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(54) **INTEGRAL EVAPORATOR AND DEFROST HEATER SYSTEM**

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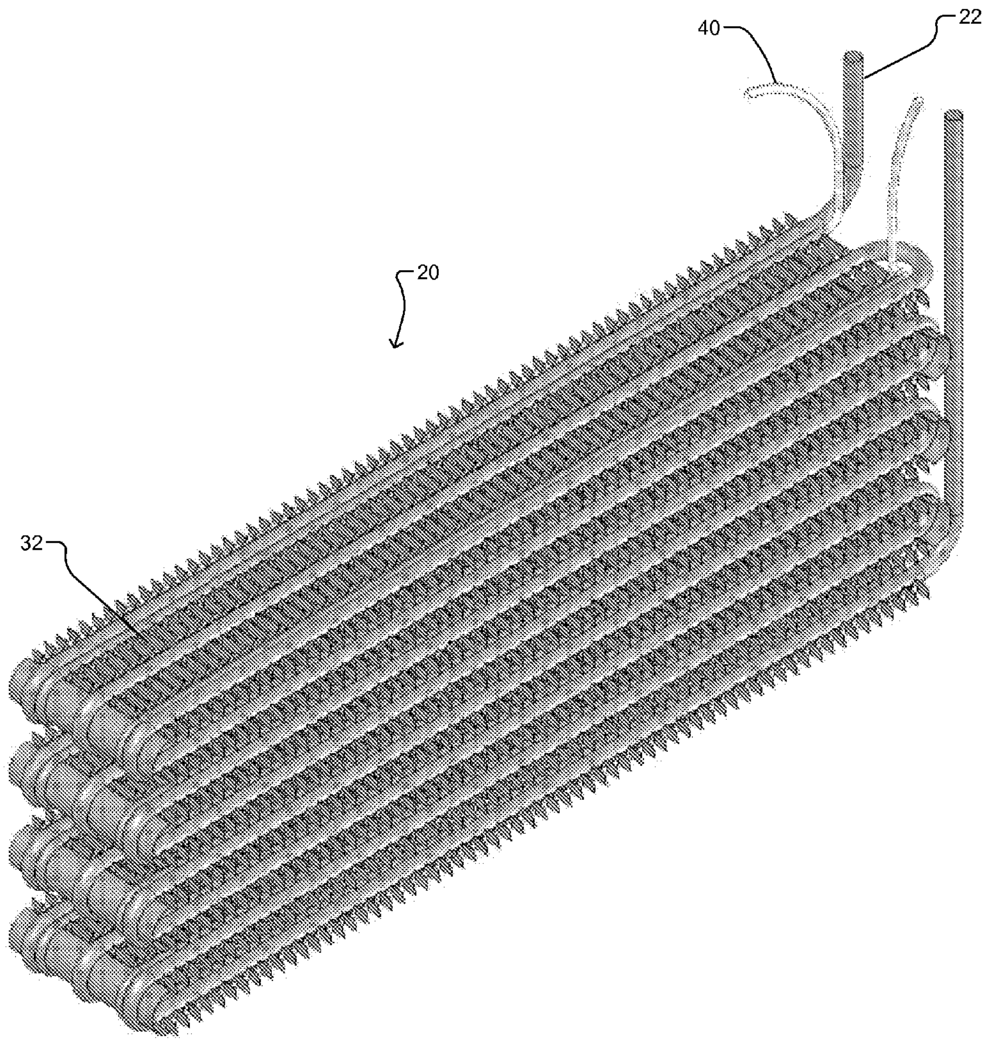
(57) **ABSTRACT**

A heat exchanger system having a fluid passage operable to fluidly communicate a first fluid and a heat transfer surface extending from the fluid passage for transferring heat between the first fluid and a second fluid. The system can further include a heating element operably coupled to and selectively applying thermal energy to at least one of the fluid passage and the heat transfer surface.



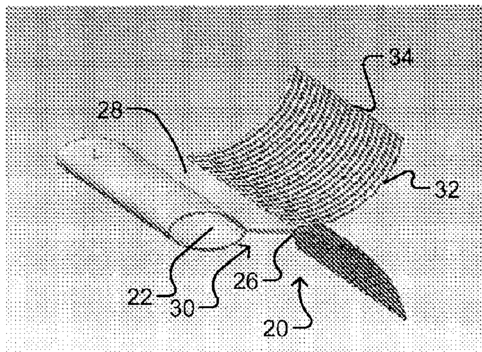


FIG. 1

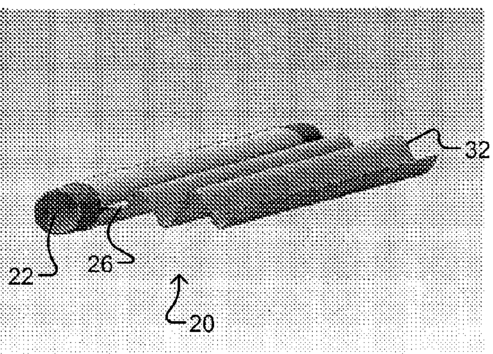


FIG. 2

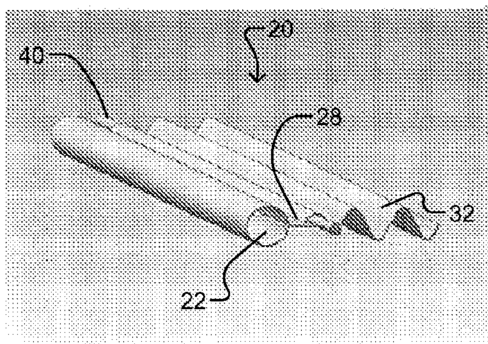


FIG. 3

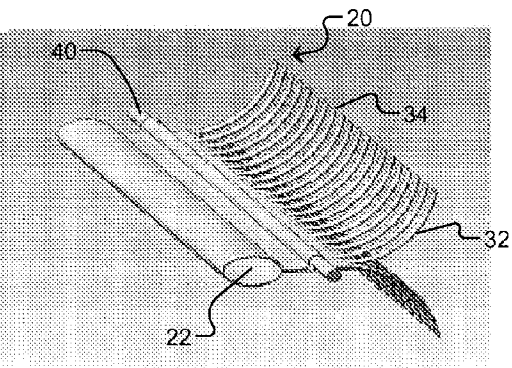


FIG. 4

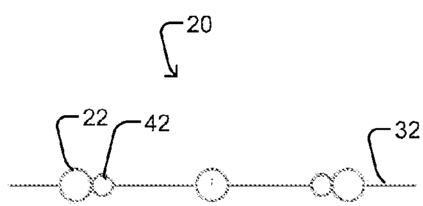


FIG. 6

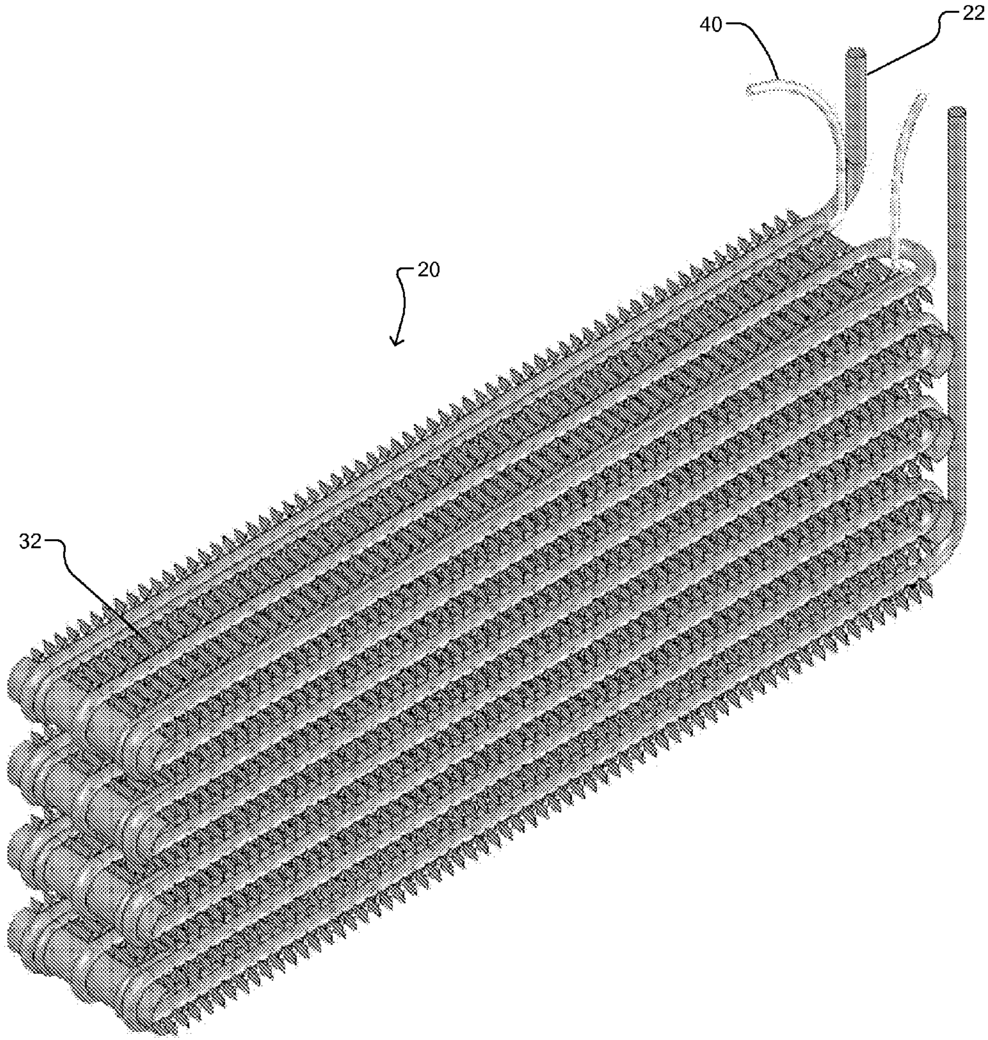


FIG. 5

INTEGRAL EVAPORATOR AND DEFROST HEATER SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/233,156, filed on Aug. 12, 2009. The entire disclosure of the above application is incorporated herein by reference.

FIELD

[0002] The present disclosure relates to heat exchangers and, more particularly, to an integrally formed evaporator having a defrost heater system.

BACKGROUND AND SUMMARY

[0003] This section provides background information related to the present disclosure which is not necessarily prior art. This section also provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0004] Heat exchangers are used in a wide variety of applications and come in a wide variety of configurations to fit these various applications. A typical heat exchanger uses a fluid transporting unit or tube portion operable to transport a fluid therethrough, such as heat conducting tubing arranged in a sinuous configuration, and a plurality of heat conducting fins (fin bank) in heat conducting contact with the tube portion. One fluid flows through the tube portion and another fluid flows along the outer surface of the tube portion between the fins thereon to transfer heat between the two fluids. Typically the tube portion is arranged in a sinuous configuration with substantially straight segments being interconnected by connecting segments (typically semicircular segments) so that the fluid flowing within the tube portion passes through the fin bank a desired number of times. Due to the differing applications that the heat exchangers are used in, the heat exchangers will come in a variety of shapes that require fins having differing quantities of columns of openings that the straight segments pass through.

[0005] The fins are typically stamped from a sheet of heat conducting material with a die configured to produce a plurality of columns of openings in the sheet for each stamp of the die (i.e., 2, 3, 4, etc. columns per stamp). The number of rows of openings in each column is determined by the height of the sheet of heat conducting material from which the fins are stamped (i.e., the sheet can have a height that yields 2, 3, 4, etc. rows of openings per stamp of the die).

[0006] Tube and fin evaporators, being a type of heat exchanger, have been used for decades in a wide variety of applications. These devices have been optimized to a point where little can be gained without a major leap in technology.

[0007] For example, in refrigeration and freezer applications, an evaporator is often installed with a defrost heater. The defrost heater must be sheathed to protect it from moisture and attached to the evaporator. The sheathing and attachment method often result in added cost that adds no additional value to the final product. Therefore, it has been found that by making the evaporator and heater an integral piece can greatly reduce the overall cost of manufacturing the product. With current technology, complex shapes must often be avoided as they tend to collect frost and are correspondingly difficult to defrost.

[0008] Therefore, according to the principles of the present teachings, a heat exchanger system is provided that comprises a fluid passage operable to fluidly communicate a first fluid and a heat transfer surface extending from the fluid passage for transferring heat between the first fluid (i.e. refrigerant) and a second fluid (i.e. air). In some embodiments, the heat exchanger system can comprise a heating element operably coupled to the fluid passage and/or the heat transfer surface to provide, in some cases, a defrost function. At least the fluid passage and the heat transfer surface can be a unitarily-formed extrusion.

[0009] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0010] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0011] FIG. **1** is a perspective view of a heat exchanger system having a plurality of spines according to some embodiments of the present teachings;

[0012] FIG. **2** is a perspective view of a heat exchanger system according to some embodiments of the present teachings;

[0013] FIG. **3** is a perspective view of a heat exchanger system having a heating system according to some embodiments of the present teachings;

[0014] FIG. **4** is a perspective view of the heat exchanger system having a heating system and a plurality of spines according to some embodiments of the present teachings;

[0015] FIG. **5** is a perspective view of a heat exchanger (evaporator) incorporating the principles of the present teachings; and

[0016] FIG. **6** is a schematic cross-sectional view of the heat exchanger system having a heating system.

[0017] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

[0018] Example embodiments will now be described more fully with reference to the accompanying drawings. Example embodiments are provided so that this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure. It will be apparent to those skilled in the art that specific details need not be employed, that example embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the disclosure.

[0019] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms “a”, “an” and “the” may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms “comprises,” “comprising,” “including,” and “having,” are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

[0020] When an element or layer is referred to as being "on", "engaged to", "connected to" or "coupled to" another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly engaged to", "directly connected to" or "directly coupled to" another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.). As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0021] Referring to FIGS. **1** and **2**, according to some embodiments of of the present teachings, a heat exchanger system **20** is provided having a fluid a fluid passage **22** extending therethrough configured and adapted to fluidly carry coolant refrigerant or other fluid therein. Heat exchanger system **20** can further comprise an integrally-formed heat transfer surface **32** extending from fluid passage **22**. Heat transfer surface **32** being configured and adapted to transfer thermal energy between the coolant refrigerant within fluid passage **22** and a fluid, such as air, external to heat exchanger system **20** adjacent heat transfer surface **32**, as will be described in greater detail.

[0022] In some embodiments, heat exchanger system **20** can comprise a thin sheet of material. This thin sheet can be made from any one of a number of materials or alloys, such as aluminum, that have desired conductivity properties. This thin sheet material can be roll formed to achieve uniformity and desired material properties.

[0023] In some embodiments, heat exchanger system **20** can be extruded as a single unitary member defining at least fluid passage **22** and heat transfer surface **32**. The extrusion can be made from any one of a number of materials or alloys, such as aluminum, that have desired conductivity and extrusion properties. It should be recognized that extruding heat exchanger system **20** provides several advantages over conventional manufacturing techniques, such as improved heat transfer capability per material weight, reduced manufacturing costs by simultaneously forming the fluid passage **22** and heat transfer surface **32**, reduced material requirements due to the improved mechanical properties of extrusions, and simplified cross-sectional shaping of the overall structure for improved fluid flow within fluid passage **22** and external to heat exchanger system **20**.

[0024] In some embodiments, heat exchanger system **20** can be contoured or otherwise shaped to any desired configuration. In some embodiments, this desired configuration generally comprises a hollow fluid passage **22** sized to carry liquid refrigerant therethrough to facilitate thermodynamic heat transfer. In some embodiments using a thin sheet material, heat exchanger system **20** can be shaped such that an end **26** of the sheet is adjacent to a mid-section **28** of the sheet. This relative proximal relationship of end **26** to mid-section **28** can extend over a sealed and/or overlapping region **30**. The sealed region **30** can be sealed to form a fluid tight connection via conventional welding, laser welding, ultrasonic welding, electric arc welding, or other means, such as brazing, bonding, or otherwise joining. It should be appreciated that sealed or overlapping region **30** can comprise any one of a number of sealing joints, such as a lap joint, butt joint, weld joint, or, in some embodiments as discussed herein, being unitarily extruded. In some embodiments, sealed region **30** can comprise a narrow layer of silicon rich alloy coated on the sheet to facilitate brazing. It should be recognized that a similar profile can be used in connection with embodiments formed through extrusion with the obvious elimination of the need to seal mid-section **28**. It should be appreciated that in some embodiments a separate fluid passage member, such as a tubular member (i.e. perhaps made of plastic or other material), can be used as fluid passage **22** and the thin sheet material can be wrapped or otherwise formed about the tubular member to minimize the complexity of ensuring fluid sealing of fluid passage **22**.

[0025] As described above, heat exchanger system **20** can further comprise heat transfer surface **32**. In some embodiments, heat transfer surface **32** can extend from mid-section **28** to form a heat transfer section particularly suited to enhanced heat transfer from the liquid refrigerant to a fluid external to heat exchanger system **20**, such as ambient air. The fluid passage **22** can be shaped or extruded to include any one of a number of shapes, such as round, oval, airfoil, and the like. Moreover, the heat exchanger system **20** can be bent or extruded in a serpentine pattern to form an evaporator to fit within the allowable envelope or the refrigeration or air conditioning device (see FIG. **5**). It should be appreciated that heat exchanger system **20** can be formed as a straight, arcuate, or other unique shape or pattern, such as spiral, sinusoidal, curved, conical, or the like.

[0026] In some embodiments, the heat transfer surface **32** can be cut or otherwise shaped to include a plurality of spines **34** that enhance heat transfer. Similarly, in some embodiments, the heat transfer surface **32** can be angled in the direction of airflow to improve heat transfer.

[0027] Heat transfer can be considered paramount in such applications and as such refrigerant passage **22** can similarly be shaped to enhance heat transfers, such as defining a round, oval, or airfoil shape.

[0028] With particular reference to FIGS. **3** and **4**, heat exchanger system **20** can further comprise a heating element **40** coupled to the thin sheet or coextruded with fluid passage **22** and heat transfer surface **32**. That is, in the thin sheet embodiments, heating element **40** can be sheathed in intimate contact with the thin sheet. Moreover, heating element **40** can be contained or otherwise sandwiched at or near sealed region **30** to protect heating element **40** from damage and further provide improved heat transfer during defrost cycles. Heating element **40** can be coupled or captured to thin sheet **22** during the forming process to simplify manufacturing thereof. In some embodiments, a heater element passage **42** can be formed during shaping of thin sheet **22** and heating element **40** can be inserted therein. The thin sheet **22** acts as the sheath for the heating element **40**.

[0029] However, in the extrusion embodiment, heating element **40** can be disposed within a heating element passage **42** formed in heat exchanger system **20**. Heating element passage **42** can be coextruded during the formation of fluid passage **22** and heat transfer surface **32** so as to form a unitary extrusion having fluid passage **22**, heat transfer surface **32**, and heating element passage **42**. In some embodiments, heating element passage **42** is extruded around heating element **40**, thereby encapsulating heating element **40**. In some embodiments, heating element passage **42** is extruded for later insertion of heating element **40**.

[0030] It should be appreciated that by incorporating heating element **40** into the structure of heat exchanger system **20**, particularly adjacent and integral with fluid passage **22** and heat transfer surface **32**, heating element **40** can more rapidly defrost the heat exchanger system, thereby allowing more complex, higher performing geometries to be used. Moreover, it should be appreciated that heating element **40** of the present teachings further provides improved defrosting efficiency due to its proximal positioning relative to fluid passage **22** and/or heat transfer surface **32**. This proximal positioning is maximized by the unique structure of the present teachings.

[0031] Therefore, according to the principles of the present teachings, a heat exchanger system is provided that comprises a fluid passage operable to fluidly communicate a first fluid and a heat transfer surface extending from the fluid passage for transferring heat between the first fluid and a second fluid. The heat exchanger system can further comprise a heating element that is operably coupled to and capable of selectively applying thermal energy to at least one of the fluid passage and the heat transfer surface. The heating element can be sheathed or otherwise covered or encapsulated to protect the heating element.

[0032] In some embodiments, the heat exchanger system can be configured such that the fluid passage and the heat transfer surface are formed from a single sheet of material. The single sheet of material can have opposing ends and can be shaped to define the fluid passage, the heat transfer surface, and a sealed area between the fluid passage and the heat transfer surface where the opposing ends are joined. These ends can be welded by laser, ultrasonics, electric arc or other means. In some embodiments, a layer of silicon rich alloy can be disposed at the overlapping area to facilitate brazing.

[0033] In some embodiments, the heat exchanger system can be configured such that the fluid passage and the heat transfer surface are a unitarily-formed extrusion. If desired, the heating element can be encapsulated within the unitarily-formed extrusion.

[0034] However, in some embodiments, a heater element passage can be formed with at least one of the fluid passage and the heat transfer surface. The heater element passage can be sized to permit subsequent insertion of the heating element therein. The heating element passage can be fluidly separate from the fluid passage. Although, in some embodiments, the heating element can be mechanically coupled to at least one of the fluid passage and the heat transfer surface. The heating element can be operated such that its thermal energy output is varied along its length for localized heating.

[0035] In some embodiments, the heat transfer surface can define a wave-like shape and/or a plurality of spines. The heat transfer surface can be angled in a direction of flow of the second fluid for improved heat transfer.

[0036] In some embodiments, the fluid passage can define a round cross-sectional shape, an oval cross-sectional shape, an airfoil cross-sectional shape, or other desired configuration.

[0037] It should be appreciated that at least one of the fluid passage and the heat transfer surface can be made of aluminum, and/or can be made of different materials.

[0038] In some embodiments, the aforementioned structure can be combined with similar structure as a multi-passage heat exchanger system and/or can define an arcuate shape. It should be appreciated that the heat exchanger system can be formed as a straight, arcuate, or other unique shape or pattern, such as spiral, serpentine, sinusoidal, curved, conical, or the like. Moreover, in some embodiments, a plurality of passages can be operably coupled to define a multi-passage heat exchanger system. The plurality of passages as described herein can be joined via connecting passage(s), jumper tube (s) and/or can comprise headers in parallel or series to form a single refrigerant carrying device. In some embodiment, only a single heating element can be used for the multi-passage heat exchanger system.

[0039] Finally, it should be appreciated that the aforementioned first fluid can comprise a refrigerant and the second fluid can comprise air.

[0040] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the invention, and all such modifications are intended to be included within the scope of the invention.

What is claimed is:

1. A heat exchanger system comprising:

a fluid passage operable to fluidly communicate a first fluid;

a heat transfer surface extending from said fluid passage for transferring heat between said first fluid and a second fluid; and

a heating element operably coupled to and selectively applying thermal energy to at least one of said fluid passage and said heat transfer surface.

2. The heat exchanger system according to claim **1** wherein said fluid passage and said heat transfer surface are formed from a single sheet of material, said single sheet of material having opposing ends and being formed to define said fluid passage, said heat transfer surface, and a sealed area whereby said opposing ends are joined.

3. The heat exchanger system according to claim **2** wherein said sealed area is welded by laser, ultrasonics, or electric arc, or brazed.

4. The heat exchanger system according to claim **2**, wherein said heating element is sheathed using said single sheet of material.

5. The heat exchanger system according to claim **1** wherein said fluid passage and said heat transfer surface are a unitarily-formed extrusion.

6. The heat exchanger system according to claim **5** wherein said heating element is encapsulated within said unitarily-formed extrusion.

7. The heat exchanger system according to claim **1**, further comprising:

a heater element passage formed with at least one of said fluid passage and said heat transfer surface, said heater element passage being sized to permit subsequent insertion of said heating element therein.

8. The heat exchanger system according to claim **7** wherein said heating element passage is fluidly separate from said fluid passage.

9. The heat exchanger system according to claim **1** wherein said heating element is mechanically coupled to at least one of said fluid passage and said heat transfer surface.

10. The heat exchanger system according to claim **1** wherein said heating element comprises varying thermal energy output along its length for localized heating.

11. The heat exchanger system according to claim **1** wherein said heat transfer surface comprises a wave-like shape.

12. The heat exchanger system according to claim **1** wherein said heat transfer surface comprises a plurality of spines.

13. The heat exchanger system according to claim **1** wherein said heat transfer surface is angled in a direction of flow of said second fluid.

14. The heat exchanger system according to claim **1** wherein said fluid passage comprises a round cross-sectional shape.

15. The heat exchanger system according to claim **1** wherein said fluid passage comprises an oval cross-sectional shape.

16. The heat exchanger system according to claim **1** wherein said fluid passage comprises an airfoil cross-sectional shape.

17. The heat exchanger system according to claim **1** wherein at least one of said fluid passage and said heat transfer surface is made of aluminum.

18. The heat exchanger system according to claim **1** wherein said fluid passage and said heat transfer surface are each made of different material.

19. The heat exchanger system according to claim **1** wherein said fluid passage, said heat transfer surface, and said heating element collectively form an arcuate shape along at least a portion thereof.

20. A heat exchanger system comprising:

a first passage operable to fluidly communicate a first fluid;

a first heat transfer surface extending from said first passage for transferring heat between said first fluid and a second fluid;

a first heating element operably coupled to and selectively applying thermal energy to at least one of said first passage and said first heat transfer surface;

a second passage operable to fluidly communicate said first fluid;

a second heat transfer surface extending from said second passage for transferring heat between said first fluid and a second fluid; and

a connecting passage fluidly coupling said first passage and said second passage for communication of said first fluid.

21. The heat exchanger system according to claim **20** wherein at least said first passage and said second passage together forming an arcuate shape along at least a portion thereof.

22. The heat exchanger system according to claim **20** wherein at least said first passage and said first heat transfer surface are a unitarily-formed extrusion.

23. The heat exchanger system according to claim **20**, further comprising:

a second heating element operably coupled to at least one of said second passage and said second heat transfer surface.

24. The heat exchanger system according to claim **20** wherein said first passage and said first heat transfer surface are formed from a single sheet of material, said single sheet of material having opposing ends and being formed to define said first passage, said first heat transfer surface, and a sealed area whereby said opposing ends are joined.

25. The heat exchanger system according to claim **20** wherein said connecting passage fluidly couples said first passage and said second passage in parallel.

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