refrigeration temperatures to effect dehumidification, circulating the least humid portion of return air in by-pass relation with said first refrigerating means, moving said least humid portion of return air and said dehumidified air over second refrigerating means operating at low temperatures to remove excess moisture therefrom, distributing said air to said display area and open front, defrosting both of said refrigeration means at predetermined intervals, defrosting said first refrigeration means at other intervals intermediate said defrost of both of said refrigeration means, and moving substantially all of said return air over said second refrigeration means and distributing it to said display area and open front during intermediate defrosting of said first refrigeration means.

12. An open front merchandiser having a display area including a lower well portion and an upper shelf portion, and a shelf positioned in the upper shelf portion of the display area, said merchandiser comprising a refrigeration system including first evaporator means for cooling air to low refrigeration temperatures, second evaporator means in advance of said first evaporator means for dehumidifying a portion of air for said merchandiser, air distribution means for circulating the low temperature air through the lower and upper portions of the display area and forming a low temperature air curtain across said open front, said last mentioned means including a duct having an air discharge adjacent to the front of the merchandiser at the top thereof forming said air curtain and secondary air outlets immediately adjacent to said air discharge, duct means below said shelf having an outlet adjacent to the front of the shelf, and other means associated with the front of said shelf for providing non-turbulent flow of said air curtain.

13. An open front display case for frozen products

comprising a vertical display area accessible through the front opening, a shelf in said display area having an unrestricted front edge, an air distribution system including a discharge portion for circulating air through the display area and forming a wall of air across the open front and a return portion for receiving return air from the display area and from said wall of air, and a refrigeration system for cooling the return air to low refrigeration temperatures and removing moisture therefrom, including first refrigeration means and first air moving means passing the total amount of return air into said discharge portion, second refrigeration means and second air moving means passing a portion of said return air having the highest moisture content from said return portion to one of said first air moving and refrigeration means, and by-pass means passing a portion of said return air having the lowest moisture content from said return portion to one of said first air moving and refrigeration means.

14. An open front display case for frozen products comprising a vertical display area accessible through the front opening, a shelf in said display area having an unrestricted front edge, an air distribution system including a discharge portion for circulating air through the display area and forming a wall of air across the open front and a return portion for receiving return air from the display area and from said wall of air, said distribution system including means controlling air flow into and through said display area to support and maintain said wall of air in a substantially non-turbulent path, and a refrigeration system for cooling the return air to low refrigeration temperatures and removing moisture therefrom, including first refrigeration means and first air moving means passing the total amount of return air into said discharge portion, second refrigeration means and second air moving means passing a portion of said return air having the highest moisture content from said return portion to one of said first air moving and refrigeration means, and by-pass means passing a portion of said return air having the lowest moisture content from said return portion to one of said first air moving and refrigeration means.

15. An open front display case for frozen products comprising a vertical display area accessible through the front opening, a shelf in said display area having an unrestricted front edge, an air distribution system including a discharge portion for circulating air through the display area and forming a wall of air across the open front and a return portion for receiving return air from the display area and from said wall of air, and a refrigeration system for cooling the return air to low refrigeration temperatures and removing moisture therefrom, including first refrigeration means and first air moving means passing the total amount of return air into said discharge portion, second refrigeration means and second air moving means passing a portion of said return air having the highest moisture content from said return portion to one of said first air moving and refrigeration means, a by-pass passage in said case passing a portion of said return air having the lower moisture content from said return portion to one of said first air moving and refrigeration means, said refrigeration system also including first means for totally defrosting said first and second refrigeration means, and second means for defrosting said second refrigeration means intermediate said total defrosts, said first and second refrigeration means being in parallel refrigerant flow paths in said refrigeration system and said second means being operable to divert all refrigerant flow to said first refrigeration means.

16. In an open front, low temperature merchandiser having a display area through which low temperature air is circulated, a refrigeration system comprising a first evaporator coil, a first fan moving air therethrough in a direction away from said first coil and effecting total air movement substantially uniformly over said first coil, a second evaporator coil in series flow relation with said first coil and having an air inlet in communication with said display area, a second fan circulating air from said display area over said second coil and discharging it toward said first fan, and a passage in series flow relation with said first fan and in by-pass relation with said second coil and having an air inlet in communication with said display area, each of said coils having fins extending substantially parallel to the direction of air flow therethrough, the fins on said second coil being closer together than the fins on said first coil, defrost means for removing frost or ice accumulations from said coils, means for effecting controlled cyclic defrost of said first and second coils at relatively widely spaced intervals and intermediate defrost of said second coil only at a shorter interval, said first coil being operable during intermediate defrost and said second fan being inoperable and restricting air flow over said second coil to a minimum.

17. The merchandiser according to claim 16 wherein the leading edges of said fins are in offset relationship in the direction of air flow through said coils.

18. The merchandiser according to claim 16 wherein said refrigeration system includes a third evaporator coil in advance of said first fan and over which the total volume of air is circulated thereby, and said first coil is positioned in series flow relation with said third coil behind the first fan, said third coil having fins extending substantially parallel to the direction of air flow therethrough, said third coil fins being spaced farther apart than the fins on said first coil.

19. An open front merchandiser having a display area including a lower well portion and an upper shelf portion, and a shelf positioned in the upper shelf portion of the display area, said merchandiser comprising a refrigeration system including first evaporator means for cooling air to low refrigeration temperatures, second evaporator means in advance of said first evaporator means for dehumidifying a portion of air for said merchandiser, air distribution means for circulating the low temperature air through the lower and upper portions of the display area and forming a low temperature air curtain across said open front, said last mentioned means including a duct having an air discharge adjacent to the front of the merchandiser at the top thereof forming said air curtain and secondary air outlets adjacent to said air discharge, duct means below said shelf having an outlet adjacent to the front of the shelf, whereby low temperature air is discharged through said secondary air outlets and duct means outlet toward said air curtain to reduce turbulence of said air curtain to a minimum.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,063,253

November 13, 1962

Edgar V. Dickson et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 63, strike out "ture cases closed by doors or having open tops have been"; column 4, line 47, for "base" read -- case --; column 6, line 43, for "product" read -- product --; column 14, line 11, for "rehumidified" read -- dehumidified --.

Signed and sealed this 7th day of May 1963.

(SEAL)

Attest:

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