The present invention provides a unit cooler adapted for use in a refrigerated environment. The unit cooler includes a housing adapted to be positioned within the refrigerated environment and at least one microchannel evaporator coil supported by the housing. The at least one microchannel evaporator coil includes an inlet manifold and an outlet manifold. The inlet manifold has an inlet port for receiving refrigerant, and the outlet manifold has an outlet port for discharging the refrigerant.
MICROCHANNEL EVAPORATOR ASSEMBLY

FIELD OF THE INVENTION

[0001] This invention relates generally to evaporator coils, and more particularly to evaporator coils for use in large-scale refrigeration systems.

BACKGROUND OF THE INVENTION

[0002] Typical large-scale refrigeration systems, such as those utilized in large-scale refrigerated environments (e.g., walk-in coolers or refrigerated warehouses), often include a single, large conventional fin-and-tube evaporator coil. Such a conventional fin-and-tube evaporator coil often displays poor efficiencies in transferring heat from an airflow passing through the coil to the refrigerant passing through the coil. As a result, the fin-and-tube evaporator coil can be rather large for the amount of heat it can remove from the airflow passing through the coil. Further, the larger the evaporator coil becomes, the more refrigerant used in the refrigeration system, thus effectively increasing potential damage to the environment by an accidental atmospheric release.

[0003] Another form of heat exchangers is the microchannel coil. Currently, the only major application of microchannel coils is in the automotive industry. In an example automotive application, microchannel coils may be used as a condenser and/or an evaporator in the air conditioning system of an automobile. A microchannel evaporator coil, for example, in an automotive air conditioning system is typically located in a housing having multiple air ducts leading to different locations in the passenger compartment of the automobile. The housing containing the microchannel evaporator coil is typically positioned behind the dashboard of the automobile, where space to mount the housing is limited. Therefore, the microchannel evaporator coil, which is much smaller than a conventional fin-and-tube evaporator coil that would otherwise be used in the automotive air conditioning system, is a suitable fit for use in an automobile. Prior to the present invention, the microchannel evaporator coil has not been used in large-scale refrigeration systems, in part, because of the high costs and difficulty that would be associated with manufacturing a microchannel evaporator coil large enough to accommodate the required refrigeration capacity of the large-scale refrigeration system.

SUMMARY OF THE INVENTION

[0004] The present invention provides, in one aspect, a unit cooler adapted for use in a refrigerated environment. The unit cooler includes a housing adapted to be positioned within the refrigerated environment and at least one microchannel evaporator coil supported by the housing. The at least one microchannel evaporator coil includes an inlet manifold and an outlet manifold. The inlet manifold has an inlet port for receiving refrigerant, and the outlet manifold has an outlet port for discharging the refrigerant.

[0005] The present invention provides, in another aspect, a unit cooler adapted for use in a refrigerated environment. The unit cooler includes a housing adapted to be positioned within the refrigerated environment, a first microchannel evaporator coil supported by the housing and configured such that the refrigerant makes at least one pass there-through, and a second microchannel evaporator coil supported by the housing and fluidly coupled with the first microchannel evaporator coil. The second microchannel evaporator coil is configured such that the refrigerant makes at least one pass through the second microchannel evaporator coil after making at least one pass through the first microchannel evaporator coil.

[0006] The present invention provides, in yet another aspect, a unit cooler adapted for use in a refrigerated environment. The unit cooler includes a housing adapted to be positioned within the refrigerated environment, a first microchannel evaporator coil supported by the housing and configured such that the refrigerant makes at least one pass therethrough, a second microchannel evaporator coil supported by the housing and configured such that the refrigerant makes at least one pass therethrough, and a distributor fluidly coupled with the first and second microchannel evaporator coils. The distributor is configured to deliver the refrigerant to the first and second microchannel evaporator coils. The unit cooler also includes an outlet header fluidly coupled with the first and second microchannel evaporator coils. The outlet header is configured to receive refrigerant from the first and second microchannel evaporator coils.

[0007] The present invention provides, in a further aspect, a method of assembling a unit cooler adapted for use in a refrigerated environment. The method includes providing a first microchannel evaporator coil configured such that the refrigerant makes at least one pass therethrough, fluidly connecting the first microchannel evaporator coil to a second microchannel evaporator coil configured such that the refrigerant makes at least one pass therethrough, and fluidly connecting a distributor to the first and second microchannel evaporator coils. The distributor is configured to deliver the refrigerant to the first and second microchannel evaporator coils.

[0008] The present invention provides, in another aspect, a method of assembling a unit cooler adapted for use in a refrigerated environment. The method includes providing a first microchannel evaporator coil configured such that the refrigerant makes at least one pass therethrough, providing a second microchannel evaporator coil configured such that the refrigerant makes at least one pass therethrough, and fluidly connecting a distributor to the first and second microchannel evaporator coils. The distributor is configured to deliver the refrigerant to the first and second microchannel evaporator coils. The method also includes fluidly connecting an outlet header to the first and second microchannel evaporator coils. The outlet header is configured to receive the refrigerant from the first and second microchannel evaporator coils. The method further includes substantially enclosing the first and second microchannel evaporator coils in a housing.

[0009] Other features and aspects of the present invention will become apparent to those skilled in the art upon review of the following detailed description, claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] In the drawings, wherein like reference numerals indicate like parts:

[0011] FIG. 1 is an exploded perspective view of a unit cooler including a first configuration of an evaporator assembly of the present invention.

[0012] FIG. 2 is an enlarged, perspective view of a first microchannel evaporator coil of the evaporator assembly of FIG. 1.
FIG. 3a is a partial section view of the first microchannel evaporator coil of FIG. 2, exposing multiple microchannels.

FIG. 3b is a broken view of the first microchannel evaporator coil of FIG. 2.

FIG. 4 is an exploded perspective view of a unit cooler including a second construction of an evaporator assembly of the present invention.

FIG. 5a is a perspective view of a second microchannel evaporator coil that may be utilized in an evaporator assembly of the present invention.

FIG. 5b is a perspective view of a third microchannel evaporator coil that may be utilized in an evaporator assembly of the present invention.

FIG. 6a is a schematic view of multiple microchannel evaporator coils arranged as a multiple row assembly, illustrating the multiple coils in a series arrangement.

FIG. 6b is a schematic view of multiple microchannel evaporator coils arranged as a multiple row assembly, illustrating the multiple coils in a parallel arrangement.

FIG. 7a is a schematic view of multiple microchannel evaporator coils arranged in a single row assembly, illustrating the multiple coils in a series arrangement.

FIG. 7b is a schematic view of multiple microchannel evaporator coils arranged in a single row assembly, illustrating the multiple coils in a parallel arrangement.

FIG. 8a is a schematic view of multiple coil assemblies in a series configuration with a distributor and an outlet header.

FIG. 8b is a schematic view of multiple coil assemblies in a parallel configuration with a distributor and an outlet header.

FIG. 9 is a perspective view of a third construction of an evaporator assembly of the present invention.

FIG. 10 is a perspective view of a fourth construction of an evaporator assembly of the present invention.

FIG. 11 is a perspective view of a fifth construction of an evaporator assembly of the present invention.

Before any features 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 arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or being carried out in various ways. Also, it is understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including”, “having”, and “comprising” and variations thereof herein is meant to encompass the items listed thereunder and equivalents thereof as well as additional items. The use of letters to identify elements of a method or process is simply for identification and is not meant to indicate that the elements should be performed in a particular order.

DETAILED DESCRIPTION

With reference to FIG. 1, a unit cooler 5 including a first configuration of an evaporator assembly 10 is shown. The unit cooler 5 may be used in a large-scale refrigeration system or a large-scale refrigerated environment, such as a walk-in cooler and a refrigerated warehouse, for example. The evaporator assembly 10 in the unit cooler 5 may therefore recirculate the air in the refrigerated environment to provide a refrigerated airflow to products stored in the walk-in cooler or refrigerated warehouse.

In a two-phase refrigeration system, the role of the evaporator assembly 10 is to receive low-pressure liquid refrigerant, remove heat from an airflow passing through the evaporator assembly 10, and discharge gaseous refrigerant to one or more compressors (not shown) remotely located from the evaporator assembly 10. The low-pressure liquid refrigerant evaporates as it passes through the evaporator assembly 10, such that the refrigerant passes through a substantial portion of the evaporator assembly 10 as a two-phase mixture (i.e., a liquid-gas state).

Gaseous refrigerant exiting the evaporator assembly 10 is drawn into the one or more compressors for re-processing into the refrigeration system. The one or more compressors pressurize the gaseous refrigerant and pump the high-pressure, gaseous refrigerant through one or more condensers (not shown), where heat transfer between the high-pressure gaseous refrigerant and an airflow passing through the one or more condensers causes the gaseous refrigerant to condense. In a large-scale refrigeration system, one or more condensers (not shown) may be positioned outside the walk-in cooler or refrigerated warehouse, such as on the rooftop of the buildings associated with the walk-in cooler and refrigerated warehouse to allow heat transfer from the condensers to the outside environment. High-pressure, liquid refrigerant exits the one or more condensers and is routed back toward the evaporator assembly 10. Before entering the evaporator assembly 10, the refrigerant passes through an expansion valve (not shown), which decreases the pressure of the liquid refrigerant for intake by the evaporator assembly 10. “Refrigerant-22,” “R-22,” “R-507,” or any hydride ammonia, for example, may be used in such a refrigeration system to provide sufficient cooling to the refrigeration system. If R-22 is used as the refrigerant of choice, the components of the refrigeration system in contact with the R-22 may be made from copper, aluminum, or steel, among other materials. However, as understood by those skilled in the art, any hydride ammonia is used as the refrigerant of choice, copper components of the refrigeration system in contact with the anyhydride ammonia may corrode. Alternatively, other refrigerants (including both two-phase and single-phase refrigerants or coolants) may be used with the evaporator assembly 10. When used with a single-phase refrigerant or coolant, the evaporator assembly 10 may be properly referred to as a heat exchanger assembly since the single-phase refrigerant or coolant will not evaporate. However, for convenience sake, the heat exchanger assembly will be referred to as an evaporator assembly 10 throughout the application and should be understood to also encompass heat exchanger assemblies of a single-phase refrigeration or cooling system.

In the illustrated construction of FIG. 1, the unit cooler 5 includes a housing 7 to support the evaporator assembly 10, which includes two microchannel evaporator cells 14a, 14b. The housing 7 includes an inlet 8 for drawing air from the refrigerated environment into the housing 7, and an outlet 9 for discharging refrigerated air from the housing.
7 back to the refrigerated environment. The housing 7 may be positioned in the walk-in cooler or refrigerated warehouse at any of a number of different elevations, and may further be suspended from the ceiling of the walk-in cooler or refrigerated warehouse. The housing 7 may be a substantially rectangular sheet metal structure as shown in FIG. 1. However, the housing 7 may be made from any of a number of different materials and comprise any number of different designs other than that shown in FIG. 1. As such, the illustrated housing 7 of FIG. 1 is intended for illustrative purposes only.

[0032] As shown in FIGS. 3a and 3b, each microchannel evaporator coil 14a, 14b includes an inlet manifold 22a, 22b and an outlet manifold 26a, 26b fluidly connected by a plurality of flat tubes 30. The inlet manifold 22a, 22b includes an inlet port 34a, 34b for receiving refrigerant, and the outlet manifold 26a, 26b includes an outlet port 38a, 38b for discharging the refrigerant. One or more baffles (not shown) may be placed in the inlet manifold 22a, 22b and/or the outlet manifold 26a, 26b to cause the refrigerant to make multiple passes through the flat tubes 30 for enhanced heat transfer between the refrigerant and the airflow passing through the coils 14a, 14b.

[0033] The flat tubes 30 may be formed to include multiple internal passageways, or microchannels 42, that are much smaller in size than the internal passageway of the coil in a conventional fin-and-tube evaporator coil. The microchannels 42 allow for more efficient heat transfer between the airflow passing over the flat tubes 30 and the refrigerant carried within the microchannels 42, compared to the airflow passing over the coil of the conventional fin-and-tube evaporator coil. In the illustrated construction, the microchannels 42 each are configured with a rectangular cross-section, although other constructions of the flat tubes 30 may have passageways of other cross-sections. The flat tubes 30 are separated into about 10 to 15 microchannels 42, with each microchannel 42 being about 1.5 mm in height and about 1.5 mm in width, compared to a diameter of about 9.5 mm (1/4") to 12.7 mm (1/2") for the internal passageway of a coil in a conventional fin-and-tube evaporator coil. However, in other constructions of the flat tubes 30, the microchannels 42 may be as small as 0.5 mm by 0.5 mm, or as large as 4 mm by 4 mm.

[0034] The flat tubes 30 may also be made from extruded aluminum to enhance the heat transfer capabilities of the flat tubes 30. In the illustrated construction, the flat tubes 30 are about 22 mm wide. However, in other constructions, the flat tubes 30 may be as wide as 26 mm, or as narrow as 18 mm. Further, the spacing between adjacent flat tubes 30 may be about 9.5 mm. However, in other constructions, the spacing between adjacent flat tubes 30 may be as much as 16 mm, or as little as 3 mm.

[0035] As shown in FIG. 3b, each microchannel evaporator coil 14a, 14b includes a plurality of fins 46 coupled to and positioned along the flat tubes 30. The fins 46 are generally arranged in a zig-zag pattern between adjacent flat tubes 30. In the illustrated construction, the fin density measured along the length of the flat tubes 30 is between 12 and 24 fins per inch. However, in other constructions of the microchannel evaporator coils 14a, 14b, the fin density may be slightly less than 12 fins per inch or more than 24 fins per inch. Generally, the fins 46 aid in the heat transfer between the airflow passing through the microchannel evaporator coils 14a, 14b and the refrigerant carried by the microchannels 42. The fins 46 may also include a plurality of louvers formed therein to provide additional heat transfer area. The increased efficiency of the microchannel evaporator coils 14a, 14b is due in part to such a high fin density, compared to the fin density of 2 to 4 fins per inch of a conventional fin-and-tube evaporator coil.

[0036] The increased efficiency of the microchannel evaporator coils 14a, 14b, compared to a conventional fin-and-tube evaporator coil, allows the microchannel evaporator coils 14a, 14b to be physically much smaller than the fin-and-tube evaporator coil. As a result, the microchannel evaporator coils 14a, 14b are not nearly as tall, and are not nearly as wide as a conventional fin-and-tube evaporator coil.

[0037] The microchannel evaporator coils 14a, 14b are attractive for use with large-scale refrigeration systems for these and other reasons. Since the microchannel evaporator coils 14a, 14b are much smaller than conventional fin-and-tube evaporator coils, the microchannel evaporator coils 14a, 14b may occupy less space in the walk-in coolers or refrigerated warehouses in which they are installed.

[0038] Since the microchannel evaporator coils 14a, 14b are much smaller than conventional fin-and-tube evaporator coils, the microchannel evaporator coils 14a, 14b may also contain less refrigerant compared to the conventional fin-and-tube evaporator coils. Further, less refrigerant may be required to be contained within the entire refrigeration system, therefore effectively decreasing potential damage to the environment by an accidental atmospheric release. Also, as a result of being able to decrease the amount of refrigerant in the refrigeration system, the buildings associated with the walk-in cooler or refrigerated warehouse may see an energy savings, since the compressor(s) may expend less energy to compress the decreased amount of refrigerant in the refrigeration system.

[0039] The evaporator assembly 10 also includes fans 50 coupled to the microchannel evaporator coils 14a, 14b to provide an airflow through the coils 14a, 14b. As shown in FIGS. 1b and 2, each microchannel evaporator coil 14a, 14b includes two fans 50 mounted therein. Alternatively, centrifugal blowers (not shown) may be used in place of the fans 50 or in combination with the fans 50. The fans 50 are supported in a fan shroud 54, which guides the airflow generated by the fans 50 through the microchannel evaporator coils 14a, 14b, and helps distribute the airflow amongst the face of each evaporator coil 14a, 14b. In a preferred construction of the evaporator assembly 10, the fans 50 may be “low-noise” fans, like the SWEPTWING™ fans available from Revoir, Inc. of Carpentersville, Ill. to help decrease noise emissions from the evaporator assembly 10. In other constructions of the evaporator assembly 10, and/or the shroud 54 may comprise any number of designs different than that shown in FIGS. 1 and 2.

[0040] FIG. 2 illustrates the shroud 54 supporting an electric motor 58 for driving one of the fans 50. The electric motor 58 may be configured to operate using either an AC or DC power source. Further, the electric motor 58 may be
electrically connected to a controller (not shown) that selectively activates the electric motor 58 to drive the fan 50 depending on any number of conditions monitored by the controller. For example, the fans 50 may be cycled on and off to either increase or decrease the heat transfer capability of the evaporator coils 14a, 14b.

[0041] FIG. 1 illustrates two microchannel evaporator coils 14a, 14b fluidly connected with the refrigeration system in a series arrangement. The inlet port 34a of a first microchannel evaporator coil 14a is shown coupled to an inlet header 59, whereby low-pressure, liquid refrigerant is pumped to the first microchannel evaporator coil 14a via the inlet header 59. In the illustrated construction, the inlet header 59 is coupled to the inlet port 34a by a brazing or welding process. Such a brazing or welding process provides a substantially fluid-tight connection between the inlet header 59 and the inlet port 34a. However, other constructions of the evaporator assembly 10 may utilize some sort of fluid-tight releasable couplings to allow serviceability of the coils 14a, 14b.

[0042] The outlet port 38a of the first microchannel evaporator coil 14a is shown coupled to an inlet port 34b of a second microchannel evaporator coil 14b via a connecting conduit 60. In the illustrated construction, the outlet port 38a of the first microchannel evaporator coil 14a is coupled to the connecting conduit 60 by a brazing or welding process, and the inlet port 34b of the second microchannel evaporator coil 14b is also coupled the connecting conduit 60 by a brazing or welding process. As previously stated, such a brazing or welding process provides a substantially fluid-tight connection between the outlet port 38a of the first microchannel evaporator coil 14a and the inlet port 34b of the second microchannel evaporator coil 14b. However, other constructions of the evaporator assembly 10 may utilize some sort of permanent or releasable fluid-tight couplings.

[0043] The outlet port 38b of the second microchannel evaporator coil 14b is shown coupled to an outlet header 61, whereby substantially gaseous refrigerant is discharged from the second microchannel evaporator coil 14b to the outlet header 61 for transport to the compressor in the refrigeration system. Further, in the illustrated construction, the outlet port 38b of the second microchannel evaporator coil 14b is coupled to the outlet header 61 by a brazing or welding process to provide a substantially fluid-tight connection between the outlet port 38b of the second microchannel evaporator coil 14b and the outlet header 61. However, other constructions of the evaporator assembly 10 may utilize some sort of permanent or releasable fluid-tight couplings.

[0044] During operation of the refrigeration system utilizing the evaporator assembly 10 of FIG. 1, the fans 50 may be activated to provide an airflow through the first microchannel evaporator coil 14a. Low-pressure, liquid refrigerant is pumped into the first microchannel coil 14a, where the heat transfer between the airflow passing through the evaporator coil 14a and the refrigerant causes the liquid refrigerant to at least partially evaporate as the refrigerant passes through the flat tubes 30. If baffles are not placed in either of the inlet or outlet manifolds 22a, 26a of the first microchannel evaporator coil 14a, the refrigerant will make one pass from the inlet manifold 22a to the outlet manifold 26a before being discharged from the first microchannel evaporator coil 14a.

[0045] Since the evaporator coils 14a, 14b are connected in a series arrangement, the refrigerant is passed from the first microchannel evaporator coil 14a to the second microchannel evaporator coil 14b. If only a portion of the low-pressure, liquid refrigerant is evaporated in the first microchannel evaporator coil 14a, then the remaining portion is evaporated in the second microchannel evaporator coil 14b. Like the first microchannel evaporator coil 14a, if baffles are not placed in either of the inlet or outlet manifolds 22b, 26b of the second microchannel evaporator coil 14b, the refrigerant will make one pass from the inlet manifold 22b to the outlet manifold 26b before being discharged from the second microchannel evaporator coil 14b. Further, the fans 50 may be activated to provide the airflow through the second microchannel evaporator coil 14b.

[0046] FIG. 4 illustrates a unit cooler 63 including the housing 7 to support an evaporator assembly 62, which includes two microchannel evaporator coils 64a, 64b fluidly connected with the refrigeration system in a parallel arrangement. The housing 7 illustrated in FIG. 4 is substantially the same as that shown in FIG. 1, the particular design of which is for illustrative purposes only and will not be further discussed. The fans 50 and the fan shrouds 54 are also substantially the same as those shown in FIG. 1, and will not be further discussed. Inlet ports 66a, 66b of the first and second microchannel evaporator coils 64a, 64b are shown extending from inlet manifolds 70a, 70b and coupled to respective inlet headers 74a, 74b, whereby low-pressure, liquid refrigerant is pumped to the first and second microchannel evaporator coils 64a, 64b via the inlet headers 74a, 74b. In the illustrated construction, the inlet headers 74a, 74b are coupled to the inlet ports 66a, 66b of the first and second microchannel evaporator coils 64a, 64b by a brazing or welding process to provide a substantially fluid-tight connection between the inlet headers 74a, 74b and the inlet ports 66a, 66b. However, other constructions of the evaporator assembly 62 may utilize some sort of permanent or releasable fluid-tight couplings.

[0047] With continued reference to FIG. 4, a distributor 65 may be used with the evaporator assembly 62 to facilitate a substantially equal distribution of refrigerant to the coils 64a, 64b. A single inlet conduit 71 may fluidly connect the distributor 65 with the one or more condensers or the single inlet conduit 71 may fluidly connect the distributor 65 with a liquid receiver storing compressed, liquid refrigerant. The inlet headers 74a, 74b fluidly connect to the distributor 65 to receive substantially equal portions of refrigerant.

[0048] One or more expansion valves may be used with the evaporator assembly 62 to decrease the pressure of the liquid refrigerant in the refrigeration system before the liquid refrigerant enters the evaporator assembly 62, as discussed above. With reference to FIG. 4, a single expansion valve may be positioned between the condensers/liquid receiver and the distributor 65, such that both of the coils 64a, 64b receive refrigerant at the same pressure. Alternatively, an expansion valve may be associated with each inlet header 74a, 74b, such that the coils 64a, 64b may receive refrigerant at different pressures.

[0049] Outlet ports 78a, 78b of the first and second microchannel evaporator coils 64a, 64b are shown extending from outlet manifolds 82a, 82b coupled to an outlet header 86, whereby substantially gaseous refrigerant is
discharged from the first and second microchannel evaporator coils 64a, 64b via the outlet header 86. In the illustrated construction, the outlet header 86 is coupled to the outlet ports 78a, 78b of the first and second microchannel evaporator coils 64a, 64b by a brazing or welding process to provide a substantially fluid-tight connection between the outlet header 86 and the outlet ports 78a, 78b. However, other constructions of the evaporator assembly 62 may utilize some sort of permanent or releasable fluid-tight couplings.

In the illustrated construction, the inlet ports 66a, 66b extend substantially transversely from the inlet manifolds 70a, 70b to fluidly connect with the inlet headers 74a, 74b, and the outlet ports 78a, 78b extend substantially transversely from the outlet manifolds 82a, 82b to fluidly connect with the outlet header 86. However, in other constructions of the evaporator assembly 62, the inlet ports 66a, 66b and the outlet ports 78a, 78b may extend from the respective inlet manifolds 70a, 70b and the outlet manifolds 82a, 82b as shown in FIG. 1, and utilize additional intermediate piping to fluidly connect the inlet ports 66a, 66b with the inlet headers 74a, 74b and the outlet ports 78a, 78b with the outlet header 86.

During operation of the refrigeration system utilizing the evaporator assembly 62 of FIG. 4, the fans 50 may be activated to provide the airflow through the coils 64a, 64b, while the low-pressure, liquid refrigerant is pumped through the single inlet conduit 71 to the distributor 65, where substantially equal portions of the liquid refrigerant enter the first microchannel condenser coil 64a and the second microchannel condenser coil 64b. Heat transfer between the airflow passing through the evaporator coils 64a, 64b and the refrigerant causes the liquid refrigerant to evaporate as the refrigerant passes through the flat tubes 30. If baffles are not placed in either of the inlet manifold 70a or the outlet manifold 82a of the first microchannel evaporator coil 64a, the refrigerant will make one pass from the inlet manifold 70a to the outlet manifold 82a before being discharged from the first microchannel evaporator coil 64a to the outlet header 86.

Since the evaporator coils 64a, 64b are connected with the refrigeration system in a parallel arrangement, and if baffles are not placed in either of the inlet manifold 70a or the outlet manifold 82a of the second microchannel evaporator coil 64b, the refrigerant will make one pass from the inlet manifold 70b to the outlet manifold 82b before being discharged from the second microchannel evaporator coil 64b to the outlet header 86, where the substantially gaseous refrigerant rejoins the substantially gaseous refrigerant discharged from the first microchannel evaporator coil 64a.

Each microchannel evaporator coil 64a, 64b may also include multiple inlet and outlet ports (not shown), corresponding with multiple baffles (not shown) located within the inlet manifolds 70a, 70b and/or the outlet manifolds 82a, 82b to provide multiple refrigeration circuits throughout each microchannel evaporator coil 64a, 64b.

The microchannel evaporator coils 14a, 14b, 64a, 64b allow for a unique method of assembling the evaporator assemblies 10, 62. As previously stated, a single, large conventional fin-and-tube evaporator coil is typically provided in refrigeration systems for large-scale refrigerated environments. This conventional fin-and-tube evaporator coil must be appropriately sized to provide the refrigeration capacity desired in the refrigerated environment. Such an evaporator coil must often be custom manufactured to the size required by the refrigeration system. Further, the housing 7 and fan shrouds may also require custom manufacturing to match up with the custom manufactured conventional fin and tube evaporator coil. This may drive up the costs associated with manufacturing an evaporator assembly utilizing a conventional fin-and-tube evaporator coil.

The microchannel evaporator coils 14a, 14b, 64a, 64b are manufactured in standard sizes, which allows the manufacturer of the evaporator assembly 10 or 62 to utilize their expertise to calculate the total refrigeration capacity of a particular refrigeration system and determine how many standard-sized microchannel evaporator coils 14a, 14b or 64a, 64b will be required to satisfy the total refrigeration capacity of the refrigeration system. After determining how many standard-sized microchannel evaporator coils 14a, 14b or 64a, 64b will be required, the manufacturer may utilize their capabilities to put together the evaporator assembly 10 or 62. Fluid connections may be made by brazing or welding processes, or releasable couplings may be used to allow serviceability of the coils 14a, 14b or 64a, 64b. Further, the fans 50 and the fan shrouds 54 may be manufactured or purchased by the evaporator assembly manufacturer in standard sizes to match up with the standard-sized microchannel evaporator coils 14a, 14b, 64a, 64b. Also, the housing 7 may be either custom made to support multiple connected microchannel evaporator coils 14a, 14b or 64a, 64b, or the housing 7 may be standard-sized to support a single or dual microchannel evaporator coils 14a, 14b or 64a, 64b, for example. This method of assembling the evaporator assemblies 10, 62 may allow the manufacturer to streamline their operation, which in turn may result in decreased costs for the manufacturer.

Although only two microchannel evaporator coils 14a, 14b or 64a, 64b are shown in the illustrated constructions of FIGS. 1 and 4, more or less than two microchannel evaporator coils 14a, 14b or 64a, 64b may be included in the evaporator assemblies 10 or 62 to satisfy the total refrigeration capacity of the refrigeration system in which the microchannel evaporator coils 14a, 14b or 64a, 64b will be used.

With reference to FIGS. 5a and 5b, other evaporator coils may be utilized in the evaporator assemblies 10, 62. FIG. 5a illustrates a microchannel evaporator coil 98 substantially similar to the coils 14a, 14b, 64a, 64b with the exception that the coil 98 includes multiple inlet ports 102 and outlet ports 106. This style of microchannel evaporator coil 98 may provide a better distribution of low-pressure, liquid refrigerant to an inlet manifold 110 of the coil 98, in addition to a better distribution of gaseous refrigerant from an outlet manifold 114 of the coil 98.

FIG. 5b illustrates another microchannel evaporator coil 118 substantially similar to the coils 14a, 14b, 64a, 64b, 98 with the exception that the coil 118 is divided into two separate and distinct fluid circuits by a baffle 122 positioned in an inlet manifold 126 of the coil 118 and another baffle 130 positioned in an outlet manifold 134 of the coil 118. This style of microchannel evaporator coil 118 may allow refrigerant from multiple refrigeration circuits to be passed through the coil 118.

With reference to FIGS. 6a-7b, any of the microchannel evaporator coils 14a, 14b, 64a, 64b, 98, or 118 may
be grouped together in either single-row assemblies or multiple-row assemblies. FIGS. 6a and 6b illustrate coils being grouped in multiple-row assemblies 138, 142, respectively. Specifically, FIGS. 6a and 6b illustrate coils being grouped in three-row assemblies 138, 142. In the three-row assemblies 138, 142 of FIGS. 6a and 6b, the coils are stacked one on top of another such that airflow is directed through all of the coils. Although three coils are shown in the multiple-row assemblies 138, 142 of FIGS. 6a and 6b, more or less than three coils 14a, 14b, 64a, 64b, 98, or 118 may be used depending on the total refrigeration capacity of a particular refrigeration system in which the assemblies 138, 142 are used. In addition, although FIGS. 6a and 6b generally illustrate the coils 14a, 14b, it should be known that any of the coils 14a, 14b, 64a, 64b, 98, or 118 may be used in forming the assemblies 138, 142.

[0060] With particular reference to FIG. 6a, the three coils in the assembly 138 are shown in a fluid series connection, whereby refrigerant is passed through the three coils one after another. However, with particular reference to FIG. 6b, the three coils in the assembly 142 are shown in a fluid parallel connection, whereby refrigerant is passed through the coils independently of one another. In constructing the evaporator assemblies 10, 62, it is up to the manufacturer to determine if multiple-row assemblies 138, 142 will be used. Furthermore, if multiple-row assemblies 138, 142 are to be used, it is up to the manufacturer to determine whether to use an assembly 138 having coils grouped in a fluid series connection, or an assembly 142 having coils grouped in a fluid parallel connection.

[0061] FIGS. 7a and 7b illustrate coils being grouped in single-row assemblies 146, 150. Specifically, FIGS. 7a and 7b illustrate the coils being grouped in a single-row assembly 146 of three coils. In the single-row assemblies 146, 150 of FIGS. 7a and 7b, the coils are unfolded, or spread out such that airflow passing through one of the coils is not directed through another of the three coils. Although three coils are shown in the single-row assemblies 146, 150 of FIGS. 7a and 7b, more or less than three coils may be used depending on the total refrigeration capacity of the particular refrigeration system in which the assemblies 146, 150 are used. In addition, although FIGS. 7a and 7b generally illustrate the coils 14a, 14b, it should be known that any of the coils 14a, 14b, 64a, 64b, 98, or 118 may be used in forming the assemblies 146, 150.

[0062] With particular reference to FIG. 7a, the three coils in the assembly 146 are shown in a fluid series connection, whereby refrigerant is passed through the three coils one after another. However, with particular reference to FIG. 7b, the three coils in the assembly 150 are shown in a fluid parallel connection, whereby refrigerant is passed through the coils independently of one another. In constructing the evaporator assemblies 10, 62, it is up to the manufacturer to determine if single-row assemblies 146, 150 will be used. Furthermore, if single-row assemblies 146, 150 are to be used, it is up to the manufacturer to determine whether to use an assembly 146 having coils grouped in a fluid series connection, or an assembly 150 having coils grouped in a fluid parallel connection.

[0063] With reference to FIGS. 8a and 8b, one or more assemblies 138, 142, 146, or 150 may be grouped into a series configuration 154 or a parallel configuration 158. As shown in FIG. 8a, a three-row assembly 138 and a single row assembly 146 are grouped into a fluid series configuration 154 between an inlet header 162 and an outlet header 166. The distributor 65 receives low-pressure, liquid refrigerant from one or more condensers or a liquid receiver via the single inlet conduit 71, and the inlet header 162 fluidly connects the distributor 65 and the three-row assembly 138. An expansion valve (not shown) may also be used to reduce the pressure of the liquid refrigerant as described above. Although the three-row assembly 138 and single-row assembly 146 are shown in the series configuration 154 of FIG. 8a, any combination of multiple-row assemblies 138 or 142 and single-row assemblies 146 or 150 may be used depending on the determination of the manufacturer. In addition, more or less than two assemblies 138, 142, 146, or 150 may be used in the series configuration 154 depending on the total refrigeration capacity of the particular refrigeration system in which the series configuration 154 is used. In addition, although FIG. 8a generally illustrates the coils 14a, 14b, it should be known that any of the coils 14a, 14b, 64a, 64b, 98, or 118 may be used in forming the assemblies 138, 142, 146, or 150 that comprise either the series configuration 154 or the parallel configuration 158.

[0064] As shown in FIG. 8b, a three-row assembly 138 and a single row assembly 146 are grouped into a fluid parallel configuration 158. The distributor 65 receives low-pressure, liquid refrigerant from one or more condensers or a liquid receiver via the single inlet conduit 71, and a first inlet header 162 fluidly connects the distributor 65 and the three-row assembly 138, and a second inlet header 162 fluidly connects the distributor 65 and the single-row assembly 146. An expansion valve (not shown) may also be used to reduce the pressure of the liquid refrigerant as described above. Although the three-row assembly 138 and the single-row assembly 146 are shown in the parallel configuration 158 of FIG. 8b, any combination of multiple-row assemblies 138 or 142 and single-row assemblies 146 or 150 may be used depending on the determination of the manufacturer. In addition, more or less than two assemblies 138, 142, 146, or 150 may be used in the parallel configuration 158 depending on the total refrigeration capacity of the particular refrigeration system in which the parallel configuration 158 is used. In addition, although FIG. 8b generally illustrates the coils 14a, 14b, it should be known that any of the coils 14a, 14b, 64a, 64b, 98, or 118 may be used in forming the assemblies 138, 142, 146, or 150 that comprise either the series configuration 154 or the parallel configuration 158.

[0065] Using the above terminology, FIG. 1 illustrates a single-row assembly 146 in a series configuration 154 between the inlet header 59 and the outlet header 61, whereby the coils 14a, 14b in the single-row assembly 146 are grouped into a fluid series connection. Also, using the above terminology, FIG. 4 illustrates a single-row assembly 150 in a parallel configuration 158 between the inlet headers 74a, 74b and the outlet header 86, whereby the coils 64a, 64b in the single-row assembly 150 are grouped into a fluid parallel connection.

[0066] FIG. 9 illustrates a third construction of an evaporator assembly 170 including three two-row assemblies 138 in a parallel configuration 158 between inlet headers 174 and an outlet header 176. Each two-row assembly 138 includes two microchannel evaporator coils 14a, 14b grouped in a fluid series connection. Rather than being permanently con-
connected to the inlet and outlet headers 174, 178, respectively, the coils 14a, 14b may be coupled to the inlet and outlet headers 174, 178 by fluid-tight releasable couplings 182. The couplings 182 are illustrated in FIG. 9, and may comprise any known suitable fluid-tight, quick-release coupling and/or releasable coupling. By using the couplings 182 in place of permanently connecting the coils 14a, 14b to the inlet and outlet headers 174, 178, the assemblies 138 are permitted to be removed and/or replaced to accommodate a varying refrigeration capacity or to permit serviceability of a damaged assembly 138.

[0067] FIG. 10 illustrates a fourth construction of an evaporator assembly 190 including a two-row assembly 138, with three separate and distinct fluid circuits, in a parallel configuration 158 between multiple inlet headers 194 and multiple outlet headers 198. The two-row assembly 138 includes two microchannel evaporator coils 118 grouped in a fluid series connection. As previously explained, the coils 118 each include respective baffles 122, 130 in the inlet and outlet manifolds 126, 134 to establish separate and distinct fluid circuits through the assembly 138. Like the assemblies 138 of FIG. 9, the assembly 138 of FIG. 10 may utilize fluid-tight couplings 182 to permit removal and/or replacement of the assembly 138 to accommodate a varying refrigeration capacity or to permit serviceability of a damaged assembly 138.

[0068] FIG. 11 illustrates a fifth construction of an evaporator assembly 202 including a single-row assembly 150 between inlet headers 206 and an outlet header 210. The single-row assembly 150 includes four microchannel evaporator coils 64a, 64b grouped in a fluid parallel connection. The coils 64a, 64b are inclined with respect to the inlet and outlet headers 206, 210, such that the footprint of the evaporator assembly 202 is reduced (compared to the assembly 62 of FIG. 4, for example). Although FIG. 11 generally illustrates the coils 64a, 64b, it should be known that any of the coils 14a, 14b, 64a, 64b, 98, or 118 may be used in forming the assembly 150.

[0069] As indicated by FIGS. 1, 4, and 9-11, the evaporator assemblies 10, 62, 170, 190, 202 can be relatively small or relatively large. If a relatively large refrigeration capacity must be satisfied, a relatively large evaporator assembly (such as the assembly 170 of FIG. 9) having a plurality of assemblies 138, 142, 146, or 150 may be used. However, if a relatively small refrigeration capacity must be satisfied, a relatively small evaporator assembly (such as the assemblies 10, 62 of FIGS. 1 and 4, respectively) having only one assembly 138, 142, 146, 150 may be used. The evaporator assemblies 10, 62, 170, 190, 202 are shown for exemplary reasons only, and are not meant to limit the spirit and/or scope of the present invention.

We claim:

1. A unit cooler adapted for use in a refrigerated environment, the unit cooler comprising:
   a housing adapted to be positioned within the refrigerated environment; and
   at least one microchannel evaporator coil supported by the housing, the at least one microchannel evaporator coil including an inlet manifold and an outlet manifold, the inlet manifold having an inlet port for receiving refrigerant, and the outlet manifold having an outlet port for discharging the refrigerant.

2. The unit cooler of claim 1, further comprising at least one fan supported by the housing, the fan being configured to generate an airflow at least partially through the microchannel evaporator coil.

3. The unit cooler of claim 1, wherein the microchannel evaporator coil includes a plurality of fins spaced thereon between 12 and 24 fins per inch.

4. The unit cooler of claim 1, wherein the microchannel evaporator coil includes a plurality of microchannels fluidly connecting the inlet manifold and the outlet manifold, the microchannels measuring between about 0.5 mm by about 0.5 mm and about 4 mm in cross-section.

5. A unit cooler adapted for use in a refrigerated environment, the unit cooler comprising:
   a housing adapted to be positioned within the refrigerated environment;
   a first microchannel evaporator coil supported by the housing and configured such that the refrigerant makes at least one pass therethrough; and
   a second microchannel evaporator coil supported by the housing and fluidly coupled with the first microchannel evaporator coil, the second microchannel evaporator coil being configured such that the refrigerant makes at least one pass through the second microchannel evaporator coil after making at least one pass through the first microchannel evaporator coil.

6. The unit cooler of claim 5, further comprising at least one fan supported by the housing, the fan being configured to generate an airflow at least partially through at least one of the first and second microchannel evaporator coils.

7. The unit cooler of claim 5, wherein at least one of the first and second microchannel evaporator coils include a plurality of fins spaced thereon between 12 and 24 fins per inch.

8. The unit cooler of claim 5, wherein at least one of the first and second microchannel evaporator coils include a plurality of microchannels fluidly connecting the inlet manifold and the outlet manifold, the microchannels measuring between about 0.5 mm by about 0.5 mm and about 4 mm in cross-section.

9. The unit cooler of claim 5, wherein the first and second microchannel evaporator coils each include an inlet manifold and an outlet manifold, and wherein the outlet manifold of the first microchannel evaporator coil is fluidly connected with the inlet manifold of the second microchannel evaporator coil.

10. The unit cooler of claim 9, wherein the respective inlet manifolds each include at least one inlet port, and the respective outlet manifolds each include at least one outlet port, and wherein the outlet port of the first microchannel evaporator coil is coupled to the inlet port of the second microchannel evaporator coil.

11. The unit cooler of claim 5, wherein the second microchannel evaporator coil is in a fluid series connection with the first microchannel evaporator coil.

12. A unit cooler adapted for use in a refrigerated environment, the unit cooler comprising:
   a housing adapted to be positioned within the refrigerated environment;
a first microchannel evaporator coil supported by the housing and configured such that refrigerant makes at least one pass therethrough;

a second microchannel evaporator coil supported by the housing and configured such that the refrigerant makes at least one pass therethrough;

da distributor fluidly coupled with the first and second microchannel evaporator coils, the distributor being configured to deliver the refrigerant to the first and second microchannel evaporator coils;

an outlet header fluidly coupled with the first and second microchannel evaporator coils, the outlet header being configured to receive refrigerant from the first and second microchannel evaporator coils.

13. The unit cooler of claim 12, further comprising at least one fan supported by the housing, the fan being configured to generate an airflow at least partially through at least one of the first and second microchannel evaporator coils.

14. The unit cooler of claim 12, wherein at least one of the first and second microchannel evaporator coils include a plurality of fins spaced thereon between 12 and 24 fins per inch.

15. The unit cooler of claim 12, wherein the first and second microchannel evaporator coils each include an inlet manifold and an outlet manifold.

16. The unit cooler of claim 15, wherein the inlet and outlet manifolds of the first and second microchannel evaporator coils are fluidly connected by a plurality of microchannels, the microchannels measuring between about 0.5 mm by about 0.5 mm and about 4 mm by about 4 mm in cross-section.

17. The unit cooler of claim 15, wherein the inlet manifolds of the first and second microchannel condenser coils are fluidly connected with the distributor.

18. The unit cooler of claim 17, wherein the inlet manifolds of the first and second microchannel evaporator coils each include at least one inlet port, the at least one inlet port of the first microchannel evaporator coil being coupled to the distributor, and the at least one inlet port of the second microchannel evaporator coil being coupled to the distributor.

19. The unit cooler of claim 15, wherein the outlet manifolds of the first and second microchannel evaporator coils are fluidly connected with the outlet header.

20. The unit cooler of claim 19, wherein the outlet manifolds of the first and second microchannel evaporator coils each include at least one outlet port, the at least one outlet port of the first microchannel evaporator coil being coupled to the outlet header, and the at least one outlet port of the second microchannel evaporator coil being coupled to the outlet header.

21. A method of assembling a unit cooler adapted for use in a refrigerated environment, the method comprising:

providing a first microchannel evaporator coil configured such that refrigerant makes at least one pass therethrough;

fluidly connecting the first microchannel evaporator coil to a second microchannel evaporator coil configured such that the refrigerant makes at least one pass through the second microchannel evaporator coil after making at least one pass through the first microchannel evaporator coil, and

substantially enclosing the first and second microchannel evaporator coils in a housing.

22. The method of claim 21, further comprising positioning at least one fan over at least one of the first and second microchannel evaporator coils, the fan being configured to generate an airflow through the at least one of the first and second microchannel evaporator coils.

23. The method of claim 21, wherein fluidly connecting the first microchannel evaporator coil to the second microchannel evaporator coil includes coupling an outlet port of the first microchannel evaporator coil with an inlet port of the second microchannel evaporator coil.

24. The method of claim 21, further comprising:

calculating a total refrigeration capacity of the refrigeration system; and

determining how many microchannel evaporator coils should be fluidly interconnected.

25. A method of assembling a unit cooler adapted for use in a refrigerated environment, the method comprising:

providing a first microchannel evaporator coil configured such that refrigerant makes at least one pass therethrough;

providing a second microchannel evaporator coil configured such that the refrigerant makes at least one pass therethrough;

fluidly connecting a distributor to the first and second microchannel evaporator coils, the distributor being configured to deliver the refrigerant to the first and second microchannel evaporator coils;

fluidly connecting an outlet header to the first and second microchannel evaporator coils, the outlet header being configured to receive the refrigerant from the first and second microchannel evaporator coils; and

substantially enclosing the first and second microchannel evaporator coils in a housing.

26. The method of claim 25, further comprising positioning at least one fan over at least one of the first and second microchannel evaporator coils, the fan being configured to generate an airflow through the at least one of the first and second microchannel evaporator coils.

27. The method of claim 25, wherein fluidly connecting the distributor to the first and second microchannel evaporator coils includes coupling respective inlet ports of the first and second microchannel evaporator coils to the distributor.

28. The method of claim 25, wherein fluidly connecting the outlet header to the first and second microchannel evaporator coils includes coupling respective outlet ports of the first and second microchannel evaporator coils to the outlet header.

29. The method of claim 25, further comprising:

calculating a total refrigeration capacity of the refrigeration system; and

determining how many microchannel evaporator coils should be fluidly interconnected.