May 15, 1962 A. G. JANOS ET AL 3,034,313

AUTOMATIC DEFROST TWO-TEMPERATURE REFRIGERATOR

Filed Aug. 7, 1959 3 Sheets-Sheet 1

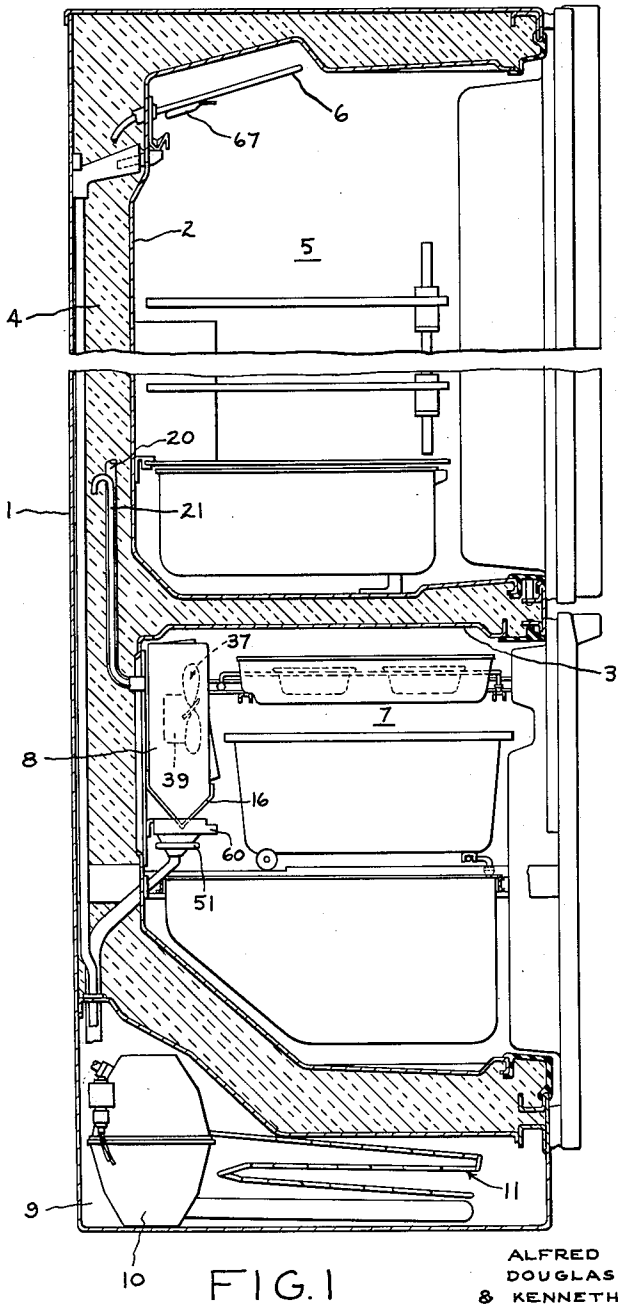


FIG. 1

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AUTOMATIC DEFROST TWO-TEMPERATURE REFRIGERATOR

Filed Aug. 7, 1959 3 Sheets-Sheet 2

FIG. 2

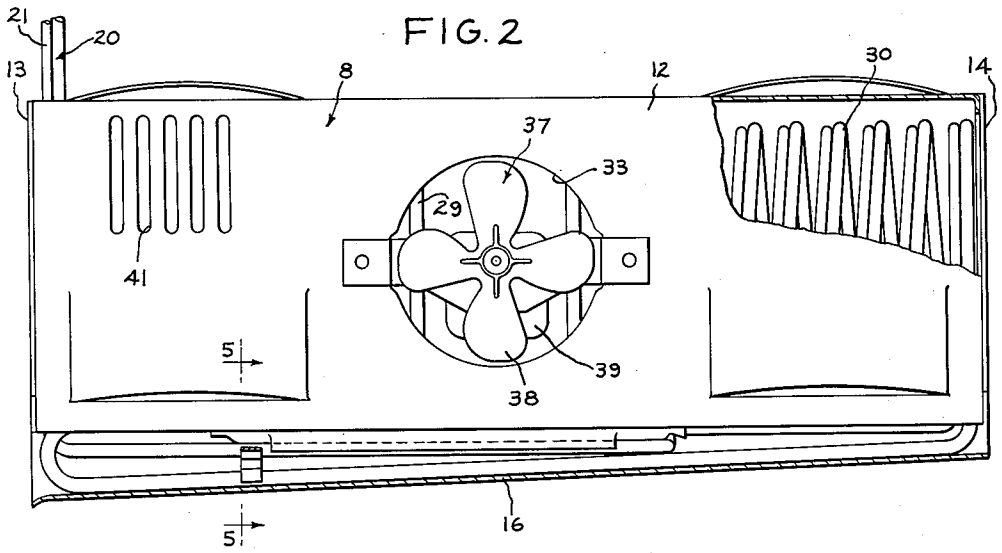


FIG. 3

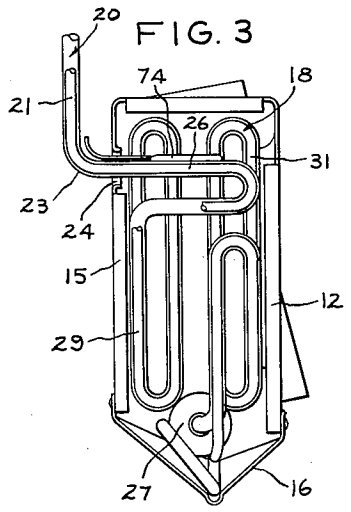
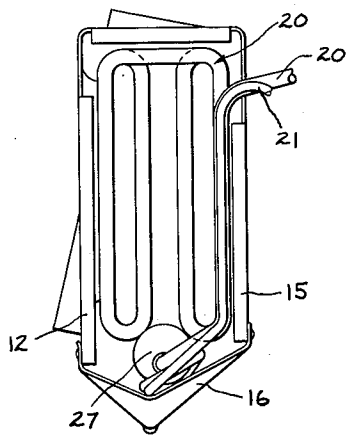


FIG. 4



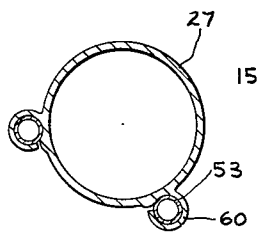


FIG. 6

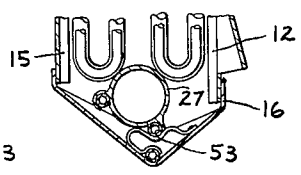


FIG. 5

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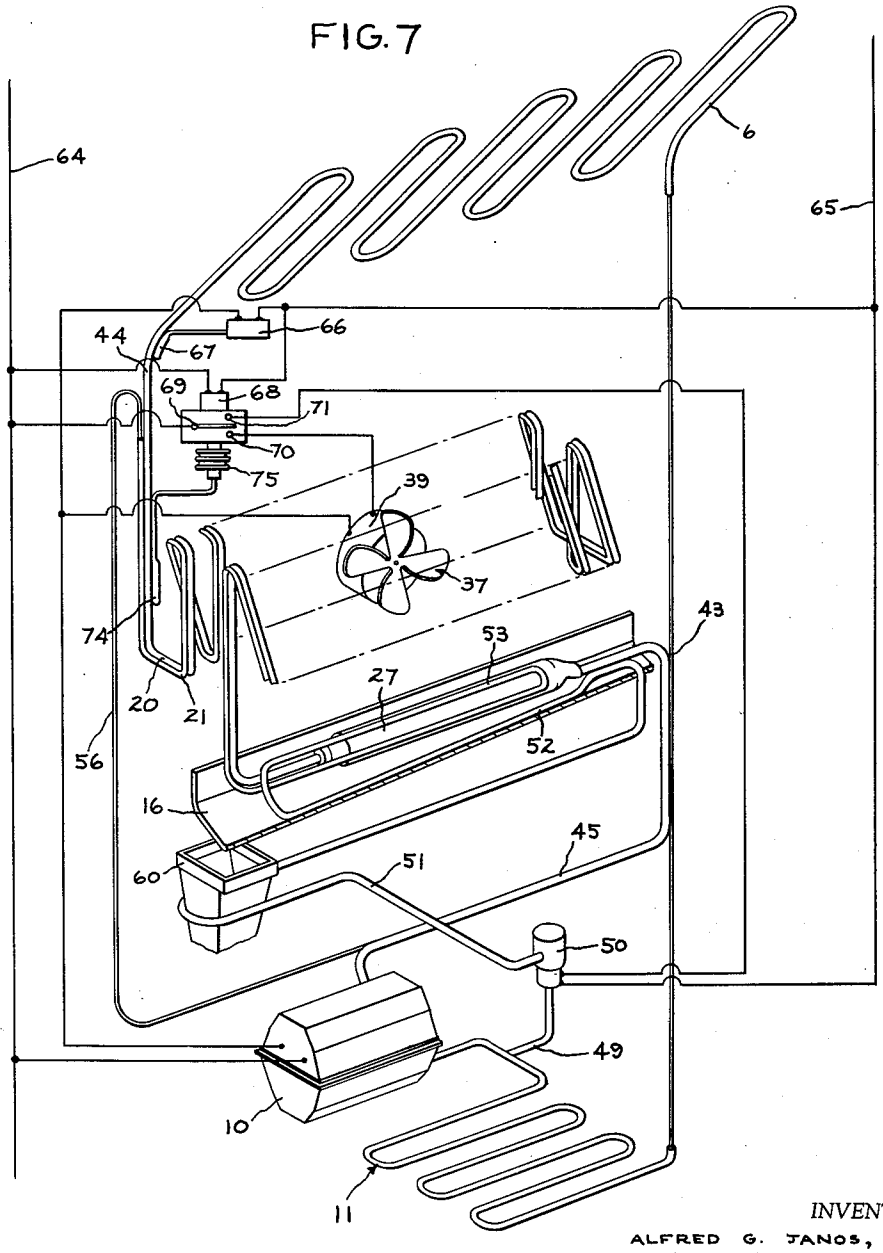
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May 15, 1962 A. G. JANOS ET AL 3,034,313

AUTOMATIC DEFROST TWO-TEMPERATURE REFRIGERATOR

Filed Aug. 7, 1959 3 Sheets-Sheet 3

FIG. 7



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3,034,313
AUTOMATIC DEFROST TWO-TEMPERATURE REFRIGERATOR

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1 Claim. (Cl. 62—155)

The present invention relates to household refrigerators and is more particularly concerned with a two-temperature refrigerator including automatically defrostable fresh food and freezer evaporators and to an improved freezer evaporator structure particularly adapted for automatic defrosting operation.

Many of the present day refrigerators for household use include a fresh food storage compartment operating at temperatures above freezing and a freezer compartment operating at sub-freezing temperatures. Since the evaporator serving the fresh food compartment operates in an ambient temperature that is substantially above freezing, an effective means for defrosting the evaporator is to permit the evaporator to reach a temperature above freezing during each "off" cycle of the refrigerating apparatus so that any frost which has collected thereon during the previous "on" cycle will melt, the defrost water being disposed of outside of the fresh food compartment.

Automatic defrosting of the freezer evaporator on the other hand presents a more difficult problem, one reason for this being that the defrosting operation must be carried out in such a manner that while the evaporator itself is warmed to a temperature above freezing, the contents of the freezer compartment are maintained below freezing and at safe frozen food storage temperatures during the defrost operation. In addition, it is essential that the entire freezer evaporator structure come up to defrosting temperatures during the defrost cycle and that all of the condensate collected thereon be disposed of before the evaporator is again refrigerated. Otherwise, ice in increasing amounts will accumulate on those portions of the freezer evaporator which are not completely defrosted and freed of defrost water. Such ice accumulation will eventually interfere with the desired operation of the refrigerator or at the very least constitute a source of annoyance to the user.

It is a general object of the present invention to provide a two-temperature household refrigerator including automatically defrostable fresh food and freezer evaporators.

It is another object of the invention to provide a refrigerator including an improved freezer evaporator which can be both quickly and effectively defrosted and freed of condensate during the defrost cycle.

A further object of the invention is to provide in a freezer compartment of a household refrigerator, a fan blown evaporator unit which is designed for good heat transfer between the evaporator cooling coil and the air stream and for quick and complete frost and moisture removal during a defrost cycle.

A still further object of the invention is to provide a simple and compact defrostable evaporator structure from which condensate will readily drain during a defrost cycle.

Further objects and advantages of the invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claim annexed to and forming a part of this specification.

In carrying out the objects of the present invention, there is provided a combination refrigerator-freezer comprising an upper fresh food compartment, a lower freezer

compartment and separate evaporators for maintaining the respective compartments at the desired operating temperatures. The defrostable evaporator unit for the freezer compartment includes a horizontally extending housing having front, rear and bottom walls, the front wall having an air inlet opening adjacent the center portion thereof and air outlet openings adjacent each end thereof and the bottom wall being V-shaped to form a trough for receiving defrost water. The evaporator coil disposed within the housing above the bottom wall comprises parallel refrigerating and defrost tubes which are integrally connected throughout their lengths to form a smooth surfaced structure from which moisture can readily flow during the defrost operation. The coil includes a first section extending along the rear wall of the housing and second and third sections along the front wall, the second and third sections being spaced on opposite sides of the air inlet opening to permit the mounting of a motor driven fan within the housing opposite the opening in such a position that the combined axial and radial air flow from the fan blades provides a turbulence within the housing which effectively sweeps over all of the surfaces of the coil for maximum heat exchange between the coil and the air. Disposed below the evaporator coil and connected to the outlet end of the refrigerant tube is a refrigerant accumulator that is nested within the V-shaped bottom wall of the housing. The conduit for conducting hot refrigerant gas to the defrost tube component of the evaporator coil has one pass in heat exchange relationship with the V-shaped bottom wall of the housing so that both of these elements are warmed to defrosting temperatures during the defrost cycle thereby facilitating the flow of condensate from the housing during each defrost cycle.

For a better understanding of the invention, reference may be had to the accompanying drawings in which:

FIG. 1 is a side elevational view, in section, of a refrigerator cabinet incorporating an embodiment of the present invention;

FIG. 2 is a front elevation, partly broken away, of the freezer evaporator unit of the present invention;

FIG. 3 is an elevation view of one end of the unit shown in FIG. 2 with the end plate or wall removed;

FIG. 4 is a view similar to FIG. 3 of the opposite end of the evaporator unit of FIG. 2;

FIG. 5 is a sectional view taken along the line 5—5 of FIG. 2;

FIG. 6 is an enlarged sectional view of the accumulator forming part of the evaporator unit; and

FIG. 7 is a diagrammatic illustration of the refrigeration system and evaporator assembly of the present invention.

Referring now to the drawing, there is shown in FIG. 1 a household refrigerator of the two-temperature type comprising an outer shell 1 and inner shells or liners 2 and 3 spaced from the outer shell 1 and from one another, the spaces being filled with suitable heat insulation 4. The upper shell 2 defines a fresh food storage compartment 5 which is maintained at fresh food storage temperatures by means of a serpentine evaporator 6, while the lower liner 3 defines a freezer compartment 7 maintained at sub-freezing temperatures by an evaporator unit 8. The refrigerator also includes a machinery compartment 9 containing a compressor 10 and a condenser 11 for supplying condensed refrigerant to the evaporators 6 and 8.

The freezer evaporator unit 8 employed for maintaining the freezer compartment 7 at sub-freezing temperatures is preferably supported along the rear wall of the freezer compartment. This unit shown in greater detail in FIGS. 2 to 4 of the drawing comprises a substantially closed housing including a front wall 12, end walls 13 and 14, a rear wall 15 and a sloping V-shaped bottom

wall 16. An evaporator coil generally indicated by the numeral 18 is contained within the housing and comprises a refrigerating tube 20 and a defrost tube 21 extending parallel to the refrigerating tube in heat exchange relationship and preferably in mechanical contact with the refrigerating tube. This structure is preferably formed as a smooth surfaced double tube extrusion so that the refrigerating tubing and the defrost tubing are in intimate mechanical contact throughout their lengths within the housing. By means of this double tube structure hot refrigerant gas can be passed through the defrost tube for periodic defrosting of the unit. Preferably, the hot gas flow is counter-current to the refrigerant flow so that refrigerant is introduced into one end of coil and hot gas into the other end.

The refrigerant inlet end or portion 23 of the evaporator coil which is connected to the evaporator 6 extends through an aperture 24 provided in the rear wall 15 of the housing and directly across the housing to form a horizontal pass 26. Most of the remaining portions of the evaporator coil are in the form of vertically elongated loops as illustrated in FIGS. 3 and 4 of the drawing, the loops extending from substantially the top of the housing to the lower edges of the front and rear walls 12 and 15 leaving a space below the evaporator coil 18 and generally within the V-shaped bottom wall 16 for an accumulator 27 forming part of the refrigerating system.

With further reference to the evaporator coil, the coil comprises a first section generally indicated by the numeral 29 extending along the length of the housing adjacent the back wall 15 and second and third sections 30 and 31 extending along the front wall 12 of the housing and respectively positioned on opposite sides of an air inlet opening 33 centrally located in the front wall 12. The refrigerant outlet end of the third section 31 is connected to one end of the accumulator 27.

The use of a double tube extrusion or an equivalent structure which presents a substantially continuous and smooth tube surface and the forming of the double tube extrusion into a plurality of vertically elongated loops having relatively sharp return bends at the tops and bottoms thereof provides a coil from which frost can be quickly removed by passing hot refrigerant gas through the defrost tubing 21. Upon melting of the frost, the condensate readily flows downwardly along the vertical surfaces of the various loops and drips off the sharp return bends or bottom portions thereof into the trough formed by the V-shaped bottom wall 16 from which it is discharged into a drain 60. An important feature of the evaporator coil is its freedom from fins or other structural configurations which are found in many evaporator structures and which cause the trapping of defrost water during defrosting operations.

In order to cool the contents of the freezer compartment 7 to sub-freezing temperatures, air from that compartment is circulated through the housing and over the coil 18 by means of a fan 37 which is positioned as indicated in FIG. 1 within the housing in approximately the same plane as the evaporator coil sections 30 and 31 or in other words with the fan blades 38 in substantial alignment with these coil sections. A motor 39 for driving the fan 37 is also located within the housing and if necessary some of the loops comprising the first evaporator coil section 29 may be spaced apart opposite the air inlet opening 33 to provide room for the motor 39. Air drawn into the housing by the fan through the air inlet 33 passes over the evaporator coil portions on each side of the air inlet 33 and is discharged back into the compartment 7 through a plurality of louvers or air outlets 41 provided in the housing and adjacent the opposite ends thereof. By placing the fan blades 38 within the housing rather than in the plane of the front wall 12 or outside of the housing an increased turbulent air flow through the housing is obtained which assures a maximum heat exchange contact of the air stream and the various loops comprising the evaporator coil 18. The radial air flow from the tips of the fan blades 38 is directed particularly over the front sections 30 and 31 of the evaporator coil while axial air flow from the fan blades contacts the rear wall 15 of the housing and then spreads outwardly towards the ends 13 and 14 of the housing to sweep the rear or first coils section 29. The mixing of these two air streams within the housing provides a turbulent air flow assuring freedom from any dead air spaces within the coil structure.

During normal or refrigerating operation of the refrigerating system schematically shown in FIG. 7 compressed refrigerant from the compressor 10 is condensed in the condenser 11 from which it flows through a capillary tube 43 into evaporator 6 where at a lower pressure a portion of the liquid refrigerant evaporates to cool the contents of the fresh food compartment 5. In the referigerating system employed in the practice of the present invention the fresh food evaporator 6 and the freezer evaporator tubing 20 are designed to operate at the same pressures and at below freezing temperatures when the compressor is operating. They are therefore connected by a non-restricting tube 44. Refrigerant liquid and gas flows from the evaporator 6 into tube 20 where some or all of the remaining liquid evaporates. Any liquid refrigerant not evaporated in the refrigerant tubing 20 forming part of the evaporator unit 8 collects in the accumulator 27 from which the gaseous refrigerant is withdrawn through the suction line 45 by the compressor 10.

For the purpose of defrosting the freezer evaporator structure 8, hot refrigerant gas from the compressor 10 is periodically passed through the defrost tubing 21 employing a defrost arrangement and circuit more fully described and claimed in the copending application of Clyde J. Nonomaque filed November 25, 1957 and assigned to the same assignee as the present invention. The inlet end 49 of the conduit 51 forming part of defrost circuit is connected to the refrigerating circuit between the compressor and the condenser 11 and a normally closed valve 50 is provided for the purpose of controlling the flow of refrigerant through the defrost circuit. When this valve is opened hot compressed refrigerant flows through the conduit 51 which contacts the drain 60 and also includes a pass 52 for warming the V-shaped bottom wall 16 of the housing and a pass 53 extending along the exterior of the accumulator 27 for heating the accumulator. The pass 53 is connected to the defrost tubing 21 which, as has previously been indicated, follows or parallels the refrigerant tube 20 throughout the evaporator coil 18 and passes out through the opening 24 in engagement with the inlet end of the refrigerant tube 20. In order to assure complete defrosting of the entire refrigerant tubing 20 within the freezer compartment, the defrost tubing 21 continues upwardly in contact with the refrigerant tubing through the insulated space between the outer shell 1 and the liners to a point between the freezer evaporator unit 8 and the evaporator 6 where it connects with a capillary tube 56 through which the refrigerant is returned to the suction line 45 and the compressor 10. For a more detailed description of the operation of this defrost circuit reference is made to the above-mentioned Nonomaque application.

As the hot gas passing through the defrost line or tube 21 warms the bottom wall 16 of the housing, the accumulator 27 and the evaporator coil 18 to temperatures above freezing, any frost collected on these surfaces or on any adjacent walls of the housing is quickly melted. The defrost water flowing down the walls of the housing or dropping from the bottom bends of the vertical loops forming the evaporator coil is collected in the V-shaped bottom wall 16 and is discharged into the drain 60 which is provided below the lower end of the sloping bottom wall 16, and which is also warmed to above-freezing temperatures by the hot gas flowing through conduit 51.

The drain disposes of the defrost water outside the freezer compartment and preferably directs it into the machinery compartment 9 where a receptacle (not shown) may be provided for receiving the condensate and evaporating it by means of the heat from the compressor and condenser.

For the purpose of obtaining good heat transfer between the accumulator 27 and the loop 53 of the defrost tubing employed to warm the accumulator during a defrost cycle, the accumulator is preferably formed in the shape of an elongated tube having flanges 60 extending outwardly from the walls thereof, the flanges being shaped to accommodate the defrost tubing 53. As shown more clearly in FIG. 6 these flanges are employed to clamp the defrost tubing into tight heat transfer engagement with the accumulator 27 thus assuring good heating contact between the accumulator and the defrost gas and also serving as a means for supporting the defrost tubing 53 in this area.

The electrical control system for controlling the refrigerating operation of the refrigerating system and for periodically defrosting the evaporator unit by means of hot gas from the compressor 10 is also illustrated in FIG. 7 of the drawing. For normal refrigerating control, the circuit comprises a pair of supply lines or conductors 64 and 65 for energizing the compressor 10 through a temperature-operated switch 66. A temperature sensing device 67 positioned in contact with the outlet end of the evaporator 6 within the fresh food storage compartment 5 operates the switch 66 so that during normal operation of the system, the compressor is energized whenever that evaporator 6 reaches a predetermined above-freezing temperature of, for example, 35° F. and is opened when the temperature reaches a low temperature of, for example, 0° F. Since there is substantially no restriction between the evaporator 6 and the refrigerant tubing 18 forming part of the evaporator unit 8, both of these units reach almost the same minimum temperature during each on or refrigerating cycle. However, as the evaporator 6 is of a smaller mass and is in a warmer environment that evaporator structure 8, its temperature will rise to an above freezing temperature during each off cycle while the freezer evaporator structure 8 experiences a much slower temperature rise and will operate continuously at below freezing temperatures.

For the purpose of automatically initiating periodic defrost operation for the freezer evaporator structure 8, there is employed a defrost control circuit which periodically energizes and opens the solenoid valve 50 to permit flow of gaseous refrigerant from the high pressure side of the system, that is from the compressor, through the defrost circuit. In the illustrated modification of the invention, periodic defrosting is controlled by a timer 68 connected across the supply lines 64—65 which timer operates a switch 69 that controls the operation of the solenoid valve 50 and the fan motor 39. The switch 69 includes normally closed contacts 70 by means of which the fan motor 39 is normally energized for operation of the fan 37 whenever the compressor is energized by closing of switch 66. At predetermined intervals, the timer motor 68 operates switch 69 to open normally closed contacts 70 in the fan circuit and close a contact 71 to energize and open the solenoid valve 50. By stopping the fan 37 during defrost, air circulation between the evaporator unit and the compartment 7 is kept at a minimum. Since the operation of the timer is independent of the refrigerating control switch 66, the energization of the solenoid 50 may take place during normal refrigerating cycle when the compressor is operating or during an off cycle. If the compressor is operating, hot refrigerant from the compressor will immediately be directed through the defrost circuit. If the compressor is not operating, the defrost flow of refrigerant is then initiated at the beginning of the next on cycle when the switch 66 again energizes the compressor in response to a predetermined rise in the temperature of the fresh food evaporator 6.

For the purpose of terminating the defrost cycle after a complete defrosting of the evaporator structure 8 there is provided a sensing bulb 74 forming part of a bellows arrangement 75 adapted to trip the switch 69 and return it to its normal refrigerating position in which the fan motor 39 is energized and the solenoid valve 50 is closed. The sensing bulb 74 is preferably positioned in contact with the horizontal pass 26 of the evaporator coil 18 adjacent the outlet end of the defrost tubing 21 as this will normally be the last portion of the evaporator structure to reach defrosting temperatures.

During the defrost operation, hot gas flowing through the conduit 51 first warms the drain 60 so that defrost water collecting in the trough 16 can flow through the drain and out of the freezer compartment 7. The passes 52 and 53 are the next portions of the defrost circuit to become warm and respectively heat the bottom or trough portion 16 of the housing and the accumulator 27 so that these portions of the evaporator structure are quickly brought up to defrosting temperatures and the accumulator emptied of liquid refrigerant to assure complete defrosting thereof. Thereafter the coil 18 is warmed to complete the defrost operation.

By extending a portion of the defrost line or tube 21 upwardly to the conduit 44 connecting the upper and lower evaporators sufficient heating of refrigerant line 20 in this area is obtained to assure complete melting of the frost on the portions of the refrigerant tube 20 within the housing.

In the light of the foregoing description, it will be seen that the present invention provides an improved two-temperature refrigerator in which both the fresh food and freezer evaporators are automatically defrosted. The structure of the evaporator unit 8 employed for maintaining the freezer compartment 7 at sub-freezing temperatures is such that during each defrost operation all of the defrost water will quickly drain from the frosted surfaces due both to the design of the evaporator coil 18 which assures quick drainage of moisture from the coil surfaces and also by the arrangement of portions of the defrost circuit in contact with the drain, the bottom wall 16 of the housing and the accumulator. By arranging the fan 37 within the housing and thereby providing a turbulent flow of air through the housing, the required heat transfer between the air circulated through the housing and the evaporator coil 18 is obtained without the use of fins or other heat transfer surfaces normally employed in connection with such structures.

While there has been shown and described a particular embodiment of the present invention, it is to be understood that the invention is not limited to this embodiment and it is intended by the appended claim to cover all modifications within the true spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

A combination refrigerator-freezer comprising an upper fresh food compartment and a lower freezer compartment, an evaporator in said upper compartment and a low temperature defrostable evaporator unit in said lower compartment, said unit comprising a horizontal housing supported along one wall of said freezer compartment and including a front wall having a centrally positioned opening therein and air outlets adjacent the ends thereof, and a V-shaped bottom wall, a double-tube evaporator coil disposed in said housing in the form of a plurality of vertically elongated loops arranged between said central opening and the opposite ends of said housing, said coil comprising a refrigerating tube and a defrost tube in parallel heat exchange relation with said refrigerating tube, an accumulator chamber supported on said V-shaped bottom wall of said housing, a compressor, a condenser, a capillary flow restrictor, a suction line, conduit means connecting said compressor, condenser, flow restrictor, high temperature evaporator, refrigerating tube, and accumulator in series flow refrigerating circuit

whereby said compressor withdraws low pressure refrigerant gas from said accumulator and discharges high pressure refrigerant to said condenser, a hot gas defrost circuit for defrosting said low temperature unit comprising in series connection a first conduit having a normally closed valve therein connecting said compressor to one end of said defrost tube and a second conduit including a flow restricting means connecting the outlet end of said defrost tube to said suction line, said first conduit including a first pass in heating engagement with said V-shaped bottom wall and a second pass in heating engagement with said accumulator, a fan disposed in said opening for circulating air from said freezer compartment through said housing and back to said compartment, and electrical control means for controlling the operation of said compressor, valve and fan including compressor control means for energizing said compressor only after said high temperature evaporator has reached a temperature above freezing and de-energizing said compressor when said high temperature evaporator has reached a temperature below freezing and defrost control means including a timer for periodically opening said valve and de-energizing said fan for defrosting said low temperature evaporator unit and means responsive to a defrosted temperature of said coil adjacent the outlet end of said defrost tube for closing said valve and energizing said fan.

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