US 20040099408A1

(19) **United States**
(12) **Patent Application Publication**
(10) **Pub. No.: US 2004/0099408 A1**
(43) **Pub. Date: May 27, 2004**

Shabtay et al.

(54) **INTERCONNECTED MICROCHANNEL TUBE**

(76) Inventors: **Yoram Leon Shabtay**, Prospect Heights, IL (US); **Liangyou Tang**, Cottontown, TN (US)

Correspondence Address:
WINSTON & STRAWN
PATENT DEPARTMENT
1400 L STREET, N.W.
WASHINGTON, DC 20005-3502 (US)

(21) Appl. No.: **10/303,717**

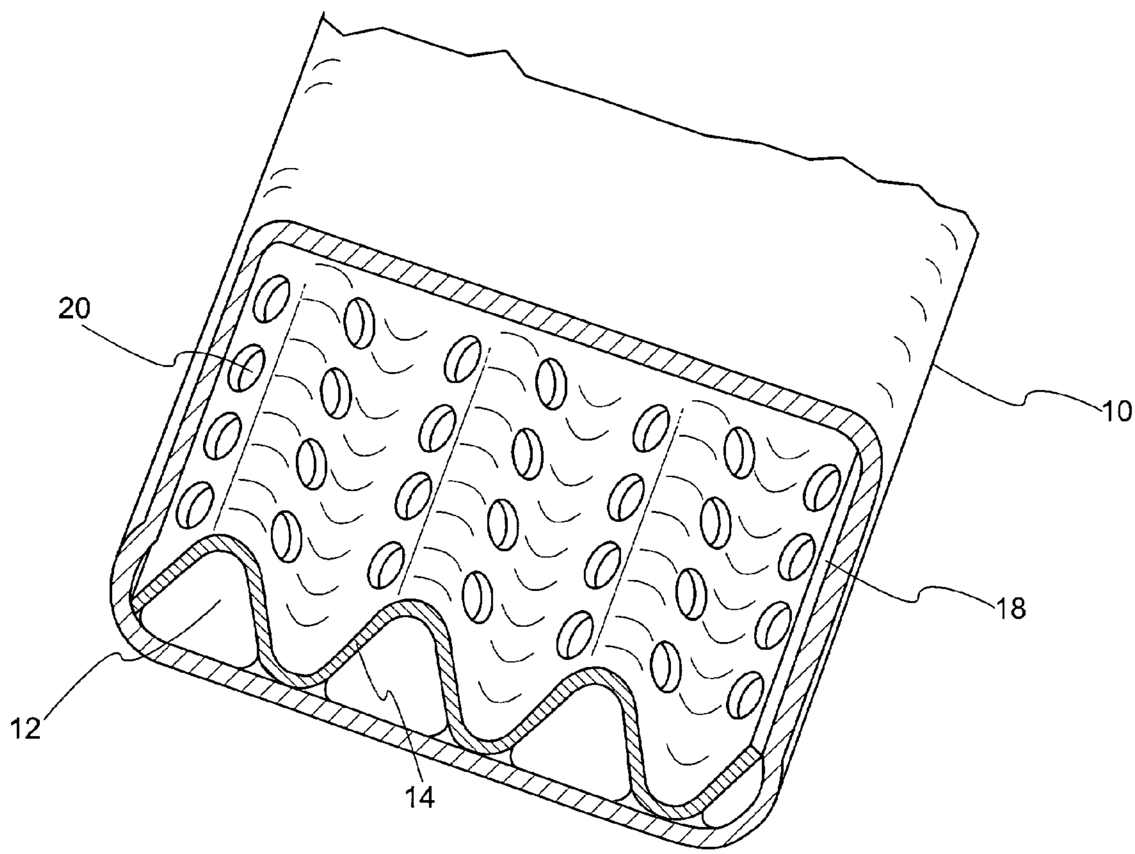
(22) Filed: **Nov. 26, 2002**

Publication Classification

(51) Int. Cl.[7] **F28F 1/14**
(52) U.S. Cl. **165/177**; 165/183

(57) **ABSTRACT**

The invention relates to a microchannel tube for use in a heat transfer system. The microchannels have openings in the partitions that separate them from each other, thereby creating many short interconnected passages through which a heat transfer medium will flow. This permits the liquid and vapor phases of the medium to mix, thereby increasing the efficiency of the system.



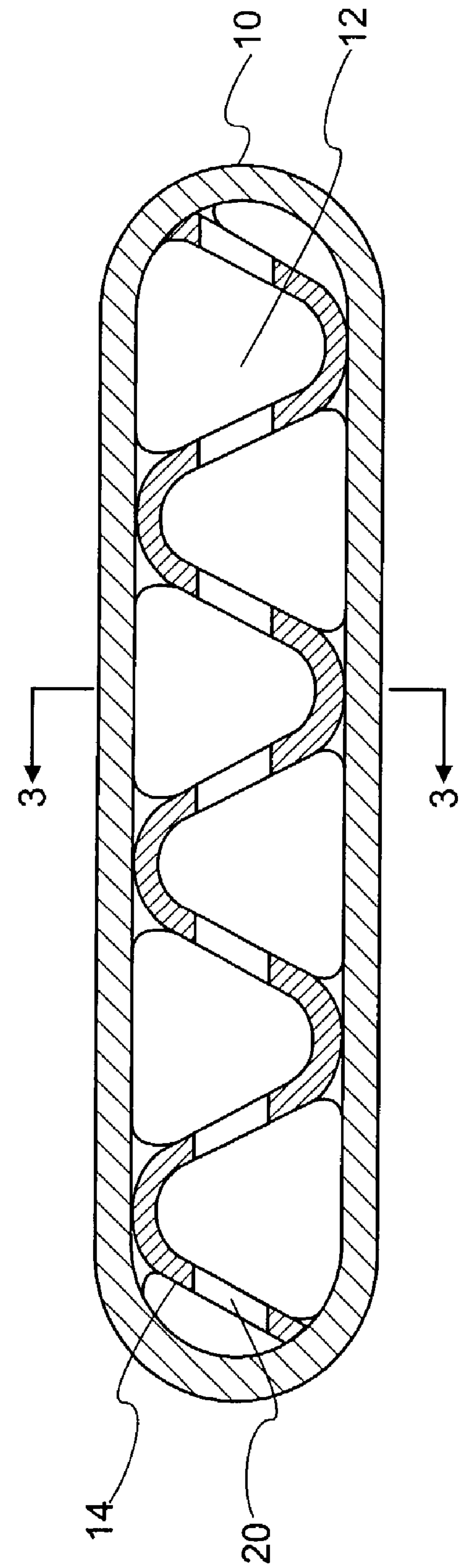


Fig. 1

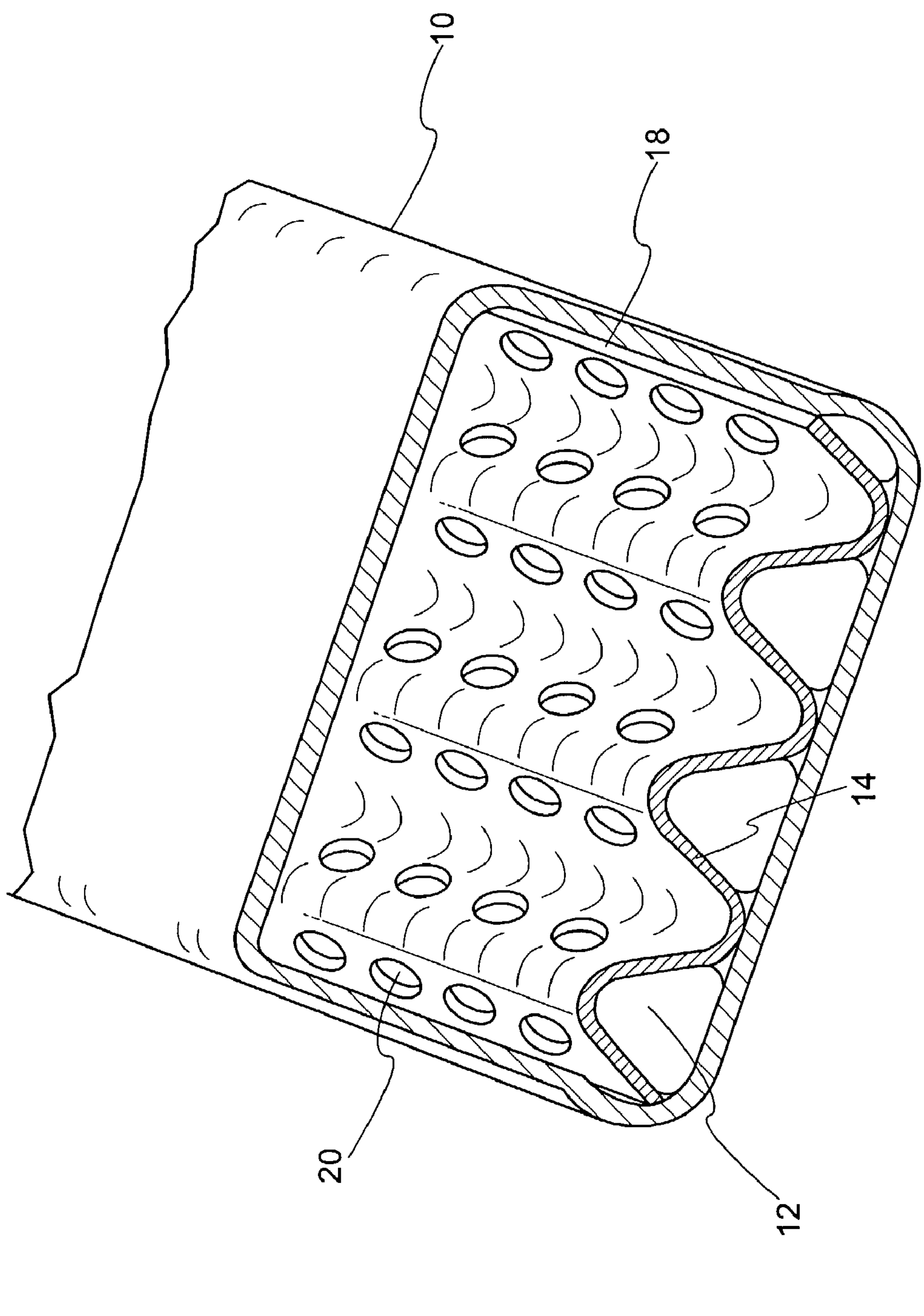


Fig. 2

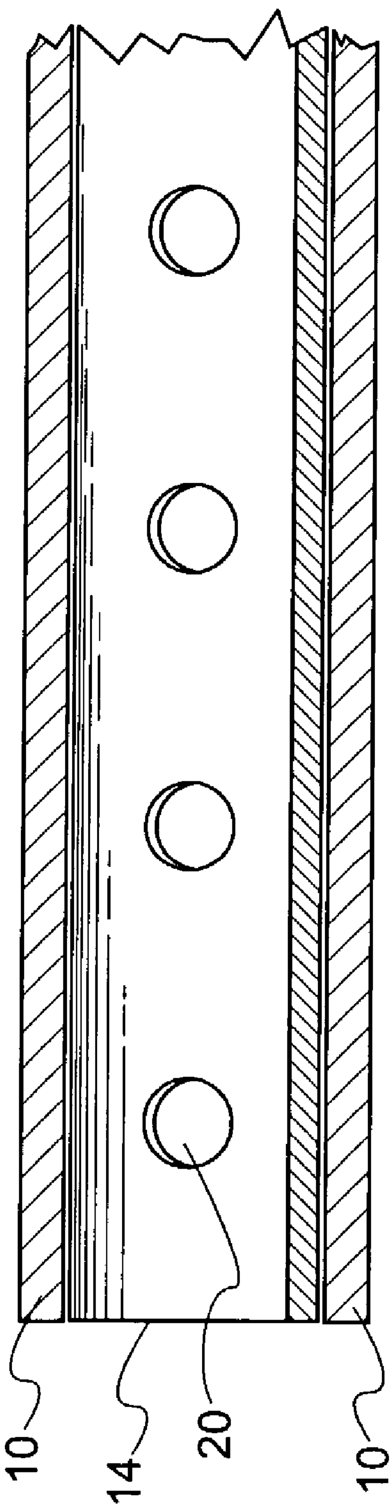


Fig. 3

INTERCONNECTED MICROCHANNEL TUBE

FIELD OF INVENTION

[0001] The present invention relates to an interconnected microchannel tube for use in a heat transfer device such as an automobile or residential or commercial air conditioning heat exchangers. The microchannel tubes are interconnected to facilitate re-mixing of the vapor-liquid phases and improve the efficiency of the heat exchanger.

BACKGROUND OF THE INVENTION

[0002] Microchannel tubes have been used in recent years in automotive air conditioning units and in residential or commercial air-conditioning heat exchangers. In use, a refrigerant flows through the multiple channels inside a float tube. The refrigerant evaporates and condenses as it passes through the tubes, absorbing and releasing heat as it changes phases between liquid and vapor. U.S. Pat. Nos. 4,998,580 and 5,372,188 ("the '188 patent") each disclose condensers having small hydraulic diameter flow paths, i.e., microchannels.

[0003] The microchannel tubes currently in use have channels that are isolated from each other, such that each channel works independently from the others when transferring heat. This creates a heat transfer imbalance between the front edge of the tube to the leeway side of the tube, in lieu of the flow direction of the external heat transfer medium. The '188 patent is limited in its scope as it requires the hydraulic diameter to be in the range of about 0.015 to 0.07 inches, where the hydraulic diameter is defined as the cross-sectional area of each of the flow paths multiplied by 4 and divided by the wetted perimeter of the corresponding flow path.

[0004] Thus, there is a need for an improved heat transfer design for heat exchangers that include microchannel tubes in order to improve the heat transfer efficiency and to balance heat transfer more uniformly across the entire width of the tubes. The present invention now provides such improvements.

SUMMARY OF THE INVENTION

[0005] The invention relates to a heat transfer tube comprising a sheath surrounding a plurality of partitions forming microchannels therein through which a heat transfer medium can flow. The partitions advantageously include sidewalls having a plurality of openings therein, such that the heat transfer medium can flow between the microchannels thereby permitting mixing of liquid and vapor phases of the heat transfer medium for improved heat transfer of the tube.

[0006] The hole openings comprise about 1% to 20% of the area of the partition sidewall, with each partition having from about 5 openings per 25 mm to about 1 opening every 75 mm along the length of the partition. These openings comprise up to about 80% of the height of the sidewall of the partition, and can be round, oval, square, rectangular, or triangular.

[0007] In one embodiment, at least 2 to 12 partitions are present so that at least 3 to 13 microchannels are provided in the tube. Preferably, at least 4 to 8 partitions are present so that at least 5 to 9 microchannels are provided in the tube. The partitions are advantageously formed from a single sheet, preferably one that forms serpentine partitions.

[0008] The sheath and partitions can be formed of a metal, such as aluminum or an aluminum alloy, although copper or a copper alloy is preferred. If desired, fins can be attached to an outer surface of the sheath to assist in transferring heat therefrom.

[0009] Another embodiment of the invention relates to an improvement in a heat exchanger that includes a plurality of microchannels therein and through which a heat transfer medium flows. The improvement comprises providing a plurality of openings in the microchannels, such that the heat transfer medium can flow between the microchannels thereby permitting mixing of liquid and vapor phases of the heat transfer medium for improved heat transfer of the tube.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The invention will be better understood in relation to the attached drawings illustrating preferred embodiments, wherein:

[0011] **FIG. 1** shows a cross-sectional view of a heat exchanger tube made according to the present invention;

[0012] **FIG. 2** shows a perspective view of a heat exchanger tube according to the invention; and

[0013] **FIG. 3** shows a cross-sectional view of the heat exchanger taken along **3-3** of **FIG. 1**.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Referring to the drawings, the figures shows a heat exchange tube formed of a sheath **10** and microchannels **12** according to the present invention. The heat transfer tube is formed by a plurality of partitions **14** that form a plurality of microchannels **12**. A heat transfer medium runs through the microchannels **12**. In one embodiment, the invention includes at least about 2 to 12 partitions to form at least about 3 to 13 microchannels. In another preferred embodiment, at least about 4 to 8 partitions are present forming at least about 5 to 9 microchannels in the sheath.

[0015] The microchannels **12** define a path through which the heat transfer medium flows. As the heat transfer medium flows through a microchannel, it evaporates or condenses, thereby changing the vapor and liquid content of the composition. The microchannel at the front edge of the tube and the leeway edge of the tube may have different levels of heat transfer, due to external reasons. It is therefore possible that the microchannel located near the front edge of the tube has a much greater amount of the vapor phase (or liquid phase) than the microchannel located near the leeway edge. It is therefore necessary to design the microchannels to mix these phases evenly across the microchannels over the entire width of the tube in order to optimize two-phase flow heat transfer. It has now been discovered that apertures or openings between the channels assists and enables the gaseous phase and liquid phase to be uniformly mixed and distributed across all the microchannels in a tube to enhance heat transfer.

[0016] The openings or holes **20** in the partitions **14** may be of any shape, such as a slot, rectangle, square, or triangle, but the preferred shape is a circle or oval as these have no sharp edges that could act as stress raisers in the structure. The openings **20** permit the liquid and vapor to mix and change phase at the same time thereby equalizing the liquid and vapor flow. This mixing will permit the individual heat transfer tube to be about 20% to 50% more efficient than a comparable tube without the openings **20** in the partitions **14**. A heat exchanger constructed with a plurality of such tubes would be about 10% to 30% more efficient than conventional heat exchangers.

[**0017**] The mixing of the gaseous and liquid phases of the heat transfer medium is important to this efficiency, but the mixing cannot be too vigorous. It is generally desirable to keep the flow within the laminar regime, as turbulent flow also causes a pressure drop that is too large that may affect the efficiency of the system.

[**0018**] The holes may be of various sizes, but are generally not larger than 80% of the height of the partition. The width of the hole is generally no larger than its height. As a typical height of a partition is about 2 mm, the maximum size hole would be a square that is about 1.6 mm by about 1.6 mm. A circular hole having a diameter of about 1.5 mm is usable as would be an oval having a larger diameter of 1.5 mm and a smaller diameter of 1 mm or even of 0.5 mm, with the larger diameter arranged to span the height of the partition. Along the length of the tube, there are typically from about 5 holes per each 25 mm in length up to about one hole every 75 mm in length, and preferably 2 holes per 25 mm in length to 1 hole for each 50 mm in length. There is no criticality in the placement of the holes and they can be arranged in a uniform fashion or in a staggered or offset arrangement. The holes are simply cut out of the partition wall and remove about 1% to 20% of the wall area of each partition. In a preferred embodiment, the holes remove about 5% to 10% of the wall area. The area between the holes must be large enough to not detract from the mechanical strength of the tube and its ability to support the pressure of the flowing heat transfer medium therein.

[**0019**] The tube and partitions may be formed of sheet metal. While it is possible to form the tube and partitions from an aluminum sheet, it is preferable to form the tube and partitions from a copper or copper alloy sheet. The latter is advantageous as it does not require a cladding layer for brazing as does aluminum. The heat exchange tube may be formed of two pieces, the outer sheath and the inner partitions, which may be corrugated fins. The tube can also be formed by a single pieces of metal sheet using a folding process. The holes are simply cut into the inner partition to form the flow paths between the microchannels.

[**0020**] The sheath **10** and partitions may be constructed of any suitable brazable material known to those of ordinary skill in the art, such as metals, alloys, or even composites. As noted above, preferred materials include copper and copper alloys or aluminum and aluminum alloys. Typical alloying elements for copper alloys include zinc, tin or nickel. In one embodiment, the tube is a welded thin wall tube made of brass. For convenience, the partitions may be constructed of the same materials as the sheath.

[**0021**] The partition insert **14** is attached to the sheath **10**, generally by brazing with a suitable brazing filler material. For sheaths made of copper and copper alloys, the brazing process may include coating the partitions **14** with braze paste before it is inserted into the sheath **10**, or inserting the partitions **14** into the sheath **10** together with a braze foil on each side of the partitions **14** in order to attach the partitions **14** to the sheath **10**. The partition insert may be coated with the braze paste by means of a roller. A preferred brazing alloy is a copper-nickel-tin-phosphorus alloy, such as OKC600, which is commercially available. OKC600 comprises about 1% to 5% nickel, about 15% to 20% tin, about 4% to 7% phosphorus, and the balance copper. It is not necessary to add flux to this braze material, since phosphorus acts as a flux, making the copper-nickel-tin-phosphorus a self-fluxing alloy. The resulting joint and construction also has better corrosion properties since no flux is present. Also, clean-up is facilitated as there is no flux residue to remove.

[**0022**] For constructions of aluminum or aluminum alloys, the inside of the sheath **10** has a clad layer, while the partition **14** is uncladded. Alternatively, a cladding layer may be used on the partition **14**, rather than on the inside of the sheath **10**. This cladding enhances the brazing operation.

[**0023**] If desired, fins **16** may be attached to the outer surface of the sheaths **10** and run between the sheaths **10** to facilitate the conduction of heat away from the sheath **10**, and to provide additional surface area for convective heat transfer by air flowing over the heat exchanger. The sheaths may be coated by rolling or spraying with a brazing material to facilitate adhesion of the fins **16**. OKC600 is a preferred brazing material for copper or copper alloy sheaths. For sheaths **10** made of aluminum or aluminum alloy, either the outside of the sheath **10** or the fins **16** should be clad to permit adhesion to the sheath. The clad layer melts during brazing and with the help of flux, creates a brazed joint.

[**0024**] A plurality of tubes may be joined to form a heat exchanger. The heat exchanger includes a header at each end of the plurality of tubes. The headers may be formed of the same material as the tubes and insert. In one embodiment, the headers are formed of copper or copper alloy and are slotted to collect the tubes. The fins are inserted between the tubes during the assembly process. The headers are pasted with a brazing paste, capped with pasted caps, and pipes are inserted if necessary and pasted with brazing paste at the joint.

[**0025**] The configuration of the microchannels with holes therebetween permits the refrigerant to pass between the channels to improve the heat distribution and performance. It basically increases the flow path of the heat transfer medium causing it to become more circuitous. The microchannels actually form many short interconnected passages through which the medium will flow. In this way, the liquid and vapor phases of the medium are more evenly mixed across the tube width thereby enhance the heat transfer of the heat exchanger and increase the energy efficiency of the system.

[**0026**] The brazing application generally takes place in a furnace. One concern during the process is to prevent oxidation of the tube or the brazing material. The furnace should have a dew point of less than about −40° C. and an oxygen content of less than about 100 ppm. Often, an inert gas atmosphere is used, such as nitrogen having a dew point of about −65° C. and an oxygen content of about 10 ppm.

[**0027**] It is to be understood that the invention is not to be limited to the exact configuration as illustrated and described herein. Accordingly, all expedient modifications readily attainable by one of ordinary skill in the art from the disclosure set forth herein, or by routine experimentation therefrom, are deemed to be within the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A heat transfer tube comprising a sheath surrounding a plurality of partitions forming microchannels therein through which a heat transfer medium can flow, the partitions including sidewalls having a plurality of openings therein, such that the heat transfer medium can flow between the microchannels thereby permitting mixing of liquid and vapor phases of the heat transfer medium for improved heat transfer of the tube.

2. The heat transfer tube of claim 1, wherein at least 2 to 12 partitions are present so that at least 3 to 13 microchannels are provided in the tube.

3. The heat transfer tube of claim 1, wherein at least 4 to 8 partitions are present so that at least 5 to 9 microchannels are provided in the tube.

4. The heat transfer tube of claim 1, wherein the openings comprise about 1% to 20% of the area of the partition sidewall.

5. The heat transfer tube of claim 4, wherein each partition has from about 5 openings per inch to about 1 opening every three inches along the length of the partition.

6. The heat transfer tube of claim 4, wherein the openings comprise up to about 80% of the height of the sidewall of the partition.

7. The heat transfer tube of claim 1, wherein the openings are round, square, rectangular, or triangular.

8. The heat transfer tube of claim 1, wherein the plurality of partitions are formed from a single sheet.

9. The heat transfer tube of claim 8, wherein the sheet forms serpentine partitions.

10. The heat transfer tube of claim 1, wherein the sheath is formed of copper or a copper alloy.

11. The heat transfer tube of claim 10, wherein the partition sidewalls are formed of copper or a copper alloy.

12. The heat transfer tube of claim 1, wherein the sheath and partition sidewalls are formed of aluminum or an aluminum alloy.

13. The heat transfer tube of claim 1, further comprising fins attached to an outer surface of the sheath to assist in transferring heat therefrom.

14. A heat exchanger comprising two opposing headers and a plurality of the heat transfer tubes extending between the headers, the heat transfer tubes comprising a sheath surrounding a plurality of partitions forming microchannels through which a heat transfer medium can flow, the partitions including sidewalls having a plurality of openings therein, such that the heat transfer medium can flow between the microchannels thereby permitting mixing of liquid and vapor phases of the heat transfer medium for improved heat transfer of the tube.

15. In a heat exchanger that includes a plurality of microchannels therein through which a heat transfer medium flows, the improvement which comprises providing a plurality of openings in the microchannels, such that the heat transfer medium can flow between the microchannels thereby permitting mixing of liquid and vapor phases of the heat transfer medium for improved heat transfer of the tube.

* * * * *