United States Patent

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[54] **SINGLE EVAPORATOR MULTIPLE TEMPERATURE REFRIGERATOR**
15 Claims, 6 Drawing Figs.

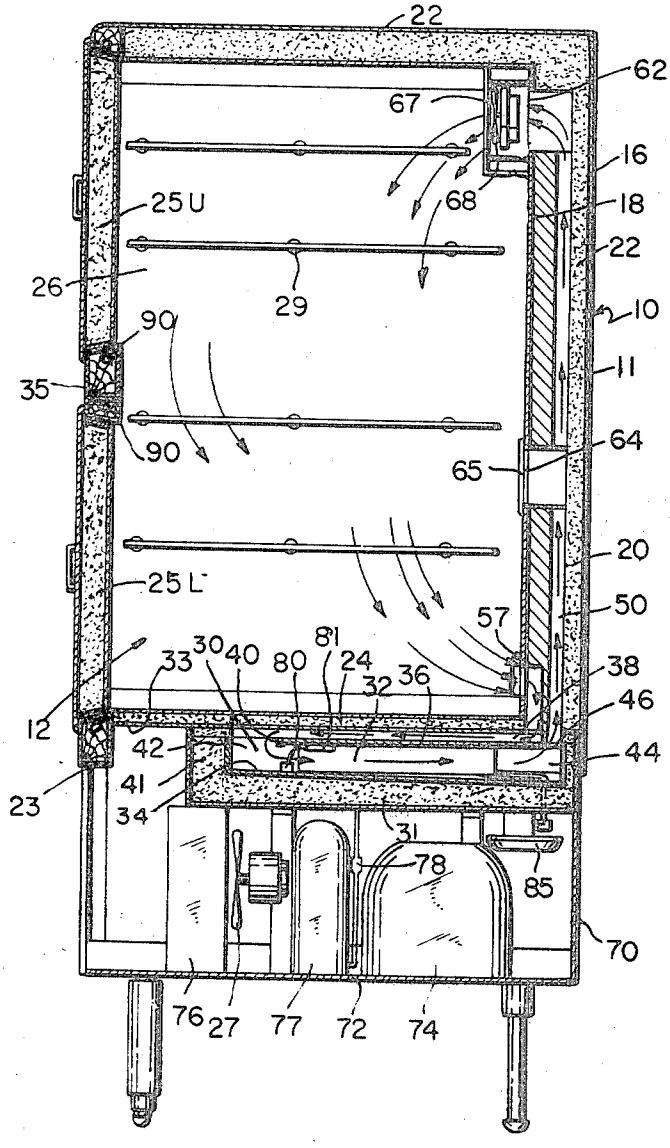
[52] **U.S. Cl.** **62/187,** 62/419, 62/97, 62/329, 62/447
[51] **Int. Cl.** **F25d 17/04**
[50] **Field of Search** 62/326, 329, 186, 447, 97187

[56] **References Cited**
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Primary Examiner—William J. Wye
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ABSTRACT: A one compartment refrigerator convertible by a removable insulated shelf into two chambers with a narrow cross-sectionally elongated open passageway past the shelf providing restricted airflow between the chambers whereby either chamber can be a freezing chamber while the other one can be an above-freezing refrigerating chamber, in both of which there is rapid temperature pulldown and the different temperatures are maintained with a high degree of accuracy with minimum sweating and frosting in the chambers.



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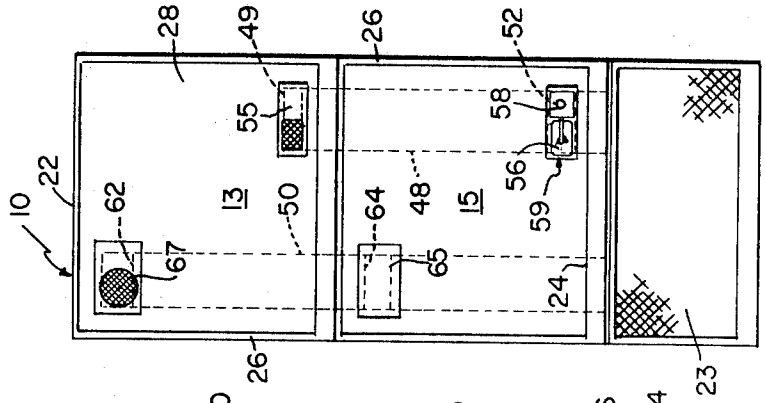


FIG 6

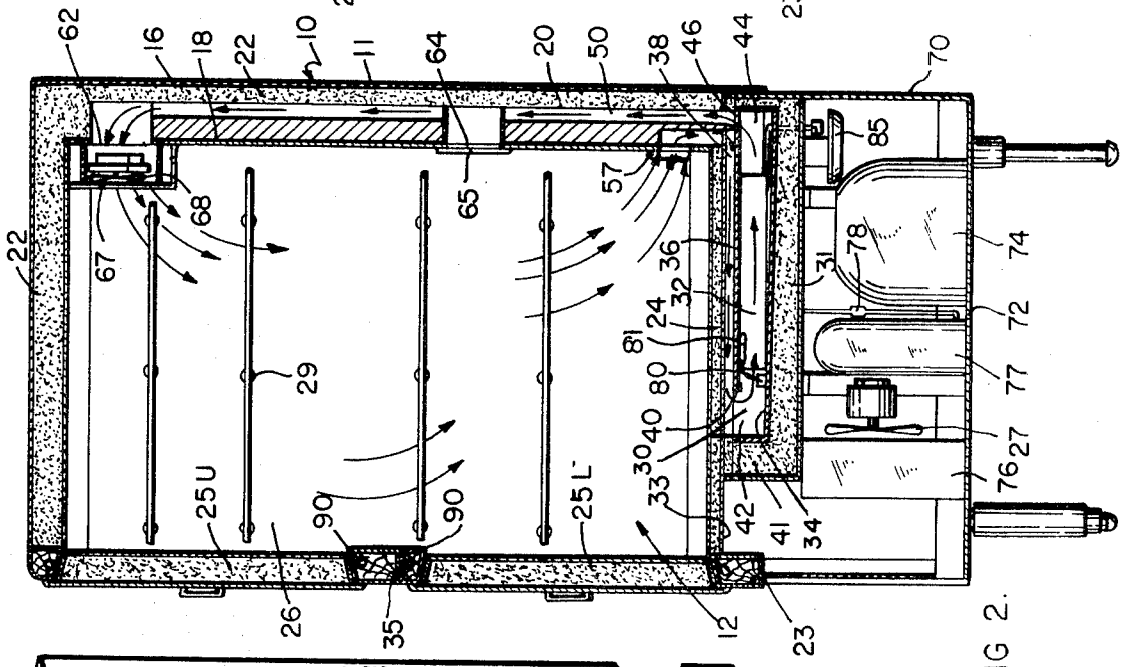


FIG 2.

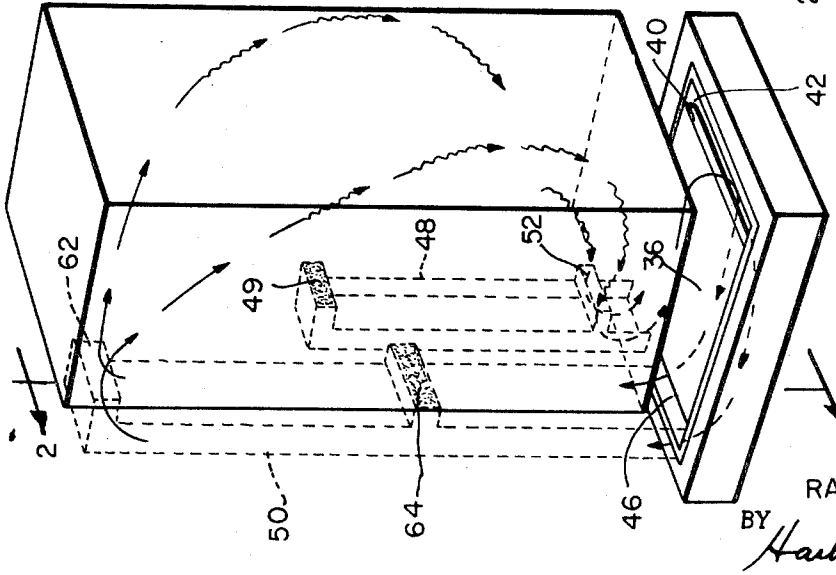


FIG 1

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FIG 4

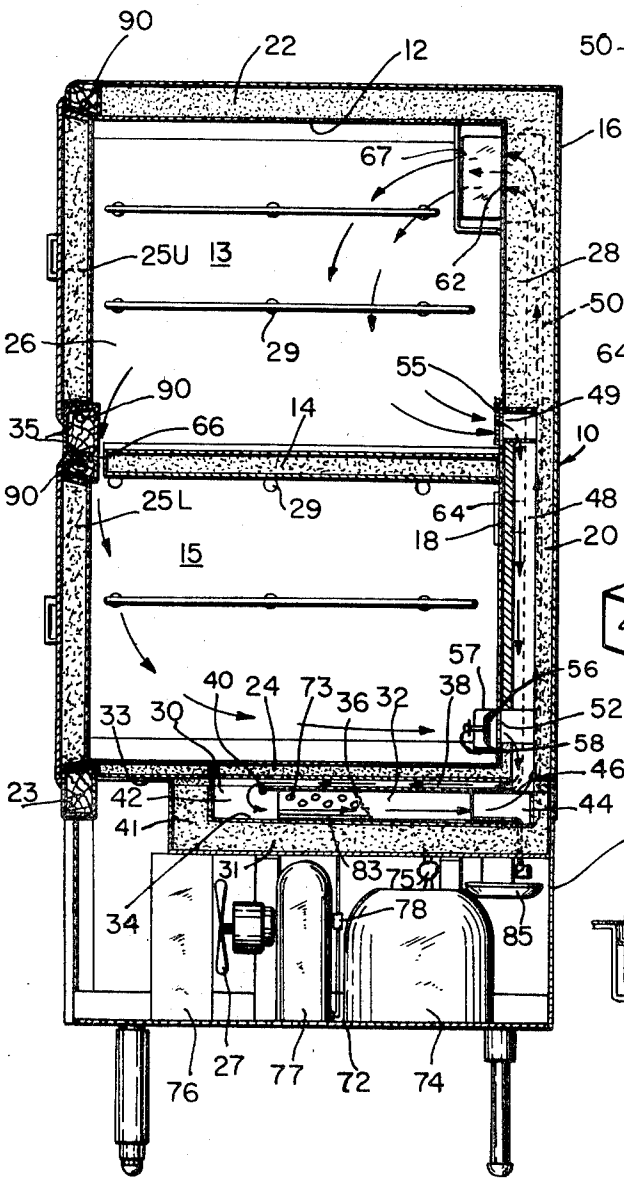
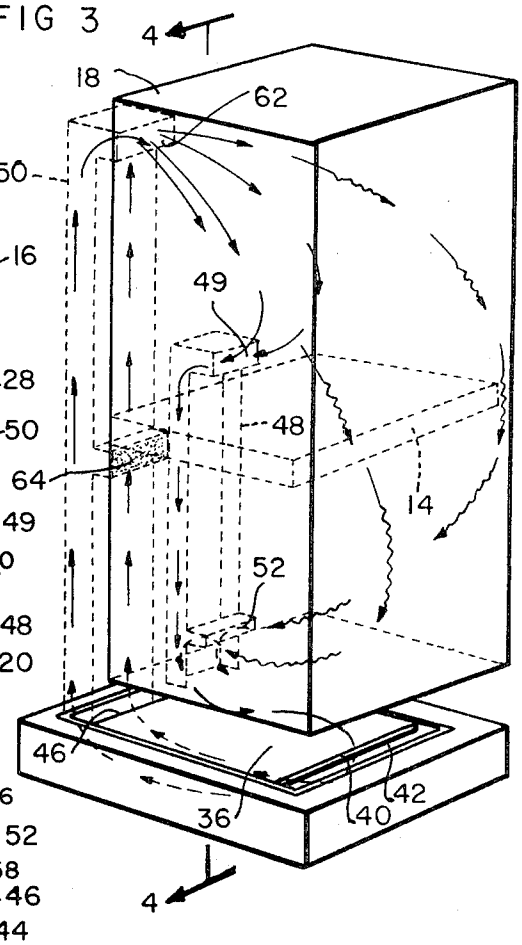


FIG 3



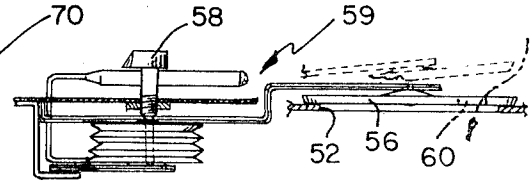


FIG 5

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SINGLE EVAPORATOR MULTIPLE TEMPERATURE REFRIGERATOR

BACKGROUND OF THE INVENTION

Heretofore, it has been comparatively costly to fabricate and provide controls for a refrigerator having two compartments for different working temperatures. The extent and duplication of power and control equipment required for the isolated compartments is well known including the cost of a liner having eight walls in order to provide a partition defining two chambers. Frosting on the walls at the divider has interfered with satisfactory working because of sweating and frosting due to temperature differentials. Frosting has generally occurred in the freezing compartment due to humid air admission when opening and closing a door thus disturbing the effectiveness of refrigeration.

Reference is made to Devery U.S. Pat. No. 3,005,321 (62—186) and Mann U.S. Pat No. 3,027,732 (62—187) for further background information on dual refrigerator compartments wherein the differential temperature compartments are isolated for separate air circulation and separate temperature controls.

INVENTION

In the present invention a cabinet is provided having a single large refrigerating compartment which may be separated into an upper chamber and a lower chamber by a removable insulated shelf having an edge spaced from an adjacent wall, preferably at the level of and adjacent to the joint between the adjacent mullions of two closures such as doors or drawers. The space provides a cross-sectional elongated and narrow passage placing the two chambers in continuous communication with each other therethrough along a wall of the cabinet. Air is dried and chilled in the evaporator compartment to a temperature approximately 0° F. and is supplied by a fan under continuous forced draft in an amount sufficient to pull down the temperature of both chambers rapidly to 0° to 5° F.

Thus, the refrigerator can be operated quite successfully as a single large compartment freezer without the shelf, as desired, or as a dual chamber and dual temperature refrigerator. With the shelf present freezing air can be supplied to either chamber and a portion thereof bypassed through said space to the other chamber in an amount adequate to replace with cooling air in said other chamber the warm return air that is above a predetermined temperature. The warm replaced air is returned to the evaporator compartment under the control of a thermostatically controlled shutter valve located remotely from the passageway.

With a continually running fan urging air chilled to 0° to 5° from the evaporator to a refrigerator freezing chamber, the temperature there is substantially constant and below freezing under the control of the evaporator expansion valve while only enough freezing air is supplied safely to the above-freezing chamber as a thin, fanned-out flow or column to refrigerate without any localized freezing of the contents as controlled by a return thermostat having a shutter or butterfly valve. Some subfreezing air from the freezing chamber is allowed to return to the evaporator compartment to maintain a substantial circulation of freezing air in the freezing compartment to remove moisture but not enough is returned to nullify an appreciable pressure differential between the two chambers that is provided across said passageway.

Also with a constant low temperature maintained in the freezing chamber there is stability against temperature straying which enables the thermostatically controlled shutter valve at the outlet of the higher temperature chamber to work on a predictable curve of operation. Its opening varies proportionally to the temperature load changes and the pressure differential across the narrow passage varies likewise whereby a rapid pulldown capability is present in both and temperatures in both can be closely maintained, there being sufficient lag due to the passage size to avoid pulldown overshoot in the refrigerating chamber.

The invention is further characterized by confining frosting and defrosting to an evaporator compartment where the evaporator is set for a low freezing temperature to collect moisture and is electrically defrosted periodically. The narrow passageway is located at the door opening where warm air reaches the edge of the shelf whenever a door is opened and antisweating low wattage mullion heaters prevent the flow area of the passage from being obstructed. Also the dried air moving from freezing to above freezing temperatures picks up moisture and carries it to the evaporator and thereby eliminates the danger of obstruction of the passage with respect to opening and closing the door in a humid atmosphere.

These being among the objects and characteristics of the invention, other and further advantages will be apparent from the description and drawings including particularly the relative low cost of manufacturing and the provision of improved results over other equipment, along with ease of adjustment and servicing.

IN THE DRAWINGS:

FIG. 1 is a partially exploded perspective view illustrating a cabinet embodiment used as a single compartment modification for either refrigerating or freezing temperatures;

FIG. 2 is a vertical sectional view of the assembled cabinet shown in FIG. 1 as taken on line 2–2 showing the freezing air duct as located in the insulated rear wall of the cabinet;

FIG. 3 is a view similar to FIG. 1 in which the cabinet is converted to a two chamber differential temperature and differential pressure embodiment;

FIG. 4 is a vertical sectional view similar to FIG. 2 but taken on line 4–4 of FIG. 3 showing the warm air return duct as located in the insulated rear wall;

FIG. 5 is an inside elevational view indicating the relative positions of the openings from the ducts shown in the other FIGS.; and

FIG. 6 is a diagrammatical view of the operating parts of the thermostatically controlled valve shown in FIG. 4.

Referring now to the drawings in further detail, a self-contained food freezer or refrigerator, or both, is shown at 10 in FIG. 2 constructed for mass production has a cabinet 11 capable of low cost conversion for at least four distinct modes of operation. It is built primarily as a large, single temperature single compartment 12 low temperature freezer or an above-freezing refrigerator as illustrated in FIGS. 1 and 2. The introduction of a removable insulated shelf 14 in the cabinet as illustrated in FIGS. 3 and 4, converts the compartment 12 into an upper chamber 13 and a lower chamber 15 to provide an inexpensive arrangement which can be used either as a two chamber refrigerator or a two chamber freezer, or as a two chamber freezer and refrigerator with either chamber operating as the freezer chamber and the other the refrigerating chamber. By way of example, and not by way of limitation, the embodiment illustrated in FIGS. 1 and 2 provides a single temperature compartment of approximately 10 to 12 foot capacity while the embodiments illustrated in FIGS. 3 and 4 have a capacity of 5.5 cubic foot for each chamber with the shelf 14 shown located midway in the compartment.

Preferably, the cabinet of the refrigerator is constructed to have an outer shell 16 and an inner nesting liner 18 defining a space between them which is filled with foam insulating material 20 to provide a unitized construction having insulated top and bottom walls 22 and 24, respectively, joined by two insulated vertical walls, 26, a third wall 28 in which vertical air ducting is secured to the liner 18 and embedded in the insulation for circulation of air to and from the compartment and the space below the bottom wall. The front wall 23 is open over the compartment area to receive the hinged insulating upper and lower doors 25U and 25L, respectively, preferably with their adjacent edges contacting mullions in sealed relationship as at 35 (FIG. 4). The insulated shelf is receivable in the compartment at the level of the joint between the doors as further described later where it can be supported on brackets 29.

The lower wall 24 (FIGS. 2 and 4) receives against its lower face 33, an insulated pan-shaped member 31 which, in combination with the bottom wall 24 and the lower end of wall 20 provides an insulated compartment 30 receiving the evaporator coil 32 of a refrigeration system. The coil rests on the bottom 34 of the member 31 and has a baffle 36 resting on top of the coil and spaced from the lower face 33 of the bottom wall 24 to provide a passage 38 therebetween for warm return air from the compartment 12 to flow therethrough. The front edge 40 of the baffle 36 is spaced from the front wall 41 of the compartment 30 to provide a return air manifold 42 receiving the warm air. The warm air flows from the manifold 42 through the evaporator coil 32 back to a chilled air supply manifold 44 which extends under the lower end of wall 20 and is covered by said baffle 36. The baffle, however, is notched as at 46 under a portion of the wall 20 (FIG. 2) to provide an upwardly directed outlet opening 46 for the chilled air supply. The wall 20 in turn is provided with two horizontally spaced vertical ducts 48 and 50 illustrated in FIGS. 1 and 3 for warm air return and chilled air supply respectively. Return duct 48 opens above the baffle 36 and the supply duct 50 opens into the opening 46 (FIG. 2) to the manifold below the baffle.

The return duct 48 may be placed in communication with the compartment 26 through vertically spaced lateral openings 49 and 52, the former, by way of illustration, being located above the midheight of the compartment and the latter above the floor level of the bottom 24. Each opening can receive a cover plate 65 closing it (FIG. 6), or a flow restricting grille 55, or a thermostatically controlled valve assembly having a grille 57 over it. An adjustment knob 58 controls the setting of the thermostat valve 59 to close it at between 30° and 40° F. for a refrigerating temperature control. As a practical matter the valve seldom closes completely during refrigeration and can be supplemented by a continuously open small flow restriction opening 60 (FIG. 5) which assures a minimum return of warm air.

The supply duct 50 (FIGS. 1 and 3) may be placed in communication with the compartment 12 through vertically spaced lateral openings 62 and 64, the former being located close to the top of the compartment 26 and the latter below the midheight of the compartment whereby the insulated shelf 14 can be received between the air supply opening 64 and the air return opening 49. Either one of the openings 62 and 64 (FIG. 2) can be closed by a plate 65 or receive a blower housing 67 having a constant running fan 68 therein.

The refrigeration system includes a conventional slide-in compressor and condenser unit that is purchased on the market and includes suitable mounting and connector elements as housed in an enclosure 70 where it is supported on a bottom plate 72 below the shell 31 housing the evaporator 32 and it may be pointed out generally, by way of a further understanding the versatility and utility of the refrigerator system, that the refrigerant handling unit includes a compressor 74 connected to the outlet of a finned coil 73 in the evaporator 32. The compressor is actuated by a low-pressure control 75. The compressed refrigerant is exhausted to the condensing coil 76 that is cooled by a fan 27 where the gas is liquified under pressure and then stored in a liquid receiver 77. The liquid outlet of the receiver is connected through a dryer 78 and then through an expansion valve 80 to the inlet of the evaporator coil 73. The expansion valve is under the control of a temperature bulb 81 located in the compartment 30. An electric heater 83 periodically defrosts the evaporator and the water is discharged to an external electrically heated water evaporator 85. As already mentioned, the refrigerator 10 can be operated completely at low temperature or completely at high temperature with or without the shelf 14, or at low temperature in the upper chamber and high temperature in the lower chamber, or inversely, at a high temperature in the upper chamber and a low temperature in the lower chamber. All of these modes can be accomplished by appropriately positioning in the compartment 12 a minimum of auxiliary elements such as the insulated shelf 14, the fan housing 67 (FIGS. 2 and 4), the thermostat 56 with the return flow control valve, the cover plate 65 (FIGS. 2 and 6) and the restricted flow grille 55 when used. These conversions can be made after the refrigerator is placed in service.

In FIGS. 1 and 2, there is no insulated shelf 14 in the compartment 12 and the air circulates freely under the forced circulation of the fan 68 which is located at the top opening 62 of the cold air supply with the lower opening 64 thereof closed by a cover 65.

As more readily seen in FIG. 4, where the sectional view is taken vertically through the warm air return duct 48, the upper opening 49 of the return duct 48 is closed by a closure plate 55 and the lower opening 52 is covered by the temperature responsive control valve 56 which can be set for either a high or a low temperature closing. The cold air is admitted to the compartment under fan pressure to the extent that air is permitted to escape from the compartment through the flow control valve 56, thereby controlling the compartment temperature.

In (FIGS. 3 and 4), the two compartment embodiment is shown with the shelf 14 in place. The pull down capacity of this embodiment is also great. The cold air supply arrangement is the same as for FIG. 2 but the upper opening 49 above the shelf is covered with a flow restricting grille 55. A restricted flow space 66 between the front edge of the insulated shelf 14 and the door admits flow of cold air to the lower chamber as controlled by the outflow volume of air through the thermostat return valve 56. The area of the restricted flow space 66 is cross-sectionally a long and narrow passage so that the flow of cold air between the chambers is thin and fanned out to prevent localized chilling yet being thin quickly mixes locally and mildly turbulates the air for a uniform temperature to an extent controlled by the volume of return air flowing through the thermostatically controlled valve 56 as the warmer air is withdrawn to the return duct 48. In this instance, the temperature of the upper chamber 13 is that controlled by the expansion valve control bulb 81 (FIG. 2) in the evaporator compartment while the higher temperature of the lower chamber 15 is determined by the exhausting of air from the lower chamber through the thermostat valve 56 as set by the knob 58.

In event the lower chamber 15 is desired to be the cold chamber, and the upper chamber 13 the warm chamber, the blower 68 could be located in the opening 64, the cover 65 over the opening 62, and the thermostatically controlled valve 56 would be located in the upper opening 49 in the upper chamber while the closure blade 55 would control outflow through opening 52. The same operation results with the compartment temperatures reversed.

The versatility of a single production unit is thus shown to serve in four or more modes merely by providing a fan, a thermostat, a cover plate, a flow restricting grille and a shelf which can be variously arranged, in two arrangements of which, and with the shelf present, the novel relationship, method, objects and advantages set forth herein are accomplished.

By way of example with a compartment 12 having a capacity of 10 to 12 cubic feet and with one evaporator assembly located below the compartment above the condensing and ducts between the evaporator and the compartment for supplying cold air supply and returning warm air, a constant running fan is provided in the upper compartment which is turned off when a door is opened. The low pressure control for low temperature is set for 10 p.s.i. cut-in and 0 p.s.i. cutout. Two lbs. of R12 refrigerant is the charge of a one-fourth H.P. unit, and the restricted passage between the shelf 14 and the door mullion is cross-sectionally 19 inches × one-fourth inches, plus or minus a one-sixteenth inch. This long dimension can be varied several inches with like refrigerator cabinets whose door width may vary. Thus, the flow area for the 10 to 12 cubic feet volume is approximately 5 square inches, providing a ratio substantially of 1 square inch of open communication per 2 cubic feet of volume.

Since the compartment disclosed is divided approximately in half and the low temperature air is a constant and substan-

tially unrestricted forced draft supply from the evaporator chamber, the more significant ratio is related to the volume of the low temperature chamber and is approximately 1 square inch per each cubic foot of the low temperature chamber space.

Furthermore, the major frosting occurs outside of the refrigeration box where the supply air is dehumidified at approximately 0° F. and any frosting is essentially confined to the evaporator unit from which it is periodically removed automatically by a low voltage heater **68** with the fan momentarily off approximately four times a day. The water runoff is collected in a drain evaporator and returned to atmosphere outside the refrigerator. Each time when the refrigerant evaporator coil reaches approximately 60° F. the defrosting cycle is turned off and the refrigeration system and fan again to a normal refrigeration cycle.

The door mullion heaters **90** border the edge of the door and comprises approximately 20 watts for each door with the two portions thereof that are opposite the restricted opening. These, along with intermittent opening of the doors assures that no sweating, frosting or icing will occur to reduce the flow area of the passage **66**.

What I claim is:

1. In a refrigerator cabinet having insulated walls and an insulated closure means defining a refrigerating compartment, removable insulated shelf means separating said compartment into chambers for different temperatures, an insulated housing adjacent to said compartment defining an evaporator compartment, an evaporator means therein for pulling down the temperature of air to a temperature below freezing to chill and dry the air and including a temperature controlled refrigerant expansion valve, a cold air supply duct in one of said walls connected to the air outlet of said evaporator compartment and having vertically spaced supply openings opening into said compartment on opposite sides of said shelf means, a warm air return duct in one of said walls connected to the air intake of said evaporator compartment and having vertically spaced return openings opening into said compartment on opposite sides of said shelf means at points remote from said supply openings, means for supplying freezing air through said supply duct continuously under forced draft while the closure is closed, means for closing the supply opening in one of said chambers, means for returning warmed return air from the other chamber including a flow limiting grille over the return opening in said one chamber and a thermostat variably closing the other return opening responsive to the above freezing temperature in the other chamber, said shelf means defining with said closure a cross-sectionally elongated continuously open passage interconnecting the chambers having approximately 1 square inch flow area per cubic foot of space present in said other chamber.

2. The refrigerator cabinet defined in claim **1** in which said insulated closure means is a door and includes a low voltage electric heater disposed along one side of said passage.

3. The refrigerator defined in claim **1** in which said closure means comprises two doors engaging in sealing relationship along their adjacent edges at the level of said passage and forms a side thereof.

4. In a refrigerator a cabinet having insulated walls and an insulated closure means defining a refrigerating compartment, an insulated housing adjacent to the compartment defining an evaporator compartment, an evaporator in said compartment, air supply duct means connecting the cold air supply outlet of the evaporator compartment to the refrigerating compartment adjacent to the top thereof through an air supply opening, fan means for moving the cold air supply at a freezing temperature through the supply duct and into the compartment, warm air return duct means connecting the refrigerating compartment through an outlet opening adjacent the bottom thereof to the warm return air intake of the evaporator compartment, thermostatically controlled valve means at said outlet opening to enable the flow of warm air therethrough above a predetermined temperature above freezing, and insulated means between said supply opening and return opening separating said compartment into a freezing chamber and an above freezing chamber and defining in said compartment a cross-sectionally elongated and narrow flow restricting open passage directly interconnecting said chambers to provide a variable pressure differential between said chambers.

5. The refrigerator defined in claim **4** in which said evaporator dehumidifies the return air entering the air supply duct in the form of frost and including means for periodically melting the frost to clear the refrigerant evaporator, and means for draining the melted frost from the evaporator compartment.

6. The refrigerator defined in claim **4** including therethrough an opening between the freezing chamber and the air return duct restricting air flow to less than the airflow capacity of the fan to maintain a pressure in the freezing chamber higher than that in said return conduit.

7. The refrigerator defined in claim **4** in which said insulated closure means is a door and includes a low voltage electric heater disposed along one side of said passage.

8. The refrigerator defined in claim **4** in which said closure means comprises two doors engaging in sealing relationship along their adjacent edges at the level of said passage and forming a side thereof.

9. In a refrigerator having an insulated cabinet and closure defining an insulated refrigerating compartment, insulated means separating said compartment into chambers for different temperatures, means for supplying freezing air to one chamber continuously under forced draft while the closure is closed, means withdrawing warmed air from the other chamber at an opening remote from said insulating means and including a variable flow control valve covering said opening and a temperature responsive element responsive to the temperature of the other chamber controlling the valve opening, said insulated separating means defining a cross-sectionally elongated passage interconnecting the chambers having approximately 1 square inch flow area per cubic foot of space present in said other chamber.

10. The refrigerator defined in claim **9** in which said passage is defined by a space between said closure and said insulated means of a spaced distance less than one-half inch.

11. The refrigerator defined in claim **9** in which a supply means includes an evaporator compartment and a refrigerant evaporator therein, and said withdrawing means comprises a return duct subjected to the air intake pressure of the evaporator compartment and flow control means interconnecting said one chamber and said return duct having an airflow restricting opening.

12. The refrigerant defined in claim **9** in which said withdrawing means comprises a return duct opening in the lower temperature chamber and leading to the intake of the evaporator, said valve opening being the opening closer to the intake of the evaporator chamber.

13. The method of refrigerating two insulated compartments at different temperatures comprising supplying by forced draft a continuous flow of freezing cold air from a source of supply to one of the compartments, restricting withdrawal of return air from said one compartment to provide relative pressure therein, absorbing thermal units from the contents of the two compartments, withdrawing from said other compartment air therein warmer than a predetermined temperature above freezing, and conducting replacement air under said pressure from said one compartment to the other compartment in a cross-sectionally elongated column whose flow area is approximately 1 square inch per cubic foot of space in the other compartment.

14. The method recited in claim **13** in which the minor dimension of said column is less than one-half inch for quick dispersion of the freezing cold air to eliminate localized freezing concentrations of said cold air in said other compartment.

15. The method recited in claim **13** in which said column of freezing cold air is thin and fanned out to enter said other compartment along and in contact with a wall thereof.