# United States Patent [19]

**Lim et al.**

[11] **3,902,551**

[45] **Sept. 2, 1975**


[54] **HEAT EXCHANGE ASSEMBLY AND FIN MEMBER THEREFOR**


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[73] Assignee: **Carrier Corporation**, Syracuse, N.Y.



[22] Filed: **Mar. 1, 1974**

[21] Appl. No.: **447,196**

[52] **U.S. Cl.** .................... **165/111**; 62/288; 62/290; 165/151

[51] **Int. Cl.²** .................... **F28B 9/10**

[58] **Field of Search** ...... 165/111; 62/272, 285, 288, 62/289, 290, 291



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,251,649 | 8/1941 | Wichmann | 62/290 |
| 2,667,041 | 1/1954 | Henderson | 62/290 |
| 2,670,611 | 3/1954 | Fagerberg | 62/290 |
| 3,148,511 | 9/1964 | Gable | 62/272 |



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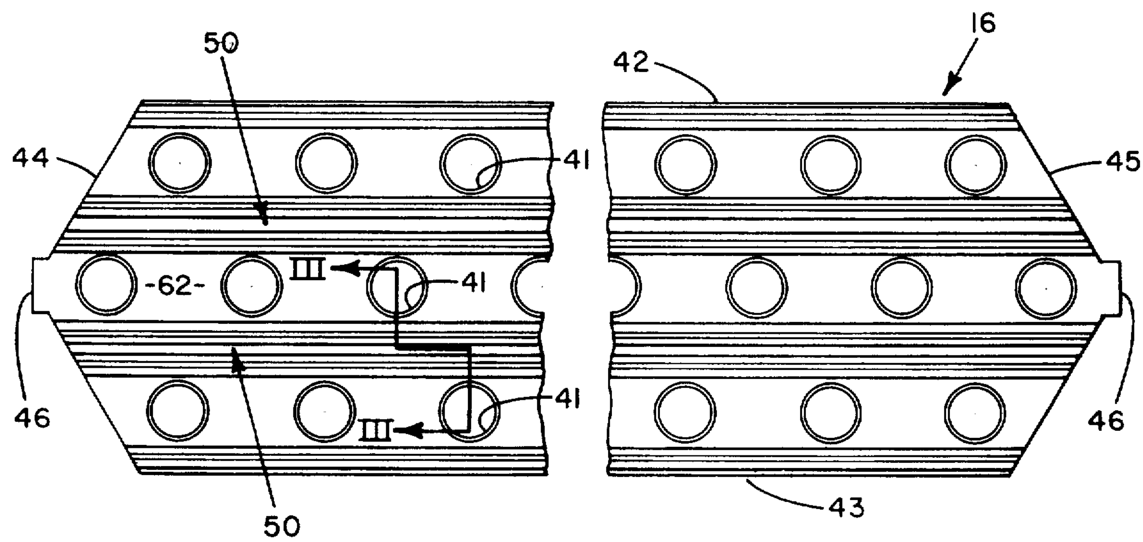
[57] **ABSTRACT**

A fin member for use in a heat exchange assembly comprising a piece of sheet-like material having at least one row of openings, each opening being provided to receive a conduit having a heat transfer medium flowing therethrough. The sheet-like material has a plurality of corrugations formed on the opposed surfaces thereof between each of the longitudinally extended sides and the row of openings. Each of the corrugations includes at least one hill-like portion and one valley-like portion. The material further includes a generally planar surface extending parallel to said corrugations and being disposed vertically thereabove. Condensate droplets formed on the planar surface flow thereacross to be deflected by a hill-like corrugation to thence flow axially along the length of said fin member into condensate collection trough.

**10 Claims, 7 Drawing Figures**

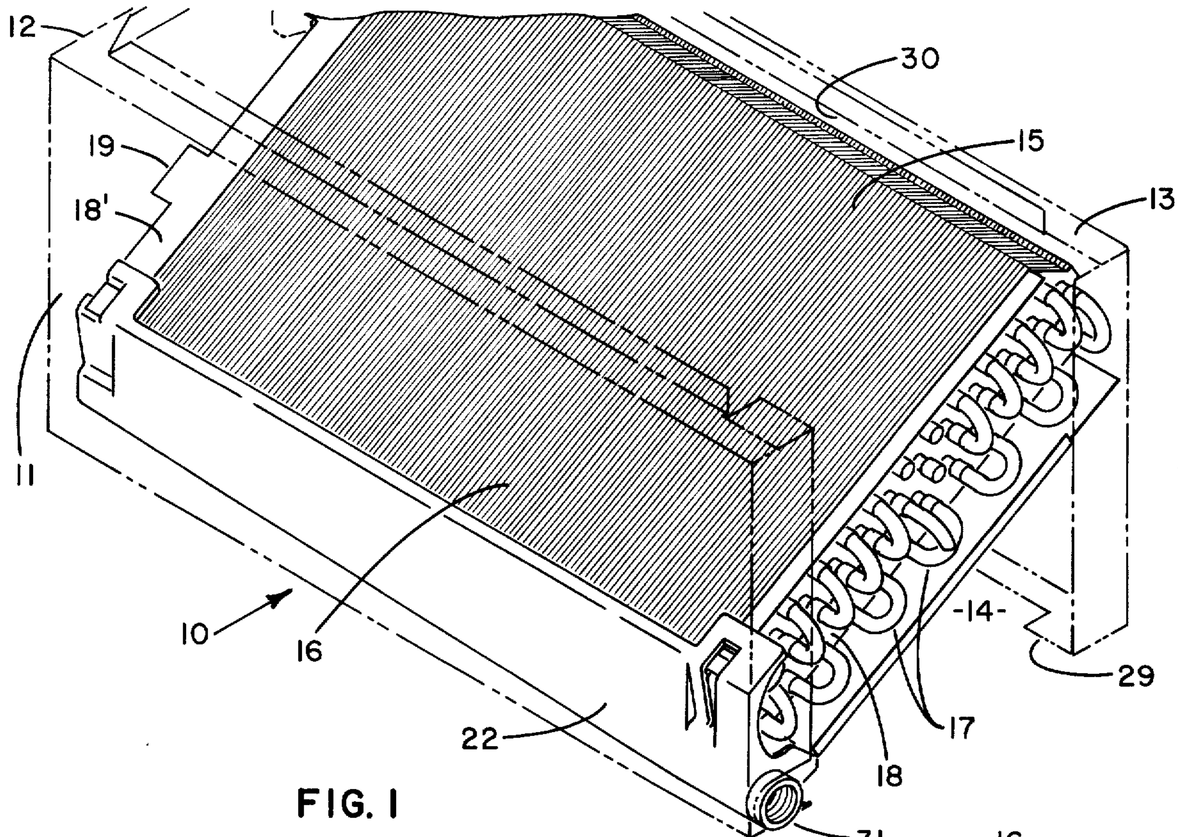



FIG. 1

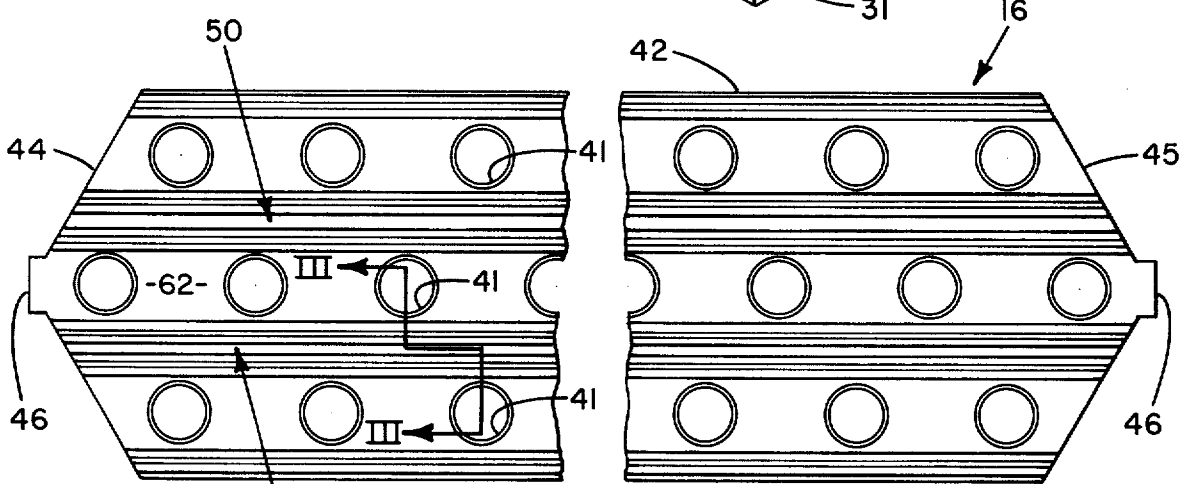



FIG. 2

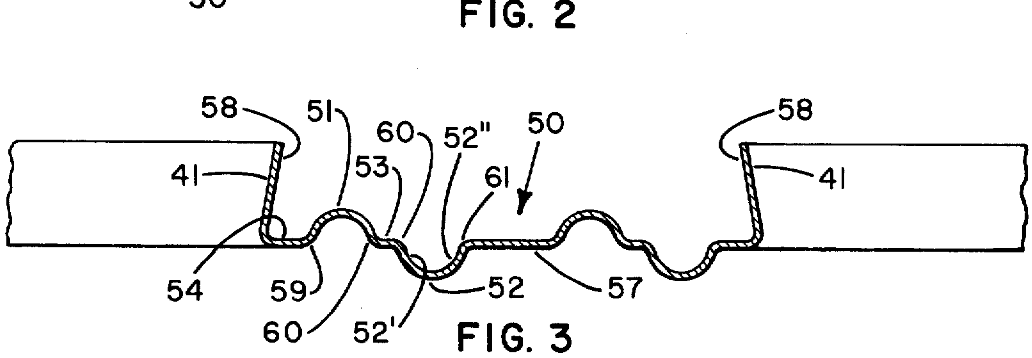



FIG. 3

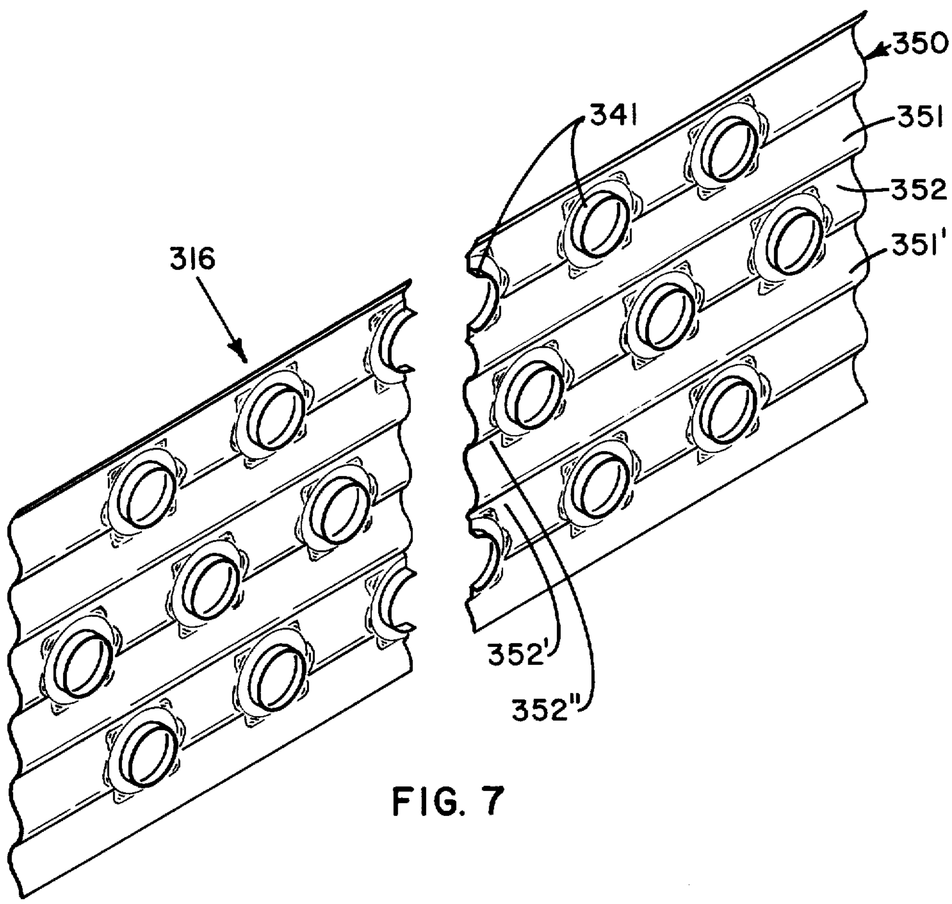



FIG. 7

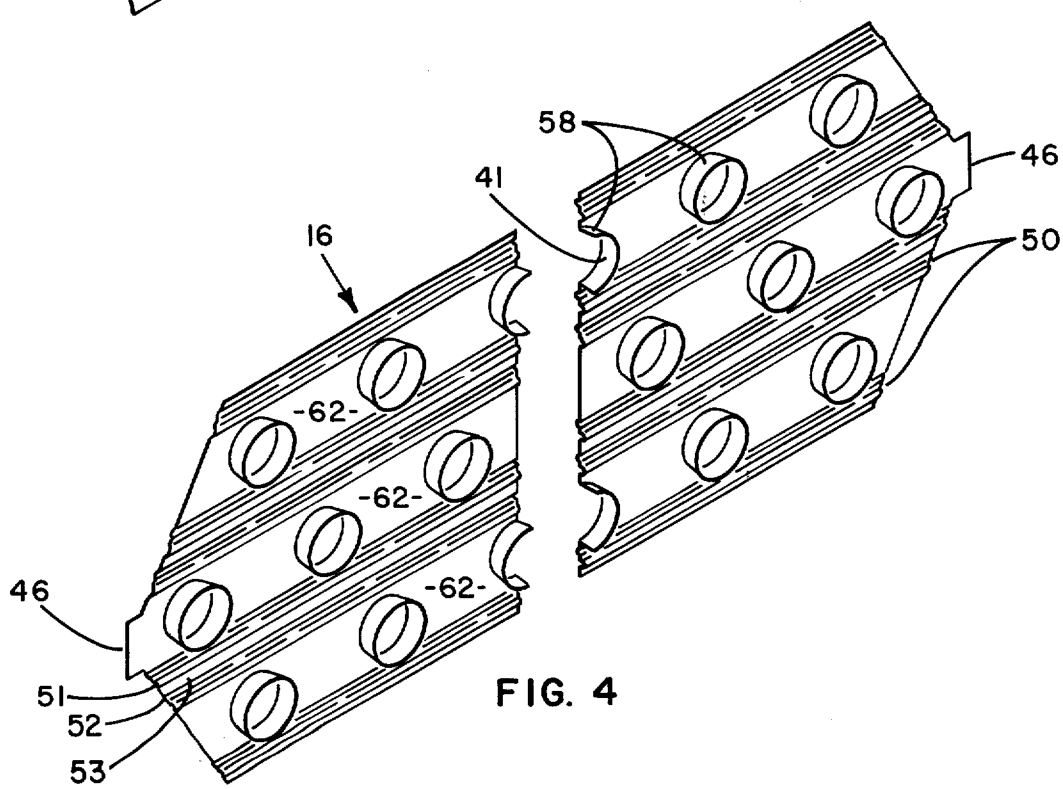



FIG. 4

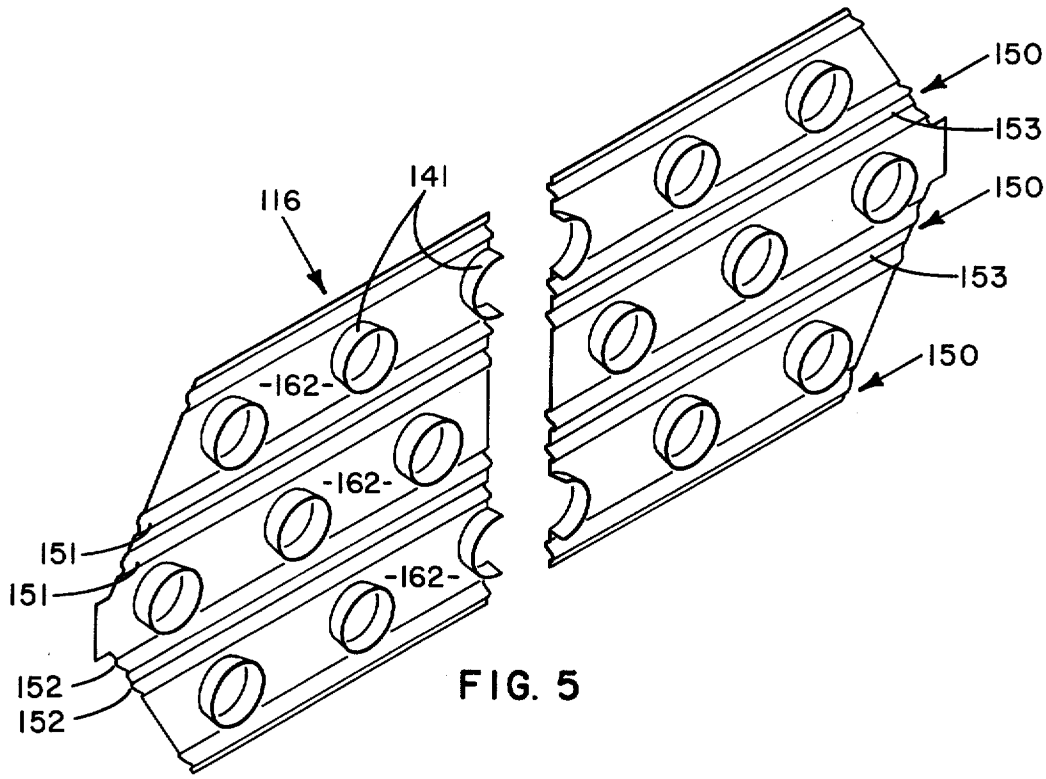

116
141
-162-
-162-
-162-
150
153
150
153
150
151
151
152
152

FIG. 5

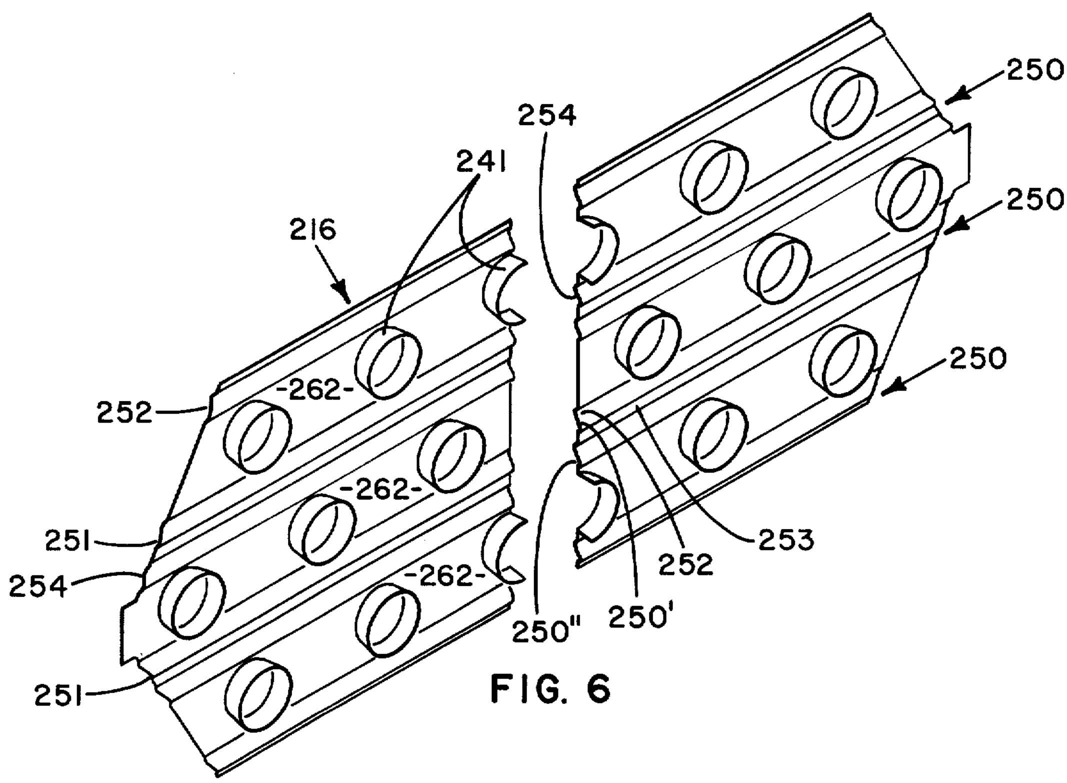

216
241
254
-262-
-262-
-262-
250
250
250
252
251
254
251
250"
250'
252
253

FIG. 6

# HEAT EXCHANGE ASSEMBLY AND FIN MEMBER THEREFOR

## BACKGROUND OF THE INVENTION

This invention relates to heat exchange assemblies. More particularly, this invention relates to heat exchange coils of the plate fin type having a novel fin construction. The plate fin in accordance with invention is particularly suitable for use where the heat exchange coil is employed to cool a relatively warm medium flowing thereover in heat transfer relation with a relatively cold medium flowing therethrough.

Various types of heat exchange assemblies known to those skilled in the art may be employed in many varied applications. One such application involves the utilization of a heat exchange assembly including a heat exchange coil as an evaporator in a refrigeration unit. Generally, when a heat exchange assembly is used as an evaporator, the heat exchange coil will be connected to a source of a relatively cold fluid medium, for example water or a suitable chemical refrigerant. Air to be cooled, is routed over the heat exchange coil in heat transfer relation with the relatively cold fluid medium. The relatively cold medium absorbs heat from the air thereby cooling the air to a desired temperature level. Often times, the air is cooled below its dew point, condensate thus forming on the surfaces of the fins of the coil.

Collection means such as pans or troughs are provided in heat exchange assemblies of the type described hereinabove to collect the condensate formed as a result of the cooling of air below its dew point. If the condensate fails to flow into the collection means, but rather falls randomly throughout the heat exchange assembly, annoying puddles of condensate will be formed.

Generally, where the fins of the heat exchange coil are positioned within the housing at an angle greater than 45° relative to a horizontal plane, the weight of the condensate will cause the condensate droplets to flow along the axial length of the fins into the condensate collection means. However, where the fins of the coil are disposed at an angle less than 45° relative to a horizontal plane, the weight of the condensate droplets will cause the condensate to flow transversely across the fins, to thereby fall randomly within the heat exchange assembly housing.

Evaporators of the type described hereinabove are typically employed in refrigeration units providing conditioned air for residential buildings. One type of air conditioning system commonly employed in residential applications is known by those familiar in the art as a "split system." In a split system, the evaporator is often installed in the ductwork supplying air from a forced air furnace. Very often, space limitations dictates that the evaporator structure be relatively compact. Thus, to provide the desired compactness, it is preferable that the fin members be installed in the heat exchange assembly housing at an angle less than 45° relative to a horizontal plane.

In order to increase the heat transfer efficiency of the fins, it has become the practice to deform the surface of the fin to increase the surface area thereof. Typically, a sinusoidal shaped corrugation has been stamped or otherwise formed on the entire fin surface to achieve the foregoing objective. However, tests have shown that, although the heat transfer efficiency of fins



has been increased by the introduction of such corrugations on the entire surface of the fins, the corrugations have not functioned to prevent the formation of puddles via the random falling of condensate droplets.

## SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a novel plate fin type heat exchange assembly construction.

It is a further object of this invention to provide a plate fin construction of novel design wherein condensate formed on the surface of the fin member will be directed axially along the length thereof into condensate collection means.

It is still another object of the present invention to provide a heat exchange coil particularly suitable for installation in a housing where the heat exchange fin members are diposed at an angle less than 45° relative to a horizontal plane.

These and other objects of the present invention are obtained by providing a heat exchange assembly having a plurality of fin members, each member comprising a piece of sheet-like material having opposite longitudinally extended side edges extending transversely to the path of flow of air through the housing of the heat exchange assembly. At least one row of openings is formed in the sheet material between the opposite side edges thereof, the openings being provided to receive conduits having a relatively cold heat exchange medium flowing therethrough. A plurality of corrugations are formed on the opposed surfaces of the sheet material between each of the opposed sides and the row of openings. Each of the corrugations includes at least one hill-like portion and one valley-like portion. The sheet-like material further includes a generally planar surface extending parallel to the corrugations and being disposed vertically thereabove. Condensate droplets formed on the generally planar surface flow transversely thereacross to be deflected by the hill-like portion of the corrugation. The droplet thence flows axially along the length of the fin member into condensate connection means.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view, partially in phantom, of a heat exchange assembly including the present invention;

FIG. 2 is a plan view of a fin employed in the heat exchange assembly illustrated in FIG. 1;

FIG. 3 is an enlarged sectional view taken along the lines III—III of FIG. 2.

FIG. 4 is an isometric view of the fin illustrated in FIGS. 2 and 3;

FIG. 5 is an isometric view of a first alternative embodiment of the invention;

FIG. 6 is an isometric view of a second alternative embodiment of the invention; and

FIG. 7 is an isometric view of a prior art fin member.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, there is disclosed a heat exchange assembly including the invention herein disclosed. In referring to the various figures of the drawing, like numerals shall refer to like parts.

With particular reference to FIG. 1, heat exchange assembly **10** includes side walls **11** and **13**, connected together by a rear wall **12**, the walls forming a casing or housing of the unit. Although not shown, it should be understood that the casing generally includes a front wall or door spaced apart from illustrated rear wall **12**. The front wall is preferably removable to permit servicing of the assembly.

A heat exchange coil **15** is disposed within chamber of plenum **14** of the casing, the chamber being defined by the front, rear and side walls. The heat exchange coil includes a plurality of plate fin members **16**, to be more fully described hereinafter. Members **16** extend outwardly from tubes not shown, the members being spaced equi-distantly along the axial length of the tubes. Each of the tubes terminates in a return bend **17**. Return bends **17** are suitably connected to the various tubes so a continuous flow circuit is formed for a suitable heat exchange medium flowing in the tubes. The heat exchange medium may be for example water or a suitable chemical refrigerant such as dichlorodifluoromethane, sold under the trademark "Freon 12". The heat exchange medium passes through the tubes of the heat exchange coil. Tube sheets **18** and **18'** are preferably provided at either end of the coil. Tube sheet **18'** has at least one tab **19** integrally formed therewith and extending therefrom. Tab **19** is received in a slot formed in an embossment provided in rear wall **12** for securing heat exchange coil **15** within chamber **14**.

Side walls **11** and **13** and rear wall **12** define at their bottom an opening **29** serving as an inlet. The walls further define at their top an opening **30** serving as an outlet from the heat exchange assembly. A medium to be cooled, for example air, is routed through opening **29** via a fan or other similar device (not shown) and passes in heat transfer relation with the relatively cold medium flowing through the tubes of the heat exchange coil **15**. The relatively cold medium absorbs heat from the relatively warm medium, to cool the warm medium to a desired temperature level. After it is cooled, the medium leaves the heat exchange assembly via outlet **30** and is delivered to an area or space requiring a relatively cold medium. It should be understood that the flow of the medium through the heat exchange assembly may be reversed so that outlet **30** functions as an inlet and inlet **29** functions as an outlet. The heat exchange assembly heretofore discussed may be typically employed as an evaporator of a refrigeration unit employed in a residential air conditioning system.

When a heat exchange assembly is employed as an evaporator, the medium to be cooled, is directed over the surface of the tubes having the relatively cold medium flowing therethrough. Adjacent pairs of fin members **16** define therebetween air flow passages for the air passing in heat transfer relation with the medium flowing through the tubes. When the medium is air, its capacity to hold moisture is reduced as its temperature is lowered; accordingly, when the air is cooled, condensate very often forms on the surface of fin members **16**.

Suitable condensate collecting means such as condensate pan or trough **22** is provided to collect condensate from the surface of fin members **16**. Preferably, condensate collection pan **22** is disposed below and extends substantially coextensive with the lower surface of heat exchange coil **15**. Pan **22** includes a suitable opening **31** which may be threaded in the manner shown, for connection to a pipe or other suitable means for draining the condensate collected in the pan. The manner in which pan **22** is connected to coil **15** is more fully disclosed in copending application, Ser. No. 401,733, filed Sept. 28, 1973, and assigned to the same assignee as the present application.

Very often, in order to meet space limitations, it is desirable to install heat exchange coil **15** within its housing at an angle of less than 45° relative to a horizontal plane. Heretofore, in such installations, very often the condensate formed on surface of fin members **16** would not flow along the axial length thereof into condensate collection pan **22**, but rather, the weight of the condensate droplets would cause the condensate to fall randomly from the fin members to form annoying puddles of water. The fin member of the present invention avoids the problem heretofore encountered.

Referring now particularly to FIGS. **2, 3** and **4**, there are shown detailed views of a first embodiment of the present invention.

Each fin member **16** is formed from a sheet-like material, each of the fin members having at least one row of openings **41** formed therethrough for receiving the tubes of coil **15**. The rows of openings are formed between the longitudinally extended side edges **42** and **43** of fin member **16**. As shown in FIG. **1**, when installed in the housing of assembly **10**, coil **15** is positioned so that edges **42** and **43** extend transversely to the path of flow of air through chamber **14**. Ends **44** and **45** have tabs **46** extending therefrom. Tabs **46** are provided so the coil may be properly indexed during the manufacturing process.

Corrugations **50** are formed between each row of openings and each of the longitudinally extended side edges. Corrugations **50** include at least one hill-like portion **51** and at least one valley-like portion **52**. Portions **51** and **52** are connected by a generally planar portion **53**. A hill-like portion **51** extending from a first surface **54** of fin member **16** defines a valley-like portion **52** on the opposed surface **57** of the fin member. Similarly, a hill-like portion **51** on the opposed surface **57** defines a valley-like portion **52** on first surface **54**. Each of the valley-like portions define drainage channels for the condensate formed on the surfaces of the fin members. At least one generally planar surface **62** extends along the fin surface and is vertically disposed relative to the corrugations **50**.

Preferably, the corrugations and collars **58** provided about each of the openings **41** in the fin member are formed via a stamping process. Collars **58** are provided so that a mechanical bond may be obtained between the tubes and fin members **16**. The drainage channels defined by the hill-like and valley-like portions of corrugations **50** permit the condensate to flow along the axial length of the fin members directly into condensate collection means **22**. Preferably, the height of either a hill-like portion **51** or the depth of a valley-like portion **52** is equal to the width thereof; the width being measured respectively from the points **59–60**, or **60–61**.

Referring to FIG. **5**, there is shown a first alternative embodiment of the invention.

Fin member **116** is formed from a sheet-like material. The member includes corrugations **150**. Corrugations **150** have a valley-like portion **152** and a hill-like portion **151**. In essence, the corrugation defines a deformed surface appearing in cross-section as a sinusoidally-shaped wave of relatively small frequency. In the illustrated arrangement, each corrugation between adjacent rows of openings **141** includes a pair of hill-like and valley-like portions, separated by a generally planar surface **153**. Each fin member has at least one generally planar surface **162** extending vertically above each corrugation.

Referring now to FIG. **6**, there is shown a second alternate embodiment. Fin member **216** includes corrugations **250** having hill-like portions **251** and valley-like portions **252**. Each hill-like portion and valley-like portion is connected via a generally diagonally extending elongated surface **254**. Each corrugation between adjacent rows of openings **241** includes a pair of hill-like and valley-like portions, first hill-like and valley-like portions **250'** being separated from second portions **250''** by a generally planar surface **253**. The fin member further includes a generally planar surface **262** extending vertically above each corrugation.

Referring now to FIG. **7**, there is illustrated a fin member of a type found in the prior art. Fin member **316** includes a sheet-like material having rows of openings **341** formed therein. The fin member includes corrugations **350** having hill-like **351** and valley-like **352** portions extending along the entire surface of the member. It should be observed that fin member **16** is devoid in having any planar surfaces, as for example surfaces **53** and **62** of the embodiment illustrated in FIGS. **2** through **4**.

The corrugations **350** define a generally sinusoidally shaped wave when the fin member is viewed in cross-section. However, the wave is of a generally large length when compared to the wave length of the fin member illustrated in FIG. **5**.

In applications where the heat exchange coil is disposed within its housing at an angle of less than 45° relative to a horizontal plane, a condensate drop forming on a surface, for example surface **351'**, of fin member **316**, will grow to a relatively large size before the forces acting thereon are of a sufficient magnitude to move the drop. The foregoing is caused as a result of the angular relationship fin surface **351'** has relative to both horizontal and vertical planes.

The force produced by the weight of the drop is resolved into two components, a first component acting parallel to the longitudinal axis of the fin, and a second component acting normal to that axis. The magnitude of the axial component force, when the drop is initially formed is less than that required to overcome the adhesive force acting in opposition thereto. Similarly, the magnitude of the normal component force is less than that required to overcome the adhesive force also acting in opposition thereto. The force of adhesion is a function of drop size and for non-wettable surfaces acts thereon in an opposed direction to any component force tending to move the drop along the surface. The surface of the fin members herein described are considered nonwettable, that is condensate will form thereon as beads or drops. (Wettable surfaces are characterized by condensate forming as a film.)

As the drop grows in size, the component forces produced by the increased weight of the drop increase in magnitude. Due to the angular relationship of surface **351'**, relative to vertical and horizontal planes, the force tending to move the drop downwardly transversely across the fin surface increases at a greater rate than the force tending to move the drop axially. At some point, the drop will commence moving transversely across the fin surface. In some instances, the drop has grown so that the hill-like portions of corrugations **350** are unable to deflect the drop into an axial flow path and thus into the condensate collection means. The non-deflected drops of condensate will fall randomly from the fin members **316** to form annoying puddles.

Additionally, by providing relatively large wavelength fin surfaces, the opposed surfaces defining a valley-like portion of corrugation **350**, for example surfaces **352'** and **352''** illustrated in FIG. **7**, are spaced relatively far apart. As a consequence, drops formed between such surfaces will have a tendency to grow in size. Some of the drops thus formed will become excessive in size and instead of flowing axially along the channels defined by valley-like portions **352**, will derail, that is, fall therefrom and flow transversely across the fin surface.

The foregoing disadvantages of the prior art are solved as a result of employing fin surfaces of the type disclosed herein. Each of the three embodiments have generally planar surfaces, for example, surfaces **62** (FIGS. **2** and **4**) **162** (FIG. **5**), and **262** (FIG. **6**) extending vertically above each of the corrugations. Condensate droplet formed on such a planar surface produces a force that will cause the droplet to move transversely across the surface while the drop is still of relatively small size. The hill-like portions of the corrugations deflect the drops so they flow axially along the fin member into the condensate collecting means.

In addition, by maintaining the opposed surfaces defining the valley-like portions of the corrugations of the fin relatively close, for example 0.050 inch, the size of the droplets formed therebetween will be limited to thus maintain the droplet therebetween. For a drop of the same size if formed between surfaces **352'** and **352''** of fin **316**, and formed between surfaces **52** and **52''** (see FIG. 3) of fin **16**, the adhesive force acting on the drop formed between the latter opposed surfaces will be greater, due to the greater surface contact between the droplet and fin.

It has been found that fin designs of the present invention that produce condensate droplets in a range of from one-sixteenth through one-eighth inches in diameter function efficiently from a heat transfer standpoint, yet avoid the prior art difficulty caused by dripping condensate.

While preferred embodiments have been described and illustrated, the invention should not be limited thereto, but may be otherwise embodied within the scope of the following claims.

We claim:

**1**. A heat exchange assembly adapted for installation in a housing having a flow of air therethrough, said assembly including a heat exchange coil having a plurality of conduits having a relatively cold heat exchange medium flowing therethrough, air flowing through a housing passing over said conduits in heat transfer relation with said medium, a plurality of plate-like fin members having at least one row of openings for receiving each one of said plurality of conduits, said plate-like members being spaced substantially equi-distant along the length of said conduits, whereby said air passing through said housing passes through a plurality of passages defined by adjacent fin members, and means for collecting condensate formed as a result of the cooling of said air, each of said fin members comprising:

a piece of sheet-like material having opposite longitudinally extended side edges extending transversely to the path of flow of said air over said fin member, said openings being formed in said sheet-like material between said opposite side edges; and

a plurality of corrugations formed on the opposed surfaces of said sheet-like material between each of said opposite sides and said row of openings, each of said corrugations including at least one hill-like portion and one valley-like portion, said sheet-like material further including at least one generally planar surface extending parallel to said corrugations and being disposed vertically thereabove, condensate droplets formed on said generally planar surface flowing transversely thereacross to be deflected by said hill-like corrugation to flow axially along the length of said corrugations into said condensate collection means.

**2.** A heat exchange assembly in accordance with claim **1** wherein the depth of a valley-like portion is substantially equal to the width thereof.

**3.** A heat exchange assembly in accordance with claim **2** wherein said coil is disposed in said housing at an angle of less than 45° but greater than 0° relative to a horizontal plane.

**4.** A heat exchange assembly in accordance with claim **3** wherein said corrugations limit the size of condensate droplets to a maximum of 0.125 inches in diameter.

**5.** A heat exchange assembly in accordance with claim **1** wherein said corrugations limit the size of condensate droplets to a maximum of 0.125 inches in diameter.

**6.** A heat exchange assembly in accordance with claim **1** wherein said coil is disposed in said housing at an angle of less than 45° but greater than 0° relative to a horizontal plane.

**7.** A fin member for use in a heat exchange coil positioned in a housing having a flow of air therethrough and further including a plurality of generally parallel fluid conduits connected to conduct a relatively cold heat exchange medium through the heat exchange coil, the air flowing through said housing passing over said conduits in heat transfer relation with said relatively cold heat exchange medium, each of said fin members comprising;

a piece of sheet-like material having opposite longitudinally extended side edges extending transversely to a path of flow of air over said fin member, said sheet-like material having at least one row of openings formed therethrough between said opposite side edges and

a plurality of corrugations formed on the opposed surfaces of said sheet-like material between each of said opposite side edges and said row of openings, each of said corrugations including at least one hill-like portion and one valley-like portion, a hill-like portion of a first surface of said material defining a valley-like portion on the opposed surface of said material, and a hill-like portion on the opposed surface defining a valley-like portion on said first surface, said sheet-like material further including a generally planar surface extending parallel to said corrugations and being disposed vertically thereabove, condensate droplets formed on said generally planar surface flowing transversely thereacross to be deflected by said hill-like corrugations to flow axially along the length of said fin member into a condensate collection means.

**8.** A fin member in accordance with claim **7** wherein the depth of a valley-like portion is substantially equal to the width thereof.

**9.** A fin member in accordance with claim **8** wherein said corrugations limit the size of condensate droplets to a maximum of 0.125 inches in diameter.

**10.** A fin member in accordance with claim **7** wherein said corrugations limit the size of condensate droplets to a maximum of 0.125 inches in diameter.

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