April 19, 1960 D. A. HARGRAVE ET AL 2,932,955

GRAVITY-FLOW OPEN-TOPPED REFRIGERATED DISPLAY CABINET

Filed Dec. 31, 1958

3 Sheets-Sheet 1

FIG. 1

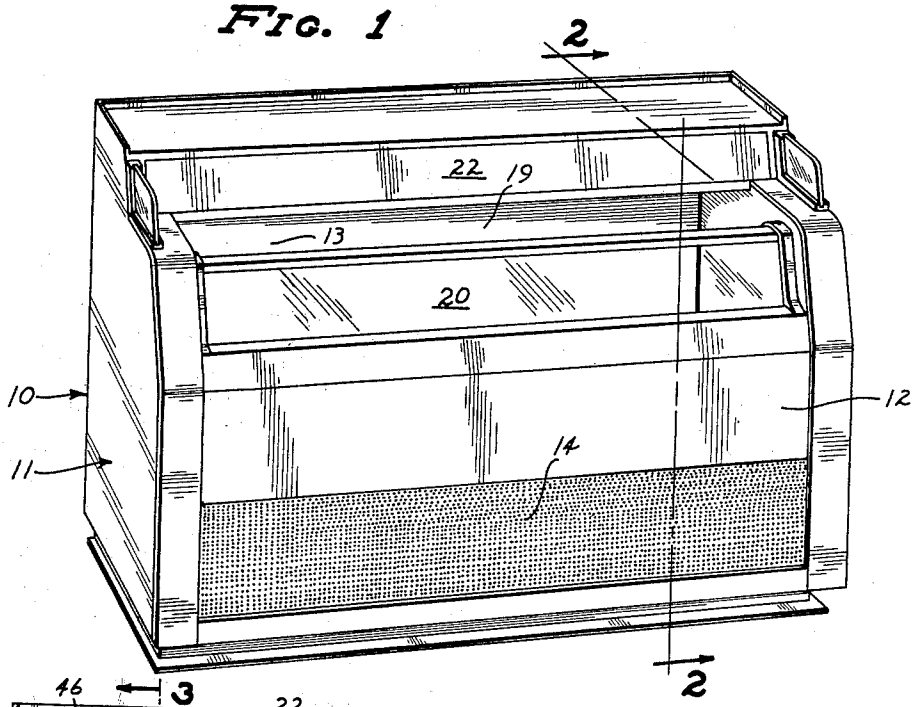
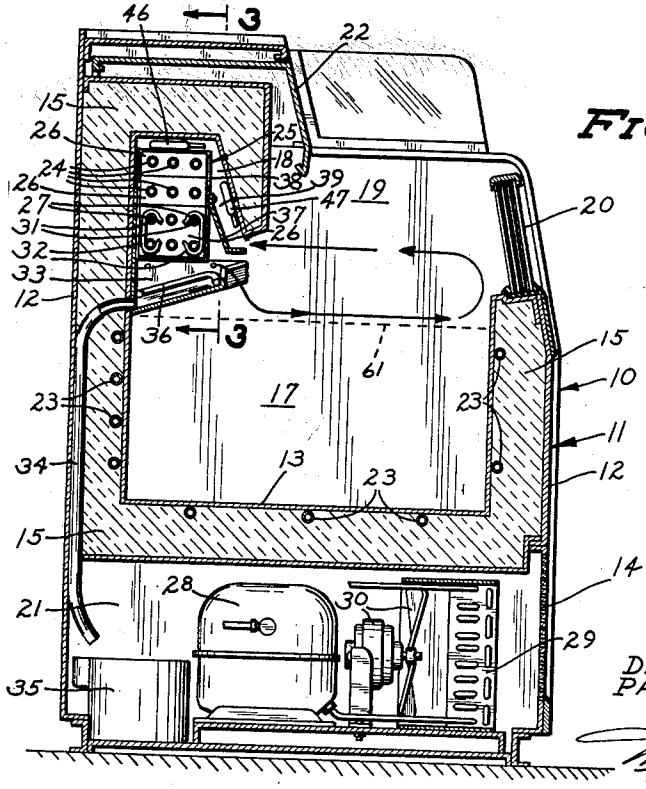


FIG. 2



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FIG. 3

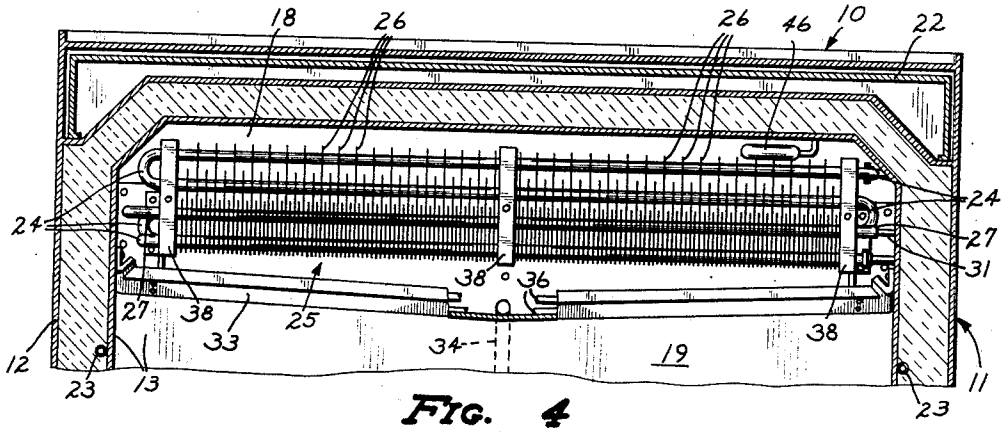


FIG. 4

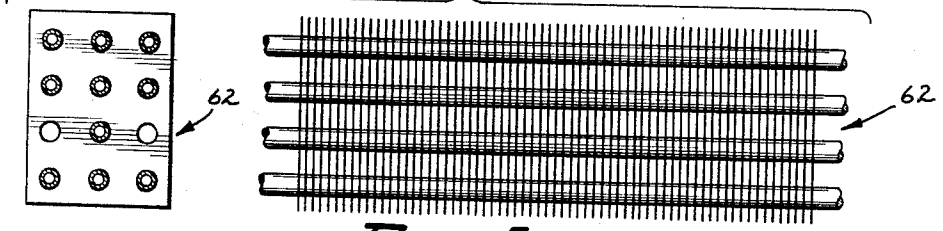


FIG. 5

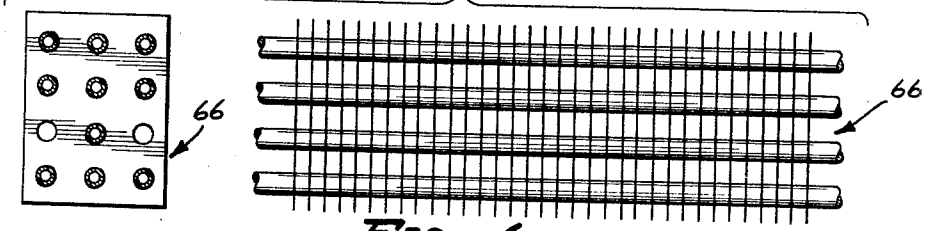
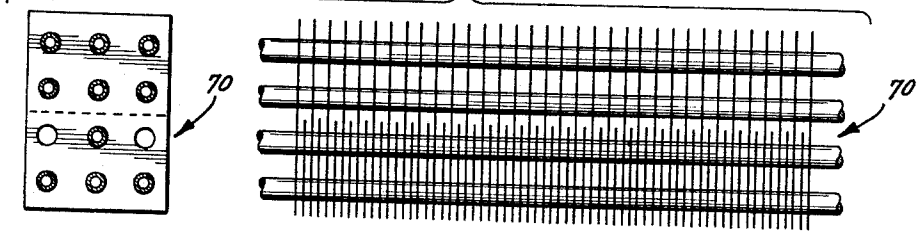


FIG. 6



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FIG. 7

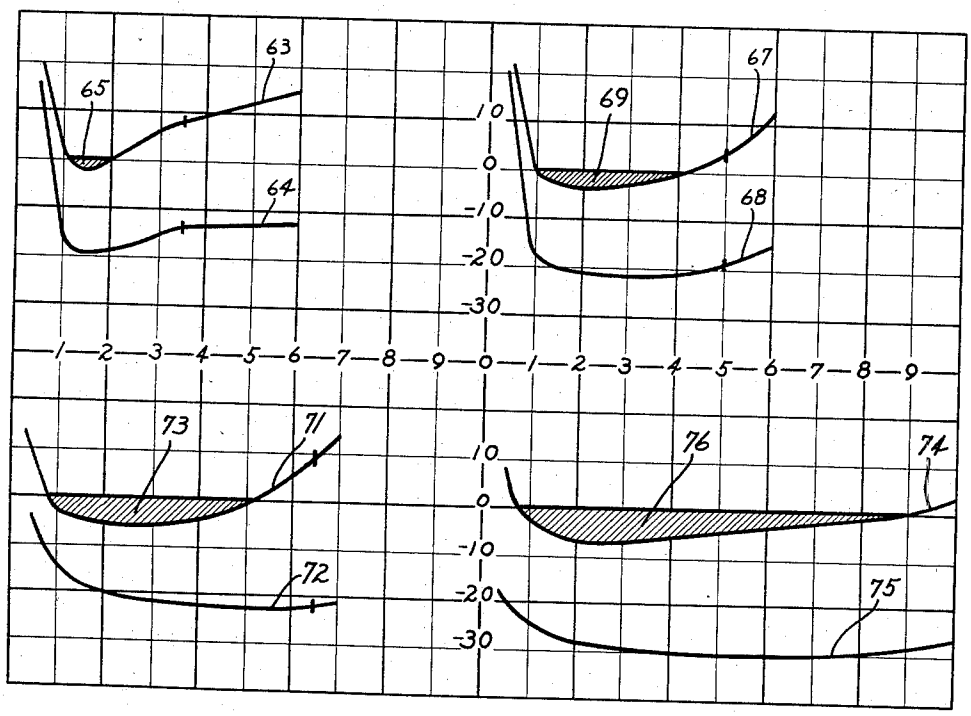
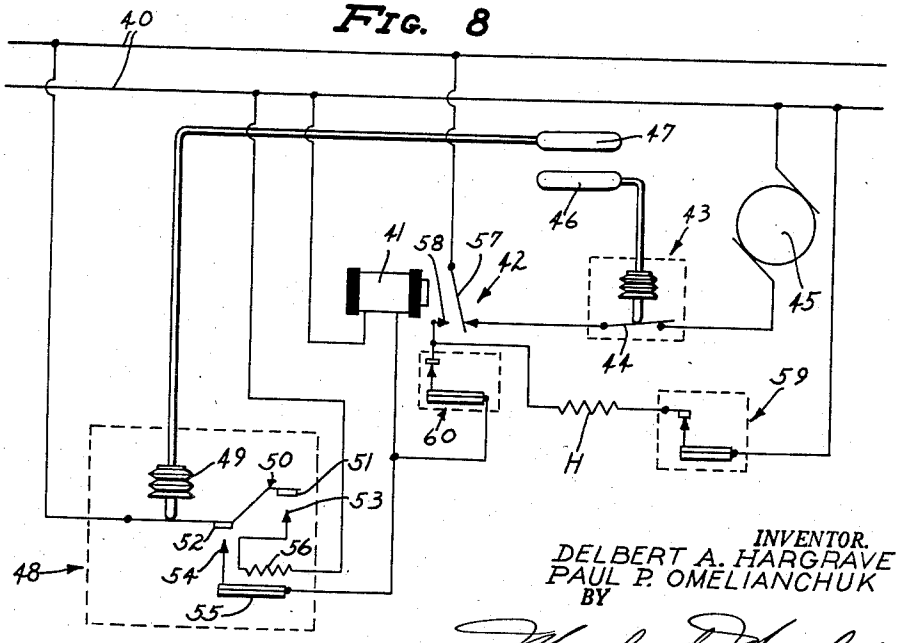


FIG. 8



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GRAVITY-FLOW OPEN-TOPPED REFRIGERATED DISPLAY CABINET

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Application December 31, 1958, Serial No. 784,126

4 Claims. (Cl. 62—255)

Our invention relates to an improved gravity-flow type open-topped display cabinet for frozen food products.

This general type of refrigerated display cabinet has been known in the art for a considerable period of time; and it is generally characterized by an open-topped lower product chamber, an upper chamber in communication with the lower product chamber, and a cooling coil in the upper chamber. In this type of cabinet there is a gravity flow circulation of air comprising warm moist air rising from adjacent the open top of the cabinet into the upper chamber to the coil and through the coil, where it is dehydrated and cooled, and the cooled air is directed into the product chamber across the product therein toward the front of the cabinet and then back to the coil in the upper chamber to complete the cycle. The coil in the upper chamber acts both to cool the circulating air and in dehydration thereof, and with respect to the latter, the coil acts to pick up most of the water vapor which migrates into the cabinet which collects on the coil as frost and this frost is removed by automatic defrost. Generally, the automatic defrosting of this coil in the upper chamber or upper coil is controlled by an automatic time-initiated defrost control, and a particular problem in this type of cabinet has been the problem of selecting the proper number of defrost cycles per unit time.

Generally, this problem has been solved in commercial cabinets of the type here involved by a compromise resulting in a higher rate of unnecessary defrost at low humidities with an inadequate number of defrost at high humidities.

One object of our invention was to provide a solution to this problem; and wherein, one aspect of our present invention was the recognition of the effect of improved coil performance on this problem.

Therefore, a further object of our invention was to provide a refrigerating means in this type of cabinet including a fin-type coil in the upper chamber which would provide maximum coil output for the greatest possible time at high humidities.

A further object of our invention was to provide an improved fin and tube evaporator in a gravity-flow type open-topped display cabinet which would provide for improved cabinet operation, and in particular, improved annual defrost cycle efficiency; and in the accomplishment of this objective, our invention provides for a new combination of elements including a staged fin design, the improved results and advantages of which have been outstanding.

A further object of our invention is to provide improved defrost control in this novel combination, including a staged fin design in a gravity-flow open-topped cabinet, which defrost control is independent of time and is initiated by the amount of frost collected on the coil.

The above and further objects and advantages of our invention will be further disclosed in the course of the following detailed description and appended claims.

Referring to the drawings, which illustrate our invention, and in which like characters indicate like parts throughout the several views:

Fig. 1 is a view in perspective of a gravity-flow open-topped refrigerated display cabinet embodying our invention;

Fig. 2 is a view partly in elevation and partly in vertical section taken generally on the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary view partly in elevation and partly in vertical section taken on the line 3—3 of Fig. 2;

Figs. 4, 5, and 6 disclose different evaporator coil designs, each with a different fin spacing, which were used in the cabinet of Fig. 1 in place of the coil therein for a comparison of results;

Fig. 7 is a graph of results of tests made on the cabinet of Fig. 1 and on the cabinet of Fig. 1 with the coils disclosed in Figs. 4–6 substituted in lieu of the coil thereof; and

Fig. 8 is a diagrammatic and schematic showing of the defrost control for use in the cabinet of Fig. 1.

Referring now more particularly to the drawings, the numeral **10** indicates in its entirety a gravity-flow type open-topped display cabinet for frozen food products embodying our invention. Cabinet **10** comprises frame structure, indicated generally by the numeral **11**, which consists of, primarily, an outer shell **12** and an inner liner **13**. Outer shell **12** includes a removable perforated panel **14**. Outer shell **12** and inner liner **13** are connected together in spaced relation with insulation **15** therebetween; and frame structure **11** is formed to provide an open-top lower product chamber **17** and an upper chamber **18** disposed generally above the lower product chamber **17** and having an open bottom in communication with the product chamber **17** adjacent the open top thereof. Lower product chamber **17** is accessible through the open top of the cabinet **10** which is indicated by the numeral **19**. Adjacent the open top **19** is a glass front partition **20** which forms a part of the frame structure **11**. Frame structure **11** is also formed to provide an equipment compartment **21** underlying the product chamber **17** adjacent one end thereof and insulated therefrom by the insulation **15**. Cabinet **10** is also provided with a night cover **22** which is shown in its open inoperative position but which is movable forward over the open top **19** to close the same. Night cover **22** is used to close the open top **19** when cabinet **10** is not being used for display purposes, such as during the night time, to aid in maintaining proper temperature.

The refrigerating apparatus for cabinet **10** is self-contained within the cabinet and is of the compressor-condenser-expander type. The refrigerating apparatus of cabinet **10** comprises a plurality of lower expansion coils, indicated by the numeral **23**, associated with the product chamber **17**. Lower expansion coils **23** are in the nature of a wrap-around coil secured to the front, bottom, back and ends of inner liner **13** in thermal transfer relationship on the outer surface thereof by soldering or the like. Connected in series with the lower expansion coils **23** are the evaporator tubes **24** of an upper fin-type expansion coil, indicated in its entirety by the numeral **25**, positioned in upper chamber **18**.

Referring more particularly to Fig. 3, upper coil **25** is a staged fin coil comprising vertically disposed fins **26** rigidly connected in laterally spaced relationship to the evaporator tubes or coils **24**, in thermal conducting relationship by welding or the like. As shown in Fig. 2, there are a plurality of vertically spaced rows of coils **24** and a plurality of laterally spaced horizontal coils **24** in each row with the exception of the third row from the top which is more specifically designated by general reference numeral **27** and will be explained in more detail subsequently. The vertically spaced rows of coils **24** being denominated upper, lower and intermediate coil

portions or stages of the upper coil 25. The fins or fin portions 26 connected to the upper row of coils 24, or to the uppermost stage of coil 25, are spaced a greater distance apart one from another than the fins or fin portions 26 connected to the next row of coils, or intermediate stage below the uppermost stage; and similarly, the fins or fin portions 26 of said intermediate stage are spaced a greater distance apart one from another than the fins 26 attached to the coils below said intermediate coil portion or stage. In particular, coil 25 provides for 3 stages of fin spacing wherein the fins 26 attached to the top row of coils 24 are spaced one fin per inch of coil; the fins 26 attached to the next row of coils 24 are two fins per inch of coil; and the lowermost stage comprises two vertically spaced rows of coils 24 and the spacing of the fins 26 attached to these coils is four fins per inch of coil. Further, it should be noted in Fig. 3 that the structure of upper coil 25 provides for the fin portions of each stage or coil portion to be integral with and form some of the fin portions of each of the stages therebelow. This provides for simplicity and an economical coil design.

The refrigerating apparatus further comprises the usual compressor 28, condenser 29, motor driven fan 30, and capillary tube not shown in the drawings. During the refrigerating cycle, refrigerant passes from the compressor 28 to the condenser 29, then is metered by the capillary tube, not shown in the drawings, to the upper fin coil 25, then through the lower wrap-around coils 23, an accumulator, not shown in the drawings but well known in the art, then back to the compressor 28 through a combination suction line-heat exchanger, not shown in the drawings but well known in this art.

As previously mentioned, the third row, indicated by the numeral 27 of upper coil 25 differs from the other rows of coils 24 in that two of the spaces for refrigerant tubes are occupied by electric defrost heaters 31. Each of the two defrost heaters 31 extend the length of coil 25 and they are maintained in good thermal transfer relationship with fins 26 by clips 32. A drain pan 33 is disposed below upper or top coil 25 to collect the condensate or water coming from upper coil 25 during defrosting thereof; and this condensate or water is directed from drain pan 33 through discharge pipe 34 to a container 35. Electric defrost heaters 36 are connected to drain pan 33 and are in the same circuit with defrost heaters 31. Defrost heaters 36 act to defrost the drain pan and insure proper drainage therefrom and also aid in defrosting upper coil 25.

We provide a longitudinally extended baffle 37 which is anchored to a plurality of mounting brackets 38 which are anchored to upper coil 25 and are used in mounting upper coil in upper chamber 18. Baffle 37 is fixedly positioned in upper chamber 18 as shown in Fig. 2 and it forms an air-flow passage 39 between the baffle and the frame structure forming a part of upper chamber 18. As shown in Fig. 2, passage 39 has a forwardly facing opening adjacent the open top of product chamber 17 and it extends to the top part of upper coil 25.

Generally, gravity-flow type open-topped display cabinets have almost exclusively used timing controls for defrost, wherein defrost commences at a certain specified time, extends for a predetermined extent of time, and then shuts off. Our improved gravity-flow display cabinet makes feasible a control system dependent upon the extent of frost collected on the upper coil 25 and we are able to eliminate the presently used timing devices. Our defrost control is shown in Fig. 8 wherein electrical wires 40 are adapted to be connected to a source of suitable electrical power. During normal refrigerating operation, relay coil 41 is deenergized and switch 42 is in the position shown in Fig. 8. At this point, the defrost cycle is inoperative and the cabinet is in its refrigerating cycle. Power is supplied through the refrigeration controller indicated generally by the numeral 43 comprising

feeler bulb control switch 44 to the compressor motor indicated by the numeral 45 on Fig. 8. Switch 44 is controlled by feeler bulb 46 disposed in contact with top coil 25, as shown in Fig. 3; wherein, refrigeration is thermostatically controlled by feeler bulb 46 to periodically operate the compressor motor 45, and thereby the refrigeration cycle, to maintain temperatures in cabinet 10 as required. Generally, for ice cream, feeler bulb 46 maintains a −10° to −15° F. cabinet temperature. Feeler bulb 47 is positioned in passage 39, as shown in Fig. 2, wherein it is responsive to the air returned to upper coil 25 for cooling. When this return air temperature begins to rise, or has risen a predetermined amount, it means that upper coil 25 has become inefficient due to frost collection and that coil 25 needs defrosting. At a predetermined return air temperature, and specifically, generally at 0° F., feeler bulb 47 actuates the defrost controller indicated generally by the reference numeral 48. Defrost control 48 comprises the usual compensating bellows 49, movable switch member 50 having contacts 51 and 52, fixed contact 53, contact 54 connected to bimetal 55, and bimetal heater 56. Defrost controller 48 operates as follows. Feeler bulb 47 and compensating bellows 49 initiate defrost by acting upon switch arm 50 to move contacts 51 and 53 into engagement and contacts 52 and 54 into engagement. The engagement of contacts 52 and 54 energizes coil 41 to move movable contact 57 of switch 42 from its position shown in Fig. 8 into contact with fixed contact 58 of switch 42. This acts to complete a circuit from wires 40 to the defrost heaters 31 and 36, shown as a single resistance element in Fig. 8 and indicated there by the letter H. In the circuit with defrost heaters H are a limit bimetal control switch 59, which will open at a predetermined temperature to insure against over-heating, and a bimetal thermostat 60, which will open at a predetermined temperature rise to terminate the defrosting cycle. Bimetal heater 56 actuates bimetal 55 and its associated contact 54 to open contacts 52 and 54 shortly after commencement of the defrost cycle so that coil 41 is energized and contacts 57 and 58 maintained in contact solely through the thermostatic bimetal switch 60. It should be mentioned that upon energization of coil 41 and contact of switch elements 57 and 58 of switch 42, the circuit to compressor motor 45 is opened to terminate the refrigeration cycle at the time of the initiation of the defrost cycle. Generally, thermostatic control switch 60 is set to open when the upper coil 25 is heated to approximately 60° F. whereupon coil 41 is deenergized and movable switch arm 57 is biased to return to its position shown in Fig. 8 to shut off defrost heaters H and complete the circuit through compressor motor 45 to re-start the refrigerator compressor.

Referring more specifically now to the general operating principles of the cabinet of our invention, lower product chamber 17 is generally filled with packages of frozen foods or the like, and particularly ice cream, to a level indicated by a dotted load line shown in Fig. 2, which is indicated by the numeral 61. Upper coil 25 creates a gravity flow circulation of air downwardly from coil 25 into the product chamber 17 and across the tops of the packages therein toward the glass front partition 20 and warmer air across the open top of product chamber 17 in a direction away from the glass front partition 20 and upwardly through passage 39 to adjacent the uppermost part of upper coil 25, and then downwardly through the coil to complete the cycle of circulation of air through the upper coil 25. This gravity-flow or thermal-syphon circulation of air across the open top of cabinet 10 acts to entrain most of the moisture coming into cabinet 10 through open top 19 into the circulation of air moving through passage 39 to upper coil 25 wherein the moisture is deposited on coil 25 are frost, as is characteristic of this type of cabinet. Thus, upper coil 25 acts to collect most of the moisture coming into cabinet 10

so as to keep the product in chamber 17 and the walls of inner liner 13, refrigerated by coils 23, substantially free of frost. In addition, upper coil 25 in cooling the air passing through the coil acts to maintain a layer of cold air over the tops of the product in chamber 17 and to absorb the heat adjacent the open top of product chamber 17. Lower coils 23 act to absorb the heat coming to the inner liner 13 and the product in chamber 17 through the side walls and bottom of the cabinet through insulation 15. Lower wrap-around coils 23 and upper coil 25 cooperate to maintain the product in chamber 17 at proper temperature.

Thus, upper coil 25 has a two-fold responsibility, as aforementioned; first, to pick up the moisture or water vapor which migrates into cabinet 10, and second, to cool the air circulating over coil 25 to a low enough temperature to properly refrigerate the top of the product load. Coil 25 is a staged fin design providing for wider spacing of the fins at the upper part of the coil to allow more room for frost collection with progressively smaller fin spaces for the stages thereafter to provide for more effective cooling; and the staged fin design of coil 25 in this combination has resulted in a tremendously improved cabinet, as is evidenced from the following tests.

We have tested the structure of cabinet 10 not only with coil 25 but also with the fin-type coils of Figs. 4, 5, and 6; and some of the results have been shown in Fig. 7. Fig. 4 comprises a fragmentary view in side elevation and a transverse section thereof of a fin-type coil, indicated by the numeral 62, which has uniform fin spacing of 4 fins per inch of coil. Referring to Fig. 7, the graph line indicated by the numeral 63 is a measurement of return air temperature versus time in a cabinet similar to cabinet 10 but utilizing coil 62 rather than upper coil 25; and graph line 64 is the plotted results of discharge air temperature versus time on this cabinet. The shaded area, indicated by the numeral 65 which is between the 0° datum line and that portion of return air temperature line 63 of the aforementioned cabinet, which will be denominated coil 62 cabinet, has been selected as a comparison point and is referred to as the useful refrigerating effect produced by coil 62 in between defrost cycles.

Fig. 5 comprises a fragmentary view in side elevation and a transverse section thereof of a fin type coil, indicated by the numeral 66 which is similar to coil 62 but comprises uniform fin spacing of 2 fins per inch of coil. Referring to Fig. 7, the graph line indicated by the numeral 67 shows the plotted results of return air temperatures versus time in a cabinet, which will be denominated coil 66 cabinet which is in all respects similar to cabinet 10 but utilizing coil 66 in place of upper coil 25 of cabinet 10. As was mentioned with respect to coil 62 cabinet, graph line 68 of Fig. 7 shows the plotted results of discharge air temperatures versus time of tests made on the coil 66 cabinet; and the shaded area, indicated by the numeral 69 on Fig. 7, refers to the useful refrigerating effect produced by coil 66 in between defrost cycles.

Fig. 6 comprises a fragmentary elevation and a transverse section thereof of a coil, indicated by the general reference numeral 70 which is a staged fin coil comprising an upper stage having two vertically spaced rows of horizontal coils wherein the spacing of the fins attached thereto is two fins per inch of coil and a lower coil portion comprising two vertically spaced rows of horizontal coils wherein the fin spacing is 4 fins per inch of coil. Tests were made on a cabinet, which will be denominated the coil 70 cabinet, as were made with respect to the coil 62 cabinet and the coil 66 cabinet; and Fig. 7 also shows test results on the coil 70 cabinet. Graph line 71 shows the plotted results of return air temperatures versus time for the coil 70 cabinet; graph line 72 shows the plotted results of discharge air temperatures versus time for the coil 70 cabinet; and the shaded area, indicated by the numeral 73, shows what has been selected as the useful refrigerating effect produced by coil 70 in between defrost cycles.

Fig. 7 also shows test results made on cabinet 10 with respect to upper coil 25; and graph line 74 shows the plotted results of return air temperatures versus time for cabinet 10 with coil 25; graph line 75 shows the plotted results of discharge air temperatures versus time for cabinet 10, using coil 25; and the shaded portion 76 shows what has been selected as the useful refrigerating effect produced by upper coil 25 in cabinet 10 in between defrost cycles.

Briefly with respect to the conditions of the tests on cabinet 10, the coil 62 cabinet, the coil 66 cabinet, and the coil 70 cabinet. In each case, the cabinet was loaded with pint packages of ice cream to the load level indicated by the numeral 61 with respect to cabinet 10, Fig. 2. Tests were performed in a humidity room under constant conditions of 80° F. dry bulb and 70% relative humidity. Room air velocities were high to effect an accelerated test. Each cabinet was operated for a 16 hour period with night cover closed, the coil was defrosted, the night cover then opened, and readings taken each half hour. Referring to Fig. 7, time is indicated along the horizontal axis in hours by the numerals 1–9; and temperature is indicated along the vertical axis of the graph of Fig. 7. Each test was concluded when upon inspection, the coil appeared 100% blocked. The cabinet position in the test room remained unchanged for all four tests to insure the same test conditions for each cabinet.

Coils 62 and 66 are the types of fin coils which have normally been used in gravity-flow type open-top display cabinets of the type here involved; and the test results of Fig. 7 indicate the improved results obtained by the staged fin coil 70 and in particular, the staged fin coil 25 in cabinet 10.

It should be mentioned that coil 62 as tested had a total fin surface of 101.4 square feet; coil 66 had a total fin surface of 50.7 square feet; coil 70 had a total fin surface of 76.0 square feet; and upper coil 25 had a total fin surface of 69.8 square feet. Thus, coil 25 not only produces improved results in the refrigerating effect and frost capacity of the coil in cabinet 10, but this is accomplished with a considerable reduction in fin surface over the fin surface of less effective coil 62.

Cabinets incorporating our invention herein described and claimed have been commercially produced; and the results of these cabinets in use together with the tests conducted aforementioned have indicated that cabinets of our invention are considerably improved over previously known prior art gravity-flow open-topped display cabinets, and in particular in two important respects. First, cabinet 10 provides for a longer frost block time than previously known cabinets, that is, cabinet 10 is able to run for a considerably longer period of time without defrosting and without blocking circulation of air through the coil by the frost collected on the coil; and second, cabinet 10 provides for a gain in refrigerating effect over previously known cabinets of this type. This improved refrigerating effect would provide a further advantage in better maintaining the product in product chamber 17. Other advantages of our invention are a reduced possibility of ice cream thermal shock because the possibility of blocking coil 25 with frost is reduced, and our invention, due to the improved refrigerating effects, better maintains a cold air seal over the open top 19 which reduces the effect of frost accumulation on the display areas of cabinet 10 and product chamber 17.

It will be obvious to those skilled in the art that our invention may be modified by many substitutions and equivalents; and it should be understood that this disclosure is intended to be illustrative only and that we intend to be limited solely by the scope of the appended claims.

What we claim is:

1. A gravity-flow type open-topped display cabinet for

frozen food products comprising frame structure defining a lower product chamber having an open-top and an upper chamber disposed above said lower chamber and communicating therewith adjacent said open-top, refrigerating apparatus comprising lower expansion coils associated with said product chamber and an upper fin-type expansion coil positioned in said upper chamber and connected to said lower expansion coils, and said upper coil being a staged fin construction comprising a plurality of generally vertically disposed fin portions rigidly connected in laterally spaced relationship to a plurality of interconnected generally horizontally disposed evaporator tube portions, some of said tube portions being disposed in vertically spaced relationship to form an upper coil stage and a lower coil stage, said coil stages being in adjacent relationship one above the other, each stage comprising a plurality of tube portions disposed in laterally spaced relationship in generally common horizontal planes, said fin portions connected to said upper coil stage being laterally spaced a greater distance apart one from another than the fin portions connected to the lower coil stage are laterally spaced one from another, said upper coil creating a circulation of air by gravity generally vertically through said upper coil which air passes first through the upper stage thereof and then to and through the lower stage thereof, whereby the fin portions connected to said upper coil stage act primarily in dehydration of the air passing through the coil and for collection of frost and the fin portions connected to the lower coil stage act primarily in cooling of the air passing through the upper coil.

2. A gravity-flow type open-topped display cabinet for frozen food products comprising frame structure defining a lower product chamber having an open-top and an upper chamber disposed above said lower chamber and communicating therewith adjacent said open-top, refrigerating apparatus comprising lower expansion coils associated with said product chamber and an upper fin-type expansion coil positioned in said upper chamber and

connected to said lower expansion coils, and said upper coil being a staged fin construction comprising at least three stages, said stages being in vertically superposed relationship and each stage being in generally horizontal planes, each stage comprising a plurality of generally horizontal laterally spaced interconnected evaporator tube portions and a plurality of generally vertically disposed fin portions fixedly and thermally connected to said tube portions in generally uniformly laterally spaced relationship, the fin portions of the uppermost stage being laterally spaced a greater distance apart one from another than the fin portions of an intermediate stage below said uppermost stage and the fin portions of said intermediate stage being laterally spaced a greater distance apart one from another than the fin portions of a stage below said intermediate stage, said upper coil creating a circulation of air by gravity generally vertically through said upper coil first through the uppermost stage thereof and downwardly through the other stages thereof into said product chamber.

3. The structure defined in claim 2 in which the fin portions of each stage except the lowermost stage are integral with and form some of the fin portions of each stage therebelow.

4. The structure defined in claim 2 in which said upper coil comprises three stages, the spacing of the fin portions of the uppermost stage being one fin per inch of coil, the spacing of the fin portions of the intermediate stage being two fins per inch of coil, and the spacing of the fin portions of the lowermost stage being four fins per inch of coil.

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