June 11, 1968 E. H. FROHBIETER 3,387,463

REFRIGERATION APPARATUS WITH DEFROST MEANS

Filed Sept. 1, 1966 2 Sheets-Sheet 1

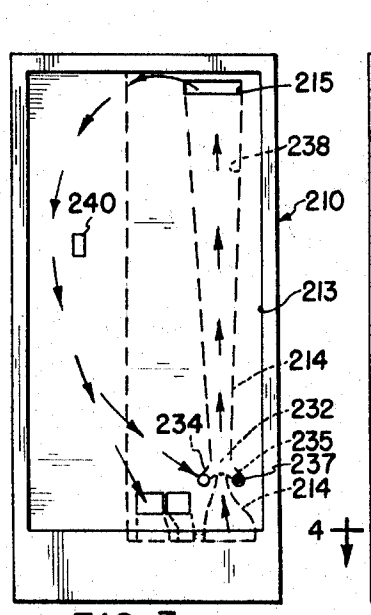


FIG. 3

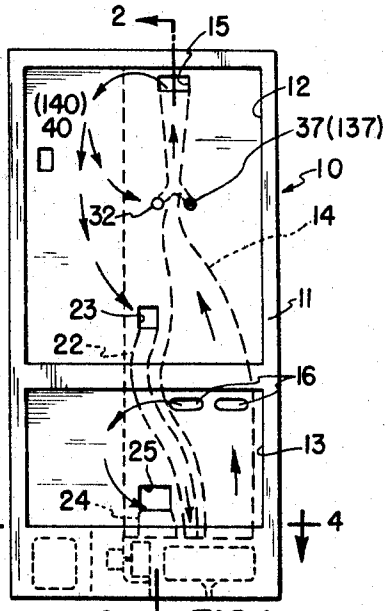


FIG. 1

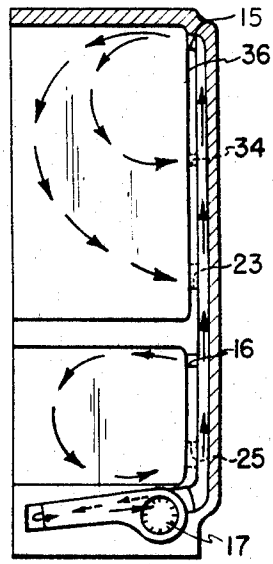


FIG. 2

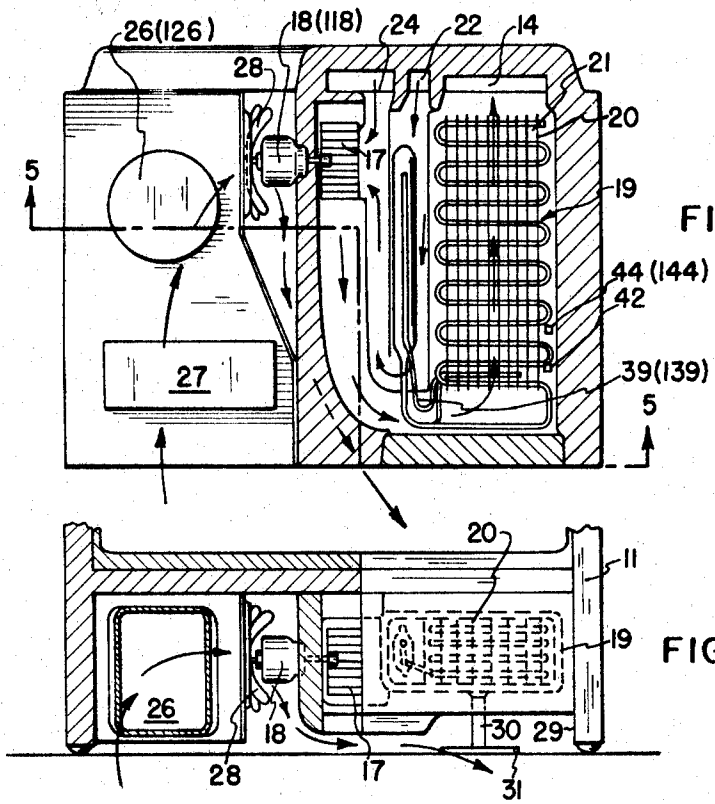


FIG. 4

FIG. 5

INVENTOR.
EDWIN H. FROHBIETER
By Hofgren, Wegner, Allen, Stellman & McCord attys.

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REFRIGERATION APPARATUS WITH DEFROST MEANS

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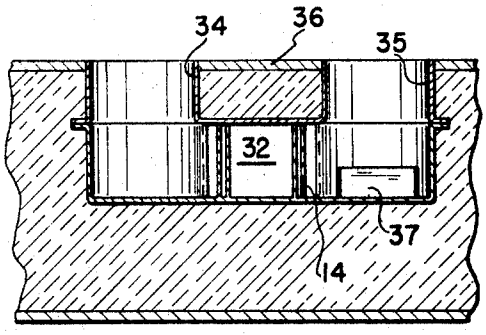


FIG. 7

FIG. 6

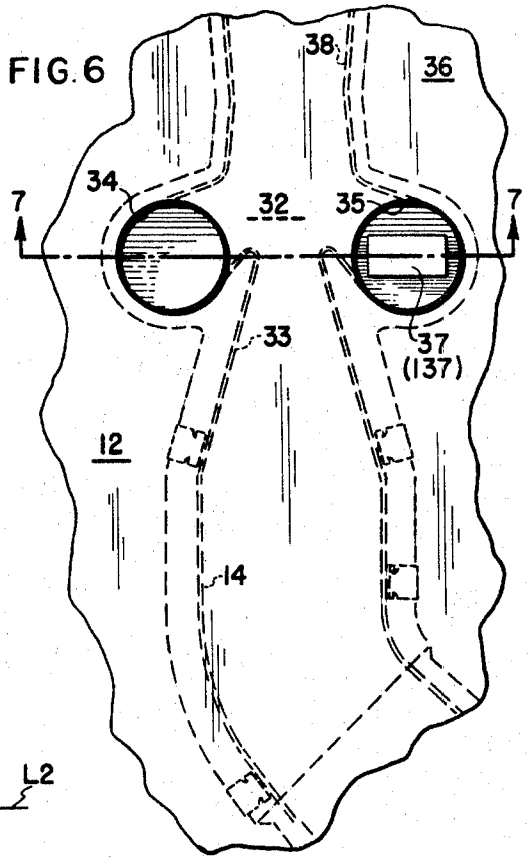
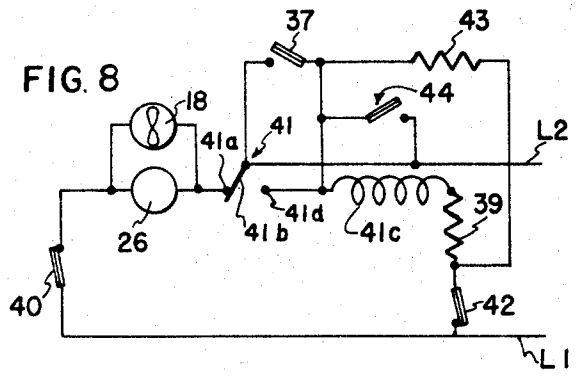


FIG. 8



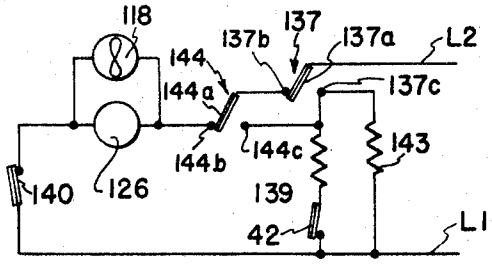


FIG. 9

INVENTOR.
EDWIN H. FROHBIETER
By Hodges, Wayne, Allen, Stellman & McCord Attys.

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3,387,463 REFRIGERATION APPARATUS WITH DEFROST MEANS

Edwin H. Frohbieter, Stevensville, Mich., assignor to Whirlpool Corporation, a corporation of Delaware

Filed Sept. 1, 1966, Ser. No. 576,636
16 Claims. (Cl. 62—140)

This invention relates to refrigeration apparatus and in particular to control means for use in refrigeration apparatus.

In one form of refrigeration apparatus, chilled air is delivered to a compartment through a duct by means of suitable air translation means. The air is chilled by being passed in heat transfer association with a suitable chilling means prior to its delivery to the compartment. A problem arises in the conventional refrigeration apparatus of this type in that the moisture in the air being chilled by the chilling means becomes deposited on the chilling means in the form of frost and when the frost deposit builds up sufficiently undesirably impedes, and in some cases blocks off, the flow of the air through the system.

A number of controls for effecting an automatic defrosting of the frosted chilling means heretofore have been employed in the refrigeration art. The present invention comprehends an improved control means for controlling the operation of the chilling means and for effecting such a defrosting operation in response to frost build-up on the chilling means.

Thus, a principal feature of the present invention is the provision of a refrigeration apparatus having new and improved control means.

Another feature of the invention is the provision of such refrigeration apparatus having new and improved means for controlling the operation of the air chilling means thereof.

Still another feature of the invention is the provision of a refrigeration apparatus having a new and improved means for tempering the chilled air delivered to the compartment by recirculating a portion of the air from the compartment into a chilled air, delivery duct for mixing with the chilled air downstream of the air translating means.

A further feature of the invention is the provision of such refrigeration apparatus having new and improved means for controlling a defrost operation thereof.

Still another feature of the invention is the provision of such refrigeration apparatus having new and improved means for controlling the operation thereof including means defining a passage between the compartment to be refrigerated and the duct for delivering chilled air to the compartment and provided with means responsive to the condition of air in the passage for controlling operation of the apparatus.

A still further feature of the invention is the provision of such refrigeration apparatus having new and improved means responsive to the temperature of the air in said passage for effecting control of the apparatus.

Yet another feature of the invention is the provision of such refrigeration apparatus wherein the passage is arranged to have alternative air flow therethrough from the compartment into the duct and from the duct into the compartment as a function of the air delivery conditions in the duct.

Another feature of the invention is the provision of such refrigeration apparatus having new and improved electrical circuitry for control thereof.

Still another feature of the invention is the provision of such refrigeration apparatus having new and improved safety control means.

A further feature of the invention is the provision of such refrigeration apparatus having new and improved means for preventing reoperation of the air chilling means until it reaches a preselected high temperature.

Another feature of the invention is the provision of such refrigeration apparatus having new and improved means for preventing reoperation of the air chilling means until substantially all melt produced in the defrosting thereof is directed to the disposal means.

Other features and advantages of the invention will be apparent from the following description taken in conjunction with the accompanying drawing wherein:

FIGURE 1 is a front elevation of a refrigeration apparatus embodying the invention with certain parts omitted for clarity;

FIGURE 2 is a vertical section thereof taken substantially along the line 2—2 of FIGURE 1;

FIGURE 3 is a front elevation of a modified form of refrigeration apparatus embodying the invention with certain parts omitted for clarity;

FIGURE 4 is an enlarged horizontal section taken substantially along the line 4—4 of FIGURE 1;

FIGURE 5 is a fragmentary vertical section taken substantially along the line 5—5 of FIGURE 4;

FIGURE 6 is a fragmentary enlarged front elevation of the apparatus of FIGURE 1 illustrating in greater detail the air flow sensing means;

FIGURE 7 is a fragmentary horizontal section taken substantially along the line 7—7 of FIGURE 6;

FIGURE 8 is a schematic wiring diagram of the electrical circuitry of the refrigeration apparatus embodying the invention; and

FIGURE 9 is a schematic wiring diagram of another form of electrical circuitry of the refrigeration apparatus embodying the invention.

In the exemplary embodiment of the invention as disclosed in FIGURES 1, 2 and 4 through 8, a refrigeration apparatus generally designated **10** is shown to comprise a cabinet **11** defining a plurality of compartments to be refrigerated, herein more specifically illustrated as an upper refrigerator compartment **12** and a lower freezer compartment **13**. Doors (not shown) are provided to close the compartments. Refrigeration of the compartments **12** and **13** is herein effected by delivering chilled air through a duct **14** having a first outlet **15** into the refrigerator compartment **12** and a second outlet **16** into the freezer compartment **13**. The air is forced through the duct **14** by suitable air translating, or moving, means such as blower **17** which may be driven by a suitable electric motor **18**, as best seen in FIGURE 4.

The air so moved by blower **17** is chilled by a heat transfer device, such as evaporator **19**, which may be of conventional construction having a plurality of fins **20** defining therebetween a plurality of passages **21**. The chilled air is returned from compartment **12** through a return duct **22** having an inlet **23** in the lower portion of compartment **12**, and the chilled air is returned from compartment **13** through a return duct **24** having an inlet **25** in the lower portion thereof.

The refrigeration apparatus may further include a conventional compressor **26** and condenser **27** with a fan **28** being also driven by motor **18** for flowing room air past the compressor and condenser in a conventional manner. As shown in FIGURE 5, the cabinet **11** may further define a lower apparatus space **29** in which the evaporator **19**, blower **17**, fan **28**, compressor **26** and condenser **27** may be installed.

In normal operation, humidity in the air flowed through the evaporator passages **21** deposits on the evaporator in the form of frost. When this frost builds up sufficiently to substantially impede the flow of the air through the pas-

sages **21**, it is desirable to discontinue the air chilling operation and to initiate a defrosting operation wherein heat is applied to the frost, causing it to melt from the evaporator. As shown in FIGURE 5, a drain tube **30** is provided for delivering the melt from the evaporator to a suitable drain pan **31**.

The present invention, as indicated briefly above, is concerned with the control of the refrigeration apparatus to initiate a defrosting operation automatically when the impediment to the air flow through the evaporator reaches a preselected level. To this end, means are provided for sensing the condition of chilled air flow through the duct **14** in a novel manner. More specifically, as shown in FIGURES 1 and 6, communication between compartment **12** and the duct **14** is provided at a location **32** spaced below the outlet **15**. The duct **14** is constricted adjacent location **32** to define a venturi portion **33**. A pair of passages **34** and **35** are provided through a compartment liner **36** communicating with duct portion **32** at opposite sides of the duct. Thus, chilled air flowing upwardly through duct **14** to outlet **15** normally draws air from compartment **12** into the duct through the passages **34** and **35** by an air entraining venturi action to cause recirculation of a portion of the compartment **12** air which mixes with the colder air in duct **14**, thereby tempering the air entering the compartment from outlet **15**. In addition, the recirculated air adds to the volume of air being delivered to compartment **12** through outlet **15**. This tends to create a relatively greater amount of air movement in compartment **12**, which alleviates stratification that sometimes occurs in refrigerator compartments. A thermostat **37** is disposed in one of the passages, herein passage **35**, for sensing the temperature of the air flowing through that passage. In normal operation when the air is being drawn from the compartment **12** into duct **14**, the air is relatively warm, for example at 34° F., as compared to the chilled air in duct **14**, for example at −10° F., and thermostat **37** is arranged to permit normal cycling of the refrigeration apparatus as hereinafter described.

When, however, frost builds up in the passages **21** of evaporator **19** to substantially block flow of the air therethrough, the flow of chilled air upwardly through duct **14** is decreased until the pressure of the air at position **32** is insufficient to raise the column of cold air in duct portion **38** to discharge it through outlet **15**. At this time, the relatively cold air at position **32** in the duct **14** will tend to flow through passages **34** and **35** into the warmer air in compartment **12**. The thermostat **37** senses the low temperature of this chilled air flowing therepast in passage **35** and in response thereto provides a signal to discontinue operation of the apparatus **10** providing chilled air to the duct **14** and further initiate operation of the apparatus to effect a defrosting of the evaporator.

The above described reversal of air flow direction through passages **34** and **35** is caused by a difference in density between the relatively cold air within duct **14** and the warmer air within compartment **12**. The colder air within portion **38** of duct **14** and above passages **34** and **35**, being denser, will under static conditions, tend to flow by gravity through passages **34** and **35** to displace the warmer air within compartment **12**. However, with the blower of the system in operation, a dynamic or velocity pressure is imposed on the cold air in portion **38** of duct **14**, which pressure is great enough to overcome the static tendency of the cold air to displace the warmer air within compartment **12**.

When the evaporator begins to frost, the volume of air which the air translation means is capable of moving past the evaporator is diminished. The diminishing air flow past the evaporator results in a reduction of dynamic or velocity pressure within duct **14**. The system may be balanced so that upon reaching a predetermined frost condition on the evaporator, the dynamic forces acting on the column of air in duct portion **38** will no longer be sufficient to raise that column of air. Then the air moving in duct **14** will seek a new flow path, namely from duct **14**, through passages **34** and **35** and into compartment **12**. The length of the portion **38** of duct **14** is selected so that the reversal of air flow through passages **34** and **35** takes place when the evaporator has become undesirably blocked.

The defrosting of the evaporator may be effected by a heater **39** disposed in thermal transfer association with the evaporator **19**, although as will be obvious to those skilled in the art other suitable means for effecting defrosting of the evaporator may be employed. A control circuit associating the thermostat **37** with the heater **39** is illustrated in FIGURE 8. As shown in FIGURE 8, the blower motor **18** and compressor **26** are connected in parallel to one power supply lead L_1 through a conventional thermostat switch **40** which may be mounted in compartment **12** in the conventional manner for controlling the temperature thereof. The other side of the paralleled motor **18** and compressor **26** is connected to the other power supply lead L_2 through a single pole, double throw relay switch **41** having a fixed contact **41***a* connected to the blower motor **18** and compressor **26** and a moving contact **41***b* connected to power supply lead L_2. The switch **41** is operated by a suitable electromagnetic coil **41***c* which is connected to a second fixed contact **41***d* of switch **41** in series with heater **39**, and a normally closed thermally responsive switch **42** disposed in the evaporator **19** which is arranged to open at a predetermined high temperature in the evaporator, such as 55° F. Thermostat **37** comprises a thermally responsive switch means arranged to close at a predetermined temperature such as 20° F., and may comprise a conventional bimetallic switch connected between moving contact **41***b* of relay switch **41** and power supply lead L_1 through a reset heater **43** and thermally responsive switch **42**. The heater **43** when energized provides heat to the thermostat **37**. A normally open thermally responsive switch **44** mounted on evaporator **19**, which closes in response to a predetermined low temperature such as −40° F., is connected in parallel with switch **37** to power supply lead L_2.

The operation of apparatus **10** with the control arranged as shown in FIGURE 8 is as follows. In normal operation, the compressor **26** and blower motor **18** are energized periodically under the control of the thermostat switch **40** so as to maintain the temperature in the refrigerator chamber **12** at a preselected temperature such as 34° F. When, however, frost accumulates on the evaporator fins **20** so as to effectively block air flow therethrough, thermostat switch **37** closes as a result of the above described flow of the relatively cold air at a temperature such as −10° F. in duct **14** through the passage **35** in heat transfer association with the thermostat switch **37**. Thus, a circuit is completed from power supply lead L_2 through the closed switch **37** and through relay coil **41***c* and heater **39** to the other power supply lead L_1 through closed thermostat switch **42**. Energization of coil **41***c* causes moving contact **41***b* of relay switch **41** to be thrown from fixed contact **41***a* to fixed contact **41***d*, thereby discontinuing operation of the blower motor **18** and compressor **26**, and maintaining energization of the coil **41***c* to hold the relay switch **41** in the thrown position notwithstanding a subsequent opening of the switch **37**. The heater **43** is currently energized to reopen switch **37** and thereby establish the control for a subsequent cycle of operation. Coil **41***c* remains energized until thermostat switch **42** opens at the relatively high temperature indicating a completion of the defrosting operation. Deenergization of coil **41***c* by the opening of switch **42** permits relay switch **41** to return to the normal position of FIGURE 8, reestablishing the normal circuit through the blower motor **18** and compressor **26** under the control of cabinet thermostat **40**. Switch **44** is provided to initiate the above described defrost cycle in the event thermostat switch **37** fails to close and, thus, functions as a safety switch.

Referring to FIGURE 9, another illustrative circuit for controlling the paralleled blower motor **18** and compressor **26** is shown to include a double throw thermostat switch **137** in lieu of the single throw switch **37**. As shown in FIGURE 9, a moving contact **137***a* of the switch **137** is connected to one power supply lead L_2 and is selectively closable with a first fixed contact **137***b* in turn connected to a moving contact **144***a* of a double throw safety switch **144**, and a second fixed contact **137***c* connected to series related evaporator heater **39** and thermostat switch **42**. The reset heater **143** is also connected between fixed contact **137***c* and power supply lead L_1. Moving contact **144***a* of switch **144** is selectively engageable with a first fixed contact **144***b* thereof connected to one side of the paralleled blower motor **118** and compressor **126**, and with a second fixed contact **144***c* connected to fixed contact **137***c* of switch **137**.

Where the control of the apparatus is as shown in FIGURE 9, the operation is as follows. Switch **137** is normally in engagement with fixed contact **137***b*, as shown in FIGURE 9, as long as the air flow through duct **14** is upwardly therethrough to the outlet **15**. When a reversal of the air flow, however, occurs as discussed above, the switch **137** is thrown so as to have movable contact **137***a* become spaced from fixed contact **137***b* and engage fixed contact **137***c*. This breaks the circuit to the blower fan **118** and compressor **126** so that further operation thereof is prevented until the defrosting cycle is completed. Power is supplied at this time from power supply lead L_2 through the switch **137** to the heater **139** which remains energized until the switch **42** opens when the evaporator reaches the relatively high temperature indicating a complete defrosting thereof such as 55° F., as indicated above. The heater **143** in parallel with heater **139** provides heat to the switch **137** and is selected so that the switch **137** will reset itself in the condition of FIGURE 9 only after the defrost cycle is terminated by the opening of switch **42**. Thus, a period of time is provided during which the melt may be conducted from the evaporator **19** before operation of the compressor **126** is recommenced. The safety switch **144** preferably has a reset temperature similar to that of the switch **137**.

The invention has been disclosed above in connection with a two compartment refrigeration apparatus. The invention may similarly be employed with a single compartment apparatus such as vertical freezer apparatus **210**, as shown in FIGURE 3, wherein the passages **234** and **235** are provided adjacent the bottom of the single compartment **212**. In this embodiment, the length of the duct portion **238** above the duct portion **232** is of substantially greater length than that of the duct portion **38** of apparatus **10** because in the freezer the temperature differential between the air in compartment **213** and duct **214** is less. In the vertical freezer, the temperature of the compartment air may be for example 0° F., with the temperature of the air in duct **214** at, for example −15° F. Thus, the difference in density between the compartment air and the duct air is less and the static tendency of the duct air to displace compartment air is less. To compensate for the lesser tendency to displace, the column of air in duct **214** above portion **232** is lengthened. Thus, the reversal of air flow through passages **234** and **235** may be preselected to take place at approximately the same frost build-up condition on the evaporator. While the lengthened column of air in the freezer duct is preferred, it is possible to use the same duct length as in the refrigerator since the invention resides not in the exact length of the duct but rather in there being a portion of ducting above the passages **234** and **235**.

The same electrical circuits as used with the refrigerator apparatus may be used with the freezer. However, the operating temperatures of the thermostats **237** and **240** must be selected to reflect the lower compartment temperature within the freezer.

Thus, the present invention comprehends an improved refrigeration apparatus wherein chilled air delivered to a compartment is tempered by the delivery thereinto of a portion of the air in the compartment of a venturi action in the duct delivering the chilled air to the compartment. Means are provided for sensing the direction of the air flow through the recirculation passage for providing an improved control of the operation of the refrigeration apparatus. In the present disclosed embodiments of the invention, the reversal of the air flow direction in the recirculation passages may be sensed by a thermally responsive sensing means since air flowing through the duct from the compartment into the duct is at the relatively high compartment temperature compared to the temperature of the chilled air normally flowing from the duct into the compartment through the outlet **15**. As disclosed above, the invention further comprehends an improved circuit arrangement for utilizing the signal provided by the sensing means to provide improved automatic defrosting control of the refrigeration apparatus.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as defined in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a refrigeration apparatus;
means for chilling air;
cabinet means defining a compartment to be refrigerated;
duct means having a venturi portion and an outlet opening into said compartment for conducting chilled air from said chilling means through said outlet into said compartment;
air translation means upstream of said outlet for flowing chilled air from said chilling means through said duct means into said compartment; and
means defining a passage between said compartment and said duct means venturi portion and downstream of said air translation means for permitting air flowing through said duct means and outlet to draw air by venturi action from said compartment into said duct means to mix with said chilled air therein for subsequent discharge of the mixed air through said outlet into said compartment.

2. In a refrigeration apparatus:
means for chilling air;
cabinet means defining a compartment to be refrigerated;
duct means having an outlet opening into said compartment for conducting chilled air from said chilling means through said outlet into said compartment;
air translation means for flowing chilled air from said chilling means through said duct means into said compartment;
means defining a passage between said compartment and said duct means spaced from said outlet for permitting air flowing through said duct means and outlet to draw air from said compartment into said duct means to mix with said chilled air therein for subsequent discharge of the mixed air through said outlet into said compartment; and
control means including means in said passage responsive to a condition of the air therein for controlling operation of said chilling means to discontinue air chilling operation thereof.

3. The refrigeration apparatus of claim 2 wherein said last-named means is arranged to be responsive to a reversal of air flow from said duct means through said passage defining means to said compartment.

4. The refrigeration apparatus of claim 2 wherein said last-named means comprises a thermally responsive device.

5. The refrigeration apparatus of claim 2 wherein said outlet is disposed above the level of said passage defining means whereby a body of air is disposed in said duct means above said passage defining means for causing chilled air to be diverted outwardly through said passage when the pressure of said flowed air is below that necessary to move said body of air upwardly and outwardly through said outlet.

6. The refrigeration apparatus of claim 2 wherein said control means further includes means for discontinuing air chilling operation of said chilling means at a preselected low temperature in the event said means in said passage fails to discontinue said air chilling operation responsive to said condition.

7. The refrigeration apparatus of claim 2 wherein said air chilling means includes a heat transfer means having a pair of spaced heat absorbing portions, said air translation means flows air through the space between said portions for chilling the air, and said air condition responsive means is responsive to a condition of air flow through said means defining a passage resulting from a restriction in the air flow through said space due to frost build-up on said portions of the heat transfer means impeding the air flow through said space.

8. The refrigeration apparatus of claim 7 further including means actuatable by said air condition responsive means for defrosting said heat transfer means.

9. The refrigeration apparatus of claim 2 wherein said control means includes a relay having a coil and a first double throw switch operable by said coil, said air condition responsive means includes a second switch connected in series with said coil for energizing said coil when said air flow condition occurs, and said air chilling means includes electrically operable means connected to said first switch to be energized therethrough when said first switch is in one thrown condition and to be de-energized when said first switch is in the other thrown condition thereof.

10. The refrigeration apparatus of claim 9 wherein said first switch shunts said second switch when said first switch is in said other thrown condition thereof.

11. The refrigeration apparatus of claim 9 including electrically operable means for defrosting said air chilling means connected to said first switch to be energized when said first switch is in said other thrown condition.

12. The refrigeration apparatus of claim 2 wherein said air chilling means comprises electrically operable means, said air condition responsive means include switch means connected in series with said electrically operable air chilling means and arranged to de-energize said electrically operable air chilling means when said air flow condition occurs.

13. The refrigeration apparatus of claim 12 further including electrically operable means for defrosting said air chilling means and said switch means being further connected in series with said defrosting means and arranged to energize said defrosting means when said switch means is arranged to de-energize said electrically operable chilling means.

14. The refrigeration apparatus of claim 2 wherein the control means further includes means for preventing reoperation of said chilling means after discontinuation of operation thereof until said air chilling means reaches a preselected high temperature.

15. The refrigeration apparatus of claim 2 wherein means are provided for defrosting the air chilling means and directing melt arising from said defrosting to a disposal means, and said control means further includes means for preventing reoperation of said chilling means after discontinuation of operation thereof until substantially all said melt is directed to said disposal means.

16. In a forced air refrigeration apparatus having a food storage compartment to be maintained at a first temperature, air chilling means for chilling air to below freezing temperatures lower than said first temperature, and air moving means for moving air from said air chilling means to said food storage compartment, the improvement comprising: duct means for providing fluid communication between said air chilling means and said food storage compartment, said duct means including an outlet portion for delivering air to said food storage compartment, an air entraining portion spaced from said outlet portion for drawing air from said food storage compartment into said duct means, and a connecting portion for connecting said outlet portion and said air entraining portion, said connecting portion being at least partially above the level of said air entraining portion whereby during operation of said refrigeration apparatus said air moving means moves a desired predetermined volume of air to said food storage compartment from said air chilling means, and air from said food storage compartment is entrained with the air from said air chilling means and mixed therewith prior to delivery from said outlet portion, but when the volume of air moved by said air moving means is reduced below a predetermined volume due to frost build-up on said air chilling means the air moved by said air moving means is caused to flow from said duct means through said air entraining portion into said food storage compartment.

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MEYER PERLIN, *Primary Examiner.*