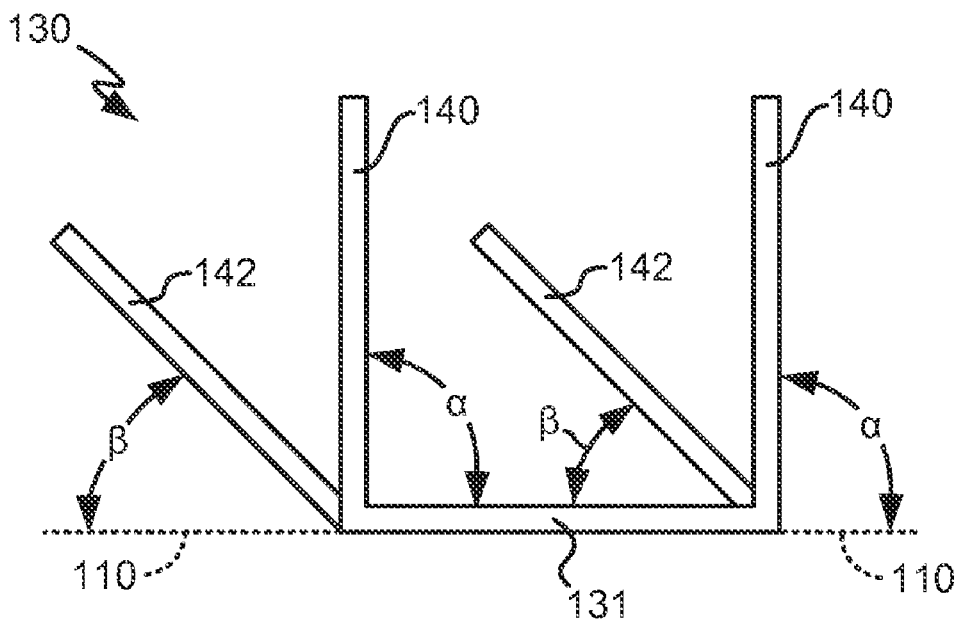


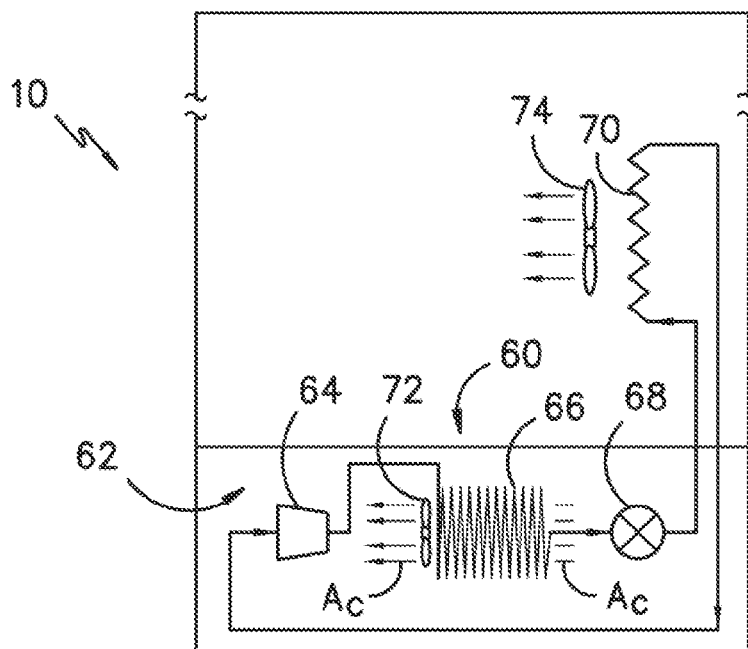
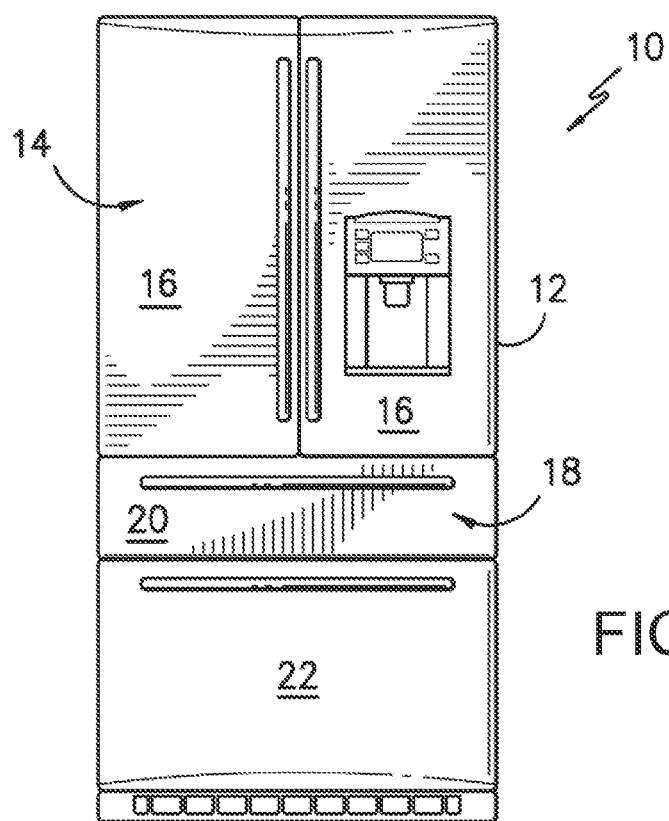


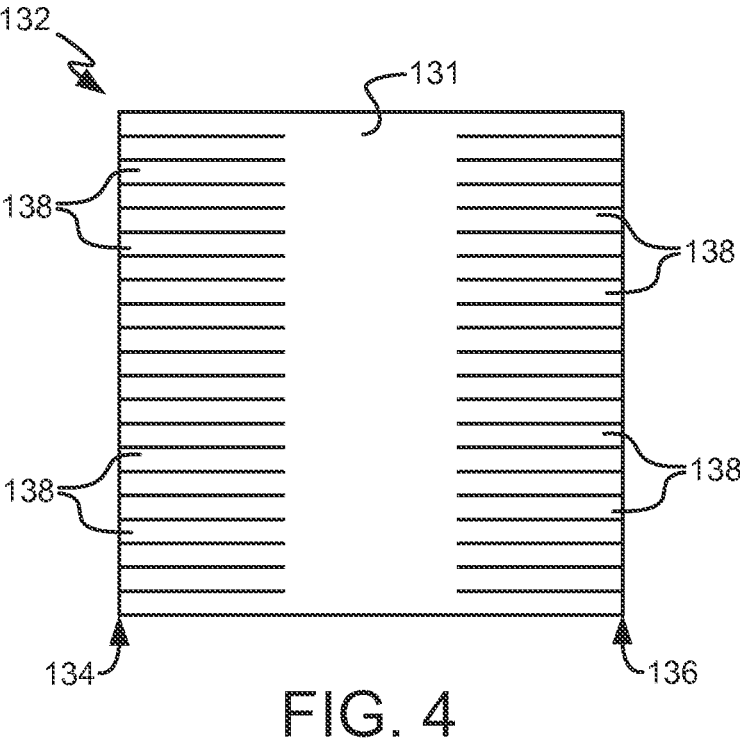
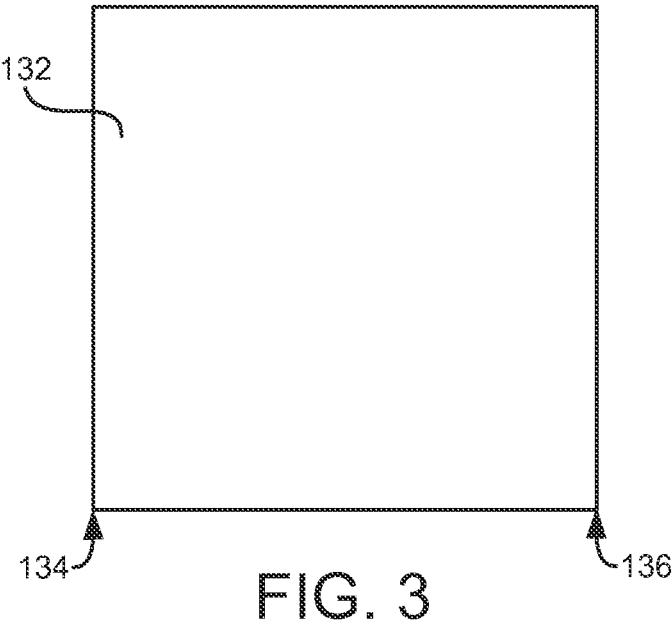
US 20170108289A1

(19) **United States**(12) **Patent Application Publication**
Kempiak(10) **Pub. No.: US 2017/0108289 A1**(43) **Pub. Date: Apr. 20, 2017**(54) **HEAT EXCHANGER AND A METHOD FOR
FORMING A HEAT EXCHANGER****Publication Classification**(51) **Int. Cl.**
F28F 1/36 (2006.01)(52) **U.S. Cl.**
CPC **F28F 1/36** (2013.01)(71) Applicant: **General Electric Company,**
Schenectady, NY (US)(72) Inventor: **Michael John Kempiaak,** Osceola, IN
(US)(21) Appl. No.: **14/885,036**(22) Filed: **Oct. 16, 2015**(57) **ABSTRACT**

A heat exchanger includes a spine fin strip wrapped onto a conduit in a helical pattern. A first plurality of spine fins of the spine fin strip extends from a base of the spine fin strip, and a second plurality of spine fins of the spine fin strip is bent relative to the spine fins of the first plurality of spine fins. A related method for forming a heat exchanger is also provided.







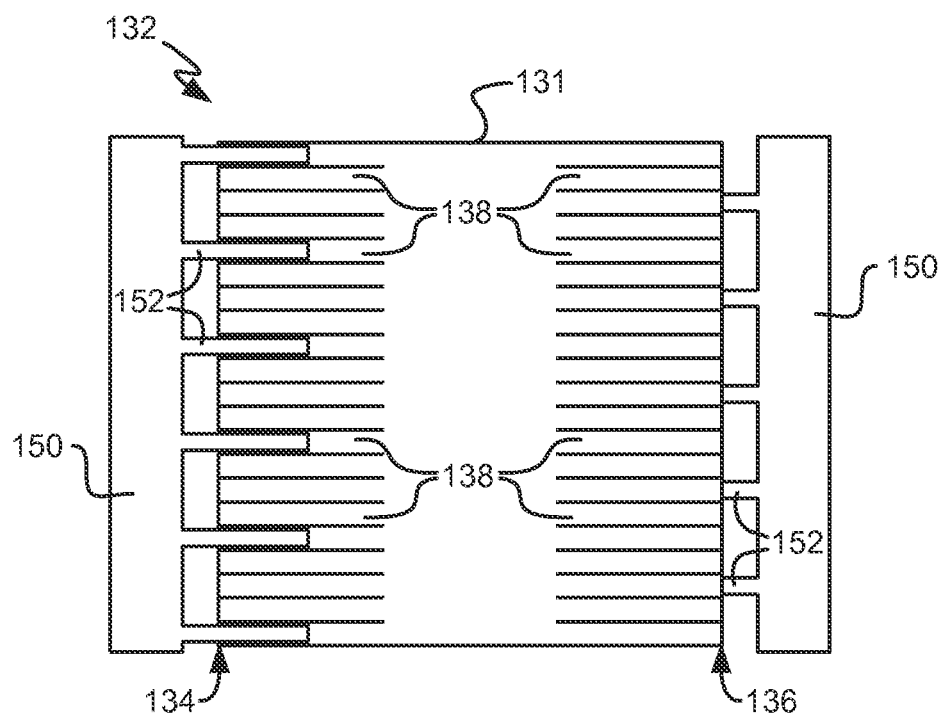


FIG. 5

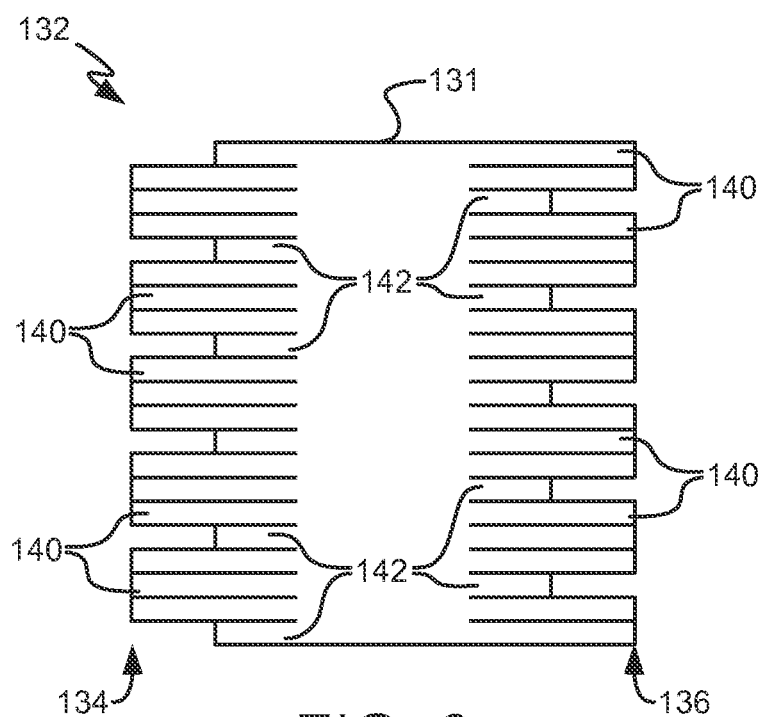


FIG. 6

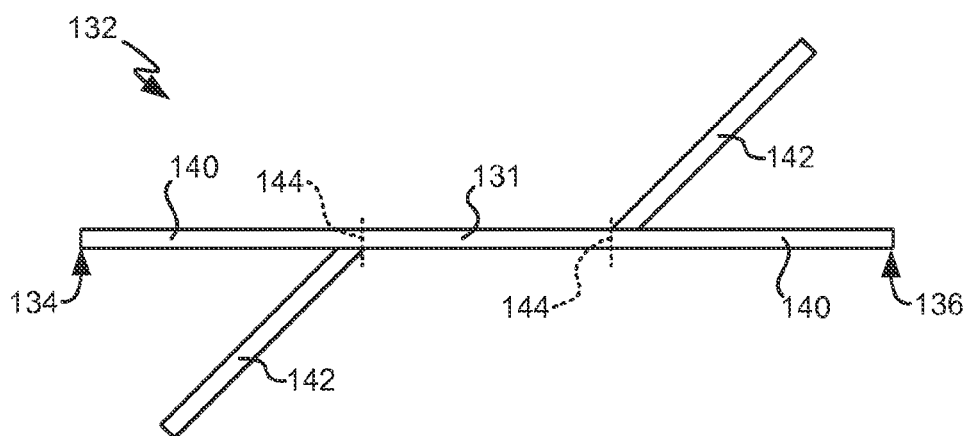


FIG. 7

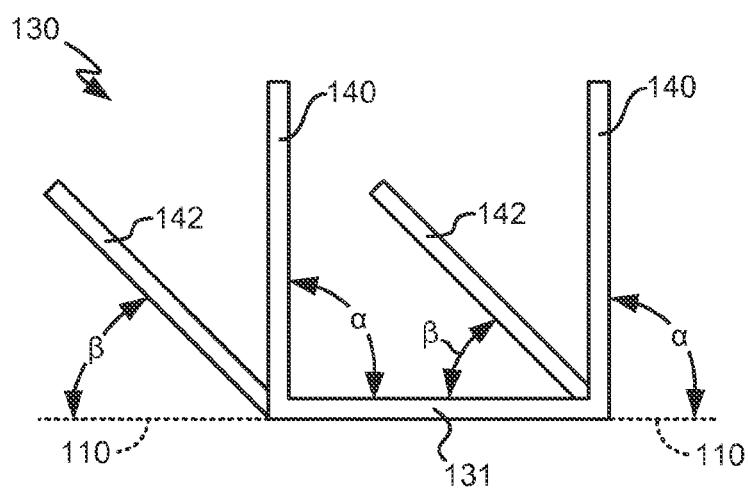


FIG. 8

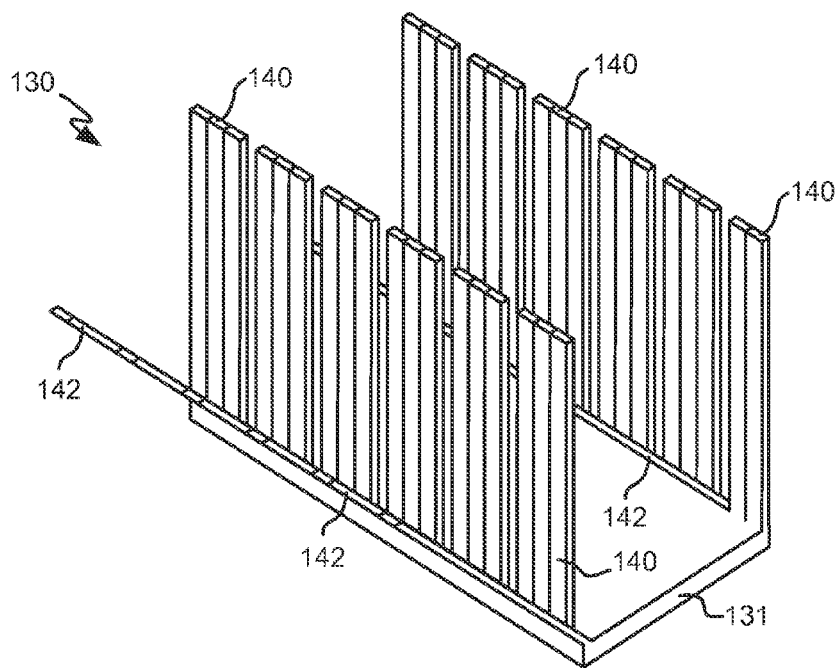


FIG. 9

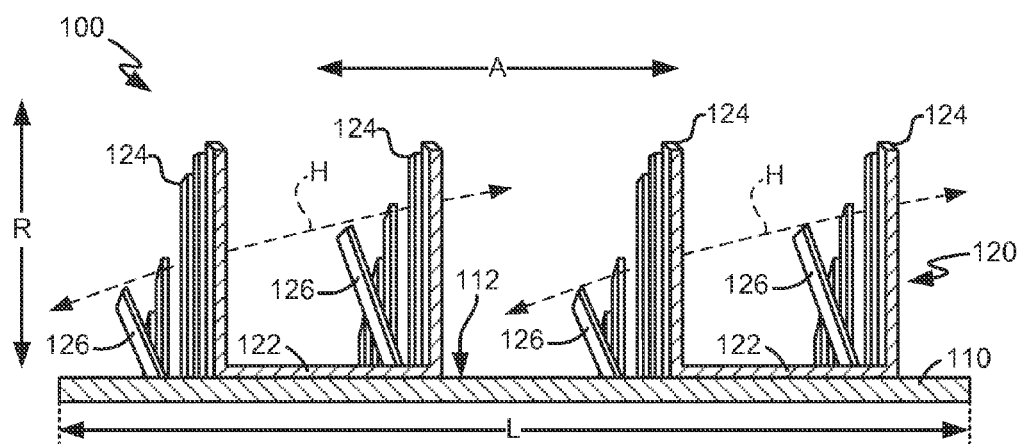


FIG. 10

HEAT EXCHANGER AND A METHOD FOR FORMING A HEAT EXCHANGER

FIELD OF THE INVENTION

[0001] The present subject matter relates generally to heat exchangers, such as heat exchangers for refrigerator appliances, and methods for forming heat exchangers.

BACKGROUND OF THE INVENTION

[0002] Refrigerator appliances generally include sealed systems for cooling chilled chambers of the refrigerator appliance. During operation of the sealed system, a compressor generates compressed refrigerant. The compressed refrigerant flows to a condenser where the refrigerant is condensed into a liquid and is sent to an expansion device. The expansion device reduces a pressure of the refrigerant before the refrigerant enters into an evaporator as a combination of liquid and vapor. The refrigerant exits the evaporator as vapor and is transported to the compressor via a suction line. Refrigerant within the evaporator absorbs heat from the chilled chambers.

[0003] Various heat exchangers are available for use in refrigerator appliances. Certain refrigerator appliances include tube fin heat exchangers, and tube fin heat exchangers may include vortex generators. The vortex generators are typically a series of winglets mounted or punched into the fins. The winglets form counter-rotating longitudinal air vortices in a flow path direction of the refrigerant that increases air mixing and thus improves heat transfer. However, tube fin heat exchangers can be expensive relative to alternative heat exchangers.

[0004] Spine fin heat exchangers include spine fin coils wrapped about a conduit. The spine fin coils can facilitate heat transfer between refrigerant within the conduit and ambient atmosphere about the spine fin heat exchanger. Spine fin heat exchangers are generally less expensive than comparable tube fin heat exchangers.

[0005] Accordingly, a spine fin heat exchanger with vortex generators would be useful. In particular, a spine fin heat exchanger with features for generating counter-rotating longitudinal air vortices in a flow path direction of refrigerant within the heat exchanger to increase air mixing and improve heat transfer would be useful.

BRIEF DESCRIPTION OF THE INVENTION

[0006] The present subject matter provides a heat exchanger with a spine fin strip wrapped onto a conduit in a helical pattern. A first plurality of spine fins of the spine fin strip extends from a base of the spine fin strip, and a second plurality of spine fins of the spine fin strip is bent relative to the spine fins of the first plurality of spine fins. A related method for forming a heat exchanger is also provided. Additional aspects and advantages of the invention will be set forth in part in the following description, or may be apparent from the description, or may be learned through practice of the invention.

[0007] In a first exemplary embodiment, a method for forming a heat exchanger is provided. The method includes cutting a plurality of spine fins into a sheet of metal, bending a subset of the plurality of spine fins, folding the sheet of metal to form a spine fin strip such that the plurality of spine fins extend from a base of the spine fin strip, and wrapping the spine fin strip onto a conduit in a helical pattern at an

outer surface of the conduit such that the plurality of spine fins includes spine fins that extend radially away from the outer surface of the conduit and also includes spine fins that are bent relative to the radially extending spine fins.

[0008] In a second exemplary embodiment, a heat exchanger is provided. The heat exchanger includes a conduit having an outer surface. A spine fin strip is wrapped onto the conduit in a helical pattern at the outer surface of the conduit. The spine fin strip includes a base positioned at the outer surface of the conduit. A first plurality of spine fins extends radially from the base and away from the outer surface of the conduit. A second plurality of spine fins is bent relative to the spine fins of the first plurality of spine fins. The base, the spine fins of the first plurality of spine fins and the spine fins of the first plurality of spine fins are formed from a common piece of sheet metal.

[0009] In a third exemplary embodiment, a heat exchanger is provided. The heat exchanger includes a conduit having an outer surface. A spine fin strip is wrapped onto the conduit in a helical pattern at the outer surface of the conduit. The spine fin strip includes a base positioned at the outer surface of the conduit. A first plurality of spine fins is mounted to the base. Each spine fin of the first plurality of spine fins defines an angle, α , with the outer surface of the conduit proximate the first plurality of spine fins. α is about ninety degrees. A second plurality of spine fins is mounted to the base. Each spine fin of the second plurality of spine fins defines an angle, β , with the outer surface of the conduit proximate the second plurality of spine fins. β is no greater than seventy degrees. The base, the spine fins of the first plurality of spine fins and the spine fins of the first plurality of spine fins are formed from a common piece of sheet metal.

[0010] These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures.

[0012] FIG. 1 is a front elevation view of a refrigerator appliance according to an exemplary embodiment of the present subject matter.

[0013] FIG. 2 is schematic view of certain components of the exemplary refrigerator appliance of FIG. 1.

[0014] FIGS. 3, 4, 5, 6, 7, 8 and 9 illustrate a spine fin assembly according to an exemplary embodiment of the present subject matter in various stages of formation.

[0015] FIG. 10 provides a section view of a heat exchanger according to an exemplary embodiment of the present subject matter.

DETAILED DESCRIPTION

[0016] Reference now will be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that

various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0017] FIG. 1 depicts a refrigerator appliance 10 that incorporates a sealed refrigeration system 60 (FIG. 2). It should be appreciated that the term “refrigerator appliance” is used in a generic sense herein to encompass any manner of refrigeration appliance, such as a freezer, refrigerator/freezer combination, and any style or model of conventional refrigerator. In addition, it should be understood that the present subject matter is not limited to use in appliances. Thus, the present subject matter may be used for any other suitable purpose, such as in HVAC units.

[0018] In the exemplary embodiment shown in FIG. 1, the refrigerator appliance 10 is depicted as an upright refrigerator having a cabinet or casing 12 that defines a number of internal chilled storage compartments. In particular, refrigerator appliance 10 includes upper fresh-food compartments 14 having doors 16 and lower freezer compartment 18 having upper drawer 20 and lower drawer 22. The drawers 20 and 22 are “pull-out” drawers in that they can be manually moved into and out of the freezer compartment 18 on suitable slide mechanisms.

[0019] FIG. 2 is a schematic view of certain components of refrigerator appliance 10, including a sealed refrigeration system 60 of refrigerator appliance 10. A machinery compartment 62 contains components for executing a known vapor compression cycle for cooling air. The components include a compressor 64, a condenser 66, an expansion device 68, and an evaporator 70 connected in series and charged with a refrigerant. As will be understood by those skilled in the art, refrigeration system 60 may include additional components, e.g., at least one additional evaporator, compressor, expansion device, and/or condenser. As an example, refrigeration system 60 may include two evaporators.

[0020] Within refrigeration system 60, refrigerant flows into compressor 64, which operates to increase the pressure of the refrigerant. This compression of the refrigerant raises its temperature, which is lowered by passing the refrigerant through condenser 66. Within condenser 66, heat exchange with ambient air takes place so as to cool the refrigerant. A condenser fan 72 is used to pull air across condenser 66, as illustrated by arrows A_C, so as to provide forced convection for a more rapid and efficient heat exchange between the refrigerant within condenser 66 and the ambient air. Thus, as will be understood by those skilled in the art, increasing air flow across condenser 66 can, e.g., increase the efficiency of condenser 66 by improving cooling of the refrigerant contained therein.

[0021] An expansion device (e.g., a valve, capillary tube, or other restriction device) 68 receives refrigerant from condenser 66. From expansion device 68, the refrigerant enters evaporator 70. Upon exiting expansion device 68 and entering evaporator 70, the refrigerant drops in pressure. Due to the pressure drop and/or phase change of the refrigerant, evaporator 70 is cool relative to compartments 14 and 18 of refrigerator appliance 10. As such, cooled air is produced and refrigerates compartments 14 and 18 of refriger-

ator appliance 10. Thus, evaporator 70 is a type of heat exchanger which transfers heat from air passing over evaporator 70 to refrigerant flowing through evaporator 70. An evaporator fan 74 is used to pull air across evaporator 70 and circulated air within compartments 14 and 18 of refrigerator appliance 10.

[0022] Collectively, the vapor compression cycle components in a refrigeration circuit, associated fans, and associated compartments are sometimes referred to as a sealed refrigeration system operable to force cold air through compartments 14, 18 (FIG. 1). The refrigeration system 60 depicted in FIG. 2 is provided by way of example only. Thus, it is within the scope of the present subject matter for other configurations of the refrigeration system to be used as well.

[0023] FIG. 10 provides a section view of a heat exchanger 100 according to an exemplary embodiment of the present subject matter. Heat exchanger 100 may be used in any suitable refrigeration system or HVAC system. As an example, heat exchanger 100 may be used in refrigeration system 60 of refrigerator appliance 10 (FIG. 2). Heat exchanger 100 includes features for improving performance of an associated refrigeration system or HVAC system, as discussed in greater detail below.

[0024] As may be seen in FIG. 10, heat exchanger 100 defines an axial direction A and a radial direction R. Heat exchanger 100 includes a conduit 110. Conduit 110 is configured for containing a refrigerant therein and directing a flow of refrigerant therethrough. Conduit 110 has an outer surface 112. Conduit 110 may be constructed of or with any suitable material. As an example, conduit 110 may be constructed of or with a metal, such as copper tubing or aluminum tubing. Conduit 110 may also have any suitable cross-sectional shape. For example, conduit 110 may have a circular cross-section, e.g., in a plane that is perpendicular to the axial direction A.

[0025] Heat exchanger 100 also includes a spine fin strip or assembly 120. Spine fin assembly 120 is disposed or positioned on or at outer surface 112 of conduit 110. In particular, spine fin assembly 120 is wrapped about conduit 110 such that spine fin assembly 120 is mounted to conduit 110 at outer surface 112 of conduit 110. Thus, spine fin assembly 120 may have a helical shape, e.g., when wound about conduit 110. Spine fin assembly 120 includes a base 122, a plurality of first spine fins 124 and a plurality of second spine fins 126. Base 122 is positioned on conduit 110 at outer surface 112 of conduit 110, and first spine fins 124 and second spine fins 126 are mounted to base 122 and wound about conduit 110, e.g., such that first spine fins 124 extend along the radial direction R from base 122 and second spine fins 126 are bent relative to first spine fins 124.

[0026] Spine fin assembly 120 may be constructed of or with any suitable material. As an example, spine fin assembly 120 may be constructed of or with a metal, such as copper or aluminum. In particular, spine fin assembly 120 may be constructed of or with a single, continuous sheet of material, such as a sheet of aluminum or copper. Thus, base 122, first spine fins 124 and second spine fins 126 may be defined by or formed with the single, continuous sheet of material.

[0027] As may be seen in FIG. 3, conduit 110 defines a length L, e.g., along the axial direction A. Base 122, first spine fins 124 and second spine fins 126 are wound about conduit 110 along the length L of conduit 110. Base 122, first

spine fins 124 and second spine fins 126 may be wound at any suitable rate along the length L of conduit 110. For example, base 122, first spine fins 124 and second spine fins 126 may be wound about conduit 110 at a rate of about nine windings per inch of conduit 110 along the length L of conduit 110. As another example, base 122, first spine fins 124 and second spine fins 126 may be wound about conduit 110 at a rate of greater than seven windings per inch of conduit 110 along the length L of conduit 110 and less than eleven windings per inch of conduit 110 along the length L of conduit 110.

[0028] Second spine fins 142 may also be distributed in any suitable manner on conduit 110 and/or base 131. For example, the spine fins of second spine fins 142 may be bent such that second spine fins 142 are distributed in a helical pattern (shown with arrows H) within and/or between windings of spine fin assembly 120. Bending second spine fins 126 relative to first spine fins 124 (e.g., and distributing second spine fins 126 in the helical pattern H) may assist with forming vortex generators on spine fin assembly 120. Without wishing to be bound to any particular theory, the bent second spine fins 126 may enhance heat transfer of heat exchanger 100 with ambient air about heat exchanger 100 by creating turbulent airflow about first spine fins 124 and/or directing the turbulent airflow into a wake region to reduce recirculation flow. Thus, an efficiency of a system associated with heat exchanger 100 may be improved.

[0029] It should be understood that second spine fins 126 need not be bent at a junction between second spine fins 126 and base 122 in certain exemplary embodiments. For example, second spine fins 126 may be bent such that one portion of each spine fin of second spine fins 126 extends the radial direction R from base 122 and another portion (i.e., a winglet) of each spine fin of second spine fins 126 is bent relative to first spine fins 124. Thus, second spine fins 126 may be bent away from base 122 in certain exemplary embodiments to form vortex generators.

[0030] FIGS. 3, 4, 5, 6, 7, 8 and 9 illustrate a spine fin assembly 130 (FIG. 9) according to an exemplary embodiment of the present subject matter in various stages of formation. Any suitable spine fin assembly may be formed utilizing the steps outlined below. For example, spine fin assembly 120 (FIG. 10) may be formed in the manner described below.

[0031] As may be seen in FIG. 3, a sheet of material 132 is provided. The sheet of material 132 may be any suitable material. For example, sheet of material 132 may be a metal, such as copper or aluminum. The sheet of material 132 has a first side portion 134 and a second side portion 136 positioned opposite each other on the sheet of material 132.

[0032] Turning now to FIG. 4, the sheet of material 132 is cut. In particular, the sheet of material 132 is cut such that a set of spine fins 138 is cut at first side portion 134 of the sheet of material 132 and at second side portion 136 of the sheet of material 132 with a base 131 positioned between the spine fins 138 at first and second sides 134, 136 of the sheet of material 132. The sheet of material 132 may be cut such that spine fins 138 at first side portion 134 of the sheet of material 132 are aligned with spine fins 138 at second side portion 136 of the sheet of material 132. For example, each cut at the first side portion 134 of the sheet of material 132 may be aligned with a respective cut at the second side portion 136 of the sheet of material 132.

[0033] Turning now to FIGS. 5 and 6, a subset of spine fins 138 are bent. Thus, a set of first spine fins 140 may remain straight or unbent and a set of second spine fins 142 may be bent relative to the first spine fins 140. Any suitable method or mechanism may be used to bend the second spine fins 142. For example, combs 150 at first and second side portions 134, 136 may include teeth 152 that are spaced apart from one another. Teeth 152 of combs 150 may be urged or pressed against second spine fins 142 in order to bend second spine fins 142 while first spine fins 140 pass between teeth 152 of combs 150. Thus, gaps between teeth 152 of combs 150 may be selected correspond to a desired number of first spine fins 140 between each pair of second spine fins 142.

[0034] Second spine fins 142 at first side portion 134 of the sheet of material 132 may be offset from second spine fins 142 at second side portion 136 of the sheet of material 132. For example, each second spine fin 142 at first side portion 134 of the sheet of material 132 may be positioned between a respective pair of second spine fins 142 at second side portion 136 of the sheet of material 132. The selection of the gaps between teeth 152 of combs 150 and/or the positioning of teeth 152 of combs at first and second side portion 134, 136 of the sheet of material 132 may assist with positioning second spine fins 142 in a desired pattern, as discussed in greater detail below.

[0035] As shown in FIG. 7, second spine fins 142 at first side portion 134 of the sheet of material 132 may be bent opposite second spine fins 142 at second side portion 136 of the sheet of material 132. In particular, second spine fins 142 at first side portion 134 of the sheet of material 132 may extend from a first surface of the sheet of material 132, and second spine fins 142 at second side portion 136 of the sheet of material 132 may extend from a second, opposite surface of the sheet of material 132. Thus, combs 150 may move in opposite directions during bending of second spine fins 142 at first and second side portion 134, 136 of the sheet of material 132.

[0036] Turning now to FIGS. 7 and 8, the sheet of material 132 is folded at a set of folds 144, e.g., into a U-shape. Thus, the sheet of material 132 may be folded at folds 144 such that spine fins 138 at first side portion 134 of the sheet of material 132 are spaced apart from spine fins 138 at second side portion 136 of the sheet of material 132 with base 131. As shown in FIG. 8, first spine fins 140 may extend perpendicularly from base 131 and second spine fins 142 may be angled relative to first spine fins 140 after folding the sheet of material 132 at set of folds 144. Turning now to FIG. 9, spine fin assembly 130 is formed and may be wrapped about a conduit to assemble a heat exchanger. For example, turning to FIG. 10, spine fin assembly 130 may be wrapped onto an outer surface 112 of conduit 110 in order to form heat exchanger 100.

[0037] As discussed above, second spine fins 142 are bent relative to first spine fins 140. In particular, each spine fin of first spine fins 140 defines an angle, α , with outer surface 112 of conduit 110 (e.g., or base 131) proximate first spine fins 140. The angle α may be about ninety degrees. As used herein, the term "about" means within ten degrees of the stated angle when used in the context of angles. Conversely, each spine fin of second spine fins 142 defines an angle, β , with outer surface 112 of conduit 110 (e.g., or base 131) proximate second spine fins 142. The angle β may be no

greater than seventy degrees. As another example, the angle β may be about forty-five degrees.

[0038] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they include structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A method for forming a heat exchanger, comprising: cutting a plurality of spine fins into a sheet of metal; bending a subset of the plurality of spine fins; folding the sheet of metal to form a spine fin strip such that the plurality of spine fins extend from a base of the spine fin strip; and wrapping the spine fin strip onto a conduit in a helical pattern at an outer surface of the conduit such that the plurality of spine fins includes spine fins that extend radially away from the outer surface of the conduit and also includes spine fins that are bent relative to the radially extending spine fins.
2. The method of claim 1, wherein said step of bending comprises utilizing a comb to bend the subset of the plurality of spine fins at said step of bending, the comb comprising a plurality of tines that are spaced apart from one another.
3. The method of claim 1, wherein the subset of the plurality of spine fins are bent such that the subset of the plurality of spine fins form vortex generators on the spine fin strip after said step of wrapping.
4. The method of claim 1, wherein each spine fin of the subset of the plurality of spine fins defines an angle, β , with the outer surface of the conduit proximate the subset of the plurality of spine fins after said step of wrapping, β being no greater than seventy degrees.
5. The method of claim 1, wherein the spine fins of the second plurality of spine fins are bent such that the spine fins of the second plurality of spine fins are distributed in a helical pattern between windings of the spine fin strip after said step of wrapping.
6. The method of claim 1, wherein the conduit comprises aluminum.
7. The method of claim 1, wherein the sheet of metal comprises aluminum.
8. A heat exchanger, comprising: a conduit having an outer surface; a spine fin strip wrapped onto the conduit in a helical pattern at the outer surface of the conduit, the spine fin strip comprising a base positioned at the outer surface of the conduit; a first plurality of spine fins extending radially from the base and away from the outer surface of the conduit; and

a second plurality of spine fins bent relative to the spine fins of the first plurality of spine fins;

wherein the base, the spine fins of the first plurality of spine fins and the spine fins of the first plurality of spine fins are formed from a common piece of sheet metal.

9. The heat exchanger of claim 8, wherein each spine fin of the first plurality of spine fins defines an angle, α , with the outer surface of the conduit proximate the first plurality of spine fins, α being about ninety degrees, each spine fin of the second plurality of spine fins defining an angle, β , with the outer surface of the conduit proximate the second plurality of spine fins, β being no greater than seventy degrees.

10. The heat exchanger of claim 8, wherein the spine fins of the second plurality of spine fins are bent such that the spine fins of the second plurality of spine fins are distributed in a helical pattern between windings of the spine fin strip.

11. The heat exchanger of claim 8, wherein the spine fins of the second plurality of spine fins are bent such that the spine fins of the second plurality of spine fins form vortex generators on the spine fin strip.

12. The heat exchanger of claim 8, wherein the conduit comprises aluminum.

13. The heat exchanger of claim 8, wherein the sheet metal comprises aluminum.

14. A heat exchanger, comprising:

a conduit having an outer surface;

a spine fin strip wrapped onto the conduit in a helical pattern at the outer surface of the conduit, the spine fin strip comprising

a base positioned at the outer surface of the conduit; a first plurality of spine fins mounted to the base, each spine fin of the first plurality of spine fins defining an angle, α , with the outer surface of the conduit proximate the first plurality of spine fins, α being about ninety degrees; and

a second plurality of spine fins mounted to the base, each spine fin of the second plurality of spine fins defining an angle, β , with the outer surface of the conduit proximate the second plurality of spine fins, β being no greater than seventy degrees;

wherein the base, the spine fins of the first plurality of spine fins and the spine fins of the first plurality of spine fins are formed from a common piece of sheet metal.

15. The heat exchanger of claim 14, wherein the spine fins of the second plurality of spine fins are distributed in a helical pattern between windings of the spine fin strip.

16. The heat exchanger of claim 14, wherein the spine fins of the second plurality of spine fins form vortex generators on the spine fin strip.

17. The heat exchanger of claim 14, wherein the conduit comprises aluminum.

18. The heat exchanger of claim 14, wherein the sheet metal comprises aluminum.

* * * * *