United States Patent [19]

Gelbard et al.

[11] **3,766,976**

[45] **Oct. 23, 1973**

[54] **INTEGRAL FIN EVAPORATOR**

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[52] **U.S. Cl.** **165/122,** 165/183, 62/419

[51] **Int. Cl.** **F24h 3/06**

[58] **Field of Search** 165/183, 184, 144, 165/148, 122; 62/419

[56] **References Cited**

UNITED STATES PATENTS

2,962,870	12/1960	Von Arb et al.	62/419
3,343,596	9/1967	Kritzer	165/183
3,368,615	2/1968	Brown et al.	165/184

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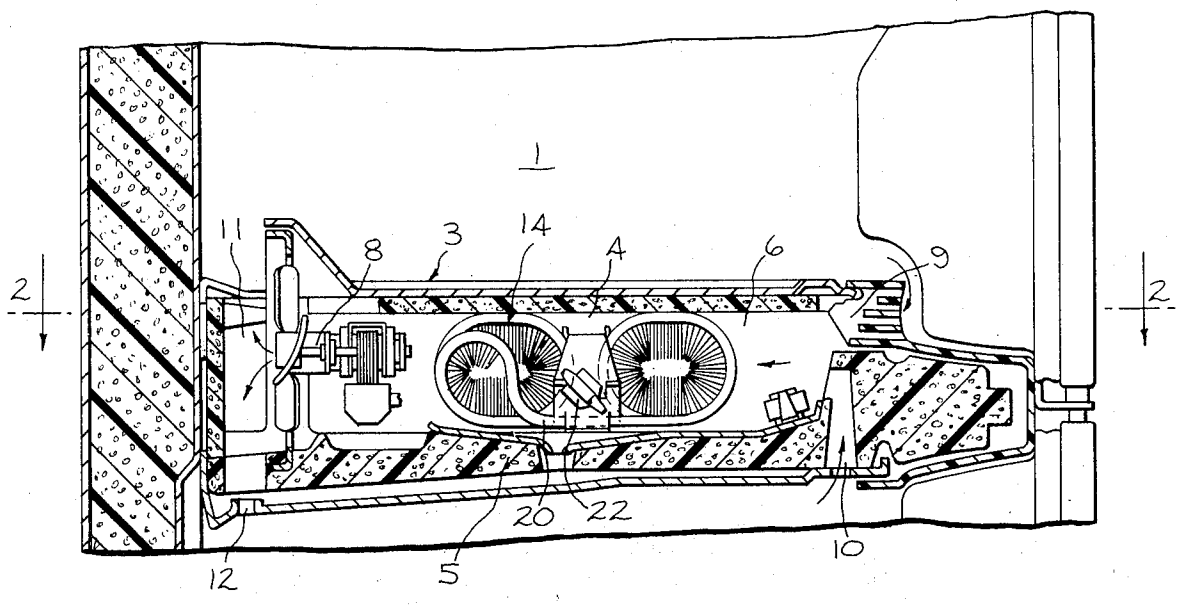
[57] **ABSTRACT**

A compact evaporator unit for refrigerators comprising a tubular member having an extended heat exchange surface in the form of a longitudinally extending flange slit to form a plurality of pin fins, the tubular member being helically coiled with all of the fins extending inwardly from the coils to provide a unit having a fin-free exterior surface.

11 Claims, 5 Drawing Figures



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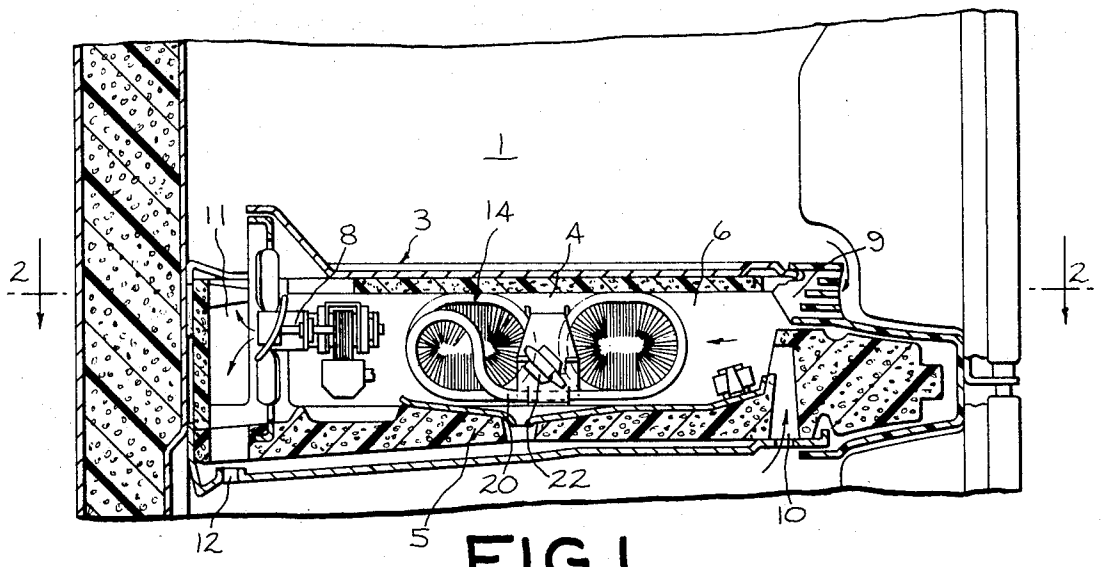

FIG. 1

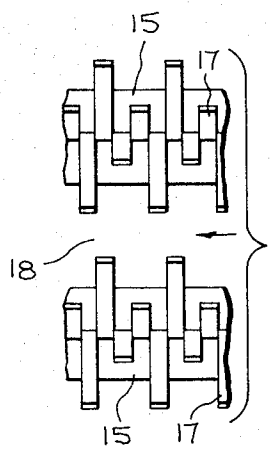

FIG. 4

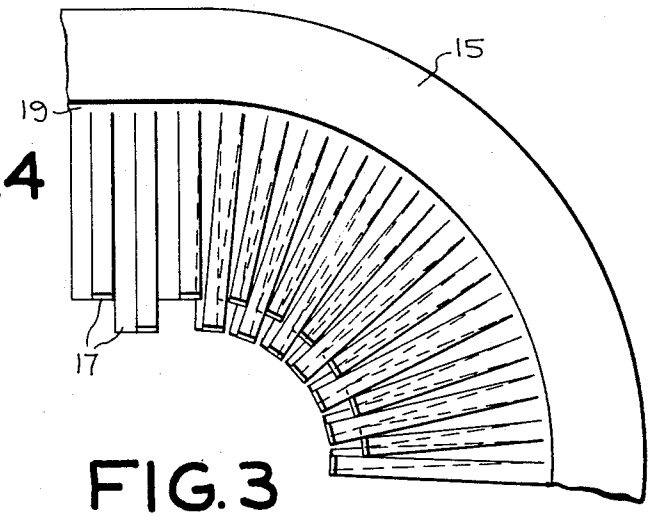

FIG. 3

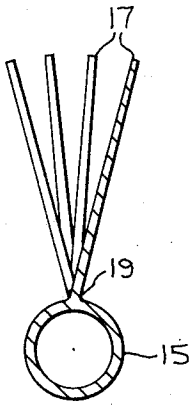

FIG. 5

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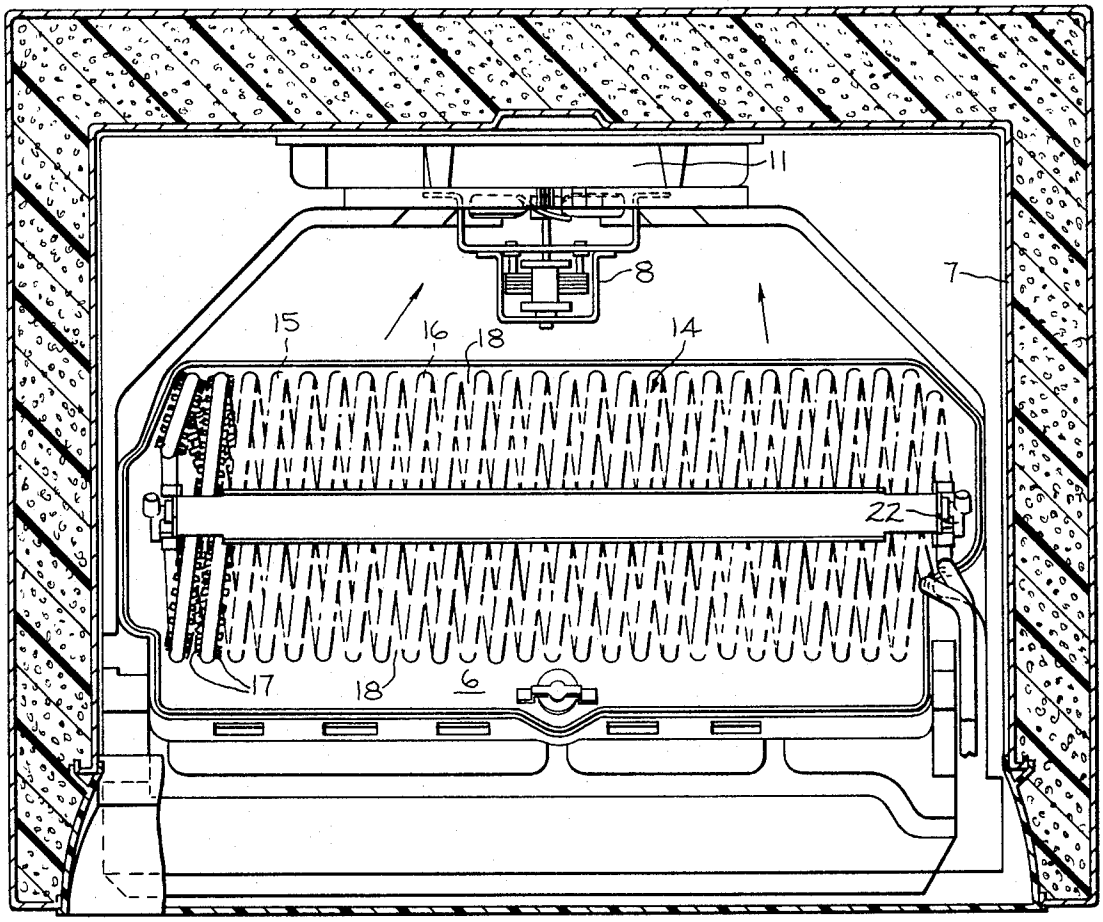

FIG. 2

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INTEGRAL FIN EVAPORATOR

BACKGROUND OF THE INVENTION

Evaporators for refrigerators, including freezers, comprise a tubular member for the circulation of refrigerant and an extended heat transfer heat exchange surface for providing the desired heat exchange between the refrigerant and the air circulated over the evaporator.

In many modern refrigerators in which the evaporator is housed in a chamber separate from the refrigerator storage area, the evaporators comprise continuous lengths of refrigerant tubing having one or more longitudinal flanges extending outwardly from the tubing wall, these flanges being slit to provide a plurality of individual fins which may be alternately bent laterally from the original plane of the flange or twisted to induce a better heat exchange contact between the heat exchange surfaces and the surrounding air. However, in the manufacture of evaporators from such finned tubing, the tubing has been coiled or bent to form an evaporator structure in which the fins form an exterior surface of the final structure. Examples of such evaporator structures will be found in U.S. Pat. Nos. 2,963,779 — Mosgard-Jensen; 3,294,162—Loehlein et al. and 3,368,615—Brown et al.

While such evaporator units in which the fins are substantially exposed to initial contact with the air stream being cooled in order to provide excellent heat exchange, the frost tolerance may be low due to the lack of space in an evaporator chamber to properly arrange the tube and fin surfaces as compared with the older well known plate-on-tube evaporators in which the air passages through the evaporator are defined by the spaces between the plate-like fins. Specifically, the leading or upstream fins on such evaporators are rather quickly bridged by condensed and frozen moisture from the air being cooled with the resultant marked decrease in the heat transfer rate and in many cases a serious interference with the air flow through the evaporator.

An additional disadvantage of such finned evaporators formed to have the fins extended outwardly from the refrigerant tubing is that if the tubing is bent sharp enough to provide the desired amount of tubing within a given volume, the fins on the outer surfaces of the bends increase the stiffness of that portion of the tubing and may tear during the bending operation.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an evaporator structure of the pin-finned type characterized by a high heat transfer efficiency per cubic inch of the evaporator displacement, plus a substantially improved frost tolerance.

Another object of the present invention is to provide an evaporator unit comprising an integal pin fin heat exchange surface characterized by the fact that the entire exterior surface of the unit is free of fins.

A further object of the invention is to provide an evaporator unit in the form of a coiled tubular evaporator unit in which the pin fin heat exchange surfaces are so positioned that substantial accumulation of frost thereon will not interfere with the air flow through the evaporator structure.

In accordance with the illustrated embodiment of the present invention, there is provided a refrigerant evaporator unit comprising a helically coiled tubular member in which the coils thereof are spaced from one another. The tubular member includes a longitudinally extending flange integral therewith which is divided into a plurality of pin fins, the member being coiled so that all of the fins extend radially inwardly from the coils whereby the tubular member defines a fin-free exterior surface of the evaporator. Preferably, the individual fins are laterally offset from one another but are spaced from the fins on adjacent coils. The air to be cooled is circulated through the evaporator unit in a direction perpendicular to the axes of the coils so that even a substantial accumulation of frost on the fins will not significantly decrease the air flow.

BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawing:

FIG. 1 is a vertical side elevational view through a portion of a refrigerator embodying the present invention;

FIG. 2 is a horizontal sectional view taken generally along line 2—2 of FIG. 1;

FIG. 3 is an enlarged view of a portion of the evaporator tubing and fin structure of the present invention;

FIG. 4 is a segmental view of adjacent coils of the evaporator of the present invention; and

FIG. 5 is a sectional view of the finned tubular member employed in the practice of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

While the present invention is applicable to any refrigerator including one or more storage compartments and an evaporator for cooling the compartment disposed in an evaporator chamber remote from the compartments, it will be particularly described with reference to a refrigerator such as that described in U.S. Pat. No. 3,320,761—Gelbard to which reference is made for detailed description of refrigerator components other than the evaporator component forming the subject matter of the present invention.

With reference to FIG. 1, the llustrated refrigerator comprises an upper below-freezing or freezer compartment 1 and a lower above-freezing or fresh food storage compartment 2 separated by an insulated partition generally indicated by the numeral 3. The partition 3 includes upper and lower walls 4 and 5 and opposed side walls 7 (FIG. 2) defining an evaporator chamber 6.

For the purpose of maintaining these two storage compartments at the desired operating temperatures by means of an evaporator contained within the evaporator chamber, a fan 8 is provided for withdrawing air from the two storage compartments through passages 9 and 10, in the partition at the forward or inlet end of the evaporator chamber and returning cooled air to the compartments through passages 11 and 12 at the rear or outlet end of the evaporator chamber 6.

In place of the plate-on-tube evaporator disclosed in the aforementioned Gelbard patent, there is provided in accordance with the present invention an improved evaporator structure having a heat transfer rate per cubic inch of evaporator displacement or volume approximately equal to the best refrigerator plate fin evaporators, a better frost tolerance than such evaporators and a lower manufacturing cost. In addition, the structure of the evaporator of the present invention can

be manufactured in various sizes without major change in manufacturing procedures.

The evaporator of the present invention generally indicated by the numeral **14** in FIGS. **1** and **2** of the drawing is positioned transversely of the evaporator chamber **6.** It comprises a tubular member **15** forming the refrigerant conduit coiled to have a substantially helical form with adjacent coils **16** spaced from one another to form an open helix. The extended heat transfer surface for transferring heat from a stream of air passed over the evaporator to the refrigerant flowing through the tubular member **15** comprises a plurality of pin fins **17** extending generally radially inwardly from the coils so that all of the fin structure is within the area or volume encompassed by the coils **16.**

The pin fins **17** are preferably spaced apart as by angularly bending the fins in opposite lateral directions as illustrated in FIGS. **4, 5** and **6** of the drawing to provide offset pins in the path of air flowing through the evaporator. For example, two adjacent fins are spread to form an angle of about 10° with one another, while the next two adjacent fins are spread to a larger angle of, for example, 30°. However, as shown in FIG. **4** of the drawing the fins are not bent or laterally offset a distance such that they contact the fins on adjacent loops or coils but rather leave a space indicated by the numeral **18** between the adjacent coils or loops and their integral fin structures.

The heat exchanger is preferably made from an extruded aluminum tube stock having a single longitudinally extending flange which is then slit transversely using any suitable slitting means such as that shown in the aforementioned Mosgard-Jensen patent to leave a relatively narrow portion **19** of the original flange adjacent the tube surface as illustrated in FIG. **3** of the drawing. The pin fins formed by the slitting operation are then offset after which the tubular member is formed into a helix with the fins extending radially inwardly. The finished helical coil may then be partially flattened to an elliptical form as illustrated in FIG. **1** of the drawing. In either the truly circular or the elliptical form the fins on opposite sides of the coil terminate short of the center line or axis of the helix.

In the illustrated embodiment of the invention, the evaporator **14** actually comprises two helically coiled portions extending parallel to one another and transversely of the chamber **6,** one coiled section **20** of which is partially straightened and deformed to provide the connection between the two sections at one side of the evaporator.

With reference to FIG. **2** of the drawing, it will be seen that air drawn into the front or inlet end of the evaporator chamber **6** by operation of the fan **8** flows laterally or transversely between the evaporator coils, i.e., through the passages **18.** Since the pin fins are all contained within the helix, the air initially contacts the tubular member **15** where any moisture begins to collect in the form of frost. The air passing through the passages **18** then comes in heat exchange contact with the internal fin structure extending part way into each of these passages from the adjacent coils and then more or less directly impinges on the fins extending radially inwardly or forwardly from a rear portion of the coil. By this pattern frost is distributed on all of these surfaces. Even if there is a substantial accumulation of frost which tends to bridge adjacent fins, this bridging action takes place entirely within the fin area on each loop. If the frost accumulation should completely bridge the spaces between the fins, substantial additional frosting is required before the spaces **18** between adjacent loops are bridged transversely of the air flow.

A particular advantage of the evaporator of the present invention as compared with prior art evaporators is that in its finished form all of the fin structure is within the volume occupied by the tubular member or in other words the entire outer surface of the evaporator is defined by the smooth surfaces of the tubular member. Thus the evaporator can be readily handled during assembly thereof into the refrigerator.

Also, since the pin fins are disposed along the inside of the round or oval or elliptical coils, the tubing portion of the evaporator does not have to be bent around as tight a radii as for example in the aforementioned Mosgard-Jensen structure in order that the evaporator be contained within a reasonable volume. In this connection, it will be noted that the evaporator preferably completely fills the chamber **6** insofar as its lateral dimensions are concerned. In other words, the portions of the coil surfaces adjacent the walls **4** and **5** are substantially in contact therewith, thus providing for the placement of a maximum length of the tubular member within the volume of the evaporator chamber and at the same time providing adequate extended surface area.

In addition, the subject evaporator construction is not limited to a single heat exchanger size. Without major expenditure, the evaporator width, depth and thickness can be varied through a large range by changing the number of coils, size of the coils, the number of rows of coils and the amount of coil flattening.

The heat transfer per cubic inch of evaporator envelope or displacement has been found to be substantially equal to the best refrigerator plate fin evaporators presently employed in the forced air circulation refrigerators of the type illustrated. In addition, for equal heat transfer, the coiled evaporator design of the present invention, for most applications, has an advantage in material cost over the known coiled integral fin evaporators in which the fins extend outwardly from the evaporator structure as well as over the known plate fin evaporator consturctions.

Preferably, the evaporator is periodically defrosted by use of a radiant heater such as that described in Turner U.S. Pat. No. 3,280,581. Such a heater, indicated generally by the numeral **22** in FIGS. **1** and **2** of the drawing, is positioned to one side of a coil section or when more than one section is employed is positioned between and parallel to the adjacent sections as illustrated in the drawing. Due to the open coil structure, heat from a radiant heater so placed will rapidly warm all portions of the evaporator to defrosting temperatures.

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 modifications as fall within the true spirit and scope of the invention.

We claim:

1. A refrigerator evaporator unit comprising a helically coiled tubular member comprising a plurality of spaced coils, said member having a longitudinally extending flange integral therewith divided into a plurality of pin fins, all of the fins on said member extending radially inwardly from said coils whereby said tubular

member defines a fin-free exterior surface of said evaporator, and

means for circulating a stream of air through said coils in a direction substantially perpendicular to the axes of said coils.

2. A refrigerant evaporator unit according to claim **1** in which adjacent fins are laterally offset from one another, but are spaced from fins on adjacent coils.

3. A refrigerant evaporator unit comprising an evaporator including a tubular member coiled to form a plurality of subsantially co-axial spaced coils, said tubular member having a plurality of spaced pin fins integral with said member and arranged substantially longitudinally thereof, all of the fins on said member extending substantially radially inward from said member and terminating short of the axes of said coils; and

means for passing an air stream through said evaporator in a direction substantially perpendicular to the axes of said coils.

4. A refrigerant evaporator according to claim **3** in which adjacent pin fins are laterally offset from one another without overlapping the fins on adjacent coils.

5. A refrigerant evaporator according to claim **3** in which said coils are of substantially elliptical shape.

6. A refrigerant evaporator unit comprising:

an evaporator including a tubular member bent to form at least two interconnected helically coiled portions, the longitudinal axes of which are substantially parallel and the individual coils of which are spaced from one another;

said tubular member including a plurality of longitudinally aligned pin fins, all of the fins on said member extending radially inwardly of said individual coils whereby the tubular member defines a fin-free exterior surface of said evaporator unit, and

means for circulating a stream of air to be cooled through said coil portions in a direction substantially perpendicular to the axes thereof.

7. A refrigerator evaporator unit according to claim **6** in which said coils are substantially elliptical and the air stream flows parallel to the longer axis of said elliptical coils.

8. A refrigerator including an evaporator chamber and means for circulating a stream of air to be cooled through said chamber;

an evaporator in said chamber comprising a tubular member coiled to form a plurality of substantially co-axial coils, said tubular member having a plurality of spaced pin fins integral with said member and arranged longitudinally thereof, all of the fins on said member being within the confines of said coils and terminating short of the axes thereof;

said evaporator being positioned in said chamber with the axes of said coils substantially perpendicular to the path of said air stream.

9. A refrigerator including an evaporator chamber having an air inlet adjacent one end thereof and an air outlet adjacent the other end and an evaporator in said chamber;

said evaporator comprising a tubular member bent to form at least two interconnected spaced helically coiled portions, the longitudinal axes of which are sub-stantially parallel;

the coils of said portions being spaced from one another;

said tubular member including a plurality of longitudinally aligned pin fins, all of the fins on said member extending substantially radially inwardly of said coils whereby the tubular member defines a fin-free exterior surface of said heat exchanger;

said evaporator being positioned in said chamber with the axes of said coiled portions extending transversely of said chamber and the tubular member closely adjacent the adjacent walls of said chamber.

10. A refrigerator according to claim **9** in which at least some of said pin fins are laterally displaced from adjacent pin fins.

11. A refrigerator according to claim **10** in which the laterally displace fins are also spaced from the fins on adjacent coils.

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