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(54) **HEAT EXCHANGER WITH FLUID EXPANSION IN HEADER**

WÄRMETAUSCHER MIT FLUIDEXPANSION IN DER ENDKAMMER

ÉCHANGEUR DE CHALEUR À DÉTENTE DU FLUIDE DANS LE COLLECTEUR

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Description

Field of the Invention

[0001] This invention relates generally to heat exchangers having a plurality of parallel tubes extending between a first header and a second header, also sometimes referred to as manifolds, and, more particularly, to providing fluid expansion within the header of a heat exchanger for improving distribution of two-phase flow through the parallel tubes of the heat exchanger, for example a heat exchanger in a refrigerant compression system. US - A 5 320 165 discloses a heat exchanger according to the preamble of claim 1.

Background of the Invention

[0002] Refrigerant vapor compression systems are well known in the art. Air conditioners and heat pumps employing refrigerant vapor compression cycles are commonly used for cooling or cooling/heating air supplied to a climate controlled comfort zone within a residence, office building, hospital, school, restaurant or other facility. Refrigeration vapor compression systems are also commonly used for cooling air or other secondary fluid to provide a refrigerated environment for food items and beverage products within, for instance, display cases in supermarkets, convenience stores, groceries, cafeterias, restaurants and other food service establishments.

[0003] Conventionally, these refrigerant vapor compression systems include a compressor, a condenser, an expansion device, and an evaporator connected in refrigerant flow communication. The aforementioned basic refrigerant system components are interconnected by refrigerant lines in a closed refrigerant circuit and arranged in accord with the vapor compression cycle employed. An expansion device, commonly an expansion valve or a fixed-bore metering device, such as an orifice or a capillary tube, is disposed in the refrigerant line at a location in the refrigerant circuit upstream, with respect to refrigerant flow, of the evaporator and downstream of the condenser. The expansion device operates to expand the liquid refrigerant passing through the refrigerant line running from the condenser to the evaporator to a lower pressure and temperature. In doing so, a portion of the liquid refrigerant traversing the expansion device expands to vapor. As a result, in conventional refrigerant vapor compression systems of this type, the refrigerant flow entering the evaporator constitutes a two-phase mixture. The particular percentages of liquid refrigerant and vapor refrigerant depend upon the particular expansion device employed and the refrigerant in use, for example R12, R22, R134a, R404A, R410A, R407C, R717, R744 or other compressible fluid.

[0004] In some refrigerant vapor compression systems, the evaporator is a parallel tube heat exchanger. Such heat exchangers have a plurality of parallel refrigerant flow paths therethrough provided by a plurality of

tubes extending in parallel relationship between an inlet header and an outlet header. The inlet header receives the refrigerant flow from the refrigerant circuit and distributes it amongst the plurality of flow paths through the heat exchanger. The outlet header serves to collect the refrigerant flow as it leaves the respective flow paths and to direct the collected flow back to the refrigerant line for a return to the compressor in a single pass heat exchanger or through an additional bank of heat exchange tubes in a multi-pass heat exchanger.

[0005] Historically, parallel tube heat exchangers used in such refrigerant compression systems have used round tubes, typically having a diameter of 1/2 inch, 3/8 inch or 7 millimeters. More recently, flat, rectangular or oval shape, multi-channel tubes are being used in heat exchangers for refrigerant vapor compression systems. Each multi-channel tube has a plurality of flow channels extending longitudinally in parallel relationship the length of the tube, each channel providing a small cross-sectional flow area refrigerant path. Thus, a heat exchanger with multi-channel tubes extending in parallel relationship between the inlet and outlet headers of the heat exchanger will have a relatively large number of small cross-sectional flow area refrigerant paths extending between the two headers. In contrast, a parallel tube heat exchanger with conventional round tubes will have a relatively small number of large flow area flow paths extending between the inlet and outlet headers.

[0006] Non-uniform distribution, also referred to as maldistribution, of two-phase refrigerant flow is a common problem in parallel tube heat exchangers which adversely impacts heat exchanger efficiency. Two-phase maldistribution problems are caused by the difference in density of the vapor phase refrigerant and the liquid phase refrigerant present in the inlet header due to the expansion of the refrigerant as it traversed the upstream expansion device.

[0007] One solution to control refrigeration flow distribution through parallel tubes in an evaporative heat exchanger is disclosed in U.S. Patent No. 6,502,413, Repice et al. In the refrigerant vapor compression system disclosed therein, the high pressure liquid refrigerant from the condenser is partially expanded in a conventional in-line expansion device upstream of the heat exchanger inlet header to a lower pressure refrigerant. Additionally, a restriction, such as a simple narrowing in the tube or an internal orifice plate disposed within the tube, is provided in each tube connected to the inlet header downstream of the tube inlet to complete the expansion to a low pressure, liquid/vapor refrigerant mixture after entering the tube.

[0008] Another solution to control refrigeration flow distribution through parallel tubes in an evaporative heat exchanger is disclosed in Japanese Patent No. JP4080575, Kanzaki et al. In the refrigerant vapor compression system disclosed therein, the high pressure liquid refrigerant from the condenser is also partially expanded in a conventional in-line expansion device to a

lower pressure refrigerant upstream of a distribution chamber of the heat exchanger. A plate having a plurality of orifices therein extends across the chamber. The lower pressure refrigerant expands as it passes through the orifices to a low pressure liquid/vapor mixture downstream of the plate and upstream of the inlets to the respective tubes opening to the chamber.

[0009] Japanese Patent No. 6241682, Massaki et al., discloses a parallel flow tube heat exchanger for a heat pump wherein the inlet end of each multichannel tube connecting to the inlet header is crushed to form a partial throttle restriction in each tube just downstream of the tube inlet. Japanese Patent No. JP8233409, Hiroaki et al., discloses a parallel flow tube heat exchanger wherein a plurality of flat, multi-channel tubes connect between a pair of headers, each of which has an interior which decreases in flow area in the direction of refrigerant flow as a means to uniformly distribute refrigerant to the respective tubes. Japanese Patent No. JP2002022313, Yasushi, discloses a parallel tube heat exchanger wherein refrigerant is supplied to the header through an inlet tube that extends along the axis of the header to terminate short of the end the header whereby the two phase refrigerant flow does not separate as it passes from the inlet tube into an annular channel between the outer surface of the inlet tube and the inside surface of the header. The two phase refrigerant flow thence passes into each of the tubes opening to the annular channel.

[0010] Obtaining uniform refrigerant flow distribution amongst the relatively large number of small cross-sectional flow area refrigerant flow paths is even more difficult than it is in conventional round tube heat exchangers and can significantly reduce heat exchanger efficiency.

Summary of the Invention

[0011] It is a general object of the invention to reduce maldistribution of fluid flow in a heat exchanger having a plurality of multi-channel tubes extending between a first header and a second header.

[0012] It is an object of one aspect of the invention to reduce maldistribution of refrigerant flow in a refrigerant vapor compression system heat exchanger having a plurality of multi-channel tubes extending between a first header and a second header.

[0013] It is an object of one aspect of the invention to distribute refrigerant to the individual channels of an array of multi-channel tubes in a relatively uniform manner.

[0014] It is an object of another aspect of the invention to provide for distribution and expansion of the refrigerant in a refrigerant vapor compression system heat exchanger having a plurality of multi-channel tubes as the refrigerant flow passes from a header to the individual channels of an array of multi-channel tubes.

[0015] In one aspect of the present invention a heat exchanger is provided having a header defining a chamber for collecting a fluid, at least one multi-channel heat exchange tube defining a plurality of discrete fluid flow

channels extending longitudinally therethrough and having an inlet opening to said plurality of discrete fluid flow channels; and one or a plurality of connector(s) having an inlet end and an outlet end and defining a fluid flow path extending from said inlet end to said outlet end, said inlet end in fluid flow communication with the chamber of said header through a first opening and said outlet end in fluid communication with the inlet opening of one or all of said multi-channel heat exchange tube(s) through a second opening, said first opening being at least one flow restricting expansion orifice having a relatively small cross-sectional flow area. In an embodiment, the flow path through the connector may be divergent in the direction of fluid flow therethrough. The first opening has a relatively small flow area so as to provide a flow restriction through which fluid passes in flowing from the chamber of the header to the flow paths of the heat exchanger

[0016] In another aspect of the invention, a refrigerant vapor compression system includes a compressor, a condenser and an evaporative heat exchanger as described above connected in refrigerant flow communication whereby high pressure refrigerant vapor passes from the compressor to the condenser, high pressure refrigerant liquid passes from the condenser to the evaporative heat exchanger, and low pressure refrigerant vapor passes from the evaporative heat exchanger to the compressor.

Brief Description of the Drawings

[0017] For a further understanding of these and objects of the invention, reference will be made to the following detailed description of the invention which is to be read in connection with the accompanying drawing, where:

[0018] Figure 1 is a perspective view of an embodiment of a heat exchanger in accordance with the invention;

[0019] Figure 2 is a perspective view, partly sectioned, taken along line 2-2 of Figure 1;

[0020] Figure 3 is a sectioned elevation view taken along line 3-3 of Figure 2;

[0021] Figure 4 is a sectioned view taken along line 4-4 of Figure 3;

[0022] Figure 5 is a sectioned view taken along line 5-5 of Figure 3;

[0023] Figure 6 is a perspective view, partly sectioned, of another embodiment of a heat exchanger in accordance with the invention;

[0024] Figure 7 is a sectioned view taken along line 7-7 of Figure 6;

[0025] Figure 8 is a sectioned view taken along line 8-8 of Figure 7;

[0026] Figure 9 is a schematic illustration of a refrigerant vapor compression system incorporating the heat exchanger of the invention;

[0027] Figure 10 is a schematic illustration of another refrigerant vapor compression system incorporating the heat exchanger of the invention;

[0028] Figure 11 is an elevation view, partly in section,

of an embodiment of a multi-pass evaporator in accordance with the invention; and

[0029] Figure 12 is an elevation view, partly in section, of an embodiment of a multi-pass condenser in accordance with the invention.

Detailed Description of the Invention

[0030] The heat exchanger 10 of the invention will be described in general herein with reference to the illustrative single pass, parallel-tube embodiment of a multi-channel tube heat exchanger as depicted in Figure 1. In the illustrative embodiment of the heat exchanger 10 depicted in Figure 1, the heat exchange tubes 40 are shown arranged in parallel relationship extending generally vertically between a generally horizontally extending inlet header 20 and a generally horizontally extending outlet header 30. However, the depicted embodiment is illustrative and not limiting of the invention. It is to be understood that the invention described herein may be practiced on various other configurations of the heat exchanger 10. For example, the heat exchange tubes may be arranged in parallel relationship extending generally horizontally between a generally vertically extending inlet header and a generally vertically extending outlet header. As a further example, the heat exchanger could have a toroidal inlet header and a toroidal outlet header of a different diameter with the heat exchange tubes extend either somewhat radially inwardly or somewhat radially outwardly between the toroidal headers. The heat exchange tubes may also be arranged in parallel tube, multi-pass embodiments, as will be discussed in further detail later herein with reference to Figures 11 and 12.

[0031] Referring now to Figures 1 - 5 in particular, the heat exchanger 10 includes an inlet header 20, an outlet header 30, and a plurality of longitudinally extending multi-channel heat exchanger tubes 40 thereby providing a plurality of fluid flow paths between the inlet header 20 and the outlet header 30. Each heat exchange tube 40 has an inlet 43 at one end in fluid flow communication to the inlet header 20 through a connector 50 and an outlet at its other end in fluid flow communication to the outlet header 30. Each heat exchange tube 40 has a plurality of parallel flow channels 42 extending longitudinally, i.e. along the axis of the tube, the length of the tube thereby providing multiple, independent, parallel flow paths between the inlet of the tube and the outlet of the tube. Each multi-channel heat exchange tube 40 is a "flat" tube of, for instance, rectangular or oval cross-section, defining an interior which is subdivided to form a side-by-side array of independent flow channels 42. The flat, multi-channel tubes 40 may, for example, have a width of fifty millimeters or less, typically twelve to twenty-five millimeters, and a height of about two millimeters or less, as compared to conventional prior art round tubes having a diameter of 1/2 inch, 3/8 inch or 7 mm. The tubes 40 are shown in drawings hereof, for ease and clarity of illustration, as having twelve channels 42 defining flow paths

having a circular cross-section. However, it is to be understood that in commercial applications, such as for example refrigerant vapor compression systems, each multi-channel tube 40 will typically have about ten to twenty flow channels 42, but may have a greater or a lesser multiplicity of channels, as desired. Generally, each flow channel 42 will have a hydraulic diameter, defined as four times the flow area divided by the perimeter, in the range from about 200 microns to about 3 millimeters. Although depicted as having a circular cross-section in the drawings, the channels 42 may have a rectangular, triangular, trapezoidal cross-section or any other desired non-circular cross-section.

[0032] Each of the plurality of heat exchange tubes 40 of the heat exchanger 10 has its inlet end 43 inserted into a connector 50, rather than directly into the chamber 25 defined within the inlet header 20. Each connector 50 has an inlet end 52 and an outlet end 54 and defines a fluid flow path 55 extending from the inlet end 52 to the outlet end 54. The inlet end 52 is in fluid flow communication with the chamber 25 of the inlet header 20 through a first opening 51. The outlet end 54 is in fluid communication through a second opening 53 with the inlet openings 41 of the channels 42 at the inlet end of the associated heat transfer tube 40 received therein. The first opening 51 at the inlet end 52 of each connector 50 has a relatively small cross-sectional flow area. Therefore, the connectors 50 provide a plurality of flow restrictions, at least one associated with each heat transfer tube 40, that provide uniformity in pressure drop in the fluid flowing from the chamber 25 of the header 20 into the fluid flow path 55 within the connector 50, thereby ensuring a relatively uniform distribution of fluid amongst the individual tubes 40 operatively associated with the header 20.

[0033] In the embodiment depicted in Figures 1, 2 and 3, the inlet header 20 comprises a longitudinally elongated, hollow, closed end cylinder having a circular cross-section. The inlet end 52 of each connector 50 is mated with a corresponding slot 26 provided in and extending through the wall of the inlet header 20 with the inlet end 52 of the connector 50 inserted into its corresponding slot. Each connector may be brazed, welded, soldered, adhesively bonded, diffusion bonded or otherwise secured in a corresponding mating slot in the wall of the header 20. However, the inlet header 20 is not limited to the depicted configuration. For example, the header 20 might comprise a longitudinally elongated, hollow, closed end cylinder having an elliptical cross-section or a longitudinally elongated, hollow, closed end pipe having a square, rectangular, hexagonal, octagonal, or other cross-section.

[0034] In the embodiment depicted in Figures 6, 7 and 8, the inlet header 20 comprises a longitudinally elongated, hollow, closed end, half cylinder shell having a generally semi-circular cross-section and a block-like insert 58 that is brazed, welded, adhesively bonded or otherwise secured to the open face of the half cylinder shell. In this embodiment, instead of a plurality of connectors

50, the longitudinally, extending block-like insert 58 forms a single connector 50. A plurality of longitudinally spaced, parallel flow paths 55 is formed within the block-like structure of the connector 50. Each flow path 55 has an inlet end 52 having at least one relatively small flow area inlet opening 51 in fluid communication with a fluid chamber 25 defined within the header 20 and an outlet end 54 having an opening 53 adapted to receive the inlet end 42 of a heat exchange tube 40. Therefore, in this embodiment, a plurality of heat exchange tubes 40 are connected to the header by means of a single block-like connector 50. The block-like insert 58 provides a connector 50 having a plurality of flow restrictions, with at least one relatively small flow area opening 51 in operative association with each heat transfer tube 40, that provide uniformity in pressure drop in the fluid flowing from the chamber 25 of the header 20 into the fluid flow path 55 within the connector 50, thereby ensuring a relatively uniform distribution of fluid amongst the individual tubes 40 operatively associated with the header 20.

[0035] In the embodiment depicted in Figures 2, 3 and 5, only one first opening 51 of relatively small flow area is provided in the inlet end 52 of each connector 50. However, it is to be understood that, if desired, more than one first opening 51 of relatively small flow area may be provided at the inlet end 52 of the connector 50. For example, when the heat exchange tubes are relatively wide and/or have a relatively large number of channels, it may be desirable to have two, three or even more relatively small flow area first openings 51 disposed at spaced intervals in the inlet end 52 of the connector 50, such as illustrated in Figures 6, 7 and 8, to ensure uniform distribution of fluid flow to the multiplicity of flow channels 42 of the tube 40 inserted in the outlet end 54 of the connector 50.

[0036] The fluid flow path 55 extending from the inlet opening 51 at the inlet end 52 of the connector 50 to the outlet opening 53 at the outlet end 54 of the connector 50 may, as best depicted in Figure 3 and in Figure 7, diverge in the direction of fluid flow from the inlet opening 51 to the outlet opening 53. A divergent flow path assists in distributing the fluid flowing through the flow path 55 uniformly amongst the various flow channels 42 of the heat exchange tube 40 inserted into the outlet end 54 of the connector 50, particularly in refrigerant flow applications wherein the fluid is a liquid refrigerant and vapor refrigerant mixture or expands to a liquid refrigerant/vapor refrigerant mixture as the fluid passes through the relatively small flow area opening or openings 51.

[0037] Referring now to Figures 9 and 10, there is depicted schematically a refrigerant vapor compression system 100 having a compressor 60, the heat exchanger 10A, functioning as a condenser, and the heat exchanger 10B, functioning as an evaporator, connected in a closed loop refrigerant circuit by refrigerant lines 12, 14 and 16. As in conventional refrigerant vapor compression systems, the compressor 60 circulates hot, high pressure refrigerant vapor through refrigerant line 12 into the inlet header 120 of the condenser 10A, and thence through

the heat exchanger tubes 140 of the condenser 10A wherein the hot refrigerant vapor condenses to a liquid as it passes in heat exchange relationship with a cooling fluid, such as ambient air which is passed over the heat exchange tubes 140 by a condenser fan 70. The high pressure, liquid refrigerant collects in the outlet header 130 of the condenser 10A and thence passes through refrigerant line 14 to the inlet header 20 of the evaporator 10B. The refrigerant thence passes through the heat exchanger tubes 40 of the evaporator 10B wherein the refrigerant is heated as it passes in heat exchange relationship with air to be cooled which is passed over the heat exchange tubes 40 by an evaporator fan 80. The refrigerant vapor collects in the outlet header 30 of the evaporator 10B and passes therefrom through refrigerant line 16 to return to the compressor 60 through the suction inlet thereto. Although the exemplary refrigerant vapor compression cycles illustrated in Figures 9 and 10 are simplified air conditioning cycles, it is to be understood that the heat exchanger of the invention may be employed in refrigerant vapor compression systems of various designs, including, without limitation, heat pump cycles, economized cycles and refrigeration cycles.

[0038] In the embodiment depicted in Figure 9, the condensed refrigerant liquid passes from the condenser 10A directly to the evaporator 10B without traversing an expansion device. Thus, in this embodiment the refrigerant typically enters the inlet header 20 of the evaporative heat exchanger 10B as a high pressure, liquid refrigerant, not as a fully expanded, low pressure, refrigerant liquid/vapor mixture, as in conventional refrigerant compression systems. Thus, in this embodiment, expansion of the refrigerant occurs within the evaporator 10B of the invention as the refrigerant passes through the relatively small area opening or openings 51 at the inlet end 52 into the flow path 55 of the connector 50, thereby ensuring that expansion occurs only after the distribution has been achieved in a substantially uniform manner.

[0039] In the embodiment depicted in Figure 10, the condensed refrigerant liquid passes through an expansion valve 50 operatively associated with the refrigerant line 14 as it passes from the condenser 10A to the evaporator 10B. In the expansion valve 50, the high pressure, liquid refrigerant is partially expanded to lower pressure and lower temperature, liquid refrigerant or a liquid/vapor refrigerant mixture. In this embodiment, the final expansion of the refrigerant is completed within the evaporator 10B as the refrigerant passes through the relatively small flow area opening or openings 51 at the inlet end 52 into the flow path 55 of the connector 50. Partial expansion of the refrigerant in an expansion valve upstream of the inlet header 20 to the evaporator 10B may be advantageous when the cross-sectional flow area of the openings 51, can not be made small enough to ensure complete expansion as the liquid passes through the openings 51 or when an expansion valve is used as a flow control device.

[0040] Referring now to Figure 11, the heat exchanger

10 of the invention is depicted in a multi-pass, evaporator embodiment. In the illustrated multi-pass embodiment, the inlet header 20 is partitioned into a first chamber 20A and a second chamber 20B, the outlet header is also partitioned into a first chamber 30A and a second chamber 30B, and the heat exchange tubes 40 are divided into three banks 40A, 40B and 40C. The tubes of the first tube bank 40A have inlet ends inserted into respective connectors 50A that are open into the first chamber 20A of the inlet header 20 and outlet ends are open to the first chamber 30A of the outlet header 30. The tubes of the second tube bank 40B have inlet ends inserted into respective connectors 50B that are open into the first chamber 30A of the outlet header 30 and outlet ends are open to the second chamber 20B of the inlet header 20. The tubes of the third tube bank 40C have inlet ends inserted into respective connectors 50C that open into the second chamber 20B of the inlet header 20 and outlet ends are open to the second chamber 30B of the outlet header 30. In this manner, refrigerant entering the heat exchanger from refrigerant line 14 passes in heat exchange relationship with air passing over the exterior of the heat exchange tubes 40 three times, rather than once as in a single pass heat exchanger. In accord with the invention, the inlet end 43 of each of the tubes of the first, second and third tube banks 40A, 40B and 40C is inserted into the outlet end 54 of its associated connector 50 whereby the channels 42 of each of the tubes 40 will receive a relatively uniform distribution of expanded refrigerant liquid/vapor mixture. Distribution and expansion of the refrigerant occurs as the refrigerant passes from the header into the connector through the relatively small cross-sectional flow area opening 51, not only as the refrigerant passes into the first tube bank 40A, but also as the refrigerant passes into the second tube bank 40B and into the third tube bank 40C, thereby ensuring more uniform distribution of the refrigerant liquid/vapor upon entering the flow channels of the tubes of each tube bank.

[0041] Referring now to Figure 12, the heat exchanger 10 of the invention is depicted in a multi-pass, condenser embodiment. In the illustrated multi-pass embodiment, the inlet header 120 is partitioned into a first chamber 120A and a second chamber 120B, the outlet header 130 is also partitioned into a first chamber 130A and a second chamber 130B, and the heat exchange tubes 140 are divided into three banks 140A, 140B and 140C. The tubes of the first tube bank 140A have inlet end openings into the first chamber 120A of the inlet header 120 and outlet end openings to the first chamber 130A of the outlet header 130. The tubes of the second tube bank 140B have inlet ends inserted into respective connectors 50B that are open into the first chamber 130A of the outlet header 130 and outlet ends that are open to the second chamber 120B of the inlet header 120. The tubes of the third tube bank 140C have inlet ends inserted into respective connectors 50C that are open into the second chamber 120B of the inlet header 120 and outlet ends are open to the second chamber 130B of the outlet header 130. In this

manner, refrigerant entering the condenser from refrigerant line 12 passes in the heat exchange relationship with air passing over the exterior of the heat exchange tubes 140 three times, rather than once as in a single pass heat exchanger. The refrigerant entering the first chamber 120A of the inlet header 120 is entirely high pressure, refrigerant vapor directed from the compressor outlet via refrigerant line 14. However, the refrigerant entering the second tube bank and the third tube bank typically will be a liquid/vapor mixture as refrigerant partially condenses in passing through the first and second tube banks. In accord with the invention, the inlet end of each of the tubes of the second and third tube banks 140B, 140C is inserted into the outlet ends of their associated connectors 50B, 50C whereby the channels 42 of each of the tubes will receive a relatively uniform distribution of expanded refrigerant liquid/vapor mixture. Obviously, it has to be noted that pressure drop through the openings 51 has to be limited to not exceed a predetermined threshold for the condenser applications, in order not to compromise the heat exchanger efficiency. Further, a person ordinarily skilled in the art would understand that other multi-pass arrangements for condensers and evaporators are also within the scope of the invention.

[0042] While the present invention has been particularly shown and described with reference to the preferred mode as illustrated in the drawing, it will be understood by one skilled in the art that various changes in detail may be effected as defined by the claims.

Claims

1. A heat exchanger (10) comprising:

a header (20) defining a chamber (25) for collecting a fluid;
at least one multi-channel heat exchange tube (40) defining a plurality of discrete fluid flow channels (42) extending longitudinally there-through and having an inlet opening (41) to said plurality of discrete fluid flow channels (42); and
one or a plurality of connector(s) (50) having an inlet end (52) and an outlet end (54) and defining a fluid flow path (55) extending from said inlet end (52) to said outlet end (54), said inlet end in fluid flow communication with the chamber (25) of said header (20) through a first opening (51) and said outlet end (54) in fluid communication with the inlet opening (41) of one or all of said multi-channel heat exchange tube(s) (40) through a second opening (53), **characterised in that** said first opening (51) being at least one flow restricting expansion orifice having a relatively small cross-sectional flow area.

2. A heat exchanger (10) as recited in claim 1 wherein the fluid flow path (55) of the or each of said connec-

- tor(s) (50) comprises a divergent fluid flow path expanding uniformly in cross-section in the direction of fluid flow therethrough from said first opening (51) to said second opening (53) to uniformly distribute fluid through said flow path (55) to each discrete fluid flow channel (42) of said plurality of discrete fluid flow channels (42).
3. A heat exchanger (10) as recited in claim 1 wherein said at least one multi-channel heat exchange tube (40) has a flattened, non-round cross-section.
 4. A heat exchanger (10) as recited in claim 3 wherein said at least one multi-channel heat exchange tube (40) has a flattened, rectangular cross-section.
 5. A heat exchanger (10) as recited in claim 3 wherein said at least one multi-channel heat exchange tube (40) has a flattened, generally oval cross-section.
 6. A heat exchanger (10) as recited in claim 1 wherein each of said plurality of discrete fluid flow channels (42) defines a flow path having a non-circular cross-section.
 7. A heat exchanger (10) as recited in claim 6 wherein each of said plurality of discrete fluid flow channels (42) defines a flow path (55) selected from a group of a rectangular, triangular or trapezoidal cross-section.
 8. A heat exchanger (10) as recited in claim 1 wherein each of said plurality of discrete fluid flow channels (42) defines a flow path (55) having a circular cross-section.
 9. A heat exchanger (10) as recited in claim 1 wherein said first opening (51) comprises a plurality of openings (51).
 10. A refrigerant vapor compression system (100) comprising:
 - a compressor (60), a condenser (10A) and an evaporative heat exchanger (10B) as recited in claim 1 connected in fluid flow communication in a refrigerants circuit whereby high pressure refrigerant vapor passes from said compressor (60) to said condenser (10A), high pressure refrigerant passes from said condenser (10A) to said evaporative heat exchanger (10B), and low pressure refrigerant vapor passes from said evaporative heat exchanger (10B) to said compressor (60).
 11. A refrigerant vapor compression system (100) as recited in claim 10 wherein said first opening (51) of said connector (50) comprises an expansion orifice.
 12. A refrigerant vapor compression system (100) as recited in claim 10 wherein the fluid flow path (55) of the or each of said connector(s) (50) comprises a divergent fluid flow path expanding in cross-section in the direction of fluid flow therethrough from said first opening (51) to said second opening (53).
 13. A refrigerant vapor compression system (100) as recited in claim 12 wherein said first opening (51) of the or each of said connectors (50) comprises an expansion orifice.
 14. A refrigerant vapor compression system (100) as recited in claim 10 wherein said at least one multi-channel heat exchange tube (40) has a fattened, non-round cross-section.
 15. A refrigerant vapor compression system (100) as recited in claim 14 wherein said at least one multi-channel heat exchange tube (40) has a flattened, rectangular cross-section.
 16. A refrigerant vapor compression system (100) as recited in claim 14 wherein said at least one multi-channel heat exchange tube (40) has a flattened, generally oval cross-section.
 17. A refrigerant vapor compression system (100) as recited in claim 10 wherein each of said plurality of discrete fluid flow channels (42) defines a flow path having a non-circular cross-section.
 18. A refrigerant vapor compression system (100) as recited in claim 10 wherein each of said plurality of discrete fluid flow channels (42) defines a flow path and is selected from a group of a rectangular, triangular or trapezoidal cross-section.
 19. A refrigerant vapor compression system (100) as recited in claim 10 wherein each of said plurality of discrete fluid flow channels (42) defines a flow path having a circular cross-section.
 20. A refrigerant vapor compression system (100) as recited in claim 10 wherein said heat exchanger (10B) comprises a single-pass heat exchanger.
 21. A refrigerant vapor compression system (100) as recited in claim 10 wherein said heat exchanger (10B) comprises a multi-pass heat exchanger.
 22. A heat exchanger as recited in claim 1 wherein said heat exchanger (10B) is a condenser.
 23. A heat exchanger as recited in claim 1 wherein said heat exchanger (10B) is an evaporator.

Patentansprüche

1. Wärmetauscher (10), aufweisend:

ein Sammelrohr (20), das eine Kammer (25) zum Sammeln eines Fluids bildet; mindestens ein Mehrkanal-Wärmeaustauschrohr (40), das eine Mehrzahl einzelner Fluidströmungskanäle (42) bildet, die sich in Längsrichtung durch dieses hindurch erstrecken und eine Einlassöffnung (41) zu der Mehrzahl der einzelnen Fluidströmungskanäle (42) aufweist; und einen oder eine Mehrzahl von Verbindern (50) mit einem Einlassende (52) und einem Auslassende (54) sowie zum Bilden eines von dem Einlassende (52) zu dem Auslassende (54) verlaufenden Fluidströmungsweges (55), wobei das Einlassende durch eine erste Öffnung (51) in Fluidströmungsverbindung mit der Kammer (25) des Sammelrohrs (20) steht und das Auslassende (54) durch eine zweite Öffnung (53) in Fluidströmungsverbindung mit der Einlassöffnung (41) von einem oder allen der Mehrkanal-Wärmeaustauschrohre (40) steht, **dadurch gekennzeichnet, dass** es sich bei der ersten Öffnung (51) um mindestens eine Strömungsbegrenzungs-Expansionsöffnung mit einer relativ kleinen Strömungsquerschnittsfläche handelt.

2. Wärmetauscher (10) nach Anspruch 1, wobei der Fluidströmungsweg (55) von dem oder jedem der Verbinder (50) einen divergierenden Fluidströmungsweg aufweist, der in seinem Querschnitt in der Fluidströmungsrichtung durch diesen hindurch von der ersten Öffnung (51) zu der zweiten Öffnung (53) gleichmäßig expandiert, um das Fluid durch den Fluidströmungsweg (55) zu jedem einzelnen Fluidströmungskanal (42) der Mehrzahl von einzelnen Fluidströmungskanälen (42) gleichmäßig zu verteilen.

3. Wärmetauscher (10) nach Anspruch 1, wobei das mindestens eine Mehrkanal-Wärmeaustauschrohr (40) einen abgeflachten, nicht-runden Querschnitt aufweist.

4. Wärmeaustauscher (10) nach Anspruch 3, wobei das mindestens eine Mehrkanal-Wärmeaustauschrohr (40) einen abgeflachten rechteckigen Querschnitt aufweist.

5. Wärmetauscher (10) nach Anspruch 3, wobei das mindestens eine Mehrkanal-Wärmeaustauschrohr (40) einen abgeflachten, allgemein ovalen Querschnitt aufweist.

6. Wärmetauscher (10) nach Anspruch 1,

wobei jeder der Mehrzahl der einzelnen Fluidströmungskanäle (42) einen Strömungsweg mit einem nicht-kreisförmigen Querschnitt bildet.

7. Wärmetauscher (10) nach Anspruch 6, wobei jeder der Mehrzahl der einzelnen Fluidströmungskanäle (42) einen Strömungsweg (55) bildet, der aus einer Gruppe aus einem rechteckigen, einem dreieckigen oder einem trapezförmigen Querschnitt ausgewählt ist.

8. Wärmetauscher (10) nach Anspruch 1, wobei jeder der Mehrzahl der einzelnen Fluidströmungskanäle (42) einen Strömungsweg (55) mit kreisförmigem Querschnitt bildet.

9. Wärmetauscher (10) nach Anspruch 1, wobei die erste Öffnung (51) eine Mehrzahl von Öffnungen (51) umfasst.

10. Kältemitteldampfkompensationssystem (100), aufweisend:

einen Verdichter (60), einen Kondensator (10A) und einen Verdampfungs-Wärmetauscher (10B) gemäß Anspruch 1, die in Fluidströmungsverbindung in einem Kältemittelkreislauf verbunden sind, wobei unter hohem Druck stehender Kältemitteldampf von dem Verdichter (60) zu dem Kondensator (10A) strömt, unter hohem Druck stehendes Kältemittel von dem Kondensator (10A) zu dem Verdampfungs-Wärmetauscher (10B) strömt und unter niedrigem Druck stehender Kältemitteldampf von dem Verdampfungs-Wärmetauscher (10B) zu dem Verdichter (60) strömt.

11. Kältemitteldampfkompensationssystem (100) nach Anspruch 10, wobei die erste Öffnung (51) des Verbinders (50) eine Expansionsöffnung aufweist.

12. Kältemitteldampfkompensationssystem (100) nach Anspruch 10, wobei der Fluidströmungsweg (55) von dem oder jedem der Verbinder (50) einen divergierenden Fluidströmungsweg aufweist, der in seinem Querschnitt in der Fluidströmungsrichtung durch diesen hindurch von der ersten Öffnung (51) zu der zweiten Öffnung (53) expandiert.

13. Kältemitteldampfkompensationssystem (100) nach Anspruch 12, wobei die erste Öffnung (51) von dem oder jedem der Verbinder (50) eine Expansionsöffnung aufweist.

14. Kältemitteldampfkompensationssystem (100) nach

- Anspruch 10,
wobei das mindestens eine Mehrkanal-Wärmeaus-
tauschrohr (40) einen abgeflachten, nicht-runden
Querschnitt aufweist.
- 5
15. Kältemitteldampfkompresseionssystem (100) nach
Anspruch 14,
wobei das mindestens eine Mehrkanal-Wärmeaus-
tauschrohr (40) einen abgeflachten rechteckigen
Querschnitt aufweist.
- 10
16. Kältemitteldampfkompresseionssystem (100) nach
Anspruch 14,
wobei das mindestens eine Mehrkanal-Wärmeaus-
tauschrohr (40) einen abgeflachten, allgemein ova-
len Querschnitt aufweist.
- 15
17. Kältemitteldampfkompresseionssystem (100) nach
Anspruch 10,
wobei jeder der Mehrzahl der einzelnen Fluidströ-
mungskanäle (42) einen Strömungsweg mit einem
nicht-kreisförmigen Querschnitt bildet.
- 20
18. Kältemitteldampfkompresseionssystem (100) nach
Anspruch 10,
wobei jeder der Mehrzahl der einzelnen Fluidströ-
mungskanäle (42) einen Strömungsweg (55) bildet
und aus einer Gruppe aus einem rechteckigen, ei-
nem dreieckigen oder einem trapezförmigen Quer-
schnitt ausgewählt ist.
- 25
- 30
19. Kältemitteldampfkompresseionssystem (100) nach
Anspruch 10,
wobei jeder der Mehrzahl der einzelnen Fluidströ-
mungskanäle (42) einen Strömungsweg (55) mit
kreisförmigem Querschnitt bildet.
- 35
20. Kältemitteldampfkompresseionssystem (100) nach
Anspruch 10,
wobei der Wärmetauscher (10B) einen Einzeldurch-
gang-Wärmetauscher umfasst.
- 40
21. Kältemitteldampfkompresseionssystem (100) nach
Anspruch 10, wobei der Wärmetauscher (10B) einen
Mehrfachdurchgang-Wärmetauscher umfasst.
- 45
22. Wärmetauscher nach Anspruch 1,
wobei es sich bei dem Wärmetauscher (10B) um ei-
nen Kondensator handelt.
- 50
23. Wärmetauscher nach Anspruch 1,
wobei es sich bei dem Wärmetauscher (10B) um ei-
nen Verdampfer handelt.
- 55

Revendications

1. Echangeur de chaleur (10) comprenant :

un réceptacle (20) définissant une chambre (25)
permettant de collecter un fluide ;
au moins un tube d'échange de chaleur multi-
canal (40) définissant une pluralité de canaux
d'écoulement de fluide distincts (42) s'étendant
longitudinalement au travers et comportant une
ouverture d'admission (41) vers ladite pluralité
de canaux d'écoulement de fluide distincts (42) ;
et
un raccord ou une pluralité de raccords (50)
comportant une extrémité d'admission (52) et
une extrémité de refoulement (54) et définissant
un chemin d'écoulement de fluide (55) s'éten-
dant de ladite extrémité d'admission (52) à ladite
extrémité de refoulement (54), ladite extrémité
d'admission étant en communication d'écoule-
ment de fluide avec la chambre (25) dudit ré-
ceptacle (20) par l'intermédiaire d'une première
ouverture (51) et ladite extrémité de refoulement
(54) étant en communication de fluide avec
l'ouverture d'admission (41) d'un ou de la totalité
desdits tube(s) d'échange de chaleur multica-
naux (40) par l'intermédiaire d'une seconde
ouverture (53), **caractérisé en ce que** ladite
première ouverture (51) est au moins un orifice
de dilatation réducteur de débit ayant une su-
perficie d'écoulement en coupe relativement pe-
tite.

2. Echangeur de chaleur (10) selon la revendication 1,
dans lequel le chemin d'écoulement de fluide (55)
du ou de chacun desdits raccord(s) (50) comprend
un chemin d'écoulement de fluide divergent se dila-
tant uniformément en section dans la direction
d'écoulement de fluide en travers depuis ladite pre-
mière ouverture (51) vers ladite seconde ouverture
(53) pour distribuer uniformément un fluide à travers
ledit chemin d'écoulement (55) vers chaque canal
d'écoulement de fluide distinct (42) de ladite pluralité
de canaux d'écoulement de fluide distincts (42)..
3. Echangeur de chaleur (10) selon la revendication 1,
dans lequel ledit au moins un tube d'échange de
chaleur multicanal (40) a une section non ronde apla-
tie.
4. Echangeur de chaleur (10) selon la revendication 3,
dans lequel ledit au moins un tube d'échange de
chaleur multicanal (40) a une section rectangulaire
aplatie.
5. Echangeur de chaleur (10) selon la revendication 3,
dans lequel ledit au moins un tube d'échange de
chaleur multicanal (40) a une section généralement
ovale aplatie.
6. Echangeur de chaleur (10) selon la revendication 1,
dans lequel chacun de ladite pluralité de canaux

d'écoulement de fluide distincts (42) définit un chemin d'écoulement ayant une section non circulaire.

7. Echangeur de chaleur (10) selon la revendication 6, dans lequel chacun de ladite pluralité de canaux d'écoulement de fluide distincts (42) définit un chemin d'écoulement (55) choisi dans le groupe constitué par une section rectangulaire, triangulaire ou trapézoïdale. 5
8. Echangeur de chaleur (10) selon la revendication 1, dans lequel chacun de ladite pluralité de canaux d'écoulement de fluide distincts (42) définit un chemin d'écoulement (55) ayant une section circulaire. 10
9. Echangeur de chaleur (10) selon la revendication 1, dans lequel ladite première ouverture (51) comprend une pluralité d'ouvertures (51). 15
10. Système de compression de vapeur à fluide frigorigène (100) comprenant : 20
 - un compresseur (60), un condenseur (10A) et un échangeur de chaleur par évaporation (10B) tel que précisé dans la revendication 1, raccordés en communication de fluide dans un circuit de fluide frigorigène, où une vapeur de fluide frigorigène de haute pression passe dudit compresseur (60) audit condenseur (10A), un fluide frigorigène de haute pression passe dudit condenseur (10A) audit échangeur de chaleur par évaporation (10B), et une vapeur de fluide frigorigène de basse pression passe dudit échangeur de chaleur par évaporation (10B) audit compresseur (60). 25
11. Système de compression de vapeur à fluide frigorigène (100) selon la revendication 10, dans lequel ladite première ouverture (51) dudit raccord (50) comprend un orifice de détente. 30
12. Système de compression de vapeur à fluide frigorigène (100) selon la revendication 10, dans lequel le chemin d'écoulement de fluide (55) du ou de chacun desdits raccord(s) (50) comprend un chemin d'écoulement de fluide divergent se dilatant en section dans la direction d'écoulement de fluide en travers depuis ladite première ouverture (51) vers ladite seconde ouverture (53). 35
13. Système de compression de vapeur à fluide frigorigène (100) selon la revendication 12, dans lequel ladite première ouverture (51) du ou de chacun desdits raccord(s) (50) comprend un orifice de détente. 40
14. Système de compression de vapeur à fluide frigorigène (100) selon la revendication 10, dans lequel ledit au moins un tube d'échange de chaleur multi- 45

canal (40) a une section non ronde aplatie.

15. Système de compression de vapeur à fluide frigorigène (100) selon la revendication 14, dans lequel ledit au moins un tube d'échange de chaleur multi-canal (40) a une section rectangulaire aplatie. 50
16. Système de compression de vapeur à fluide frigorigène (100) selon la revendication 14, dans lequel ledit au moins un tube d'échange de chaleur multi-canal (40) a une section généralement ovale aplatie. 55
17. Système de compression de vapeur à fluide frigorigène (100) selon la revendication 10, dans lequel chacun de ladite pluralité de canaux d'écoulement de fluide distincts (42) définit un chemin d'écoulement ayant une section non circulaire. 60
18. Système de compression de vapeur à fluide frigorigène (100) selon la revendication 10, dans lequel chacun de ladite pluralité de canaux d'écoulement de fluide distincts (42) définit un chemin d'écoulement (55) et est choisi dans le groupe constitué par une section rectangulaire, triangulaire ou trapézoïdale. 65
19. Système de compression de vapeur à fluide frigorigène (100) selon la revendication 10, dans lequel chacun de ladite pluralité de canaux d'écoulement de fluide distincts (42) définit un chemin d'écoulement (55) ayant une section circulaire. 70
20. Système de compression de vapeur à fluide frigorigène (100) selon la revendication 10, dans lequel ledit échangeur de chaleur (10B) comprend un échangeur de chaleur à passage unique. 75
21. Système de compression de vapeur à fluide frigorigène (100) selon la revendication 10, dans lequel ledit échangeur de chaleur (10B) comprend un échangeur de chaleur à passages multiples. 80
22. Echangeur de chaleur selon la revendication 1, dans lequel ledit échangeur de chaleur (10B) est un condenseur. 85
23. Echangeur de chaleur selon la revendication 1, dans lequel ledit échangeur de chaleur (10B) est un évaporateur. 90

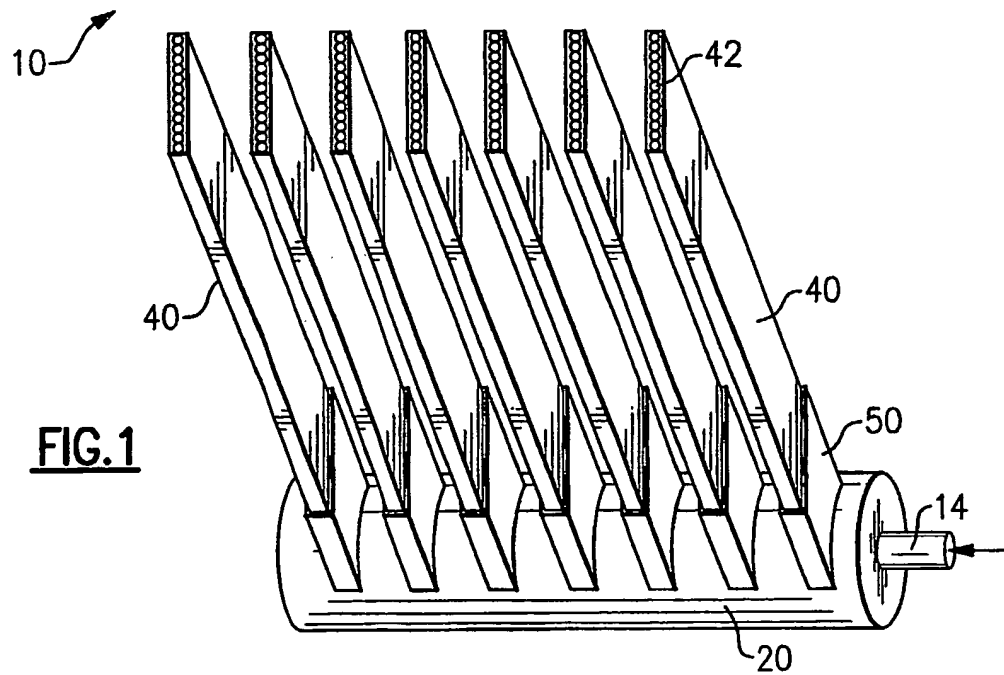
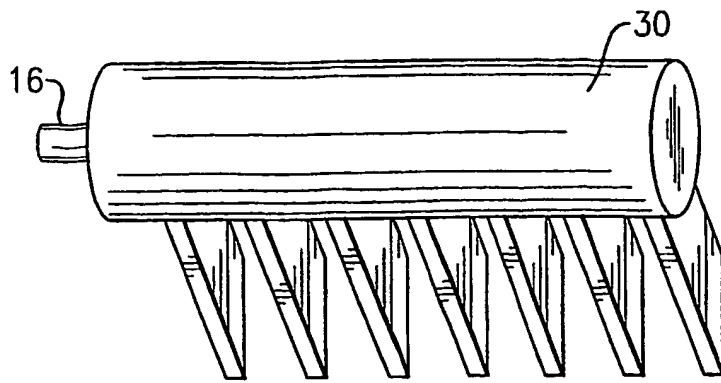


FIG. 1

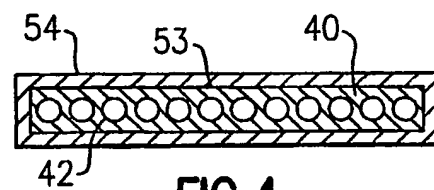


FIG. 4

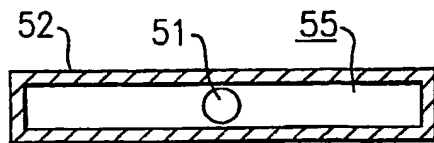


FIG. 5

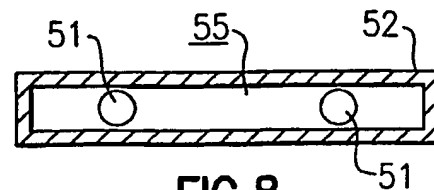
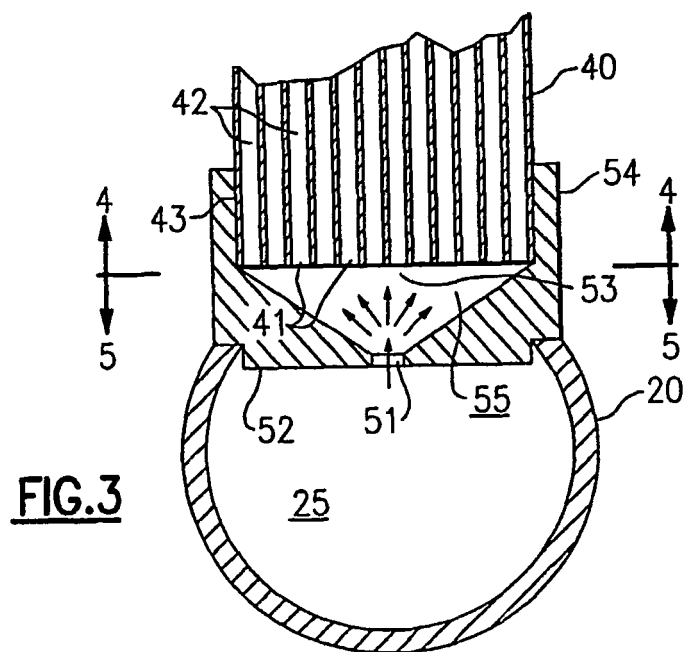
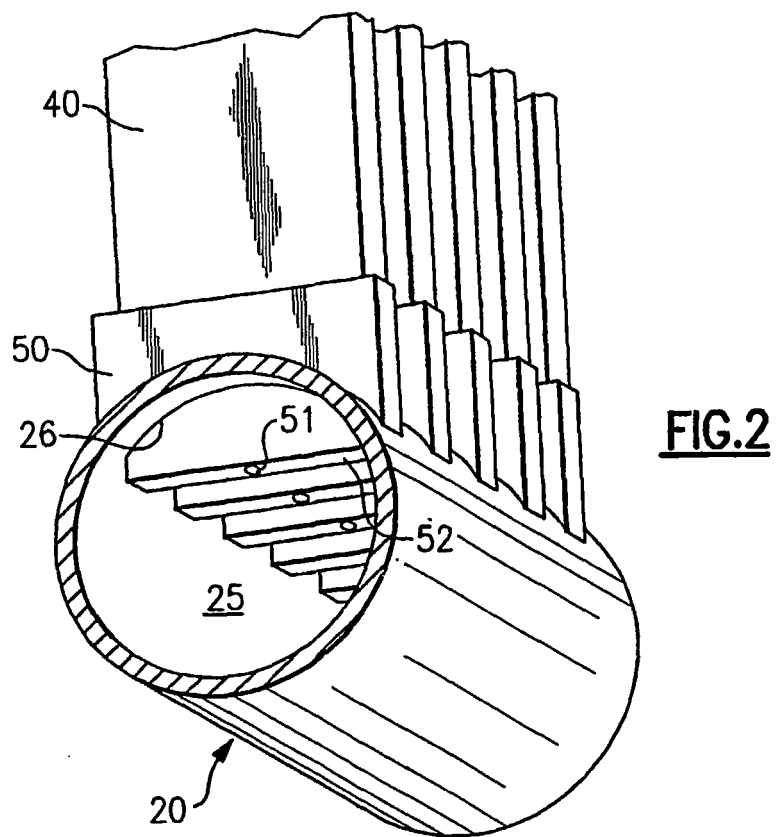
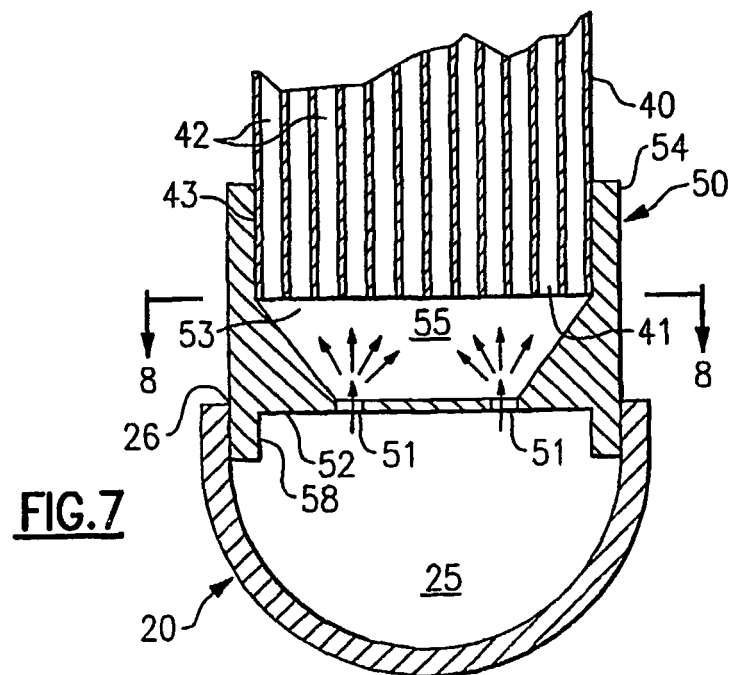
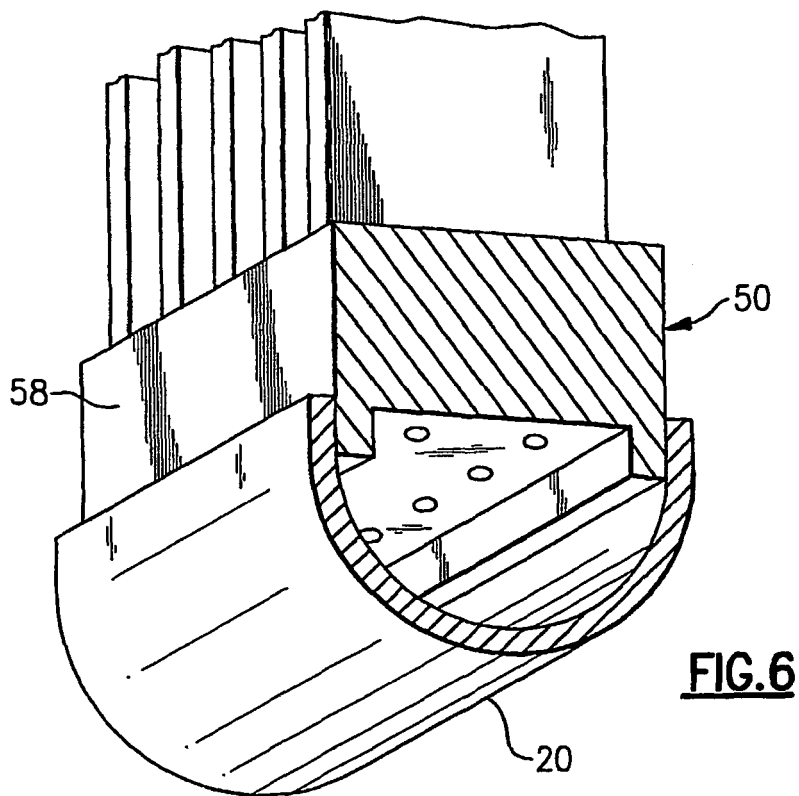
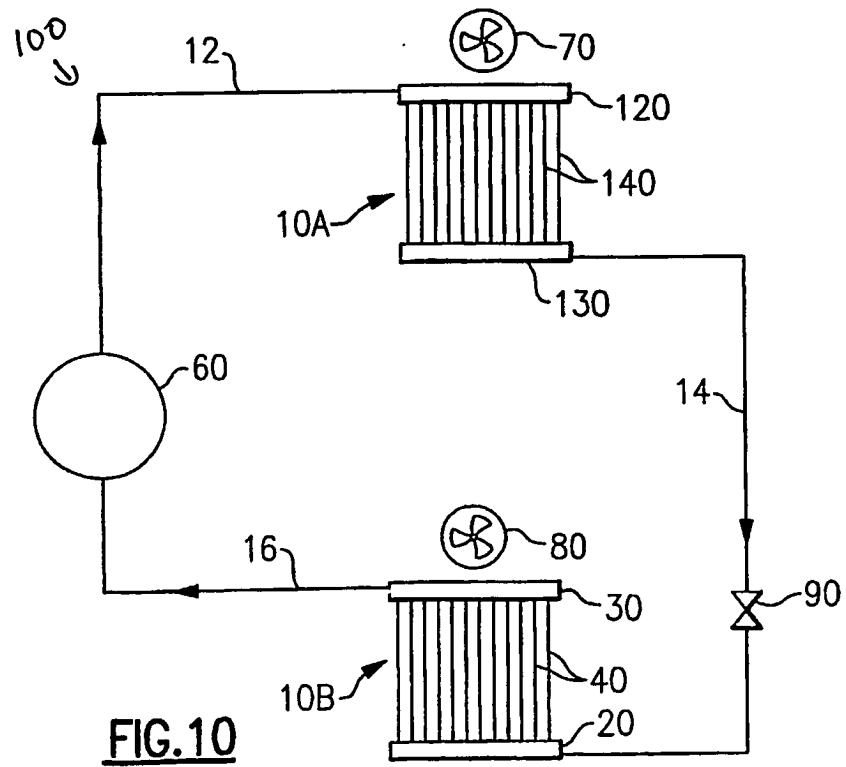
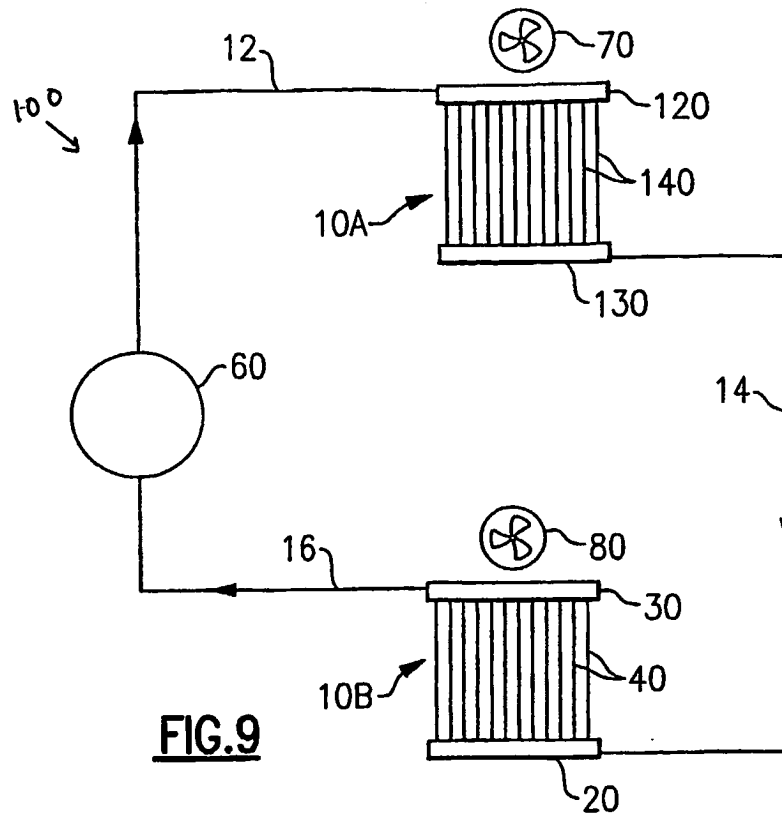


FIG. 8







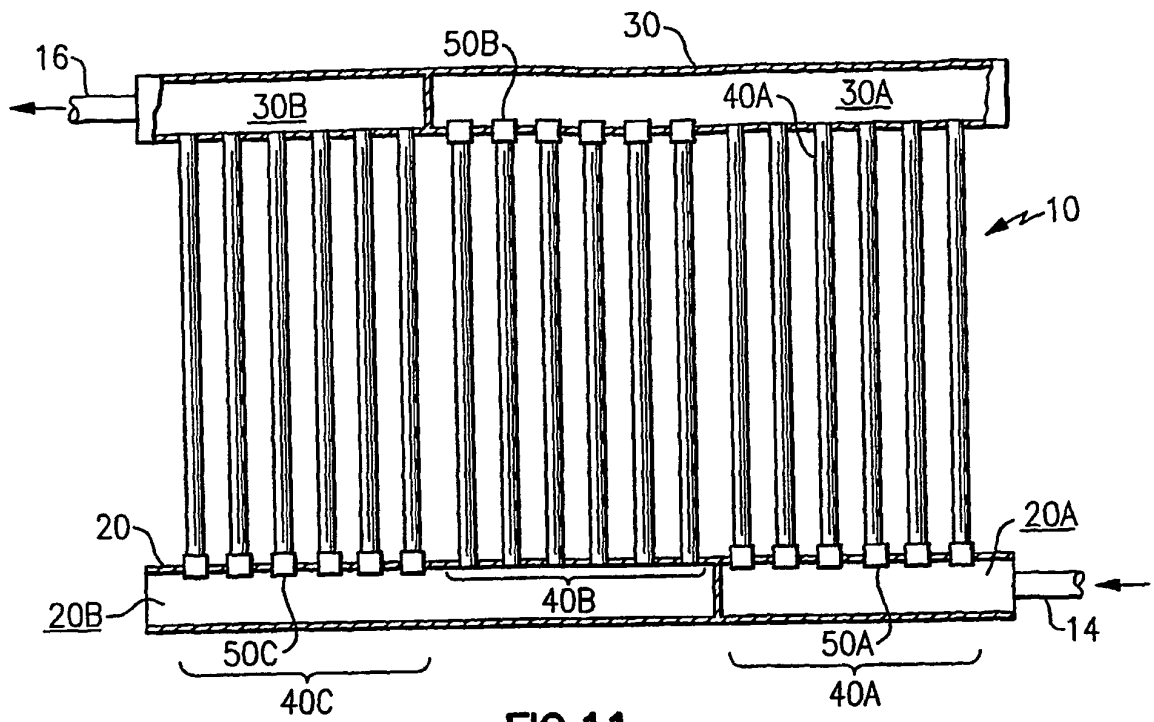


FIG. 11

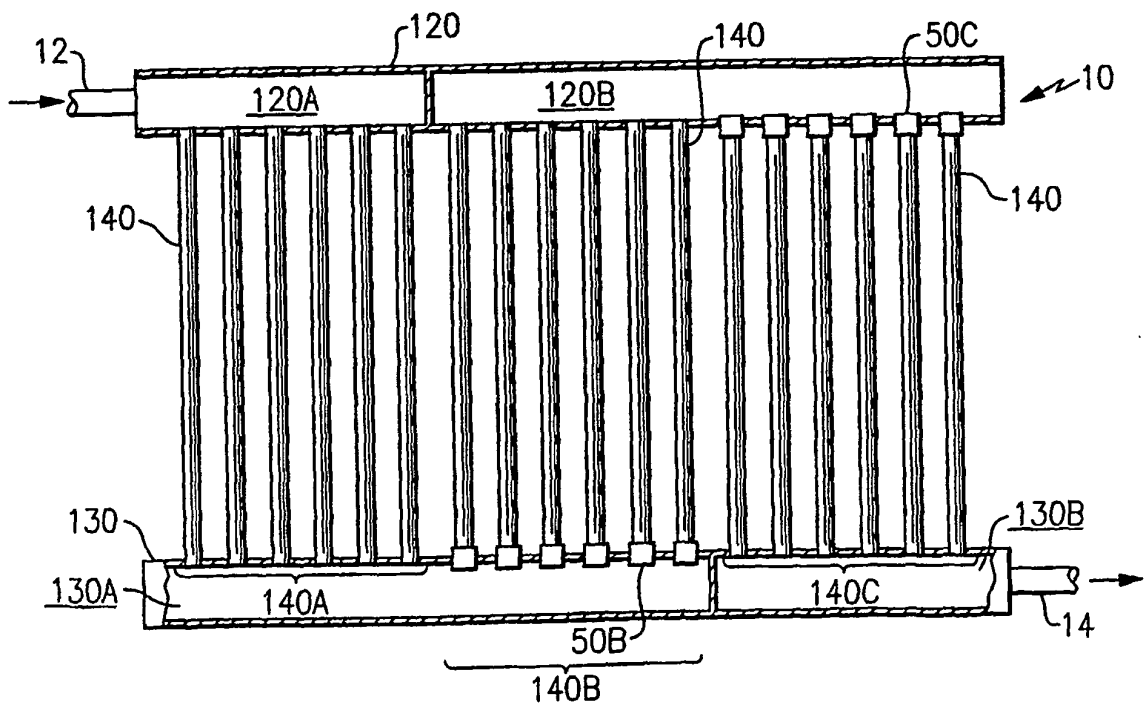


FIG. 12

REFERENCES CITED IN THE DESCRIPTION

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