Modular manifolds for heat exchangers are disclosed with a primary tube disposed alongside a heat exchanger with a port disposed adjacent to ports of the heat exchanger. A manifold block is provided with a port mounted to the primary tube for fluid communication with the primary tube. The manifold block includes a plurality of back extruded ports for direct communication with the ports of the heat exchanger. Additionally, a method is disclosed for manufacturing a modular manifold for heat exchangers.
**Fig. 1**
(PRIOR ART)

**Fig. 2**

- **EVAPORATOR**
- **COMPRRESSOR**
- **CONDENSOR**
- **EXPANSION VALVE**
MODULAR MANIFOLDS FOR HEAT EXCHANGERS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The invention relates to heat exchangers, more particularly to manifolds for heat exchangers.

[0003] 2. Background Art

[0004] Heat exchangers generally are units wherein a first fluid is conveyed in close proximity to a second fluid of a different temperature, such that heat is exchanged from one fluid to another. Heat exchangers generally include condensers and evaporators, which employ manifolds that are utilized for conveying a fluid therein. The manifolds are typically formed from a material that is both conductive and structurally adequate to retain the fluid therein for an exchange of heat to a fluid external of the manifold.

[0005] Some heat exchangers, such as coils of an air conditioner for residential use, have a plurality of ports to the multiple coils. These ports may be input ports or output ports. In order to provide fluids to the multiple ports, or collect fluid from the multiple ports, a manifold is required in fluid communication with the series of ports.

[0006] Referring now to FIG. 1, a prior art manifold 20 is illustrated for fluid communication with a series of ports on air conditioning coils of a heat exchanger. The manifold 20 includes a joining tube 22 with a series of ports 24 mounted thereto. For the given application, the heat exchanger coils include a first series of ports 26 and a second series of ports 28. As is common with air conditioner coils, the first series of ports 26 and the second series of ports 28 are equal in number, for example three in each series; and each series is arranged similarly. Accordingly, the joining tube 22 includes a port 24 for each of the ports of the first series and second series of coil port 26, 28. Additionally, a feeder tube 30 is provided for fluid communication between each of the ports 24 of the joining tube 22 and a corresponding port of one of the first or second series of coil ports 26, 28.

SUMMARY OF THE INVENTION

[0007] An aspect of the present invention is to provide a modular manifold for a heat exchanger with a primary tube disposed alongside the heat exchanger. The primary tube has a port disposed adjacent to at least a pair of ports of the heat exchanger. A manifold block has a first port mounted to the primary tube port for fluid communication with the primary tube. The manifold block also has at least a pair of back extruded ports for direct fluid communication with the at least a pair of ports of the heat exchanger.

[0008] Another aspect of the present invention is to provide a method for manufacturing a manifold for heat exchangers. The method includes forming a primary tube to approach a series of ports on a heat exchanger. A series of riser ports are formed on a manifold block that are sized to cooperate with a portion of the series of ports on the heat exchanger. The manifold block is mounted on the primary tube. The manifold block risers are mounted on the portion of the series of ports on the heat exchanger. An intermediate tube is formed to extend from the manifold block to a remaining portion of the series of ports on the heat exchanger. The intermediate tube is mounted to the manifold block. A series of riser ports are formed on a second manifold block that are sized to cooperate with the remaining portion of the series of ports on the heat exchanger. The second manifold block is mounted on the intermediate tube. The second manifold block risers are also mounted on the remaining portion of the series of ports on the heat exchanger.

[0009] The above aspects, and other aspects, embodiments, objects, features, and advantages of the present invention are readily apparent from the following detailed description of embodiments of the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is an elevation view of a prior art manifold for a heat exchanger;

[0011] FIG. 2 is a schematic view of a vapor-compression cycle utilizing heat exchangers in accordance with the present invention;

[0012] FIG. 3 is an elevation view of a manifold for a heat exchanger in accordance with the present invention;

[0013] FIG. 4 is an axial end view of another manifold block for a manifold in accordance with the present invention;

[0014] FIG. 5 is a port side elevation view of the manifold block of FIG. 4;

[0015] FIG. 6 is an elevation view of another manifold block in accordance with the present invention;

[0016] FIG. 7 is an axial end view of the manifold block of FIG. 6;

[0017] FIG. 8 is a left side elevation view of another manifold for a heat exchanger in accordance with the present invention;

[0018] FIG. 9 is a front side elevation view of the manifold of FIG. 8;

[0019] FIG. 10 is a left side elevation view of yet another manifold for a heat exchanger in accordance with the present invention;

[0020] FIG. 11 is a front side elevation view of the manifold of FIG. 10;

[0021] FIG. 12 is a port side elevation view of another manifold block in accordance with the present invention; and

[0022] FIG. 13 is a side elevation view of another manifold block in accordance with the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS OF THE INVENTION

[0023] As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various and alternative forms. The figures are not necessarily to scale; some features may be exaggerated or minimized to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be
interpreted as limiting, but merely as a representative basis for the claims and/or as a representative basis for teaching one skilled in the art to variously employ the present invention.

[0024] Referring now to FIG. 2, a simple vapor-compression cycle is illustrated and referenced generally by numeral 32. The cycle 32 includes a compressor 34, such as a pump, which pumps fluid through the cycle 32 in the direction of the arrows illustrated in the figure. The compressor 34 pumps the fluid to the heat exchanger, illustrated by condenser 36. The fluid is condensed by the compressor 34 thereby exchanging heat from the fluid in the condenser 36 to a second fluid passing through the condenser 36. The fluid is subsequently conveyed to an expansion valve 38 whereby the pressure imparted by the compressor 34 is reduced. Next, the fluid is conveyed into another heat exchanger such as an evaporator 40. At the evaporator 40, the fluid within the cycle 32 is heated by an external fluid that causes the fluid within the cycle 32 to evaporate, thereby absorbing the heat from the external fluid of the evaporator 40. The fluid within the cycle 32 is subsequently compressed by the compressor 34 and the heat absorbed at the evaporator 40 is thereby released at the condenser 36.

[0025] The cycle 32 illustrated in FIG. 2 is a simple vapor-compression cycle for illustrating practical uses of heat exchangers such as the condenser 36 and the evaporator 40. The cycle 32 may be representative of a refrigeration cycle wherein the compressor 34 pressurizes refrigerant for releasing heat at the condenser 36 to ambient air external of the refrigerant. The pressure of the refrigerant is released at the expansion valve 38 and the refrigerant evaporates within the evaporator 40 within the refrigerant for absorbing heat from the refrigerator and thereby conveying the heated refrigerant to the compressor 34.

[0026] Likewise, the cycle 32 may be representative of a cooling system for a vehicle or residential application, such as the air conditioner coils discussed with reference to FIG. 1, whereby coolant is evaporated at the evaporator 40, or at the engine of the vehicle. The pump or compressor 34 pressurizes the coolant in the condenser 36 or radiator such that the heat is transferred through the condenser 36 to air that passes through the condenser 36 or is forced through the condenser 36. The pressure on the coolant is subsequently reduced in expansion valve 38 and the cycle 32 continues.

[0027] Although a vapor-compression cycle is illustrated and specific heat exchanger applications are described, the invention contemplates that the present invention may be utilized with various heat exchangers and various cycles that incorporate heat exchangers in accordance with the present invention.

[0028] With reference now to FIG. 3, a manifold 42 is illustrated in accordance with the present invention in fluid communication with a heat exchanger 44. The heat exchanger 44 may be any heat exchanger in accordance with the present invention. For the embodiment illustrated in FIG. 3, the heat exchanger 44 is a heat exchanger for which the prior art manifold 20 of FIG. 1 is provided; and the ports 26, 28 of the manifold 20 of FIG. 1 match the ports of the heat exchanger 44 of FIG. 3. Accordingly, the manifold 42 of FIG. 3 replaces the manifold 20 of FIG. 1 for the given heat exchanger application.

[0029] The manifold 42 includes a joining tube 46 extending alongside the heat exchanger 44. For purposes of description, the manifold 42 is described as an intake manifold for conveying fluid, such as a coolant to the heat exchanger 44. The invention contemplates that the manifold 42 may also be an outlet manifold for conveying fluid from the heat exchanger 44.

[0030] The joining tube 46 has an outlet port 48 at a distal end of the joining tube 46. The outlet port 48 approaches a first array of heat exchanger ports 50. For the particular embodiment, the array of heat exchanger ports 50 includes three ports and the primary tube 46 includes a ninety degree bend 52 for approaching the first array of ports 50.

[0031] In order to convey fluid from the joining tube 46 to the first array of heat exchanger ports 50, a manifold block 54 is provided. The manifold block 54 has a first port 56 formed axially therein for receiving the outlet port 48 of the joining tube 46. The manifold block 54 also includes an array of ports 58 formed therethrough for cooperating with the first array of heat exchanger ports 50. By providing the manifold block 54, a series of feeder tubes such as the feeder tubes 30 of the prior art manifold 20 of FIG. 1, are eliminated.

[0032] For the given embodiment, the heat exchanger 44 also has a second array of heat exchanger ports 60. Accordingly, the manifold block 54 is provided with a second axial port 62 for conveying fluid from the joining tube 46 to the second array of heat exchanger ports 60. Less fluid is conveyed to the second array of heat exchanger ports 60 than that originally provided to the first manifold block 54 because of the fluid conveyed to the array of manifold block ports 58. Accordingly, the second axial port 62 has an inner diameter that is less than an inner diameter of the first axial port.

[0033] A jumper tube 64 is mounted within the second axial port 62 of the manifold block 54 for fluid communication with the manifold block 54. The jumper tube 64 approaches the second array of heat exchanger ports 60. Since the second array of heat exchanger ports 60 is not aligned with the first array of heat exchanger ports 50, the jumper tube 64 includes a bend 66 for approaching the second array of heat exchanger ports 60.

[0034] In order to convey fluid from the jumper tube 64 to the second array of heat exchanger ports 60, a second manifold block 58 is provided. The second manifold block 58 includes an axial port 70 sized to receive the jumper tube 64. Similar to the first manifold block 54, the second manifold block 58 also includes an array of ports 72 for connection with the second array of heat exchanger ports 60. Thus, fluid is conveyed through the jumper tube 64 into the second manifold block 68 through the array of manifold block ports 72 to the second array of heat exchanger ports 60.

[0035] Unlike the prior art manifold 20 of FIG. 1, the manifold 42 omits the requirement of a feeder tube for each heat exchanger port and thus minimizes the amount of materials required, the machining required, the number of ports, and the processes associated with connecting the feeder tube joints. Additionally, the reliability of the manifold 42 is greater than the manifold 20 since less manifold fluid joints are included, thereby reducing the number of points of potential failure.

[0036] Although a pair of manifold blocks 54, 68 are illustrated and described, the invention contemplates any
number of manifold blocks within the spirit and scope of the present invention. For example, one manifold block may be provided in particular applications, or multiple manifold blocks may be provided, such as a pair of manifold blocks 54, 68. An even further example may include a manifold block with six ports for fluid communication with the heat exchanger 44. Alternatively, the second manifold block 60 may be utilized with a heat exchanger having three ports. The modular manifold concept of the present invention provides various manifold block applications and combinations, as will be appreciated by one having ordinary skill in the art.

With reference now to FIGS. 4 and 5, a first manifold block 74 is illustrated in accordance with the present invention. The manifold block 74 depicted in FIG. 5 is a mirror image of the first manifold block 54 of FIG. 3 and the same or similar elements are assigned the same reference numerals wherein new elements are assigned new reference numerals. The array of ports 58 are each formed generally perpendicular to the axial ports 56 and 62 so that the manifold 42 may be displaced along the heat exchanger 44 with ports, such as ports 58, directly coupled to the heat exchanger ports 50. Each of the ports 58 within the array have an inner diameter sufficient to convey fluid to the associated heat exchanger port 50. As discussed above, the first axial port 56 of the manifold block 54 has a sufficient inner diameter to convey the total amount of fluid; and the second axial port 62 has an inner diameter sized to convey the remaining fluid downstream of the array of manifold block ports 58.

Each of the manifold block ports 58 is formed with a riser 76 extending from the manifold block 74 for extending within the associated heat exchanger port 50. Various known manufacturing processes are contemplated within the spirit and scope of the present invention for forming the manifold block 74 with risers 76. For example, the risers 76 may be formed from a back extrusion process, such as that disclosed in U.S. Pat. No. 5,642,640, which issued on Jul. 1, 1997 to Insalaco et al., the disclosure of which is incorporated in its entirety by reference herein.

The manifold block 74 may be provided with solder rings 78, each oriented about one of the risers 76. The rings 78 may be formed from a solder material having a melting temperature less than that of the manifold block 74 and the heat exchanger 44. For example, the manifold block 74 and the heat exchanger 44 may be formed from an aluminum alloy having an American National Standards Institute (ANSI) designation of 3003 and the rings 78 may be formed from an aluminum alloy having an ANSI designation of 4047, or other brazing or solder filler. Alternatively, the solder rings 78 may be formed from a solder material that includes a flux material.

Once the manifold block 74 is mounted to the heat exchanger 44, the manifold block 74 and heat exchanger 44 may be placed in a kiln, furnace, or the like and heated to a temperature greater than the melting temperature of the solder rings 78 such that the solder rings 78 solder the risers 76 to the heat exchanger 44. Alternatively, the solder rings 78 may also, through capillary action, seep between the joint of the risers 76 and the heat exchanger ports 50 thereby brazing the connection. Subsequently, the manifold block 74 and heat exchanger 44 is cooled, thereby providing a connection at the manifold and heat exchanger ports 50, 58 that is structurally sound to withstand the associated pressures and is sealed for fluid communication therebetween.

Alternatively, the manifold blocks 74 and the heat exchanger 44 may be heated directly at the connections of the risers 76 and the heat exchanger ports 50 for melting the solder rings 78.

Solder rings 78 may have an inner diameter that is less than an external diameter of the risers 76 so that the solder rings 78 are press fit upon the risers 76. This interference fit will maintain the solder rings 78 upon the risers 76 so that they do not get misplaced during assembly prior to heating of the connection between the manifold block 74 and the heat exchanger 44.

Alternatively, the solder rings 78 for the manifold block 74 may be interconnected as a unitary soldering strip, as illustrated by the bridges 80 in phantom in FIG. 5. Soldering strips are disclosed in detail in U.S. Pat. No. 5,617,992, which issued on Apr. 8, 1997 to Huddleston et al., the disclosure of which is incorporated in its entirety by reference herein.

With reference now to FIGS. 6 and 7, a second manifold block 82, which is a mirror image of the second manifold block 68 in FIG. 3, is illustrated in greater detail. Although first and second manifold blocks 54, 68 are illustrated and described, with the first manifold block having a pair of axial ports 56, 62, the invention contemplates any number of sequential manifold blocks with intermediate manifold blocks between the joining tube 46 and the last manifold block, and each having any number of ports for fluid communication through the manifold blocks.

The second manifold block 78 is illustrated with the axial port 70 being formed as a blind hole such that a second end 84 of the manifold block 68 is closed. The manifold block 68 also includes a back extruded riser 86 for each of the ports 72 that communicate with the ports 60 of the heat exchanger 44. Solder rings 78 or a soldering strip 78, 80 may be received upon the risers 84 for joining the risers 84 to the heat exchanger 44 as illustrated and described with reference to the manifold block 74 of FIGS. 4 and 5.

Heat exchangers, such as air conditioning coils, often utilize repeatable port patterns. For example, as illustrated in FIG. 3, the first array of heat exchanger ports 50 is substantially identical to the second array of heat exchanger ports 60. Likewise, the array of manifold block ports 58 on the first manifold block 54 is substantially identical to the array of manifold block ports 72 on the second manifold block 68. Thus, common manufacturing steps may be repeated for generating multiple manifold blocks 50, 60. Likewise, where heat exchanger port patterns are repeated symmetrically, symmetrical manifold blocks may be provided as well. For example, a left hand first manifold block 50 is illustrated in FIG. 3 and a right hand first manifold block 74 is illustrated in FIGS. 4 and 5. Additionally, a right hand second manifold block 68 is illustrated in FIG. 3, wherein a left hand second manifold block 82 is illustrated in FIGS. 6 and 7.

Referring now to FIGS. 8 and 9, another modular manifold 88 is illustrated in accordance with the present invention. The manifold 88 conveys fluid to or from a heat
The heat exchanger 90 of the particular embodiment has six ports within the first array 100. The six ports in the first array, repeat the pattern of the first array of three ports in the heat exchanger 44 of the prior embodiment. Accordingly, a six port manifold block could be utilized. Alternatively, a pair of left hand first manifold blocks 54 may be employed, each mounted to one of the feeder tubes 96, 98 for conveying fluids between the associated feeder tube 96, 98, through the manifold block 54 and between the heat exchanger 90.

Each first manifold block 54 may include a fitting 102 in the second axial port 62 for attaching a jumper tube 104 to each first manifold block 54. The jumper tubes 104 may extend from the first array of heat exchanger ports 100 to a second array of heat exchanger ports 106. A right hand second manifold block 68 is mounted to each of the jumper tubes 104 by a fitting 102. Each of the second manifold blocks 68 is also in fluid communication with a portion of the ports 106 of the second array of the heat exchanger 90. In summary, fluid such as coolant is conveyed through the joining tube 92, through the risers 94, through the feeder tubes 96, and to the first pair of manifold blocks 54. At the first pair of manifold blocks 54, the fluid is conveyed through the manifold ports 58 to the associated heat exchanger ports 100 and is conveyed through the jumper tubes 104 to the second manifold blocks 68. The fluid at the second pair of manifold blocks 68 is subsequently conveyed through the manifold ports 72 to the heat exchanger ports 106. Thus, adequate fluid flow is provided by the manifold 88, which minimizes the number of feeder tubes and manifold connections in comparison to the prior art. For example, the heat exchanger 90 of FIGS. 8 and 9 has twice the number of ports as an associated heat exchanger for the manifold 20 as FIG. 1. If the prior art manifold design and process were utilized, a manifold adequate for the fluid flow of the heat exchanger 90 of FIGS. 8 and 9 would require twice the number of feeder tubes 30 than that disclosed in FIG. 1.

Alternatively, the manifold 88 of FIGS. 8 and 9 may be employed for receiving fluid from the heat exchanger 90. Thus, fluid may be conveyed through the heat exchanger ports 100, 106 to the first and second pairs of manifold blocks 54, 68, respectively. The fluid received by the second pair of manifold blocks 68 is conveyed through the jumper tubes 104 to the first pair of manifold blocks 54. The fluid received by the first pair of manifold blocks 54 is conveyed through the jumper tubes 96, 98 to the risers 94, and subsequently to the joining tube 92 of the manifold 88.

Referring now to FIGS. 10 and 11, another manifold 108 is illustrated for cooperation with the heat exchanger 90 of the prior embodiment. A mechanical coupling 110 is provided on each feeder tube 96, 98 for connecting the feeder tubes 96, 98 directly to the joining tube 92. The mechanical couplings 110 may be compression fittings or the like. Additionally, the manifold 108 is illustrated without fittings 102 on the manifold blocks 54, 68.

Due to the modularity of the manifold blocks of the present invention, various manifolds and manifold configurations may be derived therefrom for fluid communication with heat exchangers.

The invention contemplates various manifold blocks regardless of the number of manifold block ports. Referring now to FIG. 12, a right hand flow-through manifold block 112 is illustrated with four risers 114 with ports 116 formed therethrough for mounting in fluid communication with corresponding ports of an associated heat exchanger. The manifold block 112 includes a first axial port 118 and a reduced diameter second port 120.

Referring now to FIG. 13, a right hand manifold block 122 is illustrated for cooperation within a manifold with the manifold block of 112. The manifold block 122 includes a corresponding array of risers 124 with ports 126 for fluid communication with associated ports on the heat exchanger. The manifold block 122 includes an axial port 128 formed therein to a blind depth. The port 128 may have an enlarged diameter at the open end for receiving a corresponding jumper tube.

In summary, the present invention provides manifolds that reduce part count, reduce the number of manifold connections, provide modularity for manifold assembly, and minimize the number of points for potential failure within the manifold.

While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A modular manifold for a heat exchanger comprising:
   a primary tube disposed alongside a heat exchanger, the primary tube having a port disposed adjacent to at least a pair of ports of the heat exchanger; and
   a manifold block having a first port mounted to the primary tube port for fluid communication with the primary tube, the manifold block having at least a pair of back extruded ports for direct fluid communication with the at least a pair of ports of the heat exchanger.

2. The modular manifold of claim 1 wherein the manifold first port has an inner diameter that is greater than that of either of the at least a pair of back extruded ports of the manifold block.

3. The modular manifold of claim 1 wherein the first port of the manifold is formed axially into the manifold block and the at least a pair of back extruded ports are generally perpendicular to the first port of the manifold block.

4. The modular manifold of claim 1 wherein the heat exchanger is a component within an air conditioning cycle.

5. The modular manifold of claim 1 wherein the heat exchanger further comprises air conditioning coils.
6. The modular manifold of claim 1 wherein the manifold block further comprises a second port formed axially into the manifold block.
7. The modular manifold of claim 6 wherein the second axial port has an inner diameter that is less than an inner diameter of the first axial port.
8. The modular manifold of claim 6 further comprising a second manifold block having a first port mounted to the second axial port of the first manifold block for fluid communication with the first manifold block.
9. The modular manifold of claim 8 wherein the first port of the second manifold block has an inner diameter that is less than that of the first port of the first manifold block.
10. The modular manifold of claim 8 further comprising an intermediate tube in fluid communication with the second axial port of the first manifold block and the first port of the second manifold block for fluid communication between the first and second manifold blocks.
11. The modular manifold of claim 8 wherein the second manifold block has a closed second end spaced apart and opposed from the first port.
12. The modular manifold of claim 8 wherein the second manifold block has at least a pair of back extruded ports for direct fluid communication with at least a second pair of ports of the heat exchanger.
13. The modular manifold of claim 12 wherein the at least a pair of back extruded ports of the second manifold block are arranged relative to the second manifold block generally corresponding to an arrangement of the at least a pair of back extruded ports of the first manifold block.
14. The modular manifold of claim 1 wherein the at least a pair of back extruded ports each further comprise a riser extending from the first manifold block.
15. The modular manifold of claim 14 further comprising at least a pair of rings formed from a material having a melting temperature less than that of the primary tube, the first manifold block, and the heat exchanger.
16. The modular manifold of claim 15 wherein each of the at least a pair of rings is displaced about one of the at least a pair of risers, and the heat exchanger and manifold are heated to a temperature greater than the melting temperature of the at least a pair of rings so that the rings melt and join the manifold to the heat exchanger.
17. The modular manifold of claim 16 wherein each of the at least a pair of rings is press fit about one of the at least a pair of risers.
18. A method for manufacturing a manifold for a heat exchanger comprising:
   forming a primary tube to approach a series of ports on a heat exchanger;
   forming a series of riser ports on a manifold block that are sized to cooperate with a portion of the series of ports on the heat exchanger;
   mounting the manifold block on the primary tube;
   mounting the manifold block risers on the portion of the series of ports on the heat exchanger;
   forming an intermediate tube to extend from the manifold block to a remaining portion of the series of ports on the heat exchanger;
   mounting the intermediate tube to the manifold block;
   forming a series of riser ports on a second manifold block that are sized to cooperate with the remaining portion of the series of ports on the heat exchanger;
   mounting the second manifold block on the intermediate tube; and
   mounting the second manifold block risers on the remaining portion of the series of ports on the heat exchanger.
19. The method of claim 18 further comprising: forming a plurality of rings from a material having a melting temperature less than that of the primary tube, the intermediate tube, the manifold blocks and the heat exchanger;
   mounting each of the plurality of rings on one of the risers of the manifold blocks;
   heating the manifold and heat exchanger to a temperature greater than the melting temperature of the rings; and
   cooling the manifold and heat exchanger.
20. A modular manifold for a heat exchanger comprising:
   a primary tube disposed alongside a heat exchanger, the primary tube having a port disposed adjacent to at least a pair of ports of the heat exchanger; and
   a first manifold block having a first port formed axially therein, the first port being mounted to the primary tube port for fluid communication with the primary tube, the first manifold block having at least a pair of back extruded ports formed generally perpendicular to the first port for direct fluid communication with the at least a pair of ports of the heat exchanger, the back extruded ports each having an inner diameter less than that of the first port, the first manifold block having a second port formed axially therein, the second port having an inner diameter less than that of the first port and greater than that of the back extruded ports;
   an intermediate tube in fluid communication with the second axial port of the first manifold block, the intermediate tube having an inner diameter less than that of the primary tube, the intermediate tube having a port disposed adjacent to at least a second pair of ports of the heat exchanger; and
   a second manifold block having a first port formed axially therein, the first port having an inner diameter that is less than that of the first port of the first manifold block, the first port of the second manifold block being mounted to the intermediate tube for fluid communication with the intermediate tube, the second manifold block having at least a pair of back extruded ports for direct fluid communication with the at least a second pair of ports of the heat exchanger, the at least a pair of back extruded ports of the second manifold block being arranged relative to the second manifold block generally corresponding to an arrangement of the at least a pair of back extruded ports of the first manifold block.