June 2, 1964 H. M. ULLSTRAND 3,135,102

FORCED AND NATURAL DRAFT COOLING ARRANGEMENT FOR REFRIGERATOR

Filed March 2, 1962 4 Sheets-Sheet 1

FIG. 1

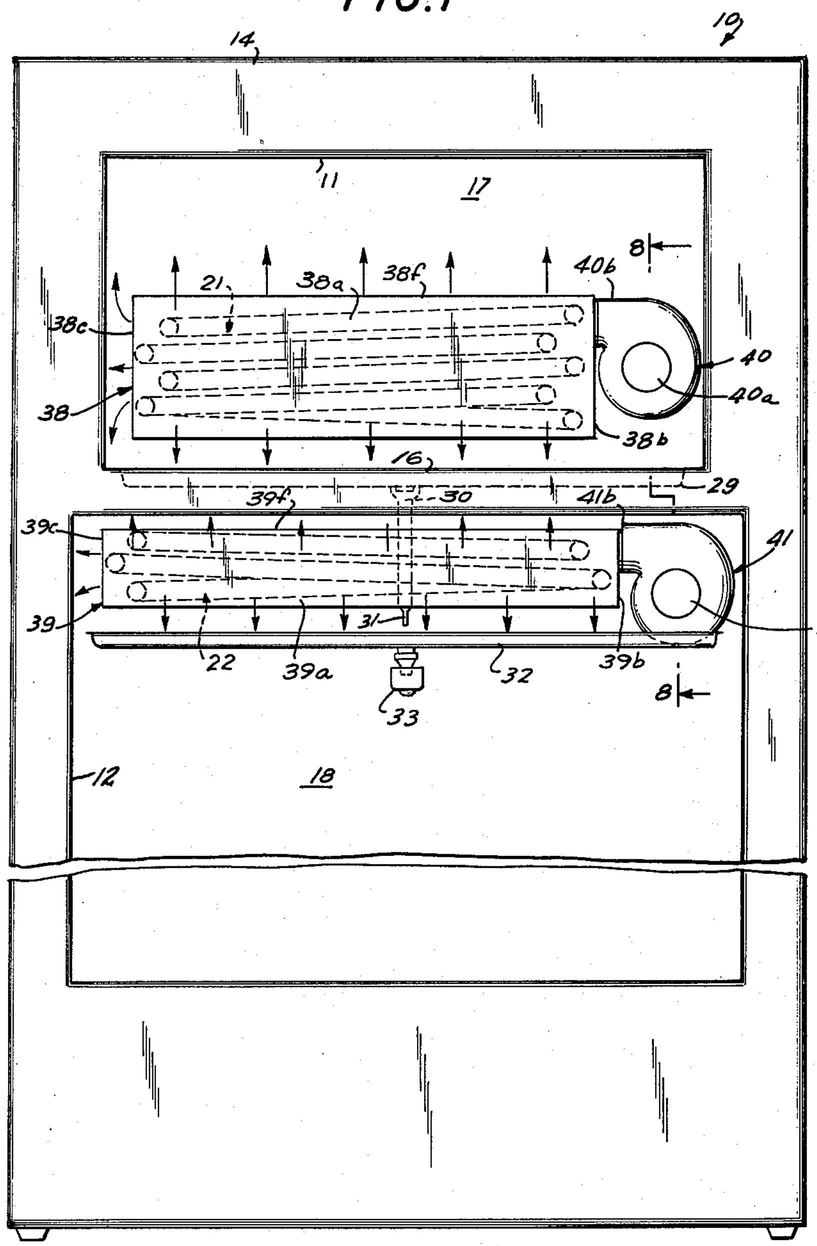

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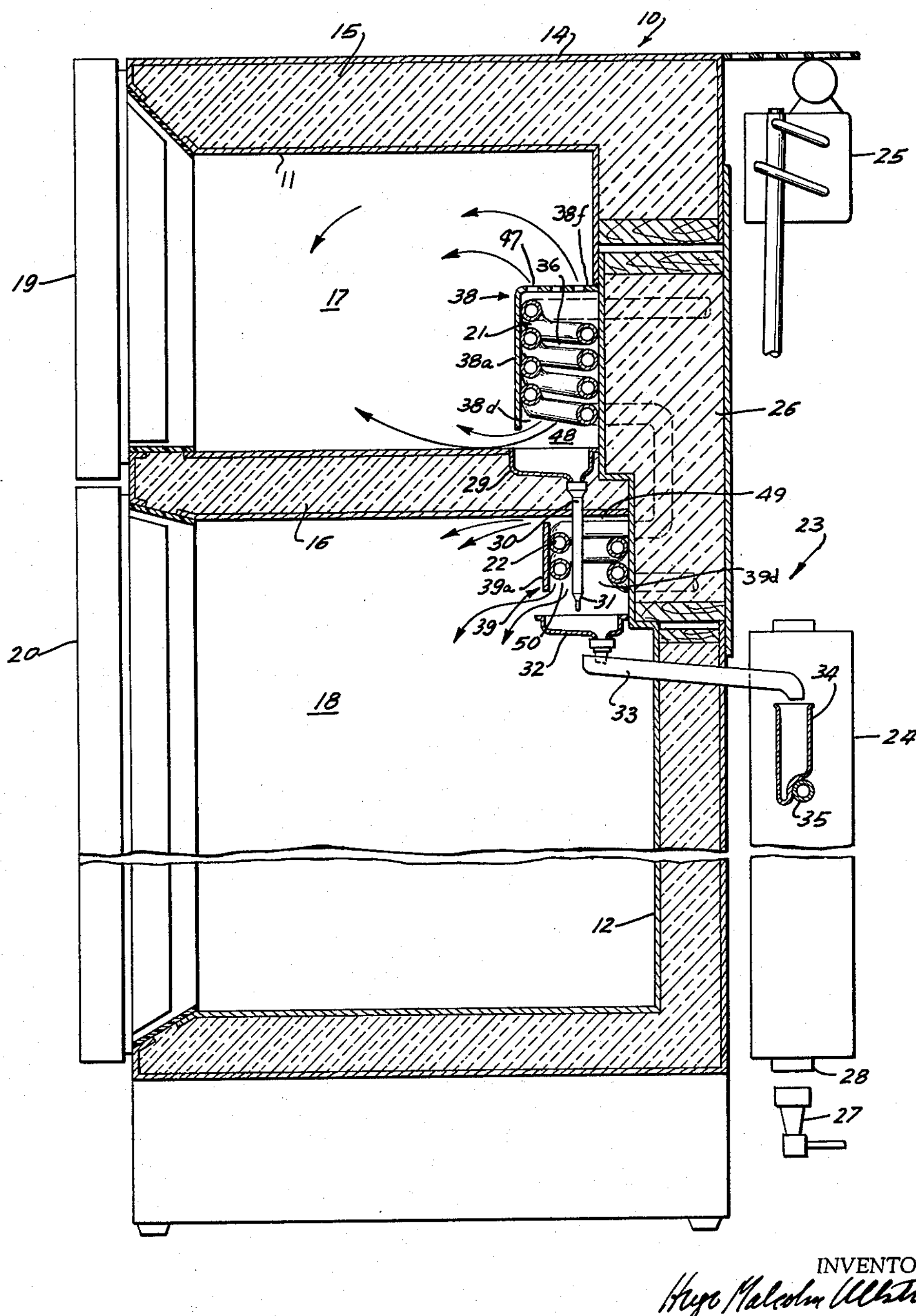
FIG. 2



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FORCED AND NATURAL DRAFT COOLING ARRANGEMENT FOR REFRIGERATOR

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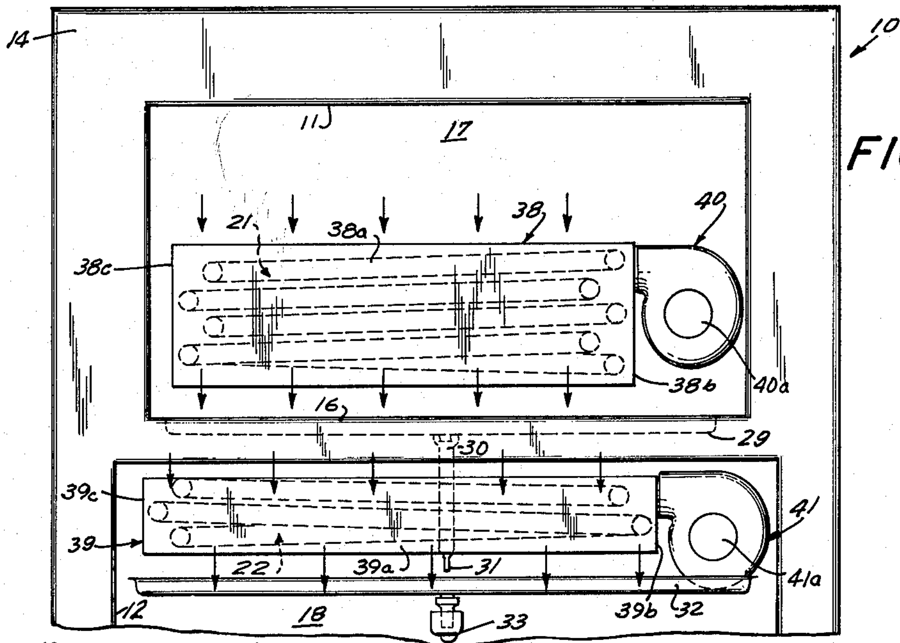

FIG. 3

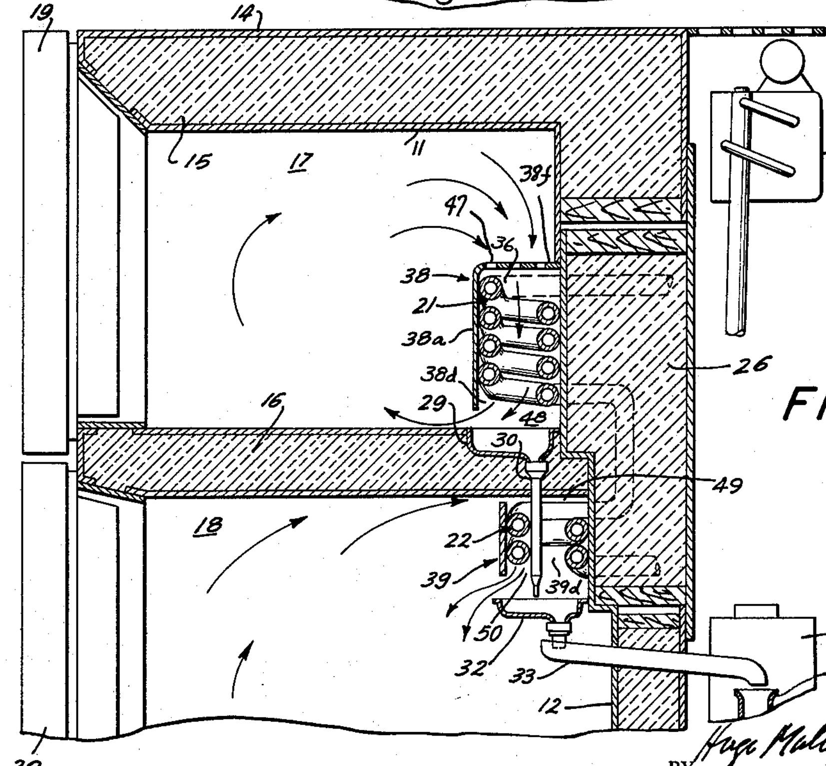

FIG. 4

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Filed March 2, 1962 4 Sheets-Sheet 4

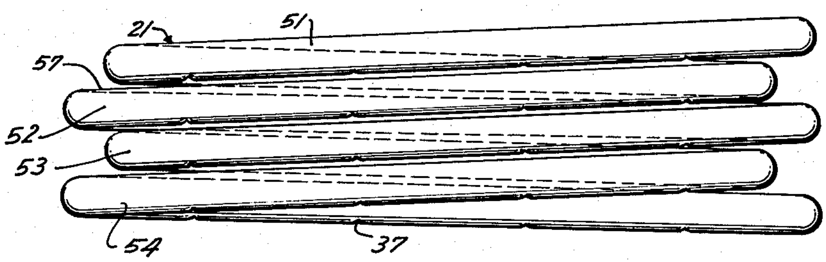

FIG. 5

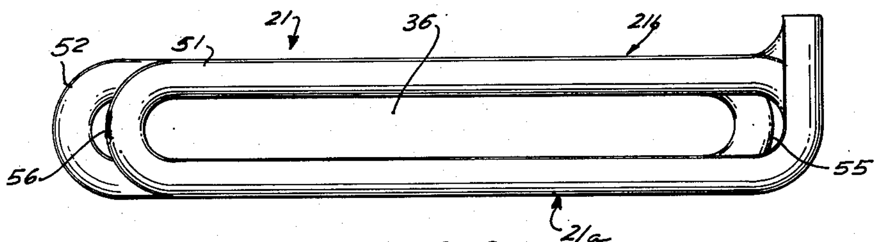

FIG. 6

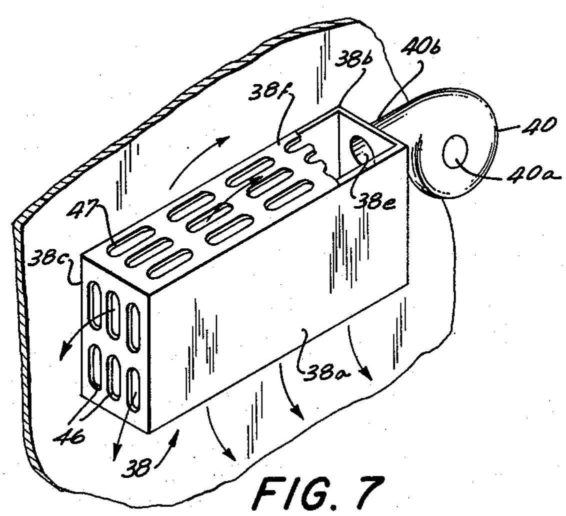

FIG. 7

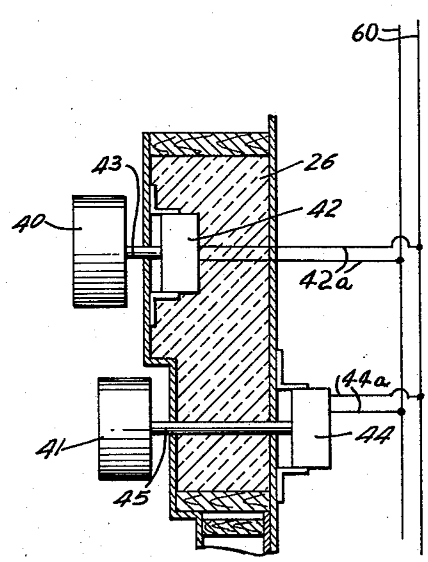

FIG. 8

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FORCED AND NATURAL DRAFT COOLING ARRANGEMENT FOR REFRIGERATOR

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10 Claims. (Cl. 62—419)

My invention relates to refrigeration, and more particularly concerns cooling of the thermally insulated interior of a refrigerator by forced and natural draft circulation of air.

It has been the practice heretofore to effect cooling of a thermally insulated compartment of a refrigerator by circulating air in thermal relation with a cooling element by forced draft with the aid of a fan, so that the temperature developed in the storage compartment will approach the temperature of the cooling element. The cooling element may form a part of refrigeration apparatus operated by a source of heat like a fluid fuel burner, for example, and the fan arranged to be driven by an electric motor. If the source of electrical supply should become unavailable for driving a fan motor in refrigeration apparatus of the heat-operated type, the apparatus still will operate normally to maintain the cooling element at its desired low temperature.

The fan for circulating air by forced draft often is located exteriorly of the storage compartment in a passageway through which air flows from and back to the compartment, and the cooling element is positioned in the passageway for cooling the air flowing in thermal relation therewith. This positioning of the cooling element would be objectable in heat-operated refrigeration apparatus, because the cooling element would be removed from the compartment and could not be employed efficiently for cooling the compartment if the fan motor should become inoperable.

The object of my invention is to provide an improvement for cooling a refrigerator compartment whereby air will be circulated by forced draft over a cooling element by a motor-driven fan when the fan motor is operable, and, if the fan motor should become inoperable because of the failure of the source of electrical supply, the cooling element is employed to induce natural circulation of air in thermal relation therewith.

The invention, together with the above and other objects and advantages thereof, will be more fully understood from the following description and accompanying drawings forming a part of this specification, and in which:

FIG. 1 is a front elevation, partly broken away, of a refrigerator embodying my invention, the front doors being omitted to simplify the drawing;

FIG. 2 is a side view, partly in section, of the refrigerator shown in FIG. 1;

FIGS. 3 and 4 are views similar to FIGS. 1 and 2, respectively, to illustrate the operation of the refrigerator more clearly;

FIG. 5 is a front elevation of an evaporator or cooling element of the form illustrated in FIGS. 1 to 4, inclusive;

FIG. 6 is a top plan view of the evaporator or cooling element shown in FIG. 5;

FIG. 7 is a fragmentary perspective view of details shown in FIGS. 1 and 2; and

FIG. 8 is a fragmentary sectional view taken at line 8—8 of FIG. 1.

Referring to FIGS. 1 and 2, I have shown my invention embodied in a household refrigerator comprising a cabinet 10 having inner shells 11 and 12 supported one above the other within an outer shell 14 and insulated therefrom and from one another with any suitable insulating material 15. The insulation between the inner shells 11 and 12 and the shell walls against which it bears defines a horizontal partition 16 which thermally segregates top and bottom compartments 17 and 18 defined by the inner shells 11 and 12, respectively.

The top compartment 17 serves as a thermally insulated freezer space and the bottom compartment 18 as a space for storing foods at a higher temperature than that in the top compartment 17 and preferably at a temperature above 32° F. Access to the top and bottom compartments 17 and 18 is afforded at front openings which are adapted to be closed by insulated doors 19 and 20 hinged in any suitable manner (not shown) at the front of the cabinet 10.

The top freezer space 17 is arranged to be cooled by a cooling element or evaporator 21 and the bottom food storage space 18 is arranged to be cooled by a cooling element or evaporator 22. The cooling elements 21 and 22 desirably form low and higher temperature sections of a cooling unit of refrigeration apparatus of any suitable type. As shown, the refrigeration apparatus may be of a uniform pressure absorption type, generally as described in my United States Letters Patent No. 2,635,437, granted April 21, 1953. In apparatus of this type, the cooling elements 21 and 22 are connected by conduits (not shown) to other parts of the refrigeration apparatus 23 at the rear of the cabinet 10. Parts of the refrigeration apparatus have been ommitted and other parts, like the generator 24 and condenser 25, have been shown only diagrammatically, a complete illustration of the apparatus not being necessary for an understanding of my invention.

Parts of refrigeration apparatus of the absorption type, whose relative positions are substantially fixed, usually are formed of iron or steel when ammonia and water are employed as the refrigerant and liquid absorbent, respectively. Accordingly, the piping for the cooling elements 21 and 22, which form a unitary part of the refrigeration apparatus 23, may be formed of ferrous metal also. The rear wall of the cabinet 10 is formed with an opening through which the cooling elements 21 and 22 are inserted into the interior of the cabinet 10, such opening being closed by an insulated closure member 26 removably secured to the cabinet in any suitable manner and through which extend the conduits (not shown) connecting the cooling elements 21 and 22 and other parts of the refrigeration apparatus 23. A frame (not shown) may be provided at the rear of cabinet 10 upon which the refrigeration apparatus 23 is mounted. The refrigeration apparatus is adapted to be operated by a suitable source of heat, such as a fluid fuel burner 27, which is arranged to project its flame into the lower end of a flue 28 extending through the generator 24.

A drain pan 29 is provided in the bottom of the inner liner 11 below the cooling element 21 for collecting water dripping therefrom, as during defrosting, for example. The water drains from pan 29 through a tube 30 having a flattended lower end 31 disposed above a second drain pan 32 mounted in any suitable manner below the cooling element 22. Water in pan 32 flows therefrom by gravity through a conduit 33 extending through the rear wall of the cabinet 10 and is discharged into a pan or collecting vessel 34 in good heat conductive relation with a heated conduit 35 of the refrigeration apparatus. With this arrangement, water collected in vessel 34, as during defrosting, is effectively evaporated.

The flattened lower end 31 of tube 30, which is normally closed to seal the top and bottom compartments 17 and 18 from one another, may be formed of soft resilient material like rubber, for example. When the liquid head in the tube **30** becomes sufficiently great, the soft resilient material yields to the force developed by the liquid column and the lower end **31** of the drain tube opens to allow water to pass therethrough during periods when defrosting is being effected, for example, and the temperature at the immediate vicinity of the drain tube is above 32° F.

Each of the cooling elements **21** and **22** is in the form of a looped coil into which a refrigerant fluid, such as ammonia, is introduced for downward flow therethrough. The refrigerant evaporates in the cooling elements into an inert gas, such as hydrogen, to produce a refrigerating effect. The cooling elements are similar, cooling element **21** including two parallel banks **21***a* and **21***b* of essentially straight tubes disposed one above the other, the tubes in the banks **21***a* and **21***b* dipping downward slightly in opposite directions from the horizontal. The tube banks **21***a* and **21***b*, which are spaced from one another, form a vertical passage **36** therebetween. The ends of the tubes in the tube banks are connected by U-bends, the lower end of each tube in one tube bank being connected to the upper end of a tube in the other tube bank to provide a continuously elongated path of flow for the refrigerant fluid. As seen in FIG. 5, the bottoms of the tubes in each tube bank are indented at spaced intervals at **37** whereby shallow pools of refrigerant can form in its downward path of flow through the coil. It will be observed in FIG. 5 that vertically extending planes perpendicular to the longitudinal axes of the straight tubes in the two tube banks **21***a* and **21***b* are inclined at acute angles in opposite directions from the same given vertical plane.

The cooling elements **21** and **22** are disposed in the rear of the compartments **17** and **18** and are employed to cool air flowing in thermal transfer relation therewith. Although the straight tubes of the tube banks of the cooling elements are finless, the looped coil of each cooling element is of adequate length and of sufficient size to provide a relatively extensive heat transfer surface that is sufficient to cool air in the compartments **21** and **22** in a manner which will be described presently.

The cooling elements **21** and **22** are concealed from view by the front imperforate walls **38***a*, **39***a* and spaced end walls **38***b*, **39***b* and **38***c*, **39***c* of three-sided casings **38**, **39**. The three-sided casings **38** and **39**, together with the rear walls of the inner shells **11** and **12**, define vertically extending passages **38***d*, **39***d* in which the cooling elements **21** and **22** are disposed. The front casing walls **38***a*, **39***a* may either be spaced from or heat conductively connected to the tube banks of the cooling elements **21**, **22** which are closely adjacent thereto.

Suitable fans **40**, **41** having air inlets **40***a*, **41***a* and air outlets **40***b*. **41***b* are provided for circulating air in the compartments **17** and **18** by forced draft. The fans **40**, **41** are disposed outside the passageways **38***d*, **39***d* at the rear of the compartments **17**, **18** and are arranged to be driven by electric motors which may be located either in the insulated closure member **26** or at the rear of the cabinet **10**. As seen in FIG. 8, an electric motor **42** connected by a shaft **43** to drive the fan **40** is mounted in any suitable manner within the closure member **26**, and an electric motor **44** connected by a shaft **45** to drive the fan **41** is mounted in any suitable manner to the rear wall of the closure member **26** outside the cabinet **10**. If desired, the motors **42** and **44** may both be located within the closure member **26** or outside the cabinet **10**. As seen in FIG. 8, the electrical motors **42** and **44** are respectively connected to c onductors **60** by conductors **42***a* and **44***a*, the conductors **60** in turn being connected to a suitable source of electrical supply.

It will now be understood that the cooling elements **21**, **22** form the cooling unit of refrigeration apparatus which may be operated by a source of heat like the fluid fuel burner **27**, and that the fans **40**, **41**, which circulate air by forced draft in the compartments **17**, **18**, are driven by the electric motors **42**, **44**. If the source of electrical supply should become unavailable for driving the fan motors **42**, **44**, normal operation of the refrigeration apparatus still can be effected by the fluid fuel burner **27** to maintain the cooling elements **21**, **22** at their desired low temperatures.

In accordance with my invention, the cooling elements **21**, **22** and casings **38**, **39** and fans **40**, **41** are related to one another in such manner that the air will be circulated by forced draft over the cooling elements **21**, **22** by the fans **40**, **41** when the fan motors **42**, **44** are operable to promote cooling of the compartments **17**, **18**; and, if the fan motors **42**, **44** should become inoperable because of the failure of the source of electrical supply, the cooling elements **21**, **22** can be employed to induce natural circulation of the air in thermal relation therewith to promote cooling of the compartments **17**, **18**.

Referring to FIGS. 1 and 7, the air outlets **40***b*, **41***b* of the fans **40**, **41** are connected to the casing end walls **38***b*, **39***b* in communication with openings therein, one of which is shown in FIG. 7 at **38***e*. The end walls **38***b*, **39***b* are imperforate except for the openings to which the fan air outlets **40***b*, **41***b* are connected, such openings being closely adjacent to the top edges of the end walls. The front walls **38***a*, **39***a* are imperforate whereas the end walls **38***c*, **39***c* removed from the fans **40**, **41** are provided with elongated slots **46**. The casing **38** is also provided with a top wall **38***f* having elongated slots **47**. The casing **38** is open at the bottom at **48**, and the casing **39** is open at both the top and bottom at **49** and **50**, respectively.

When the fans **40** and **41** are being operated, air in the compartments **17**, **18** is drawn into the fan inlets **40***a*, **41***a* at regions which are removed from the bottom openings **48**, **50** of the passageways **38***d*, **39***d*. The air is discharged at a higher pressure from the fan outlets **40***b*, **41***b* into the casings **38**, **39** at regions above the bottom openings of the passageways **38***d*, **39***d*. The air introduced at a relatively high velocity into the casings **38**, **39** flows horizontally across the compartments **17**, **18** in thermal relation with the spaced tube banks **21***a* and **21***b*, the inclination of the two tube banks at acute angles in opposite directions from the same given vertical plane functioning to stir and promote efficient cooling of the air. Further, successive turns of the looped cooling element coils **21** and **22** are longitudinally displaced or offset with respect to one another, as indicated at **51**, **52**, **53** and **54** in FIG. 5. With this coil construction, openings are formed between adjacent turns at the ends of the coils, as indicated at **55** and **56** in FIG. 6. The end openings **55** and **56** of the coils provide a multiplicity of paths of flow for circulating air so that air will flow in intimate physical contact with all surface regions of the cooling elements or coils **21** and **22**.

With this construction, the fact that the coils **21** and **22** are finless does not impair their ability to effect efficient cooling of air, because the openings **55** and **56** at the ends of the coils serve as inlet and outlet openings to allow the high velocity air discharged from the fans **40** and **41** to enter and leave the vertical passages within the coils, one of which is shown at **36** in FIG. 6. Cool air is discharged from the casing **38** through the openings **46** in end wall **38***c*, openings **47** in top wall **38***f*, and from the bottom opening **48**, as indicated by the arrows in FIGS. 1, 2 and 7. Cool air is discharged from the casing **39** through openings in the end wall **39***c* and from the top and bottom openings **49** and **50**, respectively, as indicated by the arrows in FIGS. 1 and 2.

If the fan motors **42**, **44** should become inoperable because of failure of the source of electrical supply, the cooling elements **21**, **22** can be employed to induce natural circulation of air in the compartments **17**, **18**. Air cooled by thermal transfer with the cooling elements **21**, **22** flows downward in the compartments **17**, **18** from the bottom openings **48**, **50** to replace warmer air which flows upward and enters the casing **38** through the openings **47** in its top wall **38***f*, and enters the casing **39** through its top opening 49. This natural circulation of air, which is indicated by the arrows in FIGS. 3 and 4, is due to the difference in specific weights of air at different temperatures. It will be observed that under this operating condition the fans 40, 41 are out of the path of flow of the air in the passages 38*d*, 39*d* in the casings 38, 39.

In view of the foregoing, it will now be understood that if the fan motors 42, 44 should become inoperable, the cooling elements 21, 22 nevertheless can be employed to effect cooling of compartments 17, 18 by inducing natural draft circulation of air therein. While natural draft circulation is not as effective as the forced draft circulation of air provided by the fan motors 42, 44, adequate cooling of the compartments is promoted to prevent food spoilage even if the fan motors 42, 44 should remain inoperable for relatively long periods of time.

Modifications of the embodiment of the invention I have illustrated and described will occur to those skilled in the art, so that I desire my invention not to be limited to the particular arrangement set forth. For example, the front walls 38*a*, 39*a* of the casings 38, 39 may be formed with openings if desired. Also, the closure member 26 at the rear insulated wall of the cabinet may be formed with recesses at its inner wall surface in which the cooling elements 21, 22 may be positioned. With such arangement, the cooling elements 21, 22 will occupy less space in the compartment 17, 18. It will be observed in the preferred embodiment that the overall depth of the refrigeration apparatus is not unduly great. This is a distinct advantage in absorption refrigeration apparatus of the kind illustrated and described for the reason that when the cooling unit is relatively near the parts of the refrigeration apparatus outside the cabinet and not laterally offset to a marked degree, crating and shipping problems are simplified. Therefore, I intend in the claims to cover all those modifications which do not depart from the spirit and scope of my invention.

I claim:

1. In a refrigerator including a cabinet having a thermally insulated interior, structure defining a vertically extending passageway having a first opening at a first level and a second opening at a second higher level, both the first and second openings of the passageway being in communication with the interior of the cabinet, heat-operated refrigeration apparatus comprising a cooling element disposed in the passageway, means including a motor-driven fan outside of the passageway having an air inlet in communication with the interior of the cabinet at a region removed from the first opening for withdrawing air from the cabinet interior and an air outlet in communication with the passageway for discharging the air over the cooling element in contact therewith and inducing forced circulation of cooled air in the interior of the cabinet, means for connecting the motor-driven fan to a source of electrical supply, the heat-operated refrigeration apparatus being operable when the motor-driven fan is inoperable due to failure of the source of electrical supply, and the passageway structure and cooling element therein functioning to induce natural circulation of air in the interior of the cabinet responsive to cessation of operation of the motor-driven fan.

2. A refrigerator as set forth in claim 1 in which the air outlet of the fan is in communication with the passageway by a connection whereby all of the air discharged from the fan is introduced into the passageway at a region above the first opening.

3. A refrigerator as set forth in claim 1 in which the outlet of the fan is constructed and arranged to discharge air therefrom in an essentially horizontally extending direction across the passageway at a level above the first opening thereof.

4. A refrigerator as set forth in claim 1 which includes thermally insulated walls defining a compartment forming the thermally insulated interior, the thermally insulated walls including a rear wall and lateral side walls, the cooling element extending horizontally between the lateral side walls adjacent to the rear wall, the outlet of the fan being constructed and arranged to discharge air therefrom in an essentially horizontal direction across the passageway in contact with the cooling element, and the structure defining the passageway being apertured at the region toward which air is horizontally discharged across the passageway whereby circulation of air is induced by forced draft in the cabinet interior with air flowing through the apertured region and both the first and second openings of the passageway.

5. A refrigerator as set forth in claim 4 in which the cooling element comprises a plurality of banks of tubes spaced from one another, said tubes extending horizontally across the passageway, the tubes of adjacent banks being inclined downward in opposite directions from the horizontal whereby air flowing over the tubes is divided into a multiplicity of paths of flow in intimate contact with the tubes.

6. A refrigerator as set forth in claim 4 in which the cooling element comprises a looped coil having essentially straight portions and connecting bends defining a vertically extending passage, the straight portions extending across the passageway, and successive turns of the coil being staggered or offset with respect to one another lengthwise of the straight portions to form openings between adjacent turns at the connecting bends to promote movement of air into and from the passage within the looped coil during its flow across the passageway from the fan outlet.

7. A refrigerator as set forth in claim 1 which includes thermally insulated walls having an inner liner defining a compartment forming the thermally insulated interior, the cooling element comprising a looped coil disposed adjacent to the liner, the passageway being formed by a casing mounted on the liner about the cooling element, the casing having a front wall and end walls, the fan outlet being connected to one end wall at an opening therein, the opposite end wall of the casing being apertured, and the casing having openings at the top and bottom serving as the first and second openings of the passageway.

8. In a refrigerator including a cabinet having a thermally insulated interior, structure defining a vertically extending passageway having a first opening at a first level and a second opening at a second higher level, both the first and second openings of the passageway being in communication with the interior of the cabinet, heat-operated absorption refrigeration apparatus comprising a plurality of parts including a heat receiving part and a cooling element in which refrigerant fluid evaporates in the presence of an inert gas, means including a fluid fuel burner for heating the heat receiving part, the cooling element being disposed in the passageway, means including a fan outside the passageway having an air inlet in communication with the interior of the cabinet at a region removed from the first opening for withdrawing air from the cabinet interior and an air outlet in communication with the passageway for discharging the air over the cooling element in contact therewith and inducing forced circulation of cooled air in the interior of the cabinet, an electric motor for driving the fan, means for connecting the fan motor to a source of electrical supply, the heat operated absorption refrigeration apparatus being operable when the fan motor is inoperable due to failure of the source of electrical supply, and the passageway structure and cooling element therein functioning to induce natural circulation of air in the interior of the cabinet responsive to cessation of operation of the electric motor.

9. A refrigerator as set forth in claim 8 in which the parts of the refrigeration apparatus are essentially immovable with respect to one another and one of the thermally insulated walls is formed with an opening through which the cooling element is insertable into and removable from the compartment, a thermally insulated closure member for closing the opening, the closure mem-

ber forming a unitary part of the refrigeration apparatus, the passageway structure including a casing mounted on the inner surface of the closure member about the cooling element, and the top and bottom of the casing having openings serving as the first and second openings of the passageway.

10. In a refrigerator including a cabinet having a plurality of thermally insulated compartments one above the other, structure in each compartment defining a vertically extending passageway having a first opening at a first level and a second opening at a second higher level, both the first and second openings of each passageway being in communication with the compartment in which it is located, heat-operated absorption refrigeration apparatus comprising a heat receiving part and first and second cooling elements in which refrigerant fluid evaporates in the presence of an inert gas, means including a fluid fuel burner for heating the heat receiving part, each cooling element being disposed in a different one of the passageways, means including fans outside the passageways each having an air inlet in communication with a different one of the compartments for withdrawing air therefrom and an air outlet in communication with a different one of the passageways for discharging air over the cooling element therein and independently inducing forced circulation of cooled air in the compartments, the air inlet of the fan in each compartment being at a region removed from the first opening of the passageway therein, an electric motor for driving each fan, means for connecting the fan motors to a source of electrical supply, the heat-operated absorption refrigeration apparatus being operable when the fan motors are inoperable due to failure of the source of electrical supply, and the passageway structure and cooling element in each compartment functioning to induce natural circulation of air therein responsive to cessation of operation of the electric motors.

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