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HOUSEHOLD REFRIGERATOR INCLUDING IMPROVED DEFROSTABLE EVAPORATOR CONSTRUCTION

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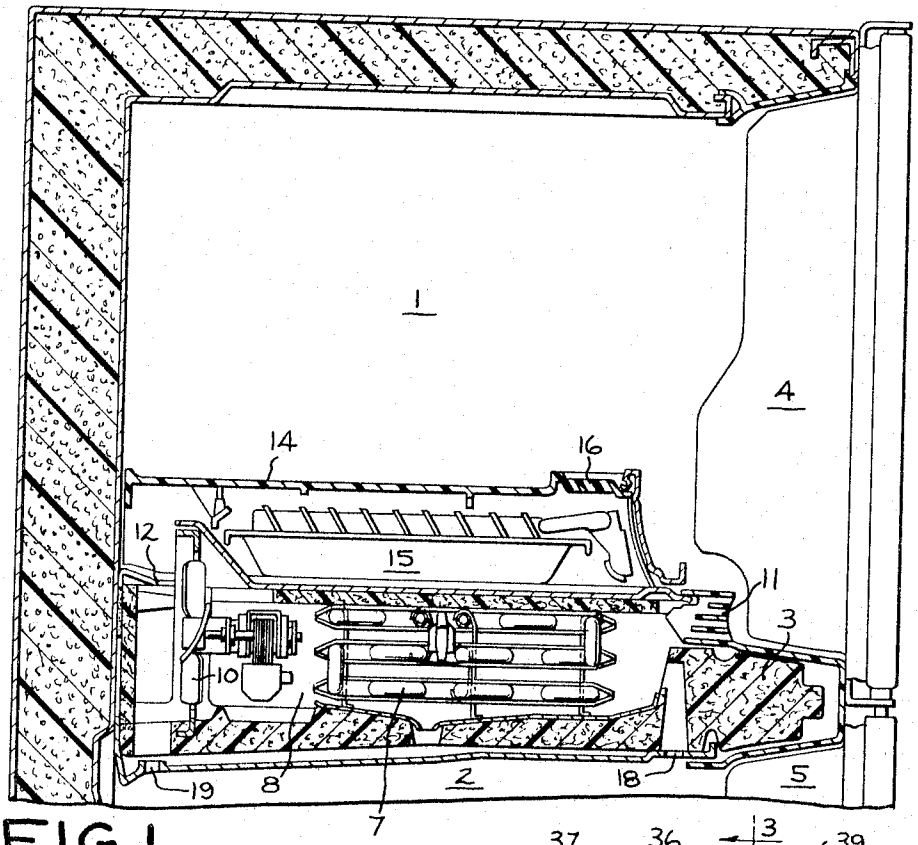


FIG. 1

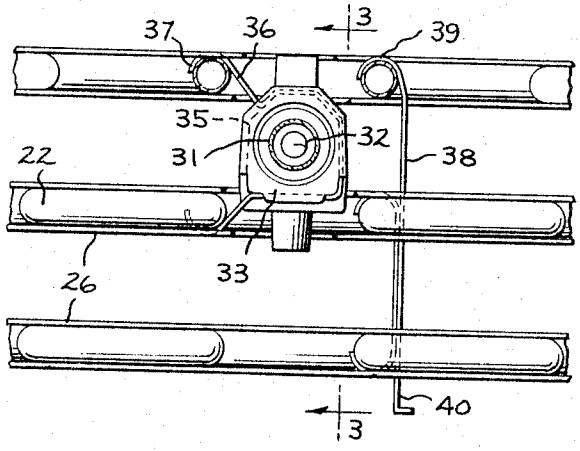


FIG. 2

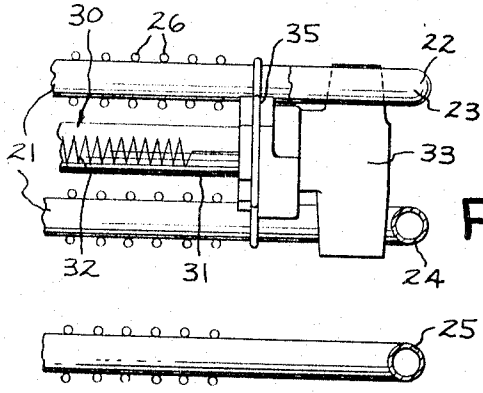


FIG. 3

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HOUSEHOLD REFRIGERATOR INCLUDING IMPROVED DEFROSTABLE EVAPORATOR CONSTRUCTION

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2 Claims. (Cl. 62—276)

The present invention relates to household refrigerators and is more particularly concerned with a refrigerator including an improved defrostable evaporator structure combining a high heat transfer rate and fast, low cost defrosting.

Many modern refrigerators include, in addition to at least one storage compartment, an evaporator housed in a chamber separate from that compartment over which air is circulated for maintaining the contents of the compartment at desired storage temperatures. One reason for locating the evaporator outside the storage compartment is to permit periodic heating of the evaporator to defrosting temperatures without effecting the temperature of the storage compartment.

A commonly used evaporator is the well-known fin-in-tube type including a plurality of parallel refrigerant conduits and a fin structure comprising a plurality of plate-like fins extending transversely of the conduits. The circulated air normally flows between the fins, or in other words in a direction parallel to the fins. As the evaporators normally operate at below freezing temperatures or in other words at temperatures such that moisture contained in the circulated aim stream tends to collect on the evaporator surfaces in the form of frost, it is necessary to remove this frost layer periodically by warming the entire evaporator structure to above freezing temperatures. An electric resistance heater is frequently employed for this purpose and the heater is generally mounted in direct heat conducting relationship with the evaporators as by embedding them directly in the fin core structure thereof. Due to the length of the resistance heater required for quickly warming all of the evaporator surfaces to defrost temperatures, such resistance heaters are expensive.

In order to decrease the cost of the heating means, radiant heaters have been substituted for the resistance heaters. However, while radiant heaters provide an ideal source of heat, their application to plate fin-on-tube evaporators presents some problems. A major problem involves the placement of the radiant heater relative to the evaporator surfaces. If the heater is positioned transversely of the fins, the major fin surfaces, that is the opposed faces of the fins, are not directly exposed to the radiant heat from the heater while if the heater is positioned in a direction generally parallel to the fins, the fins closest to the heater shield all or part of the remaining fins from direct heat radiation.

A primary object of the present invention is to provide an improved defrostable evaporator structure having a high cooling capacity and so designed that rapid and effective removal of frost from all of the evaporator surfaces can be quickly obtained.

A further object of the invention is to provide an evaporator structure which not only can be quickly defrosted by radiant heating means but also provides generous paths for air flow through the evaporator structure so that defrosting thereof is required less frequently than with the usual fin-on-tube evaporator.

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

In accordance with what is presently considered to be a preferred embodiment of the present invention, there is provided a refrigerator including a storage compartment and an evaporator chamber separate from the compartment through which air from the compartment is circulated in heat exchange relationship with an evaporator contained within that chamber. The evaporator comprises a plurality of spaced and generally parallel sections each of which includes a plurality of spaced transversely extending refrigerant conduits and a plurality of spaced longitudinally extending wires connected in heat transfer relationship to the conduits. For the purpose of periodically warming all of the evaporator surfaces to defrosting temperatures, a radiant heater comprising a tube of insulating heat transmitting material such as a quartz tube and a radiant heater coil within the tube is mounted between, and spaced from, adjacent sections of the evaporator in a position such that the radiant heat from the tube reaches substantially all of the evaporator surfaces.

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

FIGURE 1 is a vertical sectional view of a portion of a household refrigerator embodying the present invention;

FIGURE 2 is an enlarged side view, partially in section, of the evaporator structure shown in FIGURE 1; and

FIGURE 3 is a sectional view taken generally along line 3—3 of FIGURE 2.

With reference to the drawing, there is illustrated a household refrigerator comprising insulated walls defining a freezer compartment **1** intended to operate at a temperature below freezing and a fresh food compartment **2** adapted to operate at an above freezing temperature of about 35 to 40° F. The two compartments are separated by a horizontal insulating partition **3**. The access opening to the freezer compartment **1** is closed by means of a door **4** while the access opening to the fresh food campartment **2** is closed by means of a door **5**. A single evaporator **7** for refrigerating the two compartments is contained within a separate evaporator chamber **8** formed within the insulated partition **3**. It is understood that the refrigerator also includes a refrigerant condensing unit for supplying condensed refrigerant to the evaporator and for withdrawing vaporized refrigerant therefrom.

For the purpose of maintaining the two storage compartments **1** and **2** at their desired operating temperatures, air withdrawn from these two compartments is passed over the evaporator **7** and refrigerated or cooled air from the evaporator is returned to the compartments by means of a single fan generally indicated by the numeral **10**. More specifically, air is withdrawn from the freezer compartment **1** through a passage **11** connecting the freezer compartment with one end of the chamber **8** and a major portion of the air cooled or refrigerated by the evaporator **7** is returned to the freezer compartment through an air passage **12** adjacent the outlet from the fan **10**. The air leaving the passage **12** flows through a tunnel **14** containing one or more freezing trays **15** and is then introduced into the freezer compartment through passages such as a louvered passage **16**. Air from the fresh food compartment **2** is drawn into the evaporator chamber **8** through a plurality of passages **18** adjacent the front of the partition **3**. This fresh food compartment air becomes mixed with air flowing from the freezer compartment **1** and the air mixture passes over the evaporator **7**. A relatively small amount of the cooled or refrigerated air flowing from the rear or outlet end of the chamber **8** is circulated by the fan **10** downwardly through an outlet passage **19** into the fresh food compartment **2**. Since the evaporator must operate at be-

low freezing temperatures in order to maintain the freezer compartment at or below freezing temperatures, moisture contained in either of the air streams flowing through the chamber **8** will condense in the form of a layer of frost on the surfaces of the evaporator **7**

In accordance with the present invention, there is provided an evaporator structure having a relatively high frost tolerance, that is a structure capable of collecting a substantial amount of frost without interfering significantly with the air flow therethrough and radiant heating means for rapidly removing the frost layer from the evaporator surfaces during defrost periods. This evaporator structure, as is illustrated more clearly in FIGURES 2 and 3 of the drawing, may be made, for example, by forming a continuous tube into serpentine form to provide a structure including a plurality of spaced transverse refrigerant conduits **21** series-connected by U-shaped end turns **22** disposed in a plurality of parallel planes. Thus the evaporator comprises a plurality of superimposed sections of tiers **23**, **24** and **25** which are also spaced from one another.

In order to provide additional or secondary heat transfer surface for the transfer of heat from the air passing over the evaporator structure to the refrigerant flowing through the conduits **21**, the conduits of each section have welded or brazed thereto a plurality of spaced parallel wires **26** extending perpendicular to the passes **21** or in other words longitudinally of the evaporator structure. Preferably the wires **26** are secured to opposite surfaces of the conduits in each of the sections **23**, **24** and **25**.

For the purpose of periodically warming the evaporator surfaces to defrosting temperatures, there is provided a heating means in the form of a low cost radiant heater generally indicated by the numeral **30** extending transversely of the evaporator and preferably centrally positioned within the evaporator structure. This heater comprises a tubular member **31** of quartz or similar glass-like insulating material having good thermal shock resistance and radiant heat transmitting properties and a helical radiant heater coil **32** positioned within the tubular member **31**. A preferred material for the tubular member is that material known as Vycor. Sealing caps **33** provided on each end of the tubular member **31** provide means for housing the electrical connecting means (not shown) for connecting the coil **32** to a source of power and for enclosing the ends of the tubular member to prevent defrost water from entering the tubular member.

The end caps **33** are composed of an insulating material such as a molded phenolic resin and may also be employed for the purpose of mounting the radiant heater on the evaporator. To this end, each of the end caps **33** may be provided with a circumferential groove **35** adapted to receive the base or center portion of a U-shaped spring wire clamp **36**. The ends **37** of this clamp are of arcuate construction whereby the clamp can be resiliently mounted on the adjacent passes **21** of adjacent sections or tiers as for example on sections **23** and **24** of the evaporator.

As is illustrated more clearly in FIGURE 2 of the drawing, the radiant heater **30** is so designed that the tube **31** extends substantially the full width of the evaporator and is spaced from all adjacent surfaces of the evaporator **7**. By using a heater of this length and positioning the heater intermediate the ends of the evaporator structure, substantially all of the surfaces of the evaporator are subjected to the direct radiant heat from some portion of the heater whereby, during energization of the heater, all of the evaporator portions are quickly warmed to defrosting temperatures.

If desired, support means may also be provided for maintaining the various evaporator tiers or sections in spaced relationship. Such a support may be in the form of a wire member **38** including curved or arcuate portions **39** brazed or welded to a refrigerant conduit or pass **21** in each of the three sections and a leg portion **40** for supporting the evaporator in spaced relationship with the bottom of chamber **8**.

For optimum performance, the dimensions of the conduits **31** and the wires **26** are selected to provide maximum heat transfer between the refrigerant flowing through the conduits and the air passing over the evaporator. As in any evaporator construction, the wire fins provide a secondary heat transfer surface or an extension of the primary heat transfer surfaces of the conduits **31**. Comparative tests of evaporators including wire secondary heat transfer surfaces in accordance with the present invention with the usual plate-type fin-on-tube evaporators has shown that the same or better heat transfer rates can be obtained with the wire evaporators having substantially lower primary to secondary surface ratios. More specificially, it has been found that wire-on-tube evaporators having a primary to secondary surface ratio between 1 to 2 and 1 to 4 have heat transfer characteristics which are substantially equal to plate fin-on-tube evaporators having primary to secondary surface ratios of about 1 to 10.

An example of a suitable evaporator is one made of 0.25 inch tubing bent into the form of a serpentine and folded as hereinbefore described with the adjacent conduits spaced 1¼ inches. Each of three sections of this evaporator were provided with secondary surfaces in the form of wires 0.062 inch in diameter on ¼ inch centers. Another evaporator was similarly formed from the same tubing with 2 inch conduit spacings and the same wire size and spacing. In both evaporators, the wires were applied to both surfaces of each section. The total surfaces of the two evaporators were about equal. The ratio of primary or tube surface to secondary or wire surface in the first evaporator was approximately 1 to 2.1 while in the second evaporator the ratio was 1 to 3.2. Performance tests on the two evaporators indicated that the two were about equal and comparable to a plate fin-on-tube evaporator having a 1 to 10.8 primary to secondary surface ratio. In addition, the wire evaporators, primarily because of their lower total mass and construction, defrosted at a much faster rate than the plate fin evaporator. Because frost can be quickly removed from a wire evaporator, its defrost cycle can be timed rather than terminated by thermal means as is generally necessary with the more bulky plate fin construction.

By maintaining the primary to secondary surface ratios within the above limits, the spacing between the adjacent wires is sufficient both to permit a substantial amount of frost to collect on the secondary surfaces without blocking air flow through the evaporator and is also sufficient to expose substantially all of portions of the evaporator to the direct effect of the radiant heat from the defrost heater. Approximately one-half of the surfaces of each of the wires and each of the conduits are directly exposed to radiant heat from some portion of the radiant heater and this is assured by providing a heater in which the tubular component **31** and the heating coil **32** extends substantially the full width of the evaporator structure.

The evaporator component may be composed of any suitable heat conducting material. Where maximum corrosion resistance is required, both the tubular and wire portions thereof may be composed of aluminum. However, for ease of manufacture it may be desirable to employ either copper or preferably steel as these two metals are more easily joined as by brazing or the like. However, when copper or steel is employed, it may be necessary to provide a suitable inorganic or organic protective coating to prevent rusting.

While there has been shown and described a particular embodiment of the present invention, it will be understood that it is not limited thereto and it is intended by the appended claims to cover all such channges and modifications as fall within the true spirit and scope of the invention.

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

1. A refrigerator comprising a storage compartment and an evaporator chamber separate from said compartment and containing an evaporator normally operating at frost collecting temperatures,

means for circulating air from said compartment through said evaporator chamber in heat exchange relationship with said evaporator,

said evaporator comprising a plurality of spaced sections,

each of said sections including a plurality of spaced transverse tubular refrigerant conduits and a plurality of spaced longitudinally extending wires connected to said conduits, and in which the ratio of conduit surface to wire surface is from 1:2 to 1:4,

a radiant heater for periodically warming said evaporator to defrost temperatures comprising a tube of insulating heat transmitting material, and a radiant heater coil in said tube extending substantially the full length thereof,

and means for mounting said heater between and spaced from adjacent sections of said evaporator with said tube extending transversely thereof,

the length of said tube being substantially equal to the width of said evaporator whereby substantially all portions of said conduits and wires are directly exposed to radiant heat from said heater.

2. A refrigerator comprising a storage compartment and an evaporator chamber separate from said compartment and containing an evaporator normally operating at frost collecting temperatures,

means for circulating air from said compartment through said evaporator chamber in heat exchange relationship with said evaporator,

said evaporator comprising a plurality of spaced sections,

each of said sections including a plurality of spaced transverse tubular refrigerant conduits and a plurality of spaced longitudinally extending wires connected to said conduits in which the ratio of conduit surface to wire surface is from 1:2 to 1:4,

a radiant heater for periodically warming said evaporator to defrost temperatures comprising a tube of insulating heat transmitting material, insulating end caps mounted on each end of the said tube and a radiant heater coil in said tube extending substantially the full length thereof,

and means for mounting said heater between and spaced from adjacent sections of said evaporator with said tube extending transversely thereof comprising a pair of generally U-shaped resilient wire clips each including a center portion engaging one of said caps and curved end portions for respectively engaging a conduit in each of said adjacent sections,

the length of said tube being substantially equal to the width of said evaporator whereby substantially all portions of said evaporator are directly exposed to radiant heat from said heater.

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MEYER PERLIN, *Primary Examiner.*