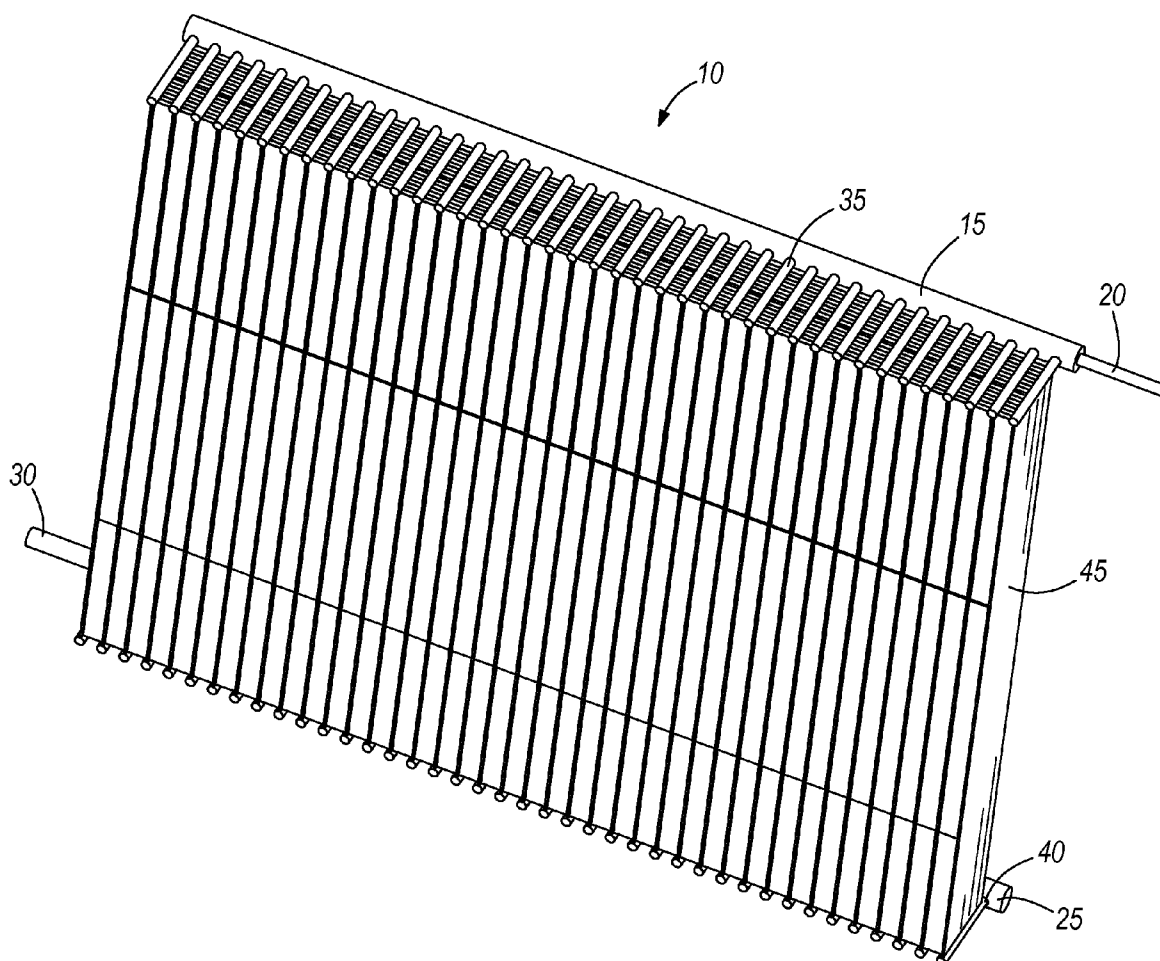


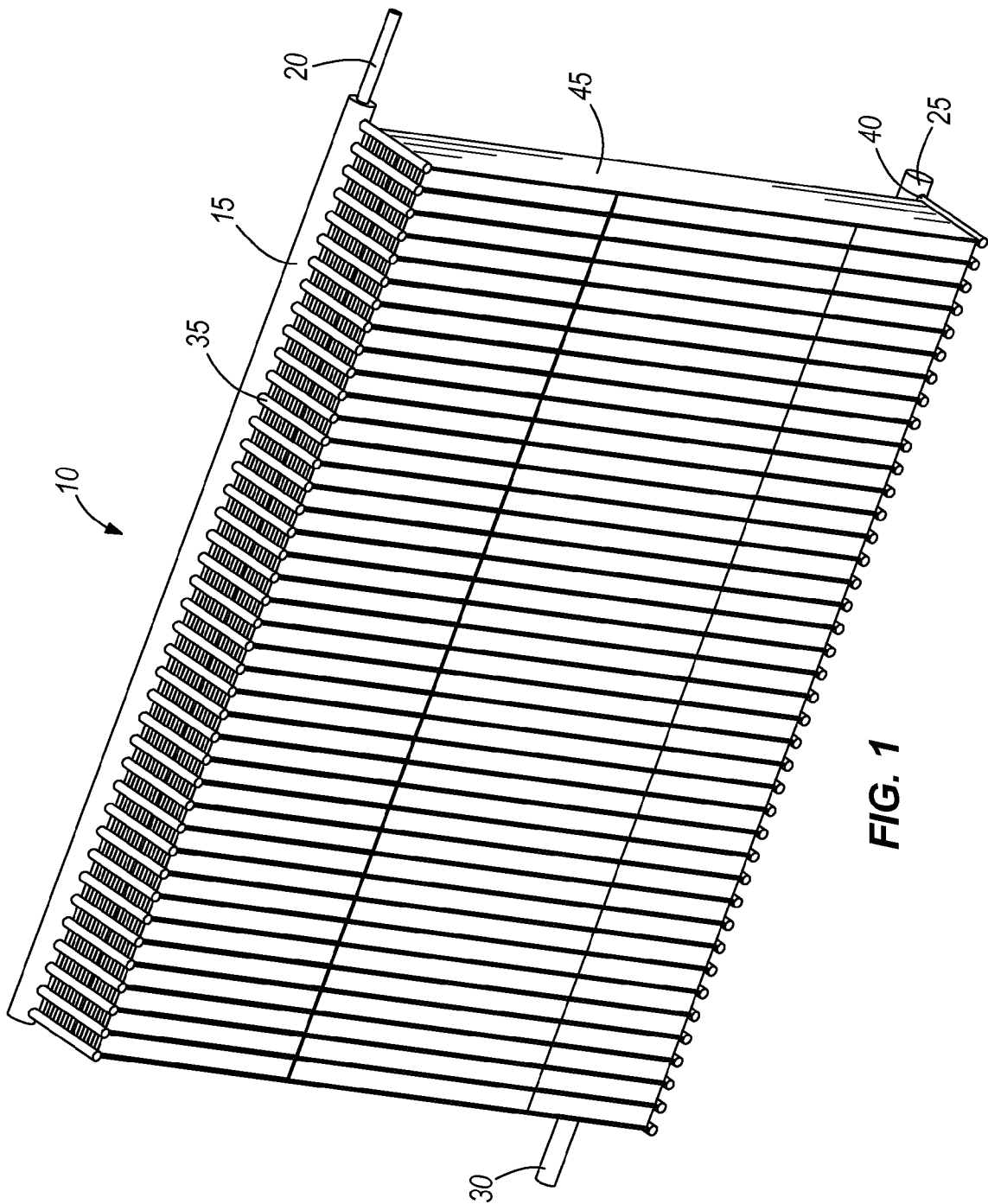


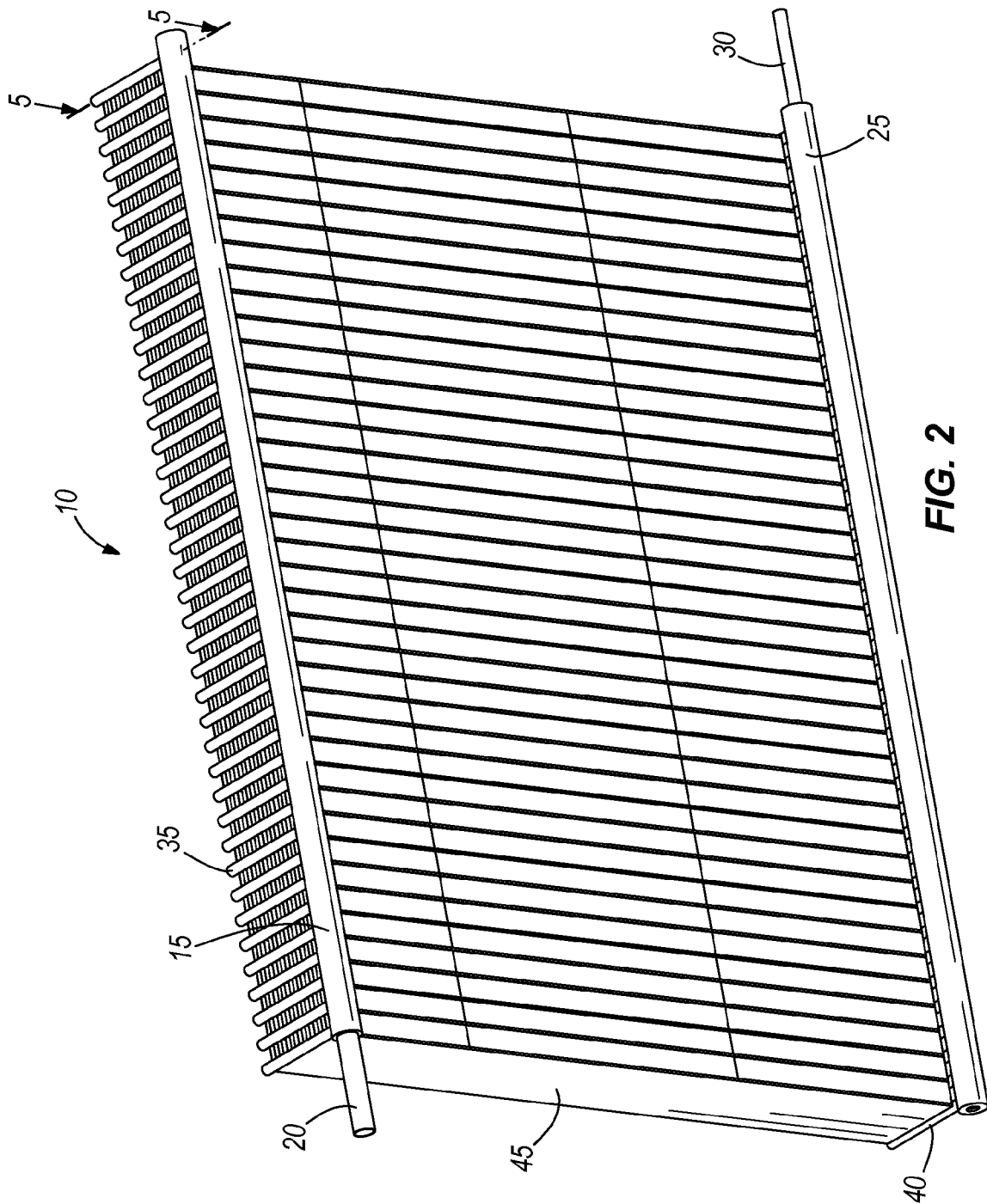
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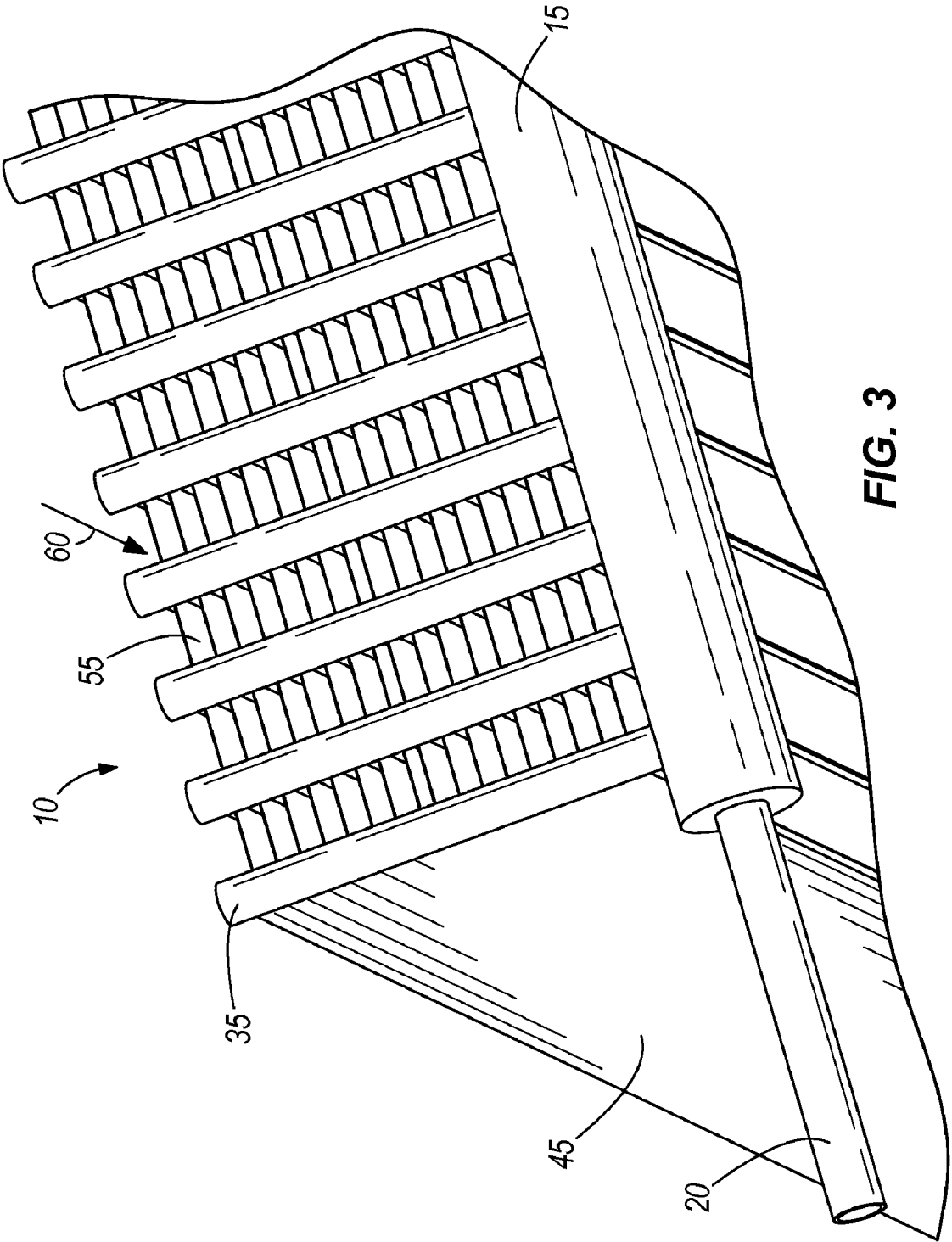
(19) **United States**(12) **Patent Application Publication**
Anderson(10) **Pub. No.: US 2012/0291998 A1**(43) **Pub. Date: Nov. 22, 2012**(54) **MICROCHANNEL HYBRID EVAPORATOR**(76) Inventor: **Timothy D. Anderson**, St. Louis,
MO (US)(21) Appl. No.: **13/472,975**(22) Filed: **May 16, 2012****Related U.S. Application Data**(60) Provisional application No. 61/486,521, filed on May
16, 2011.**Publication Classification**(51) **Int. Cl.**
F28D 15/00 (2006.01)(52) **U.S. Cl.** **165/104.14**(57) **ABSTRACT**

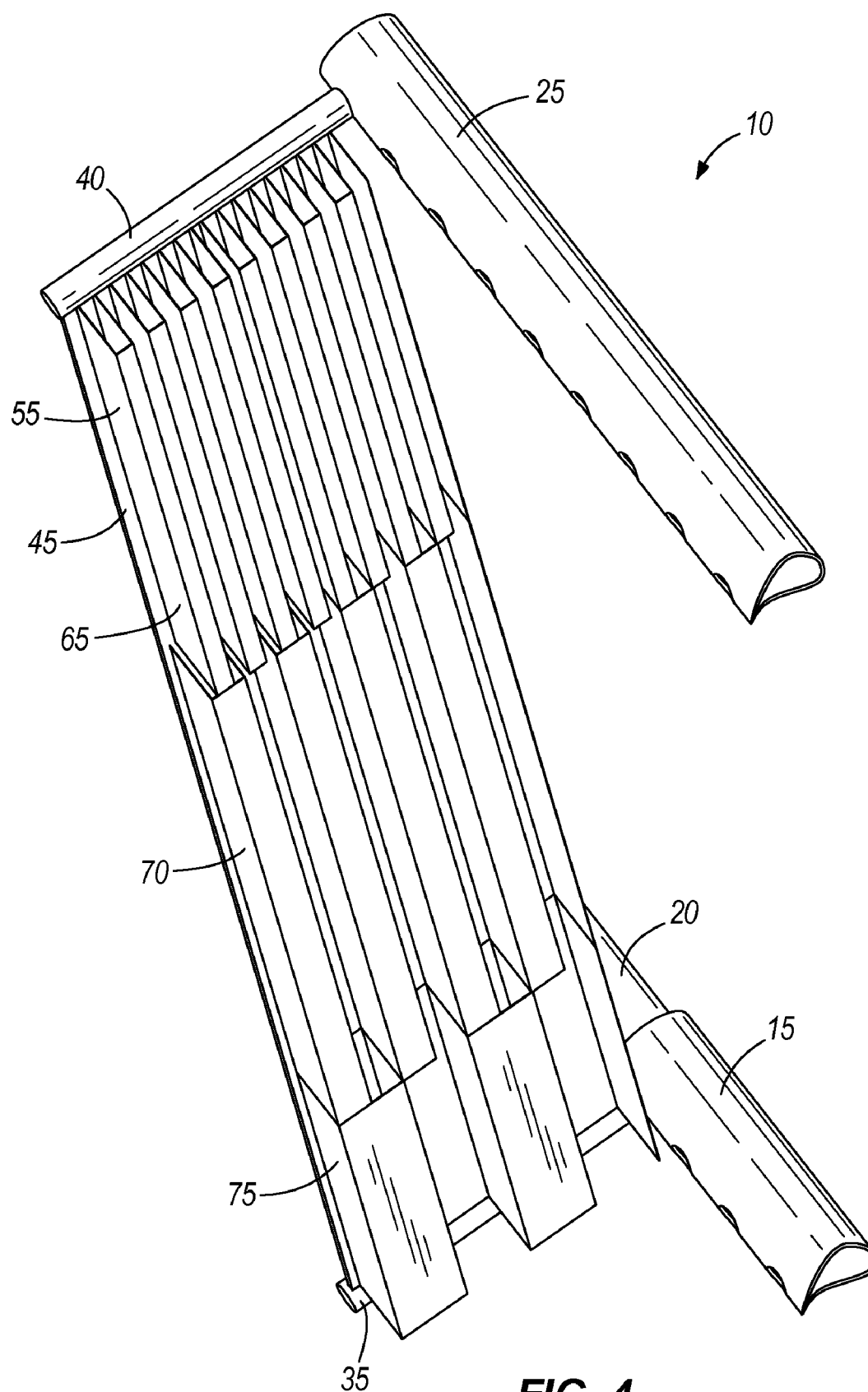
A heat exchanger including a primary inlet manifold that has an inlet port to receive refrigerant from a source, a primary outlet manifold that has an outlet port to discharge refrigerant from the heat exchanger, and a plurality of microchannel tubes fluidly connected between the primary inlet manifold and the primary outlet manifold and spaced apart from each other. Each of the plurality of microchannel tubes has a secondary inlet manifold fluidly coupled to the primary inlet manifold, a secondary outlet manifold fluidly coupled to the primary outlet manifold, and at least one microchannel fluidly coupled between the secondary inlet manifold and the secondary outlet manifold to direct refrigerant to the secondary outlet manifold. The heat exchanger also includes a plurality of fins disposed between adjacent microchannel tubes and oriented to define an airflow path along the longitudinal direction of the microchannel tubes.











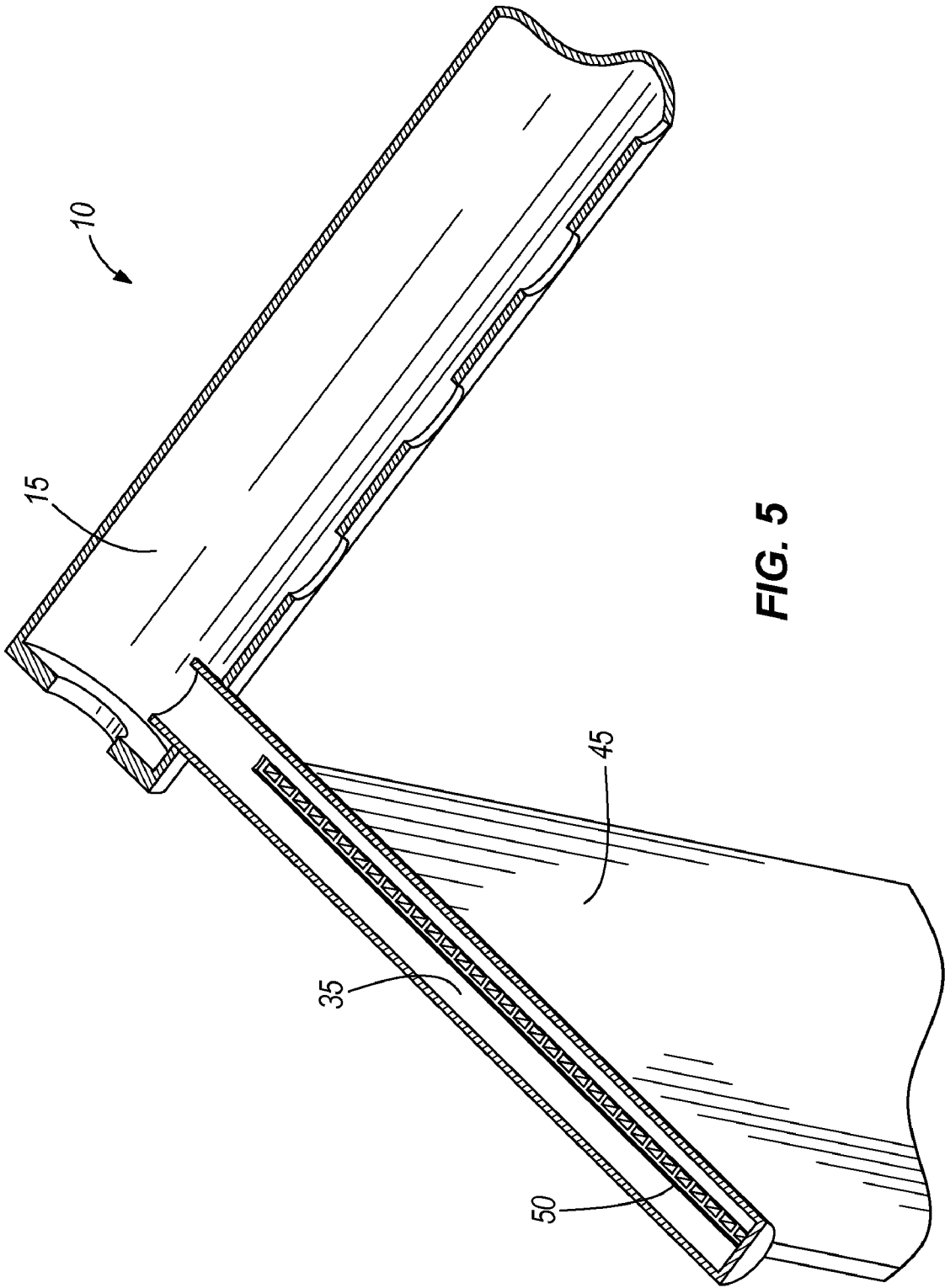
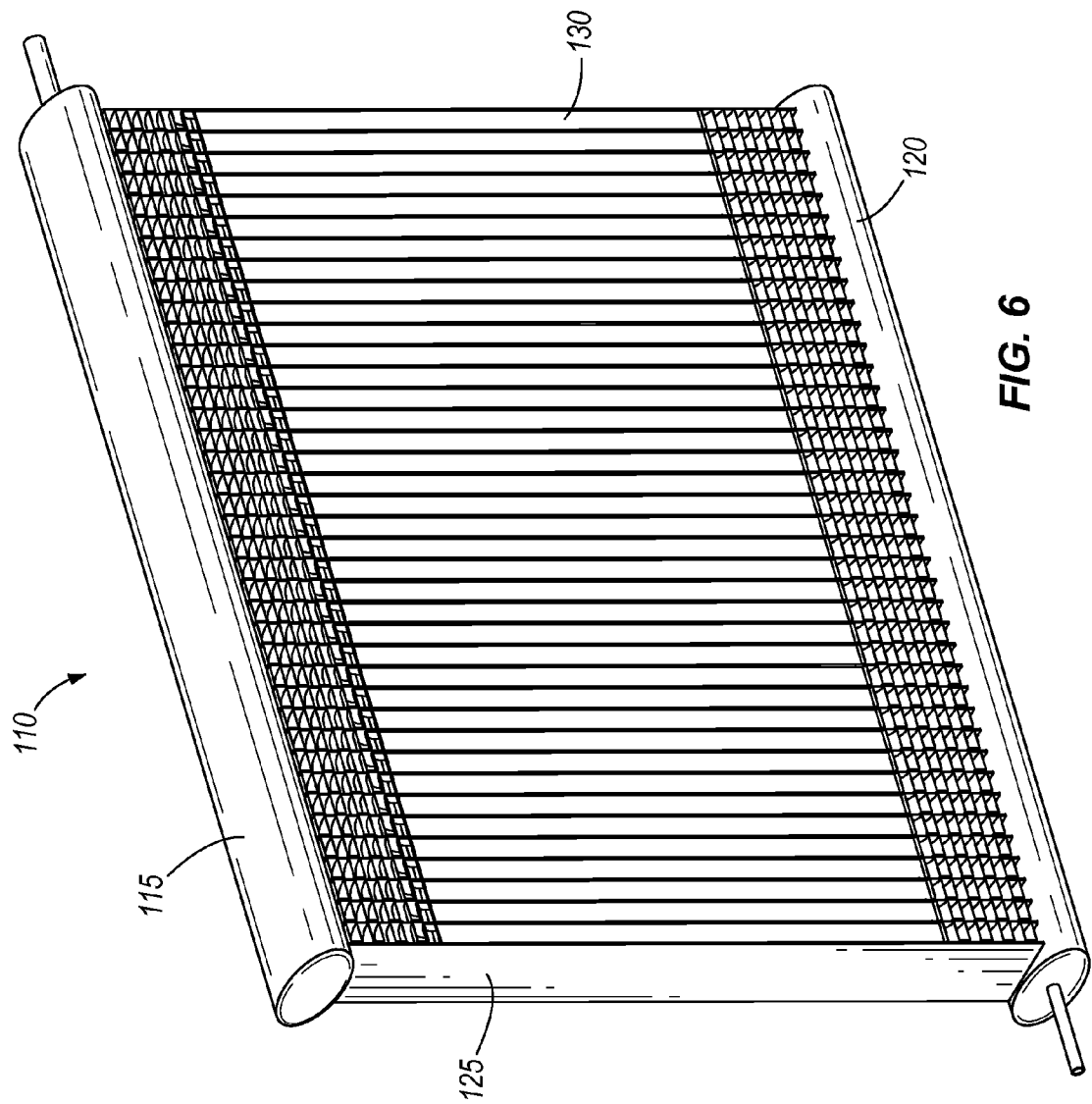


FIG. 5



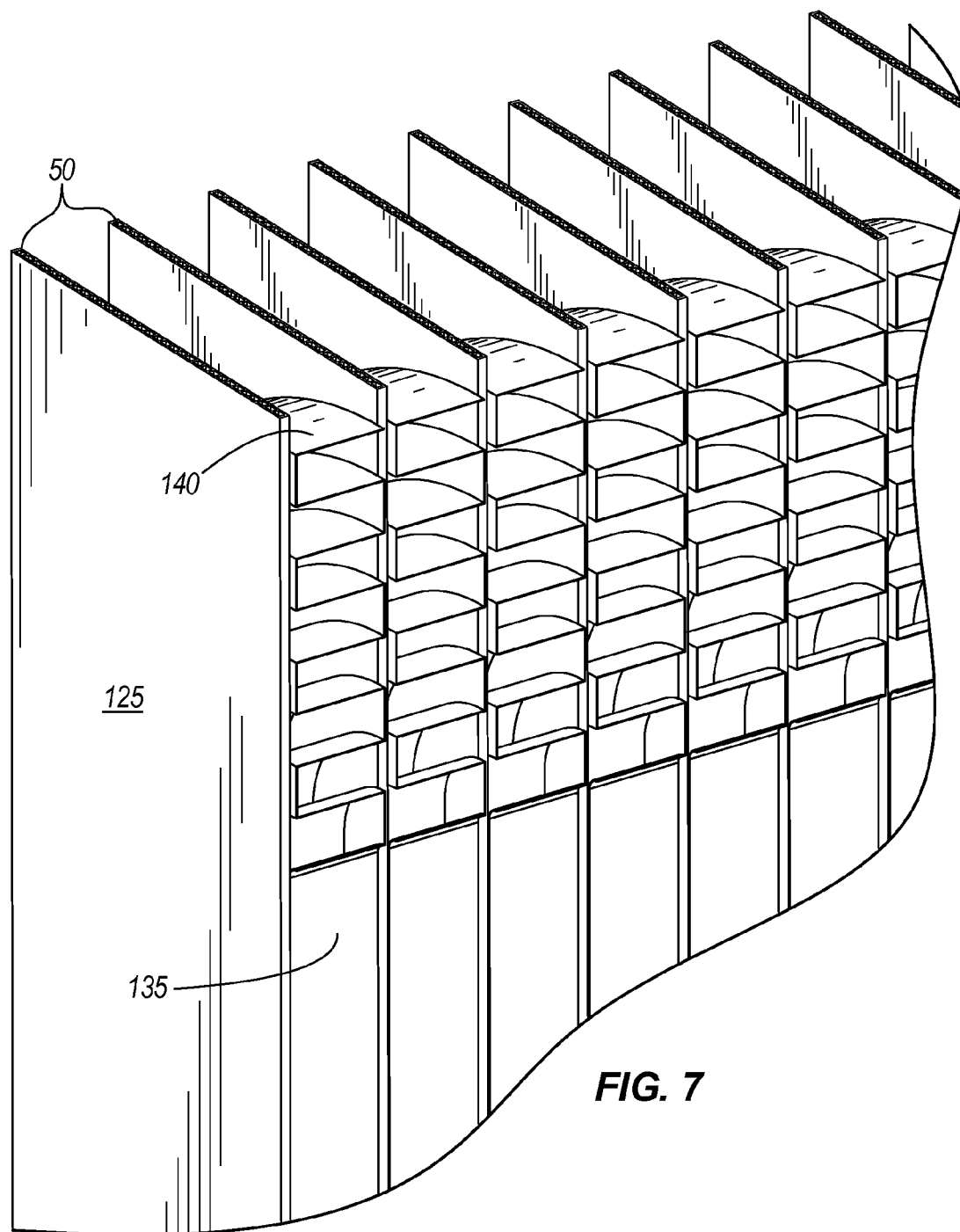


FIG. 7

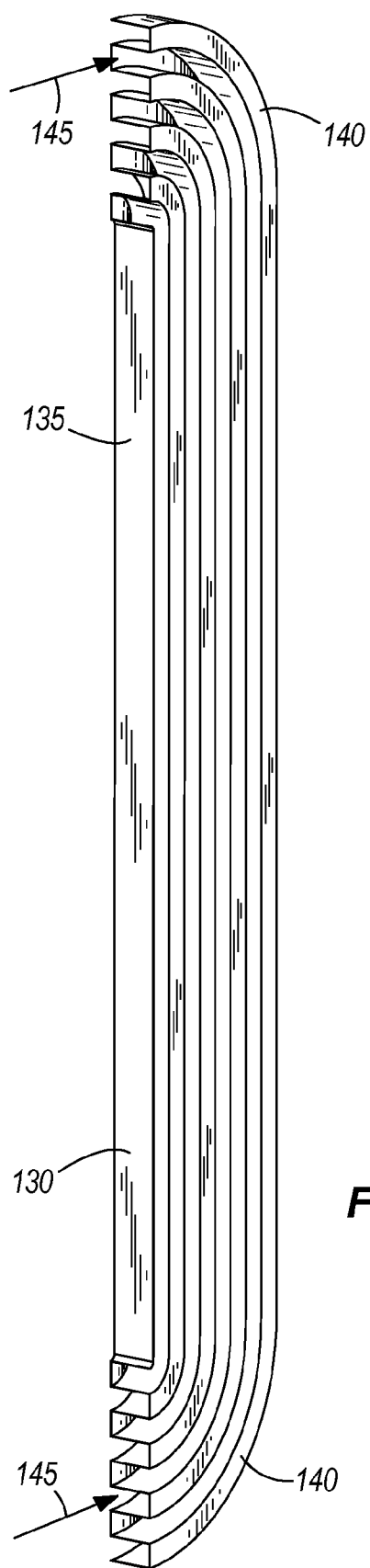


FIG. 8

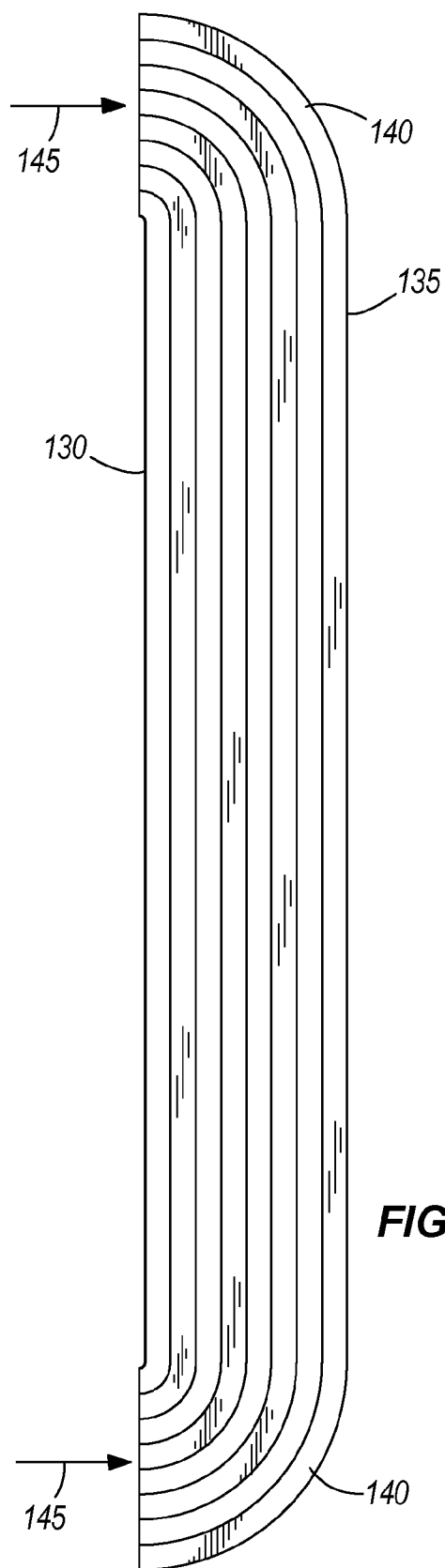


FIG. 9

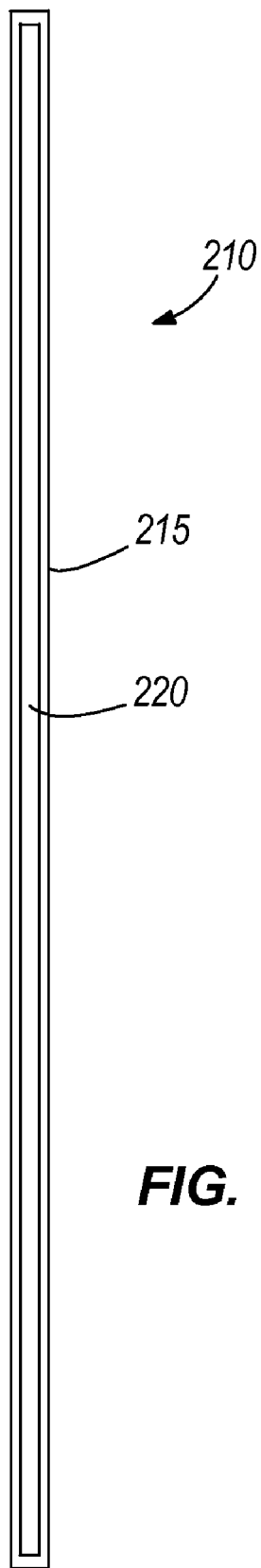


FIG. 10

MICROCHANNEL HYBRID EVAPORATOR

RELATED APPLICATIONS

[0001] This patent application claims priority to U.S. Provisional Patent Application Ser. No. 61/486,521 filed May 16, 2011, the entire contents of which are hereby incorporated by reference.

BACKGROUND

[0002] The present invention relates to an evaporator, and more particularly to a microchannel evaporator.

[0003] In conventional practice, many refrigeration circuits utilize an evaporator including a coil that is formed from round copper or aluminum tubing. Other refrigeration circuits utilize an evaporator that includes a coil with microchannel tubes and fins in very high densities that can only operate at refrigerant temperatures above 32 degrees Fahrenheit due to rapid ice buildup in the fins at temperatures below 32 degrees Fahrenheit.

SUMMARY

[0004] The invention provides a heat exchanger that includes microchannel tubes and fins for use in low (e.g., -20 degrees Fahrenheit) and medium-temperature (e.g., 26 degrees Fahrenheit) refrigeration applications. The evaporator can achieve a discharge air temperature that is as close as possible to the temperature of the refrigerant inside the coil, which allows for higher refrigerant temperatures in the coil to be used, which saves energy. The evaporator can reduce the refrigerant charge of the system by using microchannel ports inside of the coil rather than traditional round copper or aluminum tubes. The evaporator can be modular or full length such that it is the same nominal length as a merchandiser. The evaporator can vary in depth, height, and width. Refrigerant may enter and exit on the same side of the coil, on opposite sides of the coil, or somewhere in between the ends of the larger manifolds. Sandwiched between the microchannel tubes are fins which can vary in density from one to ten fins per inch depending upon the temperature application. The fins can have a variety of shapes (e.g., triangular, offset strips, wavy, louvered, perforated, etc.). Fin density in the evaporator can be the same or varied in different areas of the evaporator. Fin density can be varied along the coil such that a lower fin density can be used at the air inlet side of the coil to remove moisture from an air flow. As more moisture is removed from the air passing through the coil, higher fin densities can be used, especially near the outlet. For low temperature applications fin density can be decreased as needed to accommodate buildup of frost.

[0005] In one construction, the invention provides a heat exchanger including a primary inlet manifold that has an inlet port to receive refrigerant from a source, a primary outlet manifold that has an outlet port to discharge refrigerant from the heat exchanger, and a plurality of microchannel tubes fluidly connected between the primary inlet manifold and the primary outlet manifold and spaced apart from each other. Each of the plurality of microchannel tubes has a secondary inlet manifold fluidly coupled to the primary inlet manifold, a secondary outlet manifold fluidly coupled to the primary outlet manifold, and at least one microchannel fluidly coupled between the secondary inlet manifold and the secondary outlet manifold to direct refrigerant to the secondary outlet manifold. The heat exchanger also includes a plurality of fins

disposed between adjacent microchannel tubes and oriented to define an airflow path along the longitudinal direction of the microchannel tubes.

[0006] In another construction, the invention provides a heat exchanger including an inlet manifold that has an inlet port to receive refrigerant from a source, an outlet manifold that has an outlet port to discharge refrigerant from the heat exchanger, and a plurality of refrigerant tubes fluidly connected between the inlet manifold and the outlet manifold and spaced apart from each other. Each of the plurality of microchannel tubes has a plurality of microchannels. The heat exchanger also includes a plurality of fins positioned between adjacent microchannel tubes and having an airflow inlet oriented to receive an airflow and an airflow outlet, the fins defining a fin density that varies along the length of the refrigerant tubes based on the location of the fins relative to the airflow inlet and the airflow outlet.

[0007] In another construction, the invention provides a heat exchanger including a primary inlet manifold that has an inlet port to receive refrigerant from a source, a primary outlet manifold that has an outlet port to discharge refrigerant from the heat exchanger, and a plurality of microchannel tubes fluidly connected between the primary inlet manifold and the primary outlet manifold and spaced apart from each other. Each of the plurality of microchannel tubes has a secondary inlet manifold fluidly coupled to the primary inlet manifold, a secondary outlet manifold fluidly coupled to the primary outlet manifold, and a plurality of microchannels fluidly coupled between the secondary inlet manifold and the secondary outlet manifold to direct refrigerant to the secondary outlet manifold. The heat exchanger also includes a plurality of fins disposed between adjacent microchannel tubes. The fins have an airflow inlet oriented to receive an airflow and an airflow outlet, and define a first fin portion that has a first fin density and a second fin portion that has a second fin density such that the density of the fins varies along the length of the refrigerant tubes based on the location of the fins relative to the airflow inlet and the airflow outlet.

[0008] Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a perspective view of an evaporator embodying the invention.

[0010] FIG. 2 is another perspective view of the evaporator of FIG. 1.

[0011] FIG. 3 is an enlarged view of a portion of the evaporator of FIG. 2.

[0012] FIG. 4 is a perspective view exposing a portion of the evaporator.

[0013] FIG. 5 is a cross-section view of a portion of the evaporator taken along line 5-5 of FIG. 2.

[0014] FIG. 6 is a perspective view of another evaporator embodying the invention.

[0015] FIG. 7 is a perspective view of a portion of the evaporator of FIG. 6.

[0016] FIG. 8 is a perspective view of another portion of the evaporator of FIG. 6.

[0017] FIG. 9 is a side view of the portion of the evaporator of FIG. 8.

[0018] FIG. 10 is a cross-section view of a portion of another evaporator embodying the invention.

[0019] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways.

DETAILED DESCRIPTION

[0020] FIGS. 1 and 2 illustrate an evaporator 10 that can be used as part of a refrigeration system (not shown) in low-temperature refrigeration applications (e.g., -20 degrees Fahrenheit) and medium-temperature refrigeration applications (e.g., 26 degrees Fahrenheit) in a retail setting (e.g., grocery stores or supermarkets) to provide heat transfer from the refrigerant in the evaporator 10 to air flowing through the evaporator 10. The evaporator 10 can be used in conjunction with refrigerated merchandisers, walk-in coolers, walk-in freezers, or other cold storage spaces.

[0021] As shown in FIGS. 1-4, the evaporator 10 includes a primary inlet manifold 15 that has an inlet port 20 for receiving refrigerant, and a primary outlet manifold 25 that has an outlet port 30 for discharging refrigerant from the evaporator 10. Refrigerant can enter and exit on the same side of the evaporator 10, on opposite sides of the evaporator 10, or somewhere between the ends of the manifolds 15, 25. The evaporator 10 also includes a plurality of secondary inlet manifolds 35 that are fluidly coupled to the primary inlet manifold 15, a plurality of secondary outlet manifolds 40 that are fluidly coupled to the primary outlet manifold 25, and flat tubes 45 that are fluidly coupled between the secondary inlet manifolds 35 and the secondary outlet manifolds 40. The secondary inlet manifolds 35 are spaced apart from each other along the length of the primary inlet manifold 15, and the secondary outlet manifolds are spaced apart from each other along the length of the primary outlet manifold 25.

[0022] The flat tubes 45 can be spaced at different or varying distances relative to each other to maximize performance of the evaporator 10 at low and medium temperatures. As illustrated in FIG. 5, the flat tubes 45 include multiple internal passageways or microchannels 50. Generally, the microchannels 50 are much smaller in size than the internal passageway of a conventional fin-and-tube evaporator coil. The microchannels 50 can be defined by any suitable cross-section (e.g., rectangular, triangular, circular, oval, etc.) for distributing refrigerant.

[0023] As illustrated in FIG. 3, the evaporator 10 includes a plurality of fins 55 that are coupled between adjacent flat tubes 45. As illustrated, the fins 55 are oriented within the evaporator 10 to define an airflow path that receives an airflow 60 in a generally downward direction along the length of the flat tubes 45 (i.e., along the longitudinal direction of the tubes 45). In other constructions, the fins 55 can receive air from any suitable direction. The fins 55 can have any suitable cross-sectional shape (e.g., rectangular, oval, circular, triangular, offset strips, wavy, louvered, perforated, etc.).

[0024] The fins 55 vary in density along the length of the flat tube 45. With reference to FIG. 4, the evaporator 10 is defined by a first density fin portion 65 located adjacent the secondary outlet manifolds 40, a second density fin portion 70 at a central area of the flat tubes 45, and a third density fin portion 75 located adjacent the secondary inlet manifolds 35. The second density fin portion 70 is less dense than the first density fin portion 65, and the third density fin portion 75 is

less dense than the second fin density portion 65. For example, the fins 55 can vary in density from one to ten fins per inch between the first density fin portion 65, the second density fin portion 70, and the third density fin portion 75 depending on the temperature application. In the illustrated construction, the first, second, and third fin density portions 65, 70, 75 do not overlap. In other constructions, the first, second, and third fin density portions 65, 70, 75 may overlap. Generally, the fins 55 can have any shape suitable for heat transfer.

[0025] FIGS. 6-9 illustrate another evaporator 110 for use in a refrigeration system. Except as described below, the evaporator 110 is the same as the evaporator 10 described with regard to FIGS. 1-5, and like elements have been given the same reference numerals.

[0026] With reference to FIG. 6, the evaporator 110 includes a single inlet manifold 115 and a single outlet manifold 120. The inlet manifold 115 and the outlet manifold 120 are fluidly coupled via flat tubes 125. As illustrated in FIG. 6, a plurality of fins 130 are coupled between adjacent flat tubes 125. With reference to FIGS. 7-9, the fins 130 include a rectangular-shaped body portion 135 and a curved end portion 140, on each end. As illustrated in FIGS. 8 and 9, the fins 130 are positioned to receive an airflow 145. In other constructions, the fins 130 may be other shapes and receive air in other directions.

[0027] FIG. 10 illustrates another evaporator 210. Except as described below, the evaporator 210 is the same as the evaporator 10 described with regard to FIGS. 1-5. In particular, the illustrated evaporator 210 includes a plurality of microchannels 215 (one shown). As illustrated, the microchannel 215 has a large or over-sized cavity 220 to accommodate liquid cooling fluids (e.g., 35 percent propylene glycol).

[0028] In operation, the evaporator 10, 110, 210 functions as part of a two-phase refrigeration system in which the evaporator 10, 110, 210 receives low-pressure, low-temperature liquid refrigerant, removes heat from an airflow (e.g., airflow 60, 145) that passes through the evaporator 10, 110, 210, and discharges gaseous refrigerant to one or more compressors (not shown). The low-pressure, low-temperature liquid refrigerant evaporates as it passes through the evaporator 10, 110, 210 such that the refrigerant passes through a substantial portion of the evaporator 10, 110, 210 as a two-phase mixture (i.e., a liquid-gas state).

[0029] With reference to the evaporator 10, for example, the inlet port 20 directs low-pressure, low-temperature liquid refrigerant into the primary inlet manifold 15, which provides refrigerant to the plurality of second inlet manifolds 35. The second inlet manifolds 35 direct refrigerant to the plurality of flat tubes 45 where the refrigerant is then directed through the microchannels 50. The refrigerant flows from the microchannels 50 to the plurality of secondary outlet manifolds 40, and then to the primary outlet manifold 25 before reaching the outlet port 30.

[0030] The evaporator 10, 110, 210 achieves a discharge air temperature that is as close as possible to the temperature of the refrigerant inside the coil. The similarity in temperatures between the refrigerant and the air flowing through the evaporator 10, 110, 210 results in higher refrigerant temperatures in the coil, which reduces energy costs because it is more likely that the refrigerant directed to the compressors will be in a gaseous state. The microchannels 50, 215 minimize the refrigerant charge of the refrigeration system as compared to

conventional evaporators with round copper or aluminum tubes. The evaporator **10, 110, 210** can be modular or full length, and the size (e.g., depth, height, or width) can vary depending on the size and type of merchandiser in which the evaporator **10, 110, 210** will be used.

[0031] The evaporator **10, 110, 210** accommodates multiple or variable fin densities and microchannel tube spacing to maximize performance of the evaporator **10, 110, 210** based on the temperature application in which the evaporator **10, 110, 210** will be used. For example, the fin density can be varied in the evaporator **10, 110, 210** so that a low fin density (e.g., third density fin portion **75**) is oriented at the air inlet side of the evaporator **10, 110, 210** to remove moisture from an air flow to minimize frosting of the evaporator **10, 110, 210**. As moisture is removed from the air passing through the evaporator **10, 110, 210**, higher fin densities (e.g., first density fin portion **65**, second density fin portion **70**) can be oriented adjacent the middle and outlet-side of the evaporator **10, 110, 210**. In low temperature applications, the fin density of the evaporator **10, 110, 210** can be further decreased relative to medium temperature applications to minimize frost buildup.

[0032] The primary inlet manifold **15, 115** distributes refrigerant to the microchannels **50, 215** so that the latent heat absorbed by the refrigerant is as high as possible without frosting the evaporator **10, 110, 210**. With regard to the evaporator **10**, for example, the plurality of secondary inlet manifolds **35** evenly distribute refrigerant from primary inlet manifold **15** to the microchannels **50**. Similarly, the plurality of secondary outlet manifolds evenly distribute heated refrigerant from the microchannels **50** to the primary outlet manifold **35**.

[0033] Various features and advantages of the invention are set forth in the following claims.

1. A heat exchanger comprising:
 - a primary inlet manifold including an inlet port to receive refrigerant from a source;
 - a primary outlet manifold including an outlet port to discharge refrigerant from the primary outlet manifold;
 - a plurality of microchannel tubes fluidly connected between the primary inlet manifold and the primary outlet manifold and spaced apart from each other, each of the plurality of microchannel tubes including a secondary inlet manifold fluidly coupled to the primary inlet manifold, a secondary outlet manifold fluidly coupled to the primary outlet manifold, and at least one microchannel fluidly coupled between the secondary inlet manifold and the secondary outlet manifold to direct refrigerant to the secondary outlet manifold; and
 - a plurality of fins disposed between adjacent microchannel tubes and oriented to define an airflow path along the longitudinal direction of the microchannel tubes.
2. The heat exchanger of claim 1, wherein the plurality of microchannel tubes are spaced apart from each other along the length of the primary inlet manifold.
3. The heat exchanger of claim 1, wherein the microchannel tubes extend substantially vertically and the fins are oriented such that an airflow is directed in a generally vertical direction along the airflow path.
4. The heat exchanger of claim 1, wherein the fins have one of a rectangular cross-sectional shape, a triangular cross-sectional shape, a curved cross-sectional shape.
5. The heat exchanger of claim 4, wherein the fins define a fin density that varies along the length of each of the microchannel tubes.

6. The heat exchanger of claim 1, wherein the fins have one of a wavy profile, a louvered profile, and a perforated profile.

7. The heat exchanger of claim 1, wherein the primary inlet manifold and the primary outlet manifold are oriented substantially horizontal, and wherein the secondary inlet manifold is oriented at a non-zero angle relative to the primary inlet manifold and the secondary outlet manifold is oriented at a non-zero angle relative to the primary outlet manifold.

8. A heat exchanger comprising:

- an inlet manifold including an inlet port to receive refrigerant from a source;
- an outlet manifold including an outlet port to discharge refrigerant from the primary outlet manifold;
- a plurality of refrigerant tubes fluidly connected between the inlet manifold and the outlet manifold and spaced apart from each other, each of the plurality of microchannel tubes including a plurality of micro channels; and
- a plurality of fins positioned between adjacent microchannel tubes and having an airflow inlet oriented to receive an airflow and an airflow outlet, the fins defining a fin density that varies along the length of the refrigerant tubes based on the location of the fins relative to the airflow inlet and the airflow outlet.

9. The heat exchanger of claim 8, wherein the fin density of the fins located adjacent the airflow inlet is lower than the fin density of the fins located adjacent the airflow outlet.

10. The heat exchanger of claim 9, wherein the fins define a first fin portion having a first fin density and a second fin portion having a second fin density that is lower than the first fin density.

11. The heat exchanger of claim 10, wherein the fins further define a third fin portion having a third fin density that is lower than the second fin density.

12. The heat exchanger of claim 8, wherein the fins are oriented to define an airflow path along the longitudinal direction of the microchannel tubes.

13. The heat exchanger of claim 12, wherein the refrigerant tubes extend substantially vertically and the fins are oriented such that an airflow is directed in a generally vertical direction along the airflow path.

14. The heat exchanger of claim 8, wherein the fins have one of a rectangular cross-sectional shape, a triangular cross-sectional shape, a curved cross-sectional shape, a wavy profile, a louvered profile, and a perforated profile.

15. The heat exchanger of claim 8, wherein the fins are defined by a body portion and end portions on both ends, at least one of the end portions defining one of the airflow inlet and the airflow outlet on a face side of the heat exchanger.

16. The heat exchanger of claim 15, wherein the fins include curved end portions on both ends such that the airflow inlet and the airflow outlet are disposed in at least one face side of the heat exchanger.

17. The heat exchanger of claim 16, wherein each of the body portion and the curved end portions are defined by a substantially rectangular cross-section.

18. The heat exchanger of claim 15, wherein the airflow inlet and the airflow outlet are disposed on the same face side of the heat exchanger.

19. The heat exchanger of claim 18, wherein the airflow inlet and the airflow outlet are defined by a substantially rectangular cross-section.

20. A heat exchanger comprising:

a primary inlet manifold including an inlet port to receive refrigerant from a source;

a primary outlet manifold including an outlet port to discharge refrigerant from the primary outlet manifold;

a plurality of microchannel tubes fluidly connected between the primary inlet manifold and the primary outlet manifold and spaced apart from each other, each of the plurality of microchannel tubes including a secondary inlet manifold fluidly coupled to the primary inlet manifold, a secondary outlet manifold fluidly coupled to the primary outlet manifold, and a plurality of microchannels fluidly coupled between the secondary inlet manifold and the secondary outlet manifold to direct refrigerant to the secondary outlet manifold; and

a plurality of fins disposed between adjacent microchannel tubes and having an airflow inlet oriented to receive an

airflow and an airflow outlet, the fins defining a first fin portion having a first fin density and a second fin portion having a second fin density such that the density of the fins varies along the length of the refrigerant tubes based on the location of the fins relative to the airflow inlet and the airflow outlet.

21. The heat exchanger of claim **20**, wherein the first fin portion is disposed adjacent the secondary outlet manifold and the first fin density is higher than the second fin density.

22. The heat exchanger of claim **21**, wherein the fins further define a third fin portion disposed adjacent the secondary inlet manifold and has a third fin density that is lower than the second fin density.

23. The heat exchanger of claim **20**, wherein the fins are oriented to define an airflow path along the longitudinal direction of the microchannel tubes.

* * * * *