April 22, 1952 A. E. KNAPP 2,594,036

REFRIGERATOR HAVING FREEZER AND STORAGE COMPARTMENTS WITH SEPARATE CONTROLS

Filed May 14, 1948 3 Sheets-Sheet 1

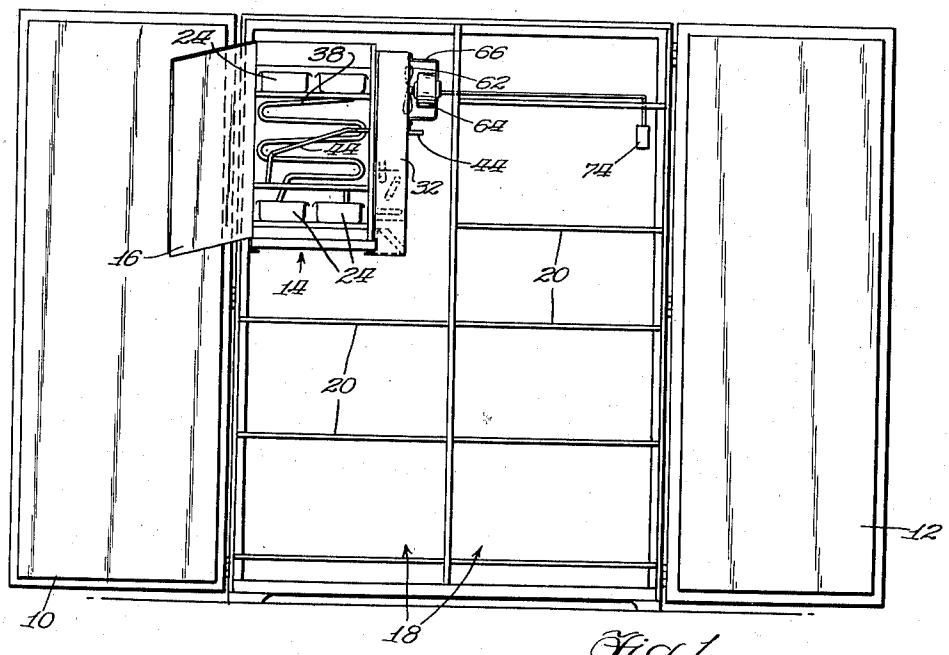
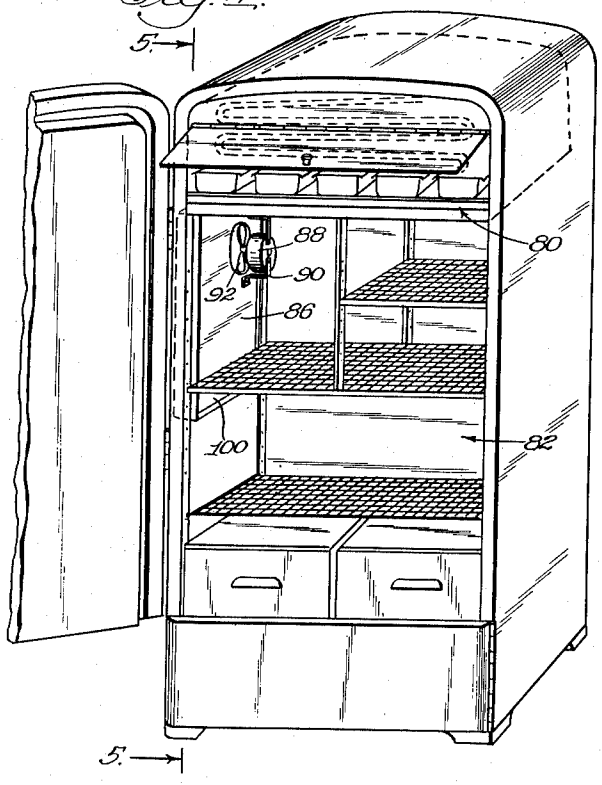


Fig. 1.

Fig. 4.



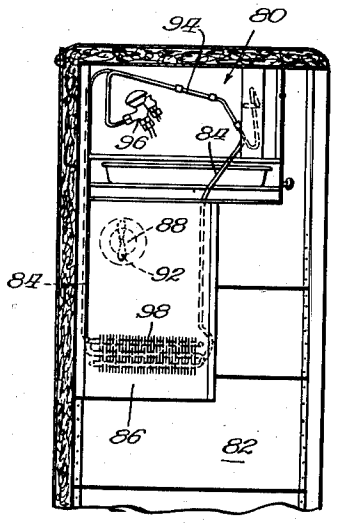


Fig. 5.

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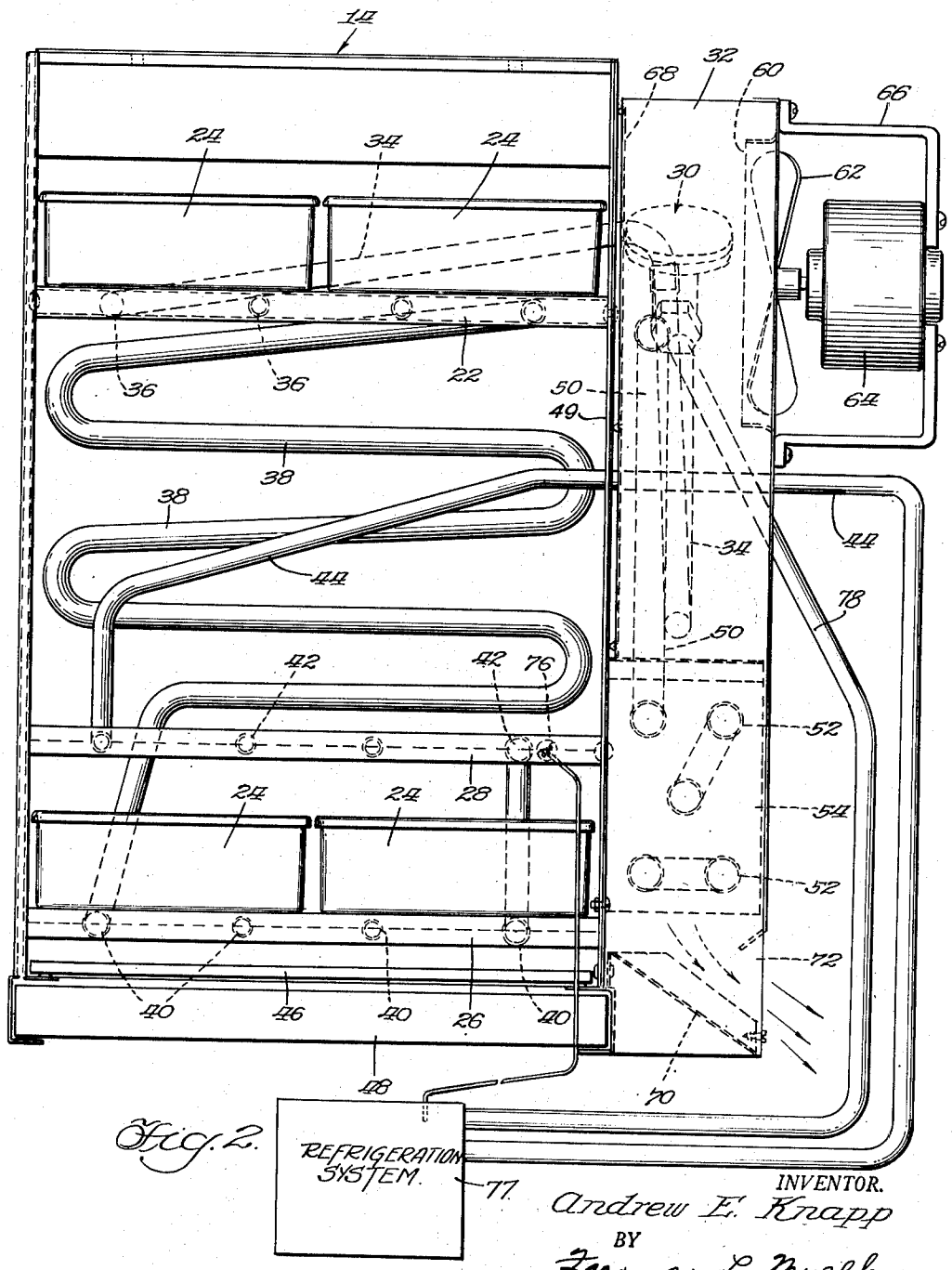


Fig. 2.

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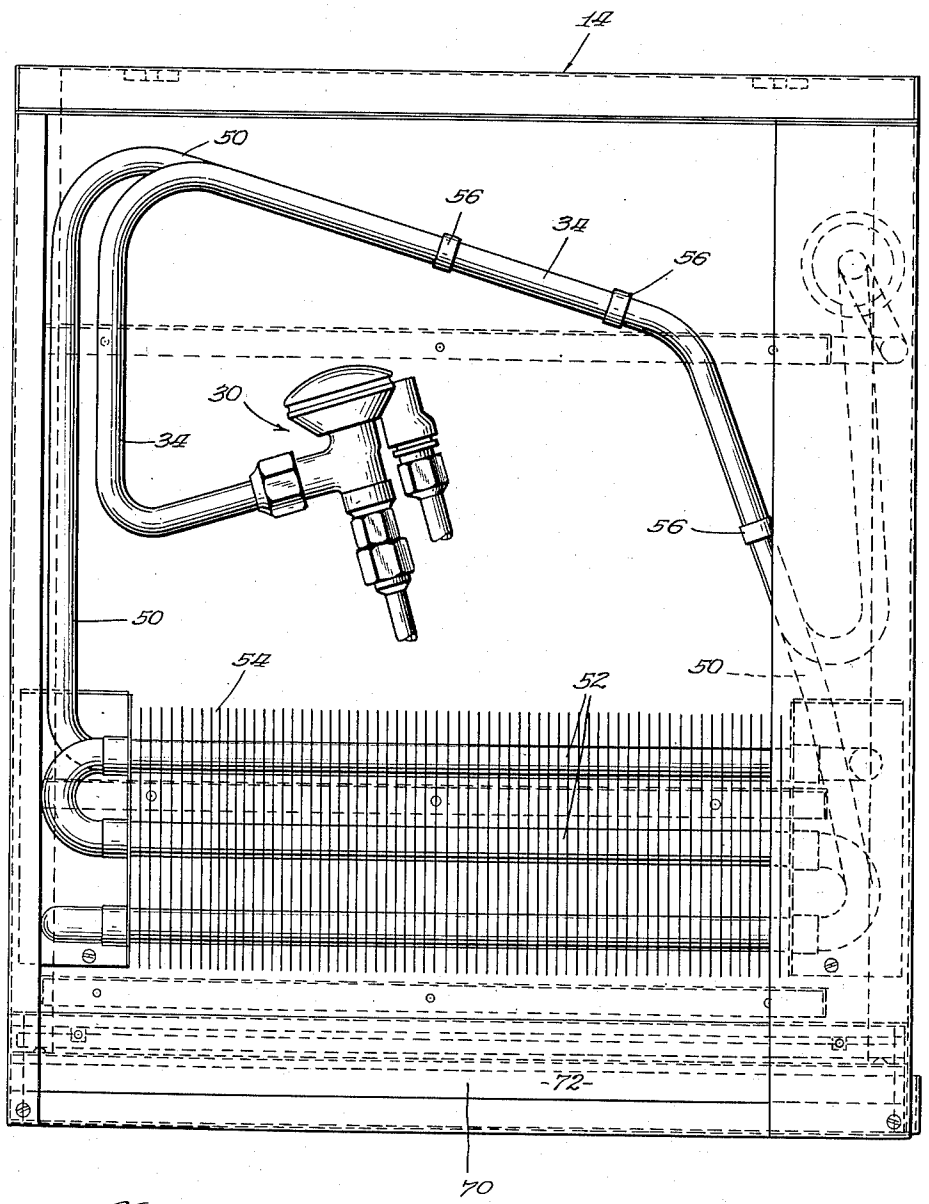


Fig. 3.

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UNITED STATES PATENT OFFICE

2,594,036

REFRIGERATOR HAVING FREEZER AND STORAGE COMPARTMENTS WITH SEPARATE CONTROLS

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2 Claims. (Cl. 62—3)

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This invention relates to refrigerators, and particularly to a refrigerator of the type in which an auxiliary refrigerating circuit (known as a "slave circuit") extends from the freezing section of the refrigerator into heat exchange relation with the food storage compartment.

It has been customary in designing refrigerators to utilize the freezer section for cooling the air in the food storage compartment. Where this practice is followed, moisture from the air in the food compartment is continually deposited as frost on the exposed parts of the freezer, tending to dehydrate the food and requiring frequent defrosting of the freezer. For this reason it is highly desirable to arrange a refrigerator so that the freezer and the food compartment are cooled substantially independently of each other, without resorting to expensive duplication of parts. To that end, it has been proposed recently to use a slave circuit for transferring heat from the food compartment to the main refrigerating circuit, thus enabling the freezer to be isolated from the food compartment so that it is not exposed to the warmer, moisture-laden air therein. However, slave circuits generally have not been considered feasible, except to a limited extent in small household refrigerators, because the rate of heat transfer heretofore accomplished through such as circuit was not sufficiently high to keep a large storage space cool. Hence, the conventional refrigerator construction has been retained to a great extent, particularly in large refrigerators, even though it has the disadvantages mentioned above.

An object of the present invention is to provide an improved refrigerator having a slave circuit which is more effective than slave circuits heretofore proposed, whereby refrigerators (even of very large capacity) having substantially independent cooling of the freezing and food storage compartments can be utilized in all practical situations.

A further object is to increase the sensitivity and heat transfer efficiency of the slave circuit by forcibly circulating air from the food compartment into heat exchange relation with the slave circuit whenever the food compartment is in need of refrigeration, thereby accelerating the action of the slave circuit and making it more responsive to changes in the air temperature.

A still further object is to arrange the slave circuit so that a very rapid circulation of the refrigerating medium through this circuit is produced.

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Another object is to reduce or substantially eliminate the problems of icing, dehydration and defrosting commonly encountered in refrigerators, whether of large or small capacity, while enabling the rate of heat transfer from the food storage compartment to be accelerated considerably in comparison with the present-day practice.

A feature of the invention is the novel combination of a slave circuit with a thermostatically controlled air circulating means in the food compartment of the refrigerator. When there is a call for refrigeration in the food compartment, the air is forcibly circulated past the lowermost portion of the slave circuit, quickly heating the refrigerant therein to produce rapid boiling thereof and accelerating the circulation of this medium through the slave circuit.

Another feature is the novel configuration of the slave circuit which produces a substantial "head" of condensed refrigerant after the discharge of the heat therefrom. This further aids in rapid circulation of the refrigerant through the slave circuit.

Still another feature is the provision of a novel control for the main refrigerating circuit so that when the slave circuit functions, the main circuit also operates.

The foregoing and other objects, features and advantages of the invention will become apparent from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a front elevational view of a large-size refrigerator (with the doors open), wherein a refrigerating system constructed in accordance with and embodying the principles of the invention is employed;

Fig. 2 is an enlarged front elevational view of the freezer unit in the refrigerator of Fig. 1 (the door of this unit being omitted for clarity of illustration);

Fig. 3 is a side view (with certain parts omitted) of the freezer unit;

Fig. 4 is a perspective view of a modified refrigerator embodying the invention; and

Fig. 5 is a vertical section on the line 5—5 in Fig. 4.

In practicing the invention, a slave circuit in the form of a closed loop or duct is secured along its uppermost portion to a portion of the main refrigerating circuit which extends through the freezer compartment of the refrigerator. The lowermost portion of the slave circuit is provided with heat-absorbing fins and is disposed

in an air passage, through which air from the food compartment of the refrigerator is adapted to circulate. A thermostatically controlled fan is adapted to force air from the food compartment through this passage. Because of the rapid air flow past the heat-absorbing portion of the slave circuit, the refrigerant contained therein is caused to boil rapidly, producing a high rate of heat transfer from the food compartment to the main refrigerating circuit. The arrangement is such that the main refrigerating circuit is caused to operate when the slave circuit is functioning. Rapid condensation of the refrigerant takes place in the upper portion of the slave circuit, and the circuit is so formed that a substantial head of condensate accumulates in that portion of the slave circuit leading from the upper portion to the lower heat-absorbing section. This further aids in producing rapid circulation of the refrigerant through the slave circuit. The temperature of the slave circuit is not nearly as low as that of the main refrigerating circuit. Instead, the high rate of flow of refrigerant through the slave circuit is depended upon for cooling effect desired.

In Fig. 1 there is illustrated a refrigerator of large capacity such as may be used in a restaurant or a large residence. Doors 10 and 12 are respectively hinged on the two sides of the refrigerator. The refrigerator has a freezer unit 14 with a door 16 shown in open position. The food storage compartment 18 of the refrigerator, which is adapted to be maintained above freezing temperature, is equipped with various shelves 20 for supporting the food and other articles to be refrigerated.

Referring now to Figs. 2 and 3, the freezer unit 14 is provided with an upper shelf or plate 22 on which are disposed ice cube trays 24, a lower shelf or plate 26 on which other ice cube trays 24 may be disposed, and an intermediate shelf or plate 28 on which frozen foods or other articles to be kept below freezing temperature may be placed.

These plates 22, 26 and 28 are made hollow for a purpose which will appear presently. The main refrigerating circuit of the refrigerator includes coils positioned in the freezer unit 14. The expansion valve 30 of this main circuit is disposed in a housing 32 which is attached to the right-hand side of the freezer unit 14. A duct 34, which is part of the main refrigerating circuit, leads from the expansion valve 30 and (after extending at a downward inclination through the housing 32) enters the freezer proper. The main circuit then is continued through horizontal coils 36 in the upper plate 22, coils 38 arranged in a vertical plane at the rear of the freezer unit 14 between the shelves 22 and 28, horizontal coils 40 in the lower plate 26, and horizontal coils 42 in the intermediate plate 28 to the return duct 44 which leads to the compressor (not shown).

A horizontal partition 46 of glass or other suitable heat-insulating material is installed below the lower shelf 26 to reduce the cooling effect of the bottom of the freezer unit 14 upon the food storage compartment 18. The defrost pan 48 at the bottom of the freezer unit 14 is closely fitted to further isolate the interior of the freezer 14 from the food compartment 18. The freezer unit includes a side wall 49, which may be insulated, separating the same from the food storage compartment. Suitable insulation also is provided at the top of the freezer unit 14. The door 16 may likewise be insulated if desired.

The housing 32 attached to the side of the freezer unit 14 is arranged to provide an air duct or passage leading downwardly and communicating with the interior of the food compartment 18. The slave circuit 50 is disposed in the housing 32. The lower portion of the slave circuit 50 is formed into coils 52 which are provided with heat-absorbing fins 54. The upper portion of the slave circuit 50 extends alongside a portion of the duct 34 in the main refrigerating circuit. The slave circuit 50 may be permanently bonded or clamped to the duct 34. Preferably, the two ducts 50 and 34 are bonded together for a limited distance and are then held together by clamps 56 for an additional distance. The use of the clamps 56 instead of permanently bonding the two ducts together at all points enables the amount of metal-to-metal contact to be varied as required in individual installations.

A circular air intake opening 60 is formed in the side of the housing 32 near the top thereof, and an air circulating fan 62 is disposed in this opening. The fan 62 is mounted on the shaft of an electric motor 64 supported by a bracket 66 which is secured to the housing 32. When the motor 64 is operating, the fan 62 forces air from the upper part of the food compartment 18 into the passage which extends down through the housing 32. A baffle plate 68 in housing 32 adjacent the side of the freezer unit 14 prevents the incoming air stream from striking the side of the freezer unit. The incoming air descends through the heat-absorbing fins 54 which transfer heat from the air to the refrigerant in the slave circuit 50. A deflector 70 guides the air out of a discharge opening 72 at the lower end of the housing 32 after the air leaves the fins 54.

The slave circuit 50 is a closed loop which operates in dependence upon the difference in temperatures between the upper portion of this circuit and the coils 52 in the lower portion of the circuit. When the air is forcibly circulated past the coils 52, the refrigerant contained in these coils is caused to boil vigorously and the vapor ascends to the vertical portion at the left-hand side of the slave circuit 50 (as viewed in Fig. 3). The vapor is cooled in the downwardly inclined upper portion of the circuit 50, which is in contact with the duct 34 of the main refrigerating circuit, and condenses. The condensate trickles down into a portion of the slave circuit 50 which extends downwardly at an angle from the vertical between the lower end of the upper portion and the coils 52. Due to the rapid refrigerating cycle in the slave circuit, a considerable head of condensed refrigerant forms in this downwardly extending portion of the slave circuit. This serves to further accelerate the refrigerating cycle in the slave circuit.

The thermostat 74, Fig. 1, which controls the fan motor 64 may be placed in any convenient location within the food compartment 18 of the refrigerator. The motor 64 therefore operates strictly in dependence upon the air temperature in the compartment 18. Theoretically, it is desired that the main refrigerating circuit be insulated completely from the food compartment 18 except for such communication as is effected through the medium of the slave circuit 50. In practice, however, it is found advisable to have a certain amount of interaction whereby the main refrigerating circuit will operate to cool the sleeve circuit whenever the slave circuit is functioning. To this end, a thermostatic element 76 (Fig. 2), which controls the compressor motor

in the main refrigerating circuit, is located in the plate 28 near the side of the freezer unit 14 where the slave circuit 50 is disposed. Compressed refrigerant is provided in the main refrigerating circuit by a refrigeration system 77, which may be of any suitable standard construction. The refrigeration system includes a compressor for providing compressed refrigerant to the expansion valve 30 through duct 78. The refrigerant is returned to the refrigeration system through duct 44. The baffle 68 terminates above the fins 54 of the slave circuit coils 52, and the fins 54 are connected in heat-conductive relation to the plate 28. This permits heat transfer from the food compartment 18 (by way of the air circulating through the housing 32) to the thermostatic element 76. Hence, whenever an air flow is induced through the slave circuit housing 32 by the fan 62, the thermostatic element 76 is warmed sufficiently to start the compressor working, thus insuring that the slave circuit 50 is adequately cooled by the main circuit. Of course, if the main refrigerating circuit already is operating, operation of the slave circuit will have no effect upon it other than to keep the main circuit operating at least as long as the slave circuit requires cooling.

Heat transfer from the food compartment 18 to the slave circuit 50 is greatly accelerated by the action of the thermostatically controlled fan 62. It is found that the rates of vaporization and condensation of the cooling medium in the slave circuit 50 are much higher with forced air circulation than would be the case with circulation of the air by natural convection in the compartment 18. Hence, the temperature gradients between the heat-absorbing and heat-discharging ends of the slave circuit, and between the heat-discharging end and the adjoining portion 34 of the main refrigerating circuit, are more pronounced. The rate of heat transfer between two points, as is well known, increases far more than linearly with each increase in temperature gradient between the points. Thus, the forced circulation of air not only tends to keep the air temperature equalized in the compartment 18, but it also effects a greater-than-proportionate increase in the rate at which the heat is transferred to the slave circuit 50.

While the slave circuit 50 is able to cool the food compartment 18 at a comparatively rapid rate, this is accomplished without exposing the air in the compartment 18 to an extremely low temperature at any point. The freezer 14 is substantially isolated from the food compartment 18 so that frosting of the freezer 14 is kept to a minimum. The temperature of the slave circuit coils 52 is not nearly as low as that of the main refrigerating coils in the freezer 14. Hence, there is less icing of the cold surfaces and correspondingly greater humidity of the air in the disclosed refrigerator than in prior types of refrigerators.

Uniform temperature and positive control of refrigeration in the food compartment are afforded by the fan 62 which is operated under thermostatic control to meet load requirements. Also, the amount of contact between the slave circuit and the main refrigerating circuit can be varied to match the load requirements. For example, when used in a hot restaurant kitchen where the door of the refrigerator is opened often, a relatively large amount of refrigeration is required in the food compartment as compared to that required when the refrigerator is used in a cool pantry of a home where it is not often opened. What little defrosting is required of the low-temperature main circuit may be performed at extremely infrequent intervals. The ice making coils can be maintained at an extremely low temperature without affecting the food compartment 18, which is maintained at the desired storage temperature irrespective of the temperature within the freezer compartment. The slave circuit and motor-driven fan associated therewith form a very compact unit much smaller in size than a slave circuit of comparable heat transfer capacity which does not employ the forced air circulating means.

In Fig. 4 there is illustrated a refrigerator of the small household type in which the freezer 80 extends entirely across the top of the food compartment 82 and is physically isolated therefrom. As in the case of the previously described embodiment, the freezer 80 communicates with the compartment 82 through the medium of a slave circuit 84, Fig. 5. The slave circuit 84 is contained in a housing 86 which may be set into a wall of the refrigerator for economizing space. The housing 86 is located immediately below the freezer 80 at one side of the refrigerator, and the slave circuit 84 extends upwardly along one side of the freezer 80 to contact a duct 94 leading from the expansion valve 96 in the main refrigerating circuit. An electric motor 88 mounted on a bracket 90 near the upper end of the housing 86 drives a fan 92 which is disposed in an opening through which air from the compartment 82 enters the downwardly extending air passage in the housing 86.

The electric motor 88 that drives the fan 92 is controlled by a suitable thermostat (not shown) in the food compartment 82, similar to the thermostat 74 in Fig. 1. As the fan 92 operates, it draws air from the upper part of the food compartment 82 into the air passage in the housing 86 and causes the air to traverse the finned heat exchange section 98 which is at the lowermost part of the slave circuit 84. The air then is discharged through an opening 100 at the bottom of the housing 86 into the lower part of the food compartment 82. The operation and general configuration of the slave circuit 84 is substantially the same as that described hereinabove in connection with the slave circuit 50 of the first embodiment of the invention. Because of the forced air circulation, the slave circuit 84 can be made very small and compact and yet perform very efficiently in refrigerating the compartment 82.

It has been noted hereinabove that the main refrigerating circuit operates whenever the food compartment or the ice compartment requires cooling. Where the refrigerator is used in a warm location and is frequently opened, this may entail frequent operation of the main circuit. Despite that fact, however, the main circuit is not unduly loaded, because the slave circuit does not absorb nearly as much heat in a short interval as the freezer unit would do if exposed, due to the difference in temperature gradient, and hence there is a quicker recovery from the warming effect of opening the doors.

From the foregoing description it is apparent that I have provided a novel refrigerating system which fulfills the above stated objects of the invention. Modifications can be made in the illustrated arrangements without departing from the principles of the invention, and it is intended that all such modifications be included within the scope of the following claims.

I claim:

1. In a refrigerator having a freezer and a separate food compartment, refrigerating coils in said freezer, a plate in said freezer cooled by said coils, a slave circuit having a first portion arranged in heat-absorbing relation to said food compartment and in heat-conductive relation to said plate, and also having a heat-discharging portion arranged in direct conductive relation to a portion of said refrigerating coils, a motor-driven fan for circulating the air in said food compartment and directing air to be cooled into contact with said heat-absorbing portion, a first thermostatic element located in the food compartment for controlling the operation of said fan, and a second thermostatic element responsive to the temperature of said plate for controlling the cooling effect of said refrigerating coils.

2. In a refrigerator having a freezer and a separate food compartment, refrigerating coils in said freezer, a plate in said freezer disposed adjacent to certain of said coils, a slave circuit having a finned portion arranged in heat-absorbing relation to said food compartment and in heat-conductive relation to said plate, and also having a heat-discharging portion arranged in direct conductive relation to a portion of said

refrigerating coils, a motor-driven fan for circulating the air in said food compartment and directing air to be cooled into contact with said finned portion, a first thermostatic element located in the food compartment for controlling the operation of said fan, and a second thermostatic element mounted in proximity to said plate for controlling the cooling effect of said refrigerating coils.

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