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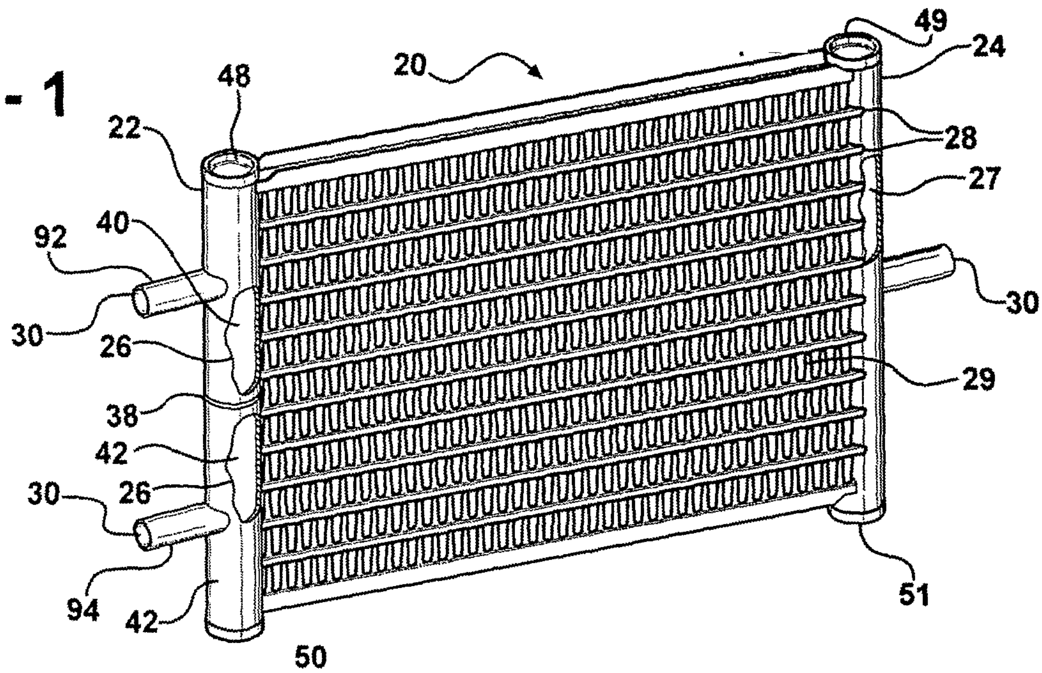
(54) **Dual mode heat exchanger assembly**

(57) A dual mode heat exchanger (**20**) has a first and second manifold (**22**, **24**) with a plurality of flow tubes (**28**) fluidly connecting the manifolds (**22**, **24**) for passing refrigerant between the manifolds (**22**, **24**). The first manifold (**22**) is divided into at least two chambers (**40**, **42**). The second manifold (**24**) defines a single cavity (**27**) but can form more than one chamber. Separators divide the cavities (**26, 27**) and are offset from each other creating groups of flow tubes (**28**) that connect one chamber in each manifold. At least one port (**28**) in each chamber of one of the manifolds (**22**, **24**) is in the open position for controlling refrigerant circulation. All of the ports (**30**) are opened in one of the manifolds (**22**, **24**) to permit refrigerant to pass through all of the plurality of tubes (**28**) in at least one pass in evaporator mode (**34**). At least one of the ports (**30**) is closed to permit refrigerant to pass through all of the plurality of flow tubes (**28**) in at least two passes in condenser mode (**36**).

FIG - 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a dual mode heat exchanger assembly and a method of operating the heat exchanger assembly.

BACKGROUND OF THE INVENTION

[0002] Dual mode heat exchanger assemblies operate in a condenser mode for cooling and an evaporator mode for heating. System operating requirements related to refrigerant phase, velocity and distribution vary between the condenser and the evaporator modes. In the evaporator mode, partially expanded two phase refrigerant enters the heat exchanger where the refrigerant continues to expand absorbing heat from the air. Momentum effects due to large mass differences between gas and liquid phase can result in separation of the phases. This two phase flow can result in poor refrigerant distribution in the heat exchanger assembly degrading performance in the evaporator mode and can cause icing/frosting of the core.

[0003] Dual mode heat exchanger assemblies and methods of addressing the differences in refrigerant flow characteristics, are known in the art. One approach involves modifying the pass arrangements depending on the mode of operation. This generally involves establishing a flow path length for circulating the refrigerant in the condenser mode and reducing the flow path length of the refrigerant in the evaporator mode, generally by bypassing some of the flow tubes that pass refrigerant between manifolds. Another method involves inclusion of distribution tubes, structures with a plurality of apertures, to facilitate the distribution of the refrigerant within the manifolds when the heat exchanger assembly is operating in the evaporator mode.

[0004] Examples of such assemblies are disclosed in Patent Application 2,409,510 A to Heys, U.K Patent Application 2,375,596 A to Heys, U.S. Patent 5,826,649 to Chapp et al.

[0005] The Heys '510 Patent Application discloses a dual purpose heat exchanger assembly with an external bypass means of reducing the number of passes during the evaporator mode. The heat exchanger assembly uses one port to introduce refrigerant and one port to exit refrigerant from the heat exchanger assembly. The bypass means is associated with one of the manifolds, which, when open, connects the manifold with the port where refrigerant is introduced, to reduce the number of passes by at least one. This reduces the length of the flow path when the system is in evaporator mode reducing the pressure drop through the heat exchanger assembly and both improving efficiency and reducing ice formation on the heat exchanger assembly during the evaporator mode.

[0006] The Heys '596 Patent Application discloses a dual mode heat exchanger assembly with an external bypass means of reducing the number of refrigerant passes when the heat exchanger assembly is operating in the evaporator mode. This is for a vehicle air conditioning system including the heat exchanger assembly in the '510 patent.

[0007] The Chapp '649 Patent discloses a dual mode heat exchanger assembly and includes curved headers to address the problem of condensate on the outside of the plurality of tubes in the evaporator mode. There is a lower and upper header with a plurality of flow tubes running vertically. In the evaporation mode, the refrigerant enters the top manifold, drop through pipes to the lower manifold and is directed to the upper manifold through a jumper tube, more similar in diameter to the manifolds, where the refrigerant drops to the lower manifold and is exited through the outlet port. When operating in the evaporator mode, the refrigerant enters the lower manifold and follows exactly the reverse path. Valves inside the heat exchanger assembly can also be used to direct the flow of refrigerant. The path length is the same for each mode.

[0008] Current dual mode heat exchanger assemblies modify the pass arrangements by providing internal and external bypass means which avoid circulating refrigerant through all of the flow tubes in the heat exchanger, resulting in sub-optimal efficiency in both modes. An opportunity exists to provide a heat exchanger assembly and a method of operating the heat exchanger assembly, which optimizes heat exchange in both the evaporator and the condenser modes.

SUMMARY OF THE INVENTION

[0009] The subject invention provides a heat exchanger assembly having a first manifold and a second manifold each defining a hollow cavity, and in spaced and substantially parallel relationship with each other. A separator is disposed within the first manifold and divides the cavity of the first manifold into a first chamber and a second chamber. A plurality of flow tubes are fluidly connected to the first and second manifolds for passing refrigerant between the manifolds. A plurality of ports are connected to at least one of the first and second manifolds. Each of the ports have an open position for allowing refrigerant to flow into and out of the manifolds and a closed position for preventing refrigerant from flowing into and out of the manifolds. There is at least a first port, a second port, and a third port. An external controller switches the heat exchanger assembly between an evaporator mode and a condenser mode. At least one of the ports in each of the chambers and cavity of one of the manifolds is in the open position for circulating refrigerant through all of the plurality of flow tubes in at least one pass when the heat exchanger assembly is operating in the evaporator mode and at least one of the ports is in the closed position for circulating refrigerant through the plurality of flow tubes in at least two passes when the heat exchanger assembly is operating in the condenser mode.

[0010] The subject invention also provides a method of operating a heat exchanger assembly circulating the refrigerant through all of the plurality of flow tubes in at least one pass in the evaporator mode and in more than one pass in the condenser mode, including the following steps: opening one of the ports in each of the manifolds to define an evaporator mode; introducing refrigerant into one of the manifolds; passing the refrigerant through all of the plurality of tubes in a single pass; exiting the refrigerant from an opposing manifold; closing the third port of the second manifold to define a condenser mode; introducing the refrigerant into one of the chambers of each one of the manifolds to define an inlet chamber; passing the refrigerant through the plurality of tubes connected to the inlet chamber; passing the refrigerant into another chamber of one of the manifolds to define a mid-flow chamber; passing the refrigerant through the plurality of tubes connected to the mid-flow chamber; passing the refrigerant into another chamber of one of the manifolds to define an outlet chamber; and exiting refrigerant through the port connected to the outlet chamber.

[0011] The subject invention also provides a method of operating a heat exchanger assembly circulating the refrigerant through all of the plurality of flow tubes in at least two circuits and in more than one pass in the evaporator mode and in more than one pass in the condenser mode, including the following steps: opening at least one of the ports in one of the manifolds to define an evaporator mode; introducing the refrigerant into one of the manifolds to define an inlet chamber; passing the refrigerant through the plurality of flow tubes connected to the inlet chamber; passing the refrigerant into the opposing manifold to define a mid-flow chamber; passing the refrigerant through the plurality of flow tubes connected to the mid-flow chamber; passing the refrigerant into the opposing manifold to define an outlet chamber; exiting the refrigerant through the port connected to the outlet chamber; closing the fourth port and opening the third and fifth ports to define a condenser mode; introducing the refrigerant into the third port of the second manifold to define an inlet chamber; passing the refrigerant through the plurality of flow tubes connected to the inlet chamber; passing the refrigerant into the first chamber of the first manifold to define a first mid-flow chamber; passing the refrigerant through the plurality of flow tubes connected to the first mid-flow chamber; passing the refrigerant into the fourth chamber of the second manifold to define a second mid-flow chamber; passing the refrigerant through the plurality of flow tubes connected to the second mid-flow chamber; passing the refrigerant into the second chamber of the first manifold to define a third mid-flow chamber; passing the refrigerant through the plurality of flow tubes connected to the third mid-flow chamber; passing the refrigerant into the fifth chamber of the second manifold to define an outlet chamber; and exiting the refrigerant through the fifth port connected to the outlet chamber.

[0012] While current dual mode heat exchanger assemblies have different refrigerant flow paths depending on the mode of operation, this has been accomplished by bypassing a portion of the plurality of flow tubes. The subject invention optimizes heat exchange when the heat exchanger assembly is operating in both the evaporator mode as well as when the heat exchanger assembly is operating in the condenser mode, by using all of the plurality of flow tubes to circulate the refrigerant in one or more passes through the heat exchanger assembly when operating in the evaporator mode and circulating the refrigerant in more than one pass when the heat exchanger assembly is operating in the condenser mode.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Other advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0014] Figure 1 is a perspective view of one embodiment of a heat exchanger assembly;

[0015] Figure 1A is a schematic planar view of the embodiment of the heat exchanger assembly of Figure 1 in an evaporator mode;

[0016] Figure 1B is a schematic planar view of the embodiment of the heat exchanger assembly of Figure 1 in a condenser mode;

[0017] Figure 1C is a schematic planar view of the embodiment of the heat exchanger assembly of Figure 1 illustrating a single pass refrigerant flow path in the evaporator mode;

[0018] Figure 1D is a schematic planar view of the embodiment of the heat exchanger assembly of Figure 1 illustrating a two pass refrigerant flow path in the condenser mode;

[0019] Figure 2 is a perspective view of another embodiment of a heat exchanger assembly;

[0020] Figure 2A is a schematic planar view of the embodiment of the heat exchanger assembly of Figure 2 in an evaporator mode;

[0021] Figure 2B is a schematic planar view of the embodiment of the heat exchanger assembly of Figure 2 in a condenser mode;

[0022] Figure 2C is a schematic planar view of the embodiment of the heat exchanger assembly of Figure 2 illustrating a single pass refrigerant flow path in the evaporator mode;

[0023] Figure 2D is a schematic planar view of the embodiment of the heat exchanger assembly of Figure 2 illustrating a three pass refrigerant flow path in the condenser mode;

[0024] Figure 3 is a perspective view of another embodiment of a heat exchanger assembly;

[0025] Figure 3A is a schematic planar view of the embodiment of the heat exchanger assembly of Figure 3 in an evaporator mode;

[0026] Figure 3B is a schematic planar view of the embodiment of the heat exchanger assembly of Figure 3 in a condenser mode;

[0027] Figure 3C is a planar view of the embodiment of the heat exchanger assembly of Figure 3 illustrating a single pass refrigerant flow path in the evaporator mode;

[0028] Figure 3D is a schematic planar view of the embodiment of the heat exchanger assembly of Figure 3 illustrating a four pass refrigerant flow path in the condenser mode;

[0029] Figure 4 is a perspective view of another embodiment of a heat exchanger assembly with a distribution tube;

[0030] Figure 4A is a schematic planar view of the embodiment of the heat exchanger assembly illustrating a two circuit, two pass refrigerant flow path in an evaporator mode;

[0031] Figure 4B is a schematic planar view of the embodiment of the heat exchanger assembly illustrating a four pass refrigerant flow path in a condenser mode.

[0032] Figure 4C is a schematic planar view of the embodiment of the heat exchanger assembly illustrating a two pass refrigerant flow path in the evaporator mode.

[0033] Figure 4D is a schematic planar view of the embodiment of the heat exchanger assembly illustrating a four pass refrigerant flow path in the condenser mode.

[0034] Figure 5 is a perspective view of another embodiment of a heat exchanger assembly with a distribution tube;

[0035] Figure 5A is a schematic planar view of the embodiment of the heat exchanger assembly illustrating a two pass refrigerant flow path in an evaporator mode;

[0036] Figure 5B is a schematic planar view of the embodiment of the heat exchanger assembly illustrating a four pass refrigerant flow path in a condenser mode.

[0037] Figure 5C is a schematic planar view of the embodiment of the heat exchanger assembly illustrating a two pass refrigerant flow path in the evaporator mode;

[0038] Figure 5D is a schematic planar view of the embodiment of the heat exchanger assembly illustrating a four pass refrigerant flow path in the condenser mode.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0039] Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, a heat exchanger assembly is generally shown at **20** in Figures 1-1D. The heat exchanger assembly **20** includes a first manifold **22** and a second manifold **24.** The first manifold **22** defines a cavity **26** and has a length and a width, substantially transverse the length, with a first end **48** and a second end **50,** adjacent the length. The second manifold **24** is in spaced and substantially parallel relationship to the first manifold **22** and defines a cavity **27.** The second manifold **24** has a length and a width, substantially transverse the length, with a first end **49** and a second end **51,** adjacent the length. The second manifold **24** is shown throughout the drawings as having the same general appearance as that of the first manifold **22,** however it can be readily appreciated that the first and second manifolds **22, 24** can have different dimensions, for example, the width of the second manifold **24** can be greater than the width of the first manifold **22.** In addition, the construction of the manifolds **22, 24** can vary, for example, but not limited to, the first manifold **22** can comprise a single piece and the second manifold **24** can comprise multiple joined pieces. Similarly, it can be appreciated that though the manifolds **22, 24** are illustrated throughout the various drawings as generally cylindrical, the manifolds can take on a variety of shapes, for example but not limited to, the cross section of the manifolds **22, 24** at the width, can define a D-shape or a polygon.

[0040] A first separator **38** is disposed within the cavity **26** of the first manifold **22** dividing the first manifold **22** into a first chamber **40** and a second chamber **42.** A substantially flat first separator **38** is shown which is disposed along the width of the first manifold **22,** however, it can be readily appreciated that the first separator **38** can have a variety of cross-section shapes, such as, but not limited to, a crescent, and the first separator **38** can also be disposed within the cavity **26** in various ways, such as, but not limited to, diagonally forming acute and obtuse angles where the first separator **38** is adjacent the first manifold **22.** It can further be appreciated that the first separator **38** can be constructed in a variety of ways, such as, but not limited to, being a portion of an insert slideably inserted within the cavity **26** or a single piece inserted through a cut in the first manifold **22.** In addition, though the first separator **38** is shown approximately midway between the ends **48, 50** of the first manifold **22,** it can be appreciated that the placement of the first separator **38** relative to the length of the first manifold **22** can vary. In addition, it can be readily appreciated that additional separators can be disposed within the first manifold cavity **26.**

[0041] A plurality of flow tubes **28** extend between and fluidly connect the first and second manifolds **22, 24** for passing refrigerant between the manifolds **22, 24.** It can be appreciated that additional heat dissipating structures, such as fins **29,** can be included adjacent the plurality of flow tubes **28.** The plurality of flow tubes **28** are substantially parallel to each other, and are generally transverse the length of the manifolds **22, 24.** For purposes of illustration throughout the drawings, ten to twelve flow tubes are depicted, however it can be readily appreciated, that the number is not limited to those illustrated, but can vary based on the requirements of the heat exchanger assembly **20.**

[0042] Groups of flow tubes **62, 64, 66, 68** are defined by flow tubes which are fluidly connected to the same chambers. Referring to Figure 1A-1B, a first group **62** of flow tubes is fluidly connected to the first chamber **40** and the cavity of the second manifold **27.** A second group **64** of flow tubes is fluidly connected to the second chamber **40** and the first cavity **27.** The groups **62, 64** of flow tubes enable the serpentine circulation path of the refrigerant through the heat exchanger assembly **20.**

[0043] A plurality of ports **30** are fluidly connected to at least one of the manifolds **22, 24,** and have an open position for allowing refrigerant into and out of the manifolds **22, 24** and a closed position for preventing the refrigerant from passing into or out of the manifolds **22, 24.** An external tube is fluidly connected to each of the ports **30,** and refrigerant passes through the external tubes to enter or exit the heat exchanger assembly **20.** It can be readily appreciated that the external tubes can be joined directly to any portion of the manifold **22, 24** in a variety of ways, including but not being limited to, by a process such as brazing or welding. Alternatively, an attachment means such as a coupler can be disposed within the port **30,** and the external tube inserted through the coupler to form the connection. It is understood that the plurality of ports **30** are illustrated throughout the figures as including the external tube as part of the port **30.** It can further be understood that the term port **30** within the context of the present invention is intended to include other structures, such as couplers, where required by a specific application. It can be readily appreciated that for the present invention, when reference is made to the port **30** having a closed position, refrigerant does not enter or exit the manifold **22, 24** at that location. Similarly when a port **30** is in the open position, refrigerant enters or exits the heat exchanger assembly **20** through the port **30.** An external controller restricts or permits the flow of refrigerant into the port **30,** and the actual means is external to the heat exchanger assembly **20.** A first port **92** is fluidly connected to the first chamber **40,** a second port **94** is fluidly connected to the second chamber **42** and a third port **96** is fluidly connected to the cavity **27** of the second manifold **24.** It can be appreciated that each port **92, 94, 96** can be used to either permit the refrigerant to enter or exit the heat exchanger assembly **20,** depending on the configuration desired.

[0044] An external controller switches the heat exchanger assembly **20** between an evaporator mode **34** for heating and a condenser mode **36** for cooling. In the evaporator mode **34,** the refrigerant is circulated through the heat exchanger assembly **20,** absorbing heat from air passing over the plurality of flow tubes **28.** As the refrigerant absorbs heat from the air, the refrigerant expands as liquid refrigerant is converted to gaseous refrigerant. In the condenser mode, the refrigerant in a gaseous state, enters the heat exchanger assembly **20** and heat is dissipated as the refrigerant is changed from the gaseous state to a liquid state. When operating in the evaporator mode **34,** refrigerant is passed through all of the plurality of flow tubes **28** in one pass by opening at least one of the plurality of ports **30** in each of the chambers **40, 42** and cavities **27.** In the condenser mode **36,** at least one of the plurality of ports **30** is closed, for allowing the refrigerant to pass through all of the plurality of flow tubes **28** in more than one pass. It can be readily appreciated, that a number of alternative embodiments are possible, by varying the number of separators, the number of ports **30** and the configuration of open and closed ports **30.**

[0045] Referring to Figure 2, another embodiment is illustrated. A second separator **52** is disposed within the cavity **27** of the second manifold **24** forming a third chamber **56** and a fourth chamber **58.** The second separator **52** is offset from the first separator **38.** Referring to Figures 2A-2B, the third port **96** is fluidly connected to the third chamber **56** and a fourth port **98** is fluidly connected to the fourth chamber **58.** Three groups of flow tubes are formed, including a first group **62** having flow tubes connected to the first chamber **40** and the third chamber **56,** a second group **64** having flow tubes connected to the second chamber **42** and the third chamber **56,** and a third group **66** having flow tubes connected to the second chamber **42** and the fourth chamber **58.** In the evaporator mode **34,** the first, second, third and fourth ports **92, 94, 96, 98** are in the open position for allowing the refrigerant to pass through all of the plurality of flow tubes **28** in one pass. In the condenser mode **36,** the first and fourth ports **92, 98** are in the open position for passing the refrigerant through the heat exchanger assembly **20** in three passes.

[0046] Referring to Figure 3, another embodiment is illustrated having having a third separator **54** disposed within the second manifold **24** further dividing the cavity **27** of the second manifold **24** into a fifth chamber **60.** The second and third separators **52, 54** in the second manifold **24** are offset from the first separator **38** in the first manifold **22.** Referring to Figures 3A-3B, four groups of flow tubes **62, 64, 66, 68** are formed, including, a first group **62** having flow tubes connected to the first chamber **40** and the third chamber **56,** a second group **64** having the flow tubes connected to the first chamber **40** and the fourth chamber **58,** a third group **66** having the flow tubes connected to the second chamber **42** and the fourth chamber **58,** and a fourth group **68,** having flow tubes connected to the second chamber **42** and the fifth chamber **60.** In the evaporator mode **34,** the first, second, third, fourth and fifth ports **92, 94, 96, 98,100** are in the open position for allowing refrigerant to pass through the heat exchanger assembly **20** in one pass. In the condenser mode **36,** the third and fifth ports **96,100** are in the open position for passing the refrigerant through the heat exchanger assembly **20** in four passes.

[0047] Referring to Figure 4, another embodiment is illustrated having no ports 30 connected to the first manifold **24.** A third separator **54** is disposed within the second manifold **24** further dividing the cavity **27** of the second manifold **24** into a fifth chamber **60.** The second and third separators **52, 54** in the second manifold **24** are offset from the first separator **38** in the first manifold **22.** Referring to Figures 4A-4B, four groups of flow tubes **62, 64, 66, 68** are formed, including, a first group **62** having flow tubes connected to the first chamber **40** and the third chamber **56,** a second group **64** having the flow tubes connected to the first chamber **40** and the fourth chamber **58,** a third group **66** having the flow tubes connected to the second chamber **42** and the fourth chamber **58,** and a fourth group **68,** having flow tubes connected to the second chamber **42** and the fifth chamber **60.** In the evaporator mode **34,** the third, fourth and fifth ports **96, 98, 100** are in the open position for allowing the refrigerant to pass through the heat exchanger assembly **20** in one pass. In the condenser mode **36,** the third and fifth ports **96, 100** are in the open position for passing the refrigerant through the heat exchanger assembly **20** in four passes.

[0048] Distribution tubes **70, 71** can be incorporated in the heat exchanger assembly **20** to facilitate distribution of the refrigerant in the evaporator mode **34.** Referring to Figure 4-4B, one embodiment is illustrated which includes a single distribution tube **70** disposed within the fourth chamber **58** of the second manifold **24.** In the evaporator mode **34,** the third, fourth and fifth ports **96, 98, 100** are in the open position. The refrigerant enters through the fourth port **98** which is directly connected to the distribution tube **70,** and passes through the plurality of apertures disposed within the distribution tube **70,** into the fourth chamber **58.** In the condenser mode **36,** the fourth port **98** is in the closed position and the third and fifth ports **96,100** are in the open position. Refrigerant enters through the third port **96,** and is circulated through the heat exchanger assembly **20,** without being affected by the presence of the distribution tube **70** disposed within the fourth chamber. It can be readily appreciated that more than one distribution tube **70** can be included in the heat exchanger assembly **20.**

[0049] Referring to Figure 5A-B, another embodiment includes the first distribution tube **70** disposed within the third chamber **56** and a second distribution tube **71** disposed within the fifth chamber **60.** A sixth port **102** is fluidly connected to the third chamber **56** and a seventh port **104** is fluidly connected to the fifth chamber **60.** The third port **96** is fluidly connected to the first distribution tube **70** and the fifth port **100** is fluidly connected to the second distribution tube **71.** The evaporator mode **34** is defined by the first, second, sixth and seventh ports **92, 94, 102,104** being in the closed position and the third, fourth and fifth ports **96, 98, 100** being in the open position. The condenser mode **36** is defined by the sixth and seventh ports **102, 104** being in the open position and the first, second, third, fourth and fifth ports **92, 94, 96, 98, 100** being in the closed position. It can be readily appreciated that any number of distribution tubes **70, 71** and additional ports **30** can be incorporated into any design. It can also be readily appreciated that the same result would be accomplished where the first manifold **22** included no ports **30.**

[0050] The various embodiments described previously can be generally descibed in the following way. There is at least a first port **92,** a second port **94** and a third port **96.** An external controller **32** switches between an evaporator mode **34** for heating and a condenser mode **36** for cooling. The first, second and third ports **92, 94, 96** are in the open position for circulating the refrigerant through all of the plurality of flow tubes **28** in n passes in the evaporator mode **34.** In the condenser mode **36,** at least one of the ports **30** is closed for circulating the refrigerant through all of said plurality of flow tubes **28** in at least n+1 passes in the condenser mode **36** where said n is an integer equal to or greater than one. It can be readily appreciated that the structure described previously encompasses any number of chambers, flow tubes and ports **30,** depending on the design requirements of the specific implementation. Similarly the schematics are merely illustrative. Any number of flow configurations in which refrigerant is introduced through different ports **30,** for example, using the reverse flow of that illustrated in the figures, or mirror images, are equivalent to those discussed.

[0051] It can be further appreciated that distribution tubes **70, 71** can by included in any of the evaporator mode **34** inlet chambers **78.** The distribution tubes **70, 71** are fluidly connected to the ports **30,** and refrigerant passes through the apertures disposed within the distribution tubes **70, 71** into the evaporator mode **34** inlet chamber **78.** It can also be appreciated that when the heat exchanger assembly **20** uses the evaporator mode **34** inlet chamber **78** as either a condenser mode **36** inlet or outlet chamber **78, 80,** additional ports **30** can be fluidly connected to the condenser mode 36 inlet and outlet chambers **78, 80** for allowing refrigerant to enter and exit the heat exchanger assembly **20.**

[0052] Two methods are described based on the structure described previously. The goal of all of the methods is the same, that is, to circulate the refrigerant in fewer passes in the evaporator mode **34** than in the condenser mode **36,** while using all of the plurality of flow tubes **28** to circulate the refrigerant in each mode. Through the use of the external controller which controls the ports that are used for introducing and exiting the refrigerant, and by the configuration of the separators, a multitude of pass arrangements can be achieved. It can further be appreciated that the methods that follow, encompass more arrangements than are illustrated, and that the methods accommodate additional separators and ports, all of which permit variations in the arrangements while still being encompassed by the methods described here. In addition, it is understood that in methods which do not require that a manifold **22, 24** have a port in an open position to effectuate the refrigerant circulation, a manifold **22, 24** without any ports produces the same effect that a manifold **22** with all ports in the closed position, and is equivalent. Detailed descriptions of the methods and several embodiments follow.

[0053] Referring to Figures 1A-1D, a method of operating a heat exchanger assembly **20** is provided wherein the refrigerant circulates in one pass in the evaporator mode **34** and in at least 2 passes in the condenser mode **36.** A heat exchanger assembly **20** has a first manifold **22** divided into a first chamber **40** and a second chamber **42** with a first port **92** and second port **94,** a second manifold **24** defining at least one chamber with a third port **96,** and a plurality of flow tubes **28** fluidly connecting the manifolds **22, 24.** The method includes the step of opening one of the ports **30** in each chamber of the manifolds **22, 24** defining an evaporator mode **34.** The method further includes introducing the refrigerant into one of the manifolds **22, 24,** to define an inlet chamber **78.** The method further includes passing the refrigerant through all of the plurality of flow tubes **28** in a single pass. The method further includes the step of passing the refrigerant into an opposing manifold **22, 24** defining an outlet chamber **80.** The method further includes the step of exiting the refrigerant from a port connected to the opposing manifold **22, 24.** The method further includes the step of closing the third port **96** of the second manifold **24** to define a condenser mode **36.** The method further includes the step of introducing the refrigerant into one of the chambers of one of the manifolds **22, 24** to define an inlet chamber **78.** The method further includes the step of passing the refrigerant through the plurality of flow tubes **28** connected to the inlet chamber **78.** The method further includes the step of passing the refrigerant into another chamber of one of the manifolds **22, 24** to define a mid-flow chamber **72.** The method further includes passing the refrigerant through the plurality of flow tubes **28** connected to the mid-flow chamber **72.** The method further includes passing the refrigerant into another chamber of one of the manifolds **22, 24** to define an outlet chamber **80.** The method further includes the step of exiting refrigerant through the port connected to the outlet chamber **80.** The method allows refrigerant to pass through the heat exchanger assembly **20** in one pass when the heat exchanger assembly **20** is operating in the evaporator mode **34,** and in more than one pass when the heat exchanger assembly **20** is operating in the condenser mode **36.** It can be readily appreciated that the method encompasses heat exchanger assemblies **20** having manifolds **22, 24** with different numbers of chambers and ports.

[0054] This method is applied in the embodiment illustrated in Figures 1C-1D. The refrigerant is introduced into the first and second ports **92, 94,** passes through all of the plurality of flow tubes **28** in a single pass, and is exited from the second manifold **24.** To define the condenser mode **36** the third port **96** is closed. The refrigerant is introduced into the second chamber **42,** and passes through the second group **64** of flow tubes into the third chamber **56.** The refrigerant is then passed through the first group **62** of flow tubes into the first chamber **40.** The refrigerant is then exited through the first port **92.** It can be readily appreciated that when the heat exchanger **20** is operating in the evaporator mode **34,** the refrigerant can alternatively be introduced through the third port **96** into the third chamber **56.** Similarly, when the heat exchanger **20** is operating in the condenser mode **36,** the refrigerant can be introduced through the first port **92** into the first chamber **40.** It can be further appreciated that distribution tubes **70, 71** can by included in any of the evaporator mode inlet chambers **78.** The distribution tubes **70, 71** are fluidly connected to the ports **30,** and refrigerant passes through the apertures disposed within the distribution tubes **70, 71** into the evaporator mode **34** inlet chamber **78.** It can also be appreciated that when the heat exchanger assembly **20** uses the evaporator mode **34** inlet chamber **78** as either a condenser mode **36** inlet or outlet chamber **78, 80,** additional ports **30** can be fluidly connected to the condenser mode **36** inlet and outlet chambers **78, 80** for allowing refrigerant to enter and exit the heat exchanger assembly **20.**

[0055] Referring to Figures 2A-2D, another embodiment of the method is described which allows the heat exchanger assembly **20** to circulate the refrigerant in one pass in the evaporator mode **34** and in at least three passes in the condenser mode **36.** In addition to the structure described previously, this embodiment includes a fourth chamber **58** and a fourth port **98** fluidly connected to the fourth chamber **58.** In addition to the steps described previously, the method further includes the step of closing the second port **94** of the first manifold **22** as well the third port **96** of the second manifold **24** and opening the first port **92** of the first manifold **22** and the fourth port **98** of the second manifold **24** to define the condenser mode **36.** The method is the same for the evaporator mode **34** as in the previous embodiment. In the condenser mode **36,** additional steps are required. After the refrigerant enters the mid-flow chamber **72,** the refrigerant is passed through the plurality of flow tubes **28** connected to the mid-flow chamber **72.** The method further includes passing the refrigerant into another chamber of one of the manifolds **22, 24** to define a second mid-flow chamber **74.** The method further includes passing a refrigerant through the plurality of flow tubes **28** connected to the second mid-flow chamber **74.** The method further includes passing the refrigerant into another chamber of one of the manifolds **22, 24** to define an outlet chamber **80.** The method further includes the step of exiting refrigerant through the port connected to the outlet chamber **80.** Thus, the method allows refrigerant to pass through the heat exchanger assembly **20** in one pass in the evaporator mode **34,** and in three or more passes when the heat exchanger assembly 20 is operating in the condenser mode **36.** It can be readily appreciated that the method encompasses heat exchanger assemblies **20** having manifolds **22, 24** with different numbers of chambers and ports.

[0056] This general embodiment is illustrated in a more specific embodiment illustrated in Figures 2C-2D. To define the evaporator mode **34,** all of the ports **92, 94, 96, 98** in each of the manifolds **22, 24** are opened. The refrigerant is introduced into the first and second ports **92, 94,** passes through all of the plurality of flow tubes **28** in a single pass, and is exited from the third and fourth ports **96, 98** of the second manifold **24.** The condenser mode **36** is defined by closing the second and third port **94, 96.** The refrigerant is introduced into the first chamber **40,** passed through the first group **62** of flow tubes, into the third chamber **56.** Refrigerant is then passed through the second group **64** of flow tubes into the second chamber

42. Refrigerant then passes through the third group **66** of flow tubes into the fourth chamber **58,** and is exited through the fourth port **98.** It can be readily appreciated that when the heat exchanger assembly **20** is operating in the evaporator mode **34,** the refrigerant can alternatively be introduced through the third port **96** and fourth port **98** into the third and fourth chambers **56, 58,** and exited through the first and second ports **92, 94** in the first manifold **22.** Similarly, when the heat exchanger assembly **20** is operating in the condenser mode **36,** the refrigerant can be introduced through the fourth port **98,** passed into the fourth chamber **58,** and exited through the first port **92** in the first chamber **40.** In addition, it can be appreciated that distribution tubes **70, 71** can by included in any of the evaporator mode **34** inlet chambers **78.** The distribution tubes **70, 71** are fluidly connected to the ports **30,** and refrigerant passes through the apertures disposed within the distribution tubes **70, 71** into the evaporator mode **34** inlet chamber **78.** It can also be appreciated that when the heat exchanger assembly **20** uses the evaporator mode **34** inlet chamber **78** as either a condenser mode **36** inlet or outlet chamber **78, 80,** additional ports **30** can be fluidly connected to the condenser mode **36** inlet and outlet chambers **78, 80** for allowing refrigerant to enter and exit the heat exchanger assembly **20** in the condenser mode **36.**

[0057] Referring to Figures 3A-3D, another embodiment of the method of operating a heat exchanger assembly **20** is provided wherein the refrigerant circulates in one pass in the evaporator mode **34** and in at least four passes in the condenser mode **36.** The heat exchanger assembly **20** includes the elements of the previous embodiment, with the addition of a fifth chamber **60** disposed within the second manifold **24** and a fifth port **100** fluidly connected to the fifth chamber **60.** The evaporator mode is the same as described in the previous embodiment. The condenser mode **36** is defined by the step of closing the first and second ports **92, 94** of the first manifold **22** and the fourth port **98** of the second manifold **24** to define a condenser mode **36.** The method further includes the step of introducing the refrigerant into one of the chambers of one of the manifolds to define an inlet chamber **78.** The method further includes the step of passing the refrigerant through the plurality of flow tubes **28** connected to the inlet chamber **78.** The method further includes the step of passing the refrigerant into another chamber of one of the manifolds **22, 24** to define a first mid-flow chamber **72.** The method further includes passing the refrigerant through the plurality of flow tubes **28** connected to the first mid-flow chamber **72.** The method further includes the step of passing the refrigerant into another chamber of one of the manifolds **22, 24** to define a second mid-flow chamber **74.** The method further includes passing the refrigerant through the plurality of flow tubes **28** connected to the second mid-flow chamber **74.** The method further includes the step of passing the refrigerant into another chamber of one of the manifolds **22, 24** to define a third mid-flow chamber **76.** The method further includes passing the refrigerant through the plurality of flow tubes **28** connected to the third mid-flow chamber **76.** The method further includes passing the refrigerant into another chamber of one of the manifolds **22, 24** to define an outlet chamber **80.** The method further includes the step of exiting refrigerant through the port connected to the outlet chamber **80.** The method allows refrigerant to pass through the heat exchanger assembly **20** in one pass when the heat exchanger assembly **20** is operating in the evaporator mode **34,** and in four or more passes when the heat exchanger assembly **20** is operating in the condenser mode **36.** It can be readily appreciated that the method encompasses heat exchanger assemblies **20** having manifolds **22, 24** with different numbers of chambers and ports.

[0058] This general embodiment is illustrated in a more specific embodiment illustrated in Figures 3C-3D. The evaporator mode is defined by opening all of the ports **92, 94, 96, 98, 100** in each of the manifolds **22, 24.** The refrigerant is introduced into the first and second ports **92, 94,** circulated through all of the plurality of flow tubes **28** in a single pass, and exited from the third, fourth and fifth ports **96, 98,100.** The condenser mode is defined by closing the first, second and fourth ports **92, 94, 98.** The refrigerant is introduced through the third port **96** into the third chamber **56,** and passed through the first group **62** of flow tubes, into the first chamber **40.** The refrigerant passes through the second group **64** of flow tubes into the fourth chamber **58.** The refrigerant passes through the third group **66** of flow tubes into the second chamber **42.** The refrigerant passes through the fourth group **68** of flow tubes into the fifth chamber **60,** and is exited through the fifth port **100.** It can be readily appreciated that when the heat exchanger **20** is operating in the evaporator mode **34,** the refrigerant can alternatively be introduced through the third, fourth and fifth ports **96, 98, 100** of the second manifold **24,** and exited through the first and second ports **92, 94** of the first manifold **22.** Similarly, when the heat exchanger **20** is operating in the condenser mode **36,** the refrigerant can be introduced through the fifth port **100** into the fifth chamber **60,** and exited through the third port **96** connected to the third chamber **56.** It can be readily appreciated that this method encompasses any number of passes in the evaporator mode and in the condenser mode. In addition, it can be appreciated that distribution tubes **70, 71** can by included in any of the evaporator mode inlet chambers **78.** The distribution tubes **70, 71** are fluidly connected to the ports **30,** and refrigerant passes through the apertures disposed within the distribution tubes **70, 71** into the evaporator mode **34** inlet chamber **78.** It can also be appreciated that when the heat exchanger assembly **20** uses the evaporator mode **34** inlet chamber **78** as either a condenser mode **36** inlet or outlet chamber **78, 80,** additional ports **30** can be fluidly connected to the condenser mode **36** inlet and outlet chambers **78, 80** for allowing refrigerant to enter and exit the heat exchanger assembly **20.**

[0059] Referring to Figures 4A-4D, another method for operating a heat exchanger assembly **20** is provided where the refrigerant is divided into more than one circuit and passes through the heat exchanger assembly **20** in at least two passes in the evaporator mode **34.** In this method, in the condenser mode **36,** the refrigerant passes through the heat exchanger assembly **20** in four or more passes, as previously described and being illustrated at Figure 3D, and will not be described again here. The heat exchanger assembly **20** has a first manifold **22** divided into a first chamber **40** and a second chamber **42** and a second manifold **24** defining a third chamber **(56),** a fourth chamber **(58)** and a fifth chamber **(60),** with a third port **(96),** a fourth port **98,** a fifth port **100** and a plurality of flow tubes **28** fluidly connecting the manifolds **22, 24.** The method includes the step of opening all of the ports **30** in the second manifold **24** to define an evaporator mode **34.** The method further includes the step of introducing the refrigerant into at least one chamber of the second manifold **24** to define an inlet chamber **78.** The method further includes the step of passing the refrigerant through the plurality of flow tubes **28** connected to the inlet chamber **78.** The method further includes the step of passing the refrigerant into the first manifold **22** to define a first and second mid-flow chamber **72, 74.** The method further includes the step of passing the refrigerant through the plurality of flow tubes **28** connected to the first and second mid-flow chambers **72, 74.** The method further includes the step of passing the refrigerant into the second manifold **24** to define at least one outlet chamber **80.** The method further includes the step of exiting the refrigerant through the port connected to the outlet chamber **80.** It can be readily appreciated that the method encompasses more complex heat exchanger assemblies **20** requiring more than two circuits as well as more than two passes for the circulation of the refrigerant.

[0060] One embodiment of this method is illustrated in Figures 4C-4D. The evaporator mode **34** is defined by opening all of the ports **96, 98, 100** in the second manifold **24.** The refrigerant is introduced into the fourth chamber **58** of the second manifold **24,** where it is separated into a first portion and a second portion. The first portion of the refrigerant passes through the second group **64** of flow tubes into the first chamber **40,** through the first group **62** of flow tubes into the third chamber **56,** and is exited through the third port **96.** Similarly, the second portion passes through the third group **66** of flow tubes, into the second chamber **42,** through the fourth group **68** of flow tubes into the fifth chamber **60,** and is exited from the fifth port **100.** It can be readily appreciated that the refrigerant can be introduced through the third and fifth ports **96, 100** and exited through the fourth port **98,** thus creating more than one inlet chamber **78, 79** and one outlet chamber **80.** It can also be readily appreciated that the same flow path is possible by closing all of the ports **30** of the first manifold **22** in embodiments which include ports **30** in the first manifold **22.** In addition, it can be appreciated that distribution tubes **70** can by included in any of the evaporator mode **34** inlet chambers **78.** The distribution tube **70** is fluidly connected to the port **30,** and refrigerant passes through the apertures disposed within the distribution tubes **70, 71** into the evaporator mode inlet chamber **78.** Here, the distribution tube **70** is illustrated as being disposed within the fourth chamber **58.** It can also be appreciated that when the heat exchanger assembly **20** uses the evaporator mode **34** inlet chamber **78** as either a condenser mode **36** inlet or outlet chamber **78, 80,** additional ports **30** can be fluidly connected to the condenser mode **36** inlet and outlet chambers **78, 80** for allowing refrigerant to enter and exit the heat exchanger assembly **20.**

[0061] Referring to Figures 5A-5D, an embodiment is illustrated including distribution tubes **70, 71** in chambers used as both evaporator mode inlet chambers and condenser mode **36** outlet chamber **80** and the condenser mode **36** inlet chamber **78.** Here the evaporator mode **34** is defined by opening the third, fourth and fifth ports **96, 98,100.** A first portion of the refrigerant is introduced into the third port **96** and a second portion of the refrigerant into the fifth port **98.** The first portion of the refrigerant passes through the first distribution tube **70** into the third chamber **56.** The refrigerant then passes through the first group **62** of flow tubes, into the first chamber **40,** through the second group **64** of flow tubes into the fourth chamber **58.** Similarly, the second portion passes into the second distribution tube **71,** into the fifth chamber **60,** through the fourth group **68** of flow tubes, into the first chamber **40,** through the third group **66** of flow tubes, and into the fourth chamber **58.** All of the refrigerant is then exited through the fourth port **98.** The condenser mode **36** is defined by closing the first, second, third, fourth and fifth port **92, 94, 96, 98, 100** and opening the sixth and seventh ports **102, 104.** The refrigerant is introduced through the seventh port **104** into the fifth chamber **60,** passes through the fourth group **68** of flow tubes, and into the second chamber **42.** The refrigerant then passes through the third group **66** of flow tubes, into fourth chamber **58.** The refrigerant then passes through the second group **64** of flow tubes, into the first chamber **40,** and through the first group **62** of flow tubes into the third chamber **56.** The refrigerant is exited through the sixth port **102.** It can be readily appreciated that when the heat exchanger **20** is operating in the condenser mode **36,** the refrigerant can alternatively be introduced into the sixth port **102** and exited through the seventh port **104.**

[0062] Obviously, many modifications and variations of the present invention are possible in light of the above teachings without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed, but that the invention will include all embodiments falling within the scope of the appended claims. The reference numerals are merely for convenience and are not to be read in any way as limiting.

Claims

1. A heat exchanger **(20)** assembly comprising:

   a first manifold **(22)** and a second manifold **(24)** each defining a hollow cavity **(26, 27)** and in spaced and substantially parallel relationship with each other;
   a plurality of flow tubes **(28)** extending between and fluidly connecting said first and second manifolds **(22, 24)** for passing refrigerant between said manifolds **(22, 24);**
   a separator **(38)** disposed within said first manifold **(22)** and dividing said cavity **(26)** into a first chamber **(40)** and a second chamber **(42);**
   a plurality of ports **(30)** fluidly connected at least one of said first and second manifolds **(22, 24)** with each of said ports **(30)** having an open position for allowing refrigerant to flow into and out of said manifolds **(22, 24)** and a closed position for preventing refrigerant from flowing into and out of said manifolds **(22, 24)** with said plurality of ports **(30)** including at least a first port **(92),** a second port **(94),** and a third port **(96);**
   an external controller (32) for switching between an evaporator mode **(34)** and a condenser mode **(36);** and
   one of said ports **(30)** in each chamber and cavity **(40, 42, 27)** of one of said manifolds **(22, 24)** being in said open position for circulating refrigerant through all of said plurality of flow tubes **(28)** in at least one pass when in said evaporator mode **(34)** and at least one of said ports **(30)** being in said closed position for circulating refrigerant through said plurality of flow tubes **(28)** in at least two passes when in said condenser mode **(36).**

2. An assembly as set forth in claim 1 wherein said first port **(92)** is connected to said first chamber **(40)** said second port **(94)** is connected to said second chamber **(42)** and said third port **(96)** is connected to said cavity **(27)** of said second manifold **(24).**

3. An assembly as set forth in claim 2 wherein said evaporator mode **(34)** is further defined by at least one of said ports **(30)** in each chamber **(40, 42)** of said first manifold **(22)** and at least one of said ports **(30)** in said cavity **(27)** of said second manifold **(24)** being in said open position for circulating refrigerant in one pass.

4. An assembly as set forth in claim 2 wherein said condenser mode **(36)** is further defined by said first port **(92)** and said second port **(94)** being in said open position and said third port **(96)** being in said closed position for circulating refrigerant in two passes.

5. An assembly as set forth in claim 2 wherein said separator **(38)** is further defined as a first separator **(38)** and further including a second separator **(52)** disposed within said cavity **(27)** of said second manifold **(24)** dividing said cavity **(27)** of said second manifold **(24)** into a third chamber **(56)** and a fourth chamber **(58).**

6. An assembly as set forth in claim 5 wherein said second separator **(52)** is offset from said first separator **(38)** with said first chamber **(40)** fluidly connected to said third chamber **(56)** through a first group **(62)** of said flow tubes **(28),** said second chamber **(42)** fluidly connected to said third chamber **(56)** by a second group **(64)** of said flow tubes **(28),** and said second chamber **(42)** fluidly connected to said fourth chamber **(58)** by a third group **(66)** of said flow tubes **(28).**

7. An assembly as set forth in claim 5 further including a fourth port **(98)** connected to said fourth chamber **(58)** with said first, second, third, and fourth ports **(92, 94, 96, 98)** being in said open position when in said evaporator mode **(34)** for circulating refrigerant in one pass.

8. An assembly as set forth in claim 7 wherein said condenser mode **(36)** is further defined by said first port **(92)** and said fourth port **(98)** being in said open position and said second port **(94)** and said third port **(96)** being in said closed position for circulating refrigerant in three passes.

9. An assembly as set forth in claim 2 wherein said separator is further defined as a first separator **(38)** and further including a second and a third separator **(52, 54)** disposed within said second manifold **(24)** dividing said cavity **(27)** into a third, fourth and fifth chamber **(56, 58, 60).**

10. An assembly as set forth in claim 9 wherein both of said second and third separators **(52, 54)** are offset from said first separator **(38)** with said first chamber **(40)** fluidly connected to said third chamber **(56)** by a first group **(62)** of said flow tubes **(28),** said first chamber **(40)** fluidly connected to said fourth chamber **(58)** by a second group **(64)** of said flow tubes **(28),** said second chamber **(42)** fluidly connected to said fourth chamber **(58)** by a third group **(66)** of said flow tubes **(28),** and said second chamber **(42)** fluidly connected to said fifth chamber **(60)** by a fourth group **(68)** of said flow tubes **(28).**

11. An assembly as set forth in claim 9 further including a fourth port **(98)** connected to said fourth chamber **(58)** and a fifth port **(100)** connected to said fifth chamber **(60)** with said first, second, third, fourth, and fifth ports **(92, 94, 96, 98, 100)** being in said

open position when in said evaporator mode **(34)** for circulating refrigerant in one pass.

12. An assembly as set forth in claim 11 wherein said condenser mode **(36)** is further defined by said first port **(92)** said second port **(94)** and said fourth port **(98)** being in said closed position and said third port **(96)** and said fifth port **(100)** being in said open position for circulating refrigerant in four passes.

13. An assembly as set forth in claim 1 wherein said separator is further defined as a first separator **(38)** and further including a second separator **(52)** and a third separator **(54)** disposed within said second manifold **(24)** dividing said cavity **(26)** into a third, fourth and fifth chamber **(56, 58, 60).**

14. An assembly as set forth in claim 13 wherein both of said second and said third separators **(52, 54)** are offset from said first separator **(38)** with said first chamber **(40)** fluidly connected to said third chamber **(56)** by a first group **(62)** of said flow tubes **(28),** said first chamber **(40)** fluidly connected to said fourth chamber **(58)** by a second group **(64)** of said flow tubes **(28),** said second chamber **(42)** fluidly connected to said fourth chamber **(58)** by a third group **(66)** of said flow tubes **(28),** and said second chamber **(42)** fluidly connected to said fifth chamber **(60)** by a fourth group **(68)** of said flow tubes **(28).**

15. An assembly as set forth in claim 13 further including a third port connected to said third chamber and a fourth port **(98)** connected to said fourth chamber **(58)** and a fifth port **(100)** connected to said fifth chamber **(60)** and with said third, fourth and fifth ports **(96, 98, 100)** being in said open position when in said evaporator mode **(34)** for circulating refrigerant in two passes.

16. An assembly as set forth in claim 15 wherein said condenser mode **(36)** is further defined by said fourth port **(98)** being in said closed position and said third port **(96)** and said fifth port **(100)** being in said open position for circulating refrigerant in four passes.

17. An assembly as set forth in claim 1 including a distribution tube **(70)** disposed within one of said chambers **(22, 24)** and said cavity **(27)** with said distribution tube **(70)** having a plurality of apertures and with said distribution tube **(70)** being fluidly connected to one of said plurality of ports **(30)** for passing refrigerant from one of said plurality of ports **(30)** into at least one of said chambers **(40, 42)** and said cavity **(27)** and further defining an evaporator mode **(36)** inlet chamber **(78).**

18. An assembly as set forth in claim 17 including a fourth port **(98)** fluidly connected to said evaporator mode **(34)** inlet chamber **(78)** for circulating the refrigerant in said condenser mode **(36).**

19. A method of operating a heat exchanger **(20)** having a first manifold **(22)** divided into a first chamber **(40)** and a second chamber **(42)** with a first port **(92)** and second port **(94),** a second manifold **(24)** defining at least one chamber with a third port **(96),** and a plurality of flow tubes **(28)** fluidly connecting the manifolds **(22, 24),** said method comprising the steps of:

opening one of said ports **(30)** in each chamber of said manifolds **(22, 24)** to define an evaporator mode **(34) ;**
introducing refrigerant into one of the manifolds **(22, 24)** defining an inlet chamber **(78);**
passing the refrigerant through all of the plurality of flow tubes **(28)** in a single pass;
exiting the refrigerant from an opposing manifold;
closing the third port **(96)** of the second manifold **(24)** to define a condenser mode **(36);**
introducing the refrigerant into one of the chambers of one of the manifolds **(20, 22)** to define an inlet chamber **(78);**
passing the refrigerant through the plurality of flow tubes **(28)** connected to the inlet chamber **(78);**
passing the refrigerant into another chamber of one of the manifolds **(22, 24)** to define a mid-flow chamber **(72);**
passing the refrigerant through the plurality of flow tubes **(28)** connected to the mid-flow chamber **(72);**
passing the refrigerant into another chamber of one of the manifolds **(22, 24)** to define an outlet chamber **(80);** and
exiting the refrigerant through the port connected to the outlet chamber **(80).**

20. A method of operating a heat exchanger **(20)** having a first manifold **(22)** divided into a first chamber **(40)** and a second chamber **(42)** and a second manifold **(24)** divided onto a third chamber **(56),** a fourth chamber **(58)** and a fifth chamber **(60),** with a third port **(96),** a fourth port **(98),** a fifth port **(100)** and a plurality of flow tubes **(28)** fluidly connecting the manifolds **(22, 24),** said method comprising the steps of:

opening at least one of the ports **(30)** to define an evaporator mode **(34);**
introducing the refrigerant into one of the manifolds **(22, 24)** to define an inlet chamber **(78);**
passing the refrigerant through the plurality of flow tubes **(28)** connected to the inlet chamber **(78);**
passing the refrigerant into the opposing manifold **(22, 24)** to define a mid-flow chamber **(72);**

passing the refrigerant through the plurality of flow tubes **(28)** connected to the mid-flow chamber **(72);**

passing the refrigerant into the opposing manifold **(22, 24)** to define an outlet chamber **(80);**

exiting the refrigerant through the port **(30)** connected to the outlet chamber **(80);**

closing the fourth port **(94)** and opening the third and fifth ports **(96, 100)** to define a condenser mode **(36);**

introducing the refrigerant into the third port **(96)** of the second manifold **(24)** to define an inlet chamber **(78);**

passing the refrigerant through the plurality of flow tubes **(28)** connected to the inlet chamber **(78);**

passing the refrigerant into the first chamber **(40)** of the first manifold **(22)** to define a first mid-flow chamber **(72);**

passing the refrigerant through the plurality of flow tubes **(28)** connected to the first mid-flow chamber **(72);**

passing the refrigerant into the fourth chamber **(58)** of the second manifold **(22)** to define a second mid-flow chamber **(74);**

passing the refrigerant through the plurality of flow tubes **(28)** connected to the second mid-flow chamber **(74);**

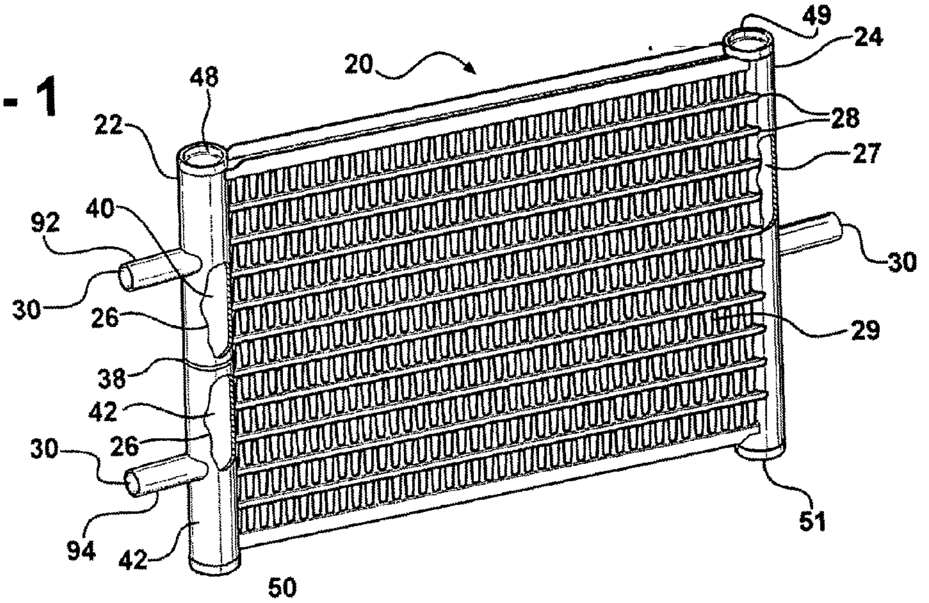
passing the refrigerant into the second chamber **(42)** of the first manifold **(22)** to define a third mid-flow chamber **(76);**

passing the refrigerant through the plurality of flow tubes **(28)** connected to the third mid-flow chamber **(76);**

passing the refrigerant into the fifth chamber **(60)** of the second manifold **(20)** to define an outlet chamber **(80);** and

exiting the refrigerant through the fifth port **(100)** connected to the outlet chamber **(80).**

FIG - 1



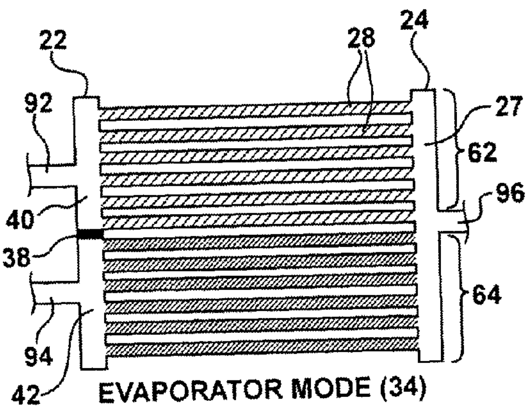


FIG - 1A

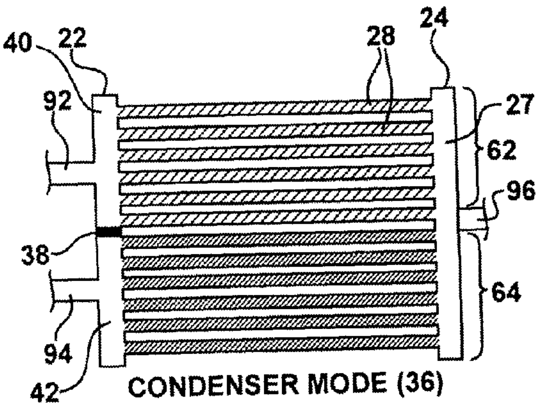


FIG - 1B

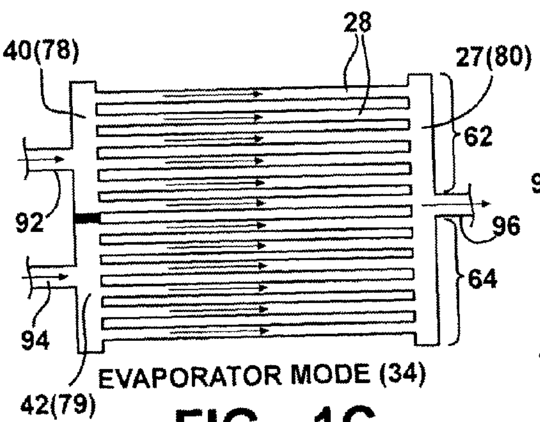


FIG - 1C

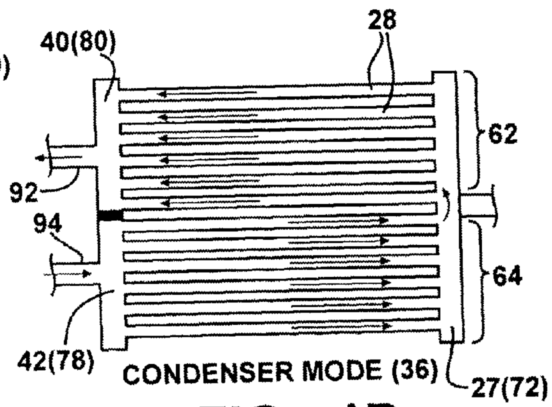
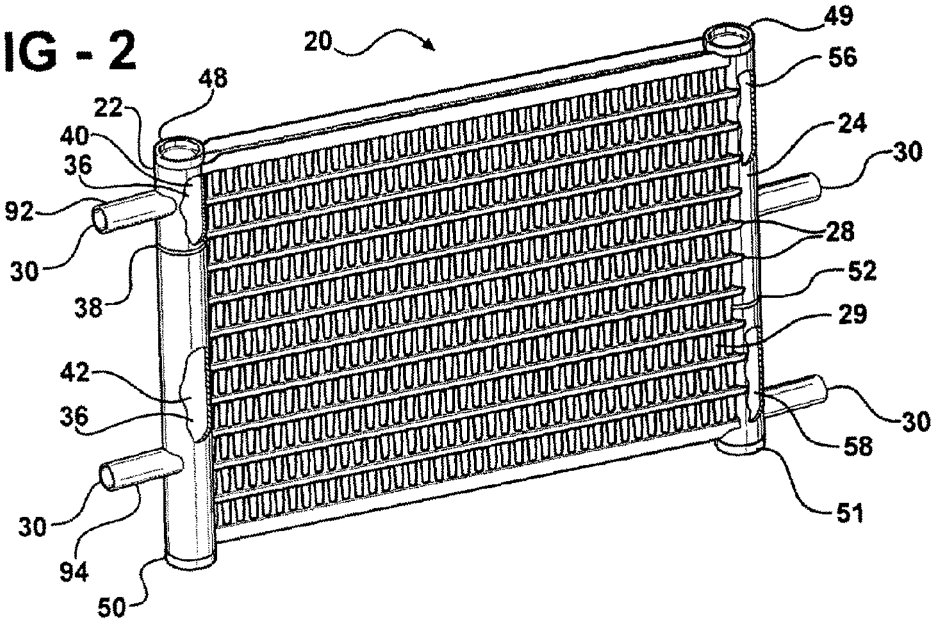


FIG - 1D

FIG - 2



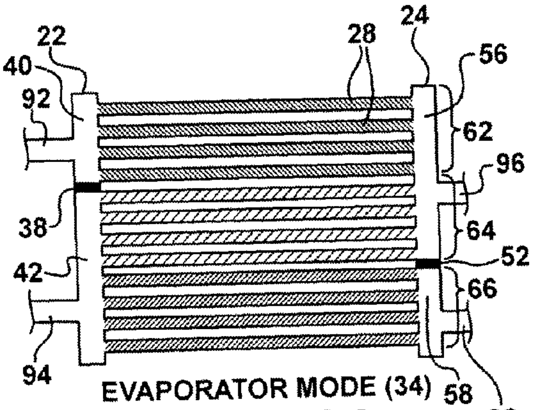


FIG - 2A

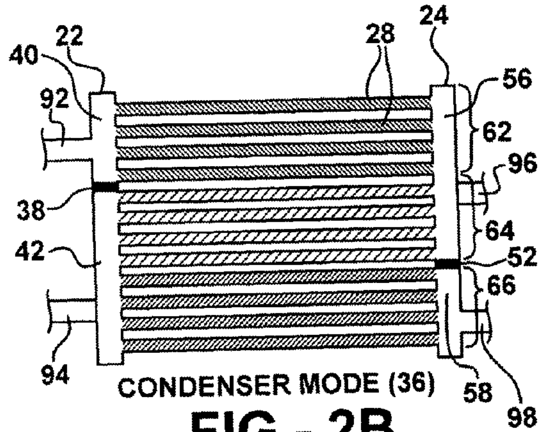


FIG - 2B

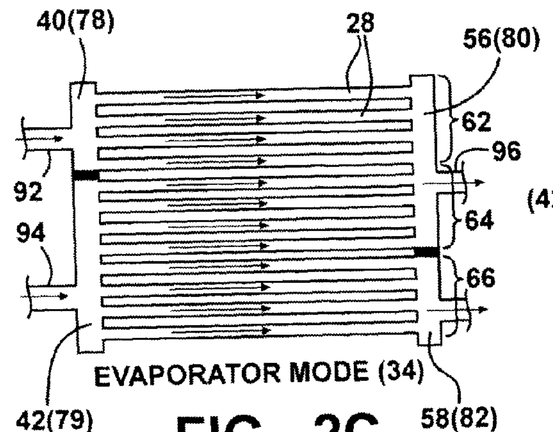


FIG - 2C

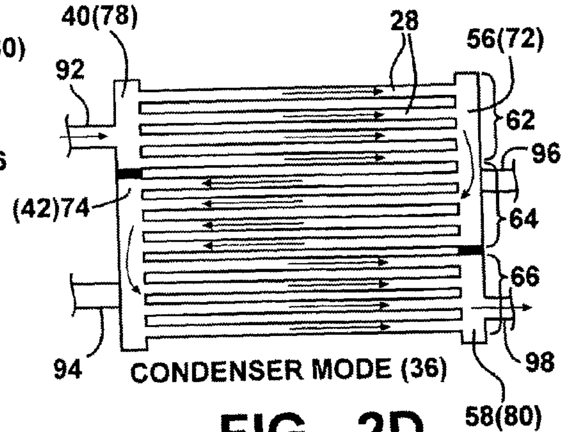
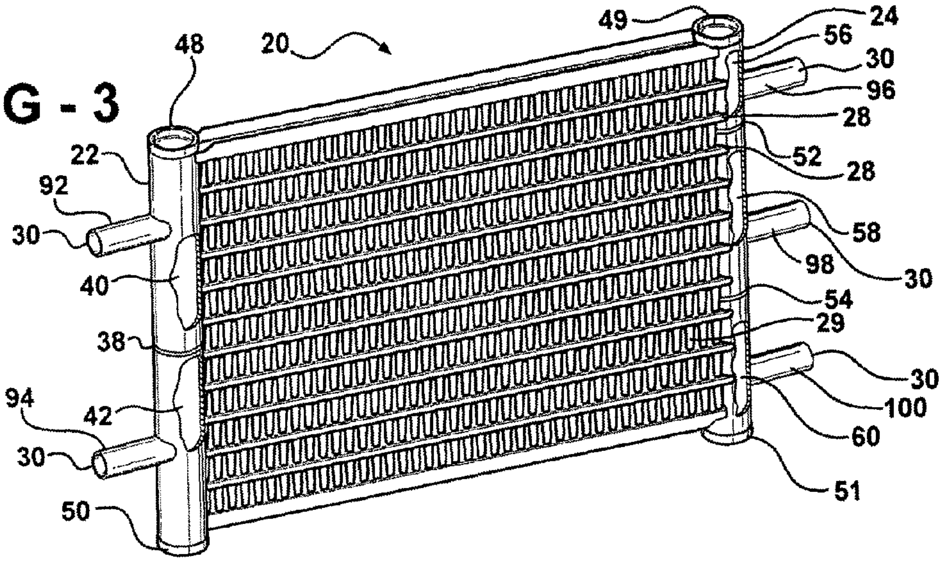


FIG - 2D

FIG - 3



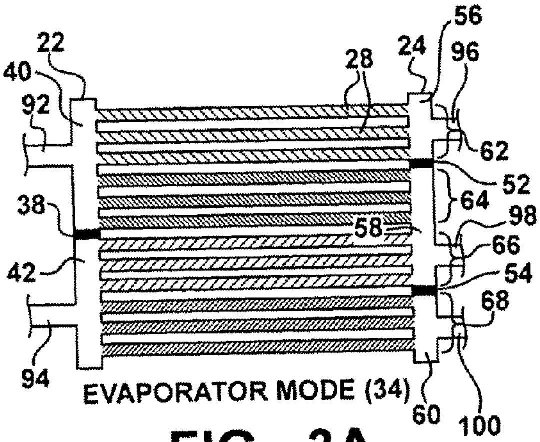


FIG - 3A

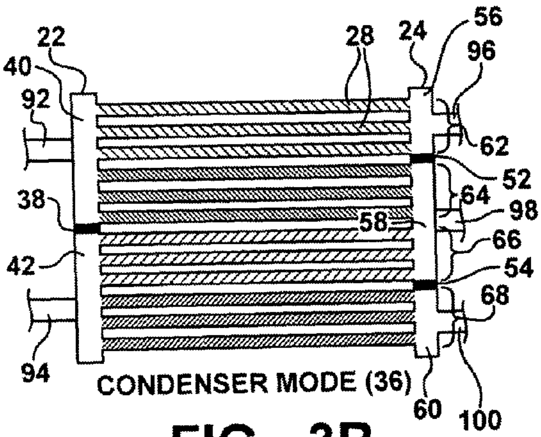


FIG - 3B

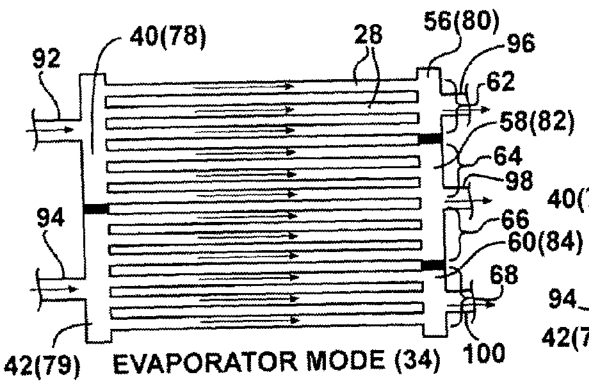


FIG - 3C

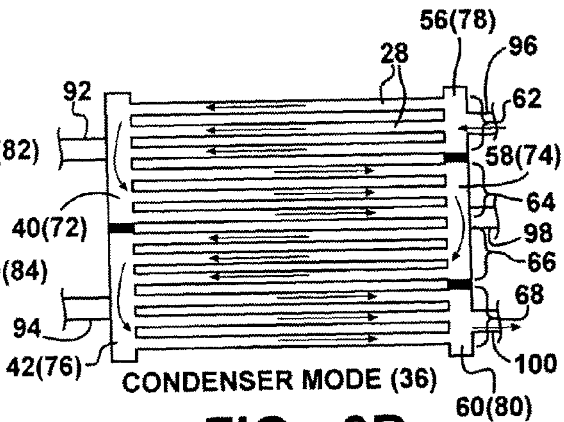
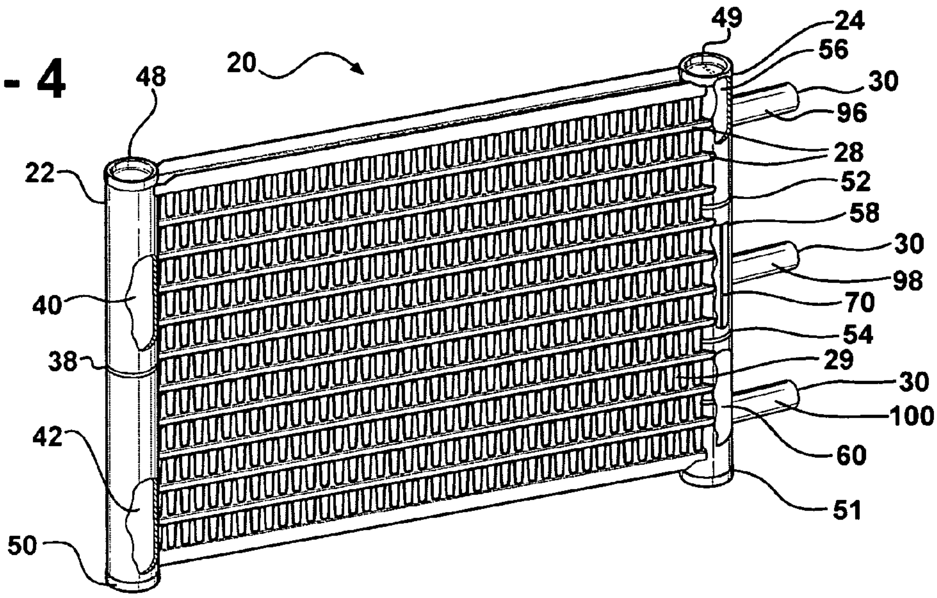


FIG - 3D

FIG - 4



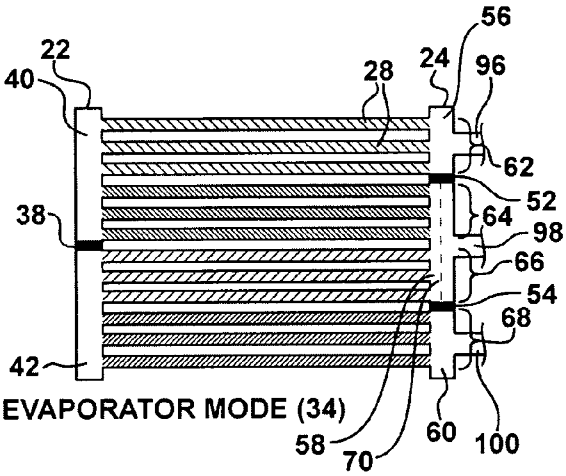


FIG - 4A

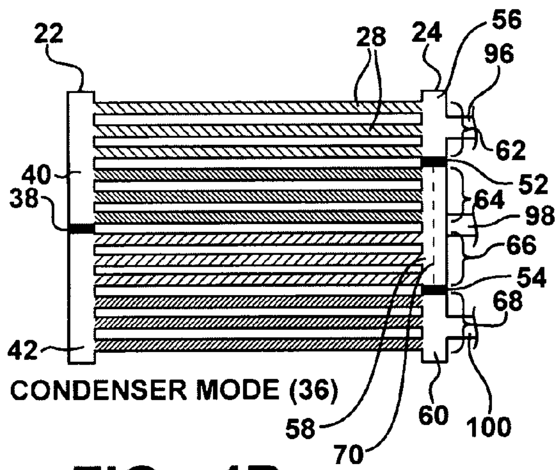


FIG - 4B

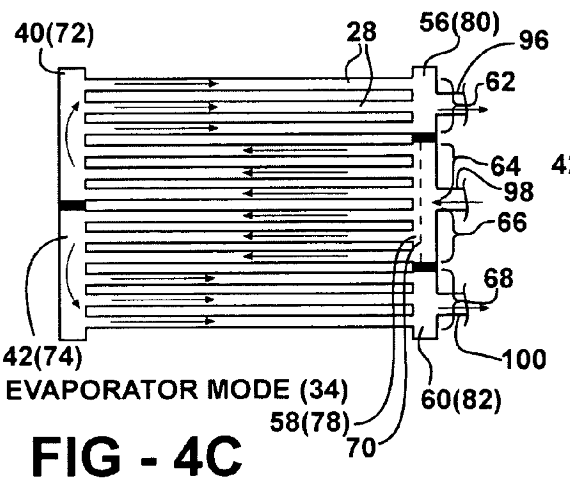


FIG - 4C

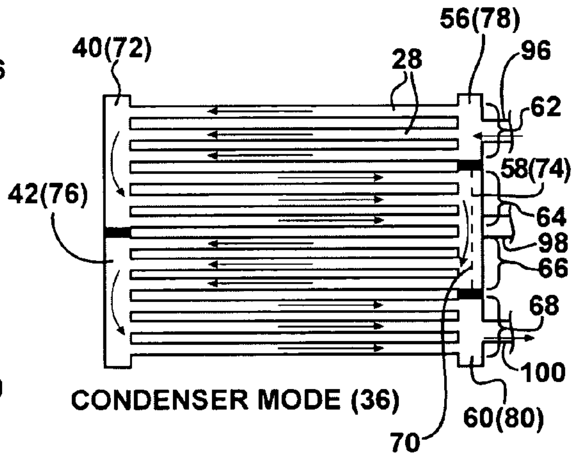
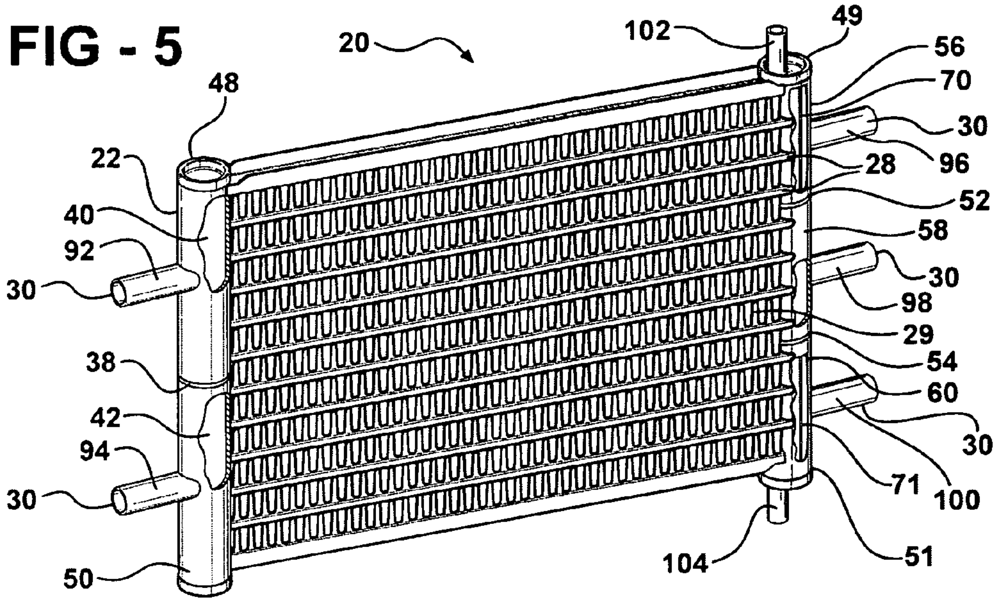


FIG - 4D

FIG - 5



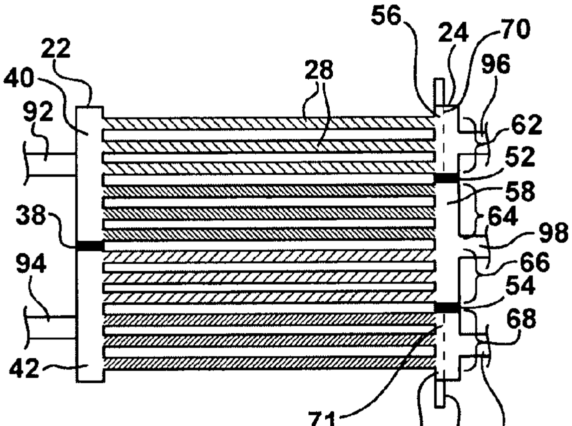


FIG - 5A

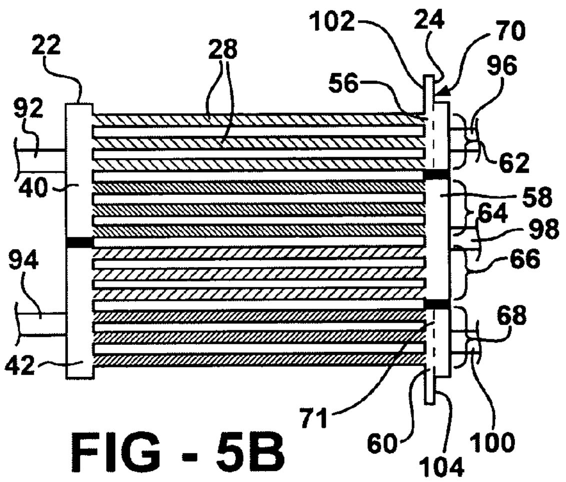


FIG - 5B

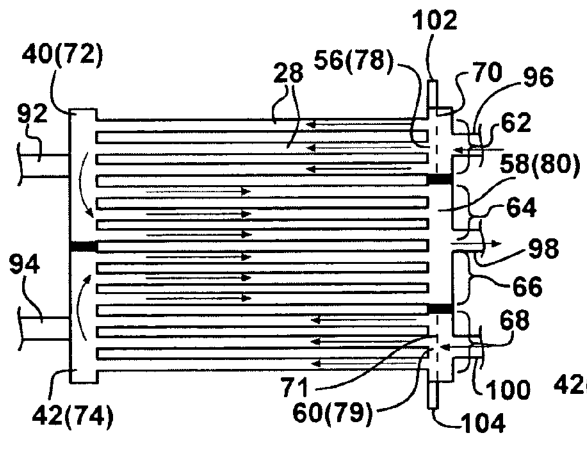


FIG - 5C

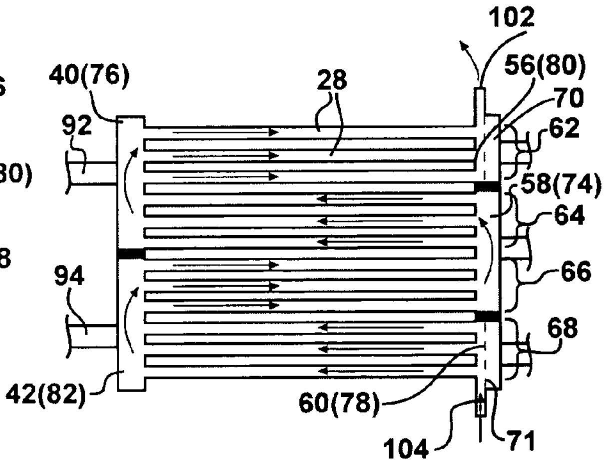


FIG - 5D

REFERENCES CITED IN THE DESCRIPTION

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