US 20080302113A1

(19) United States
(12) Patent Application Publication
Yin et al.
(10) Pub. No.: US 2008/0302113 A1
(43) Pub. Date: Dec. 11, 2008

(54) **REFRIGERATION SYSTEM HAVING HEAT PUMP AND MULTIPLE MODES OF OPERATION**

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(21) Appl. No.: **12/134,263**

(22) Filed: **Jun. 6, 2008**

Related U.S. Application Data

(60) Provisional application No. 60/933,713, filed on Jun. 8, 2007.

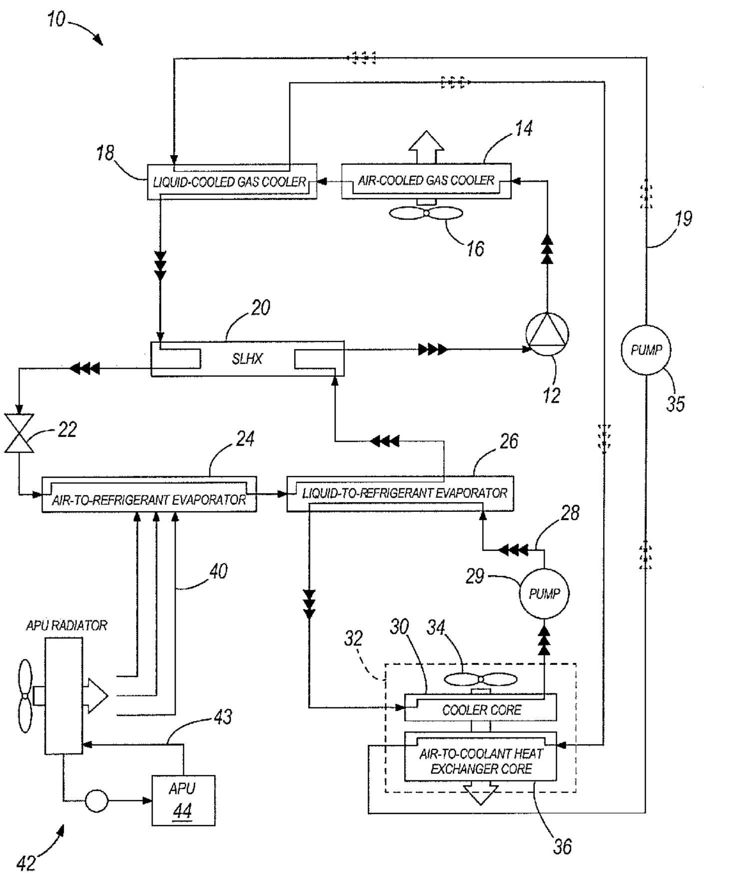
Publication Classification

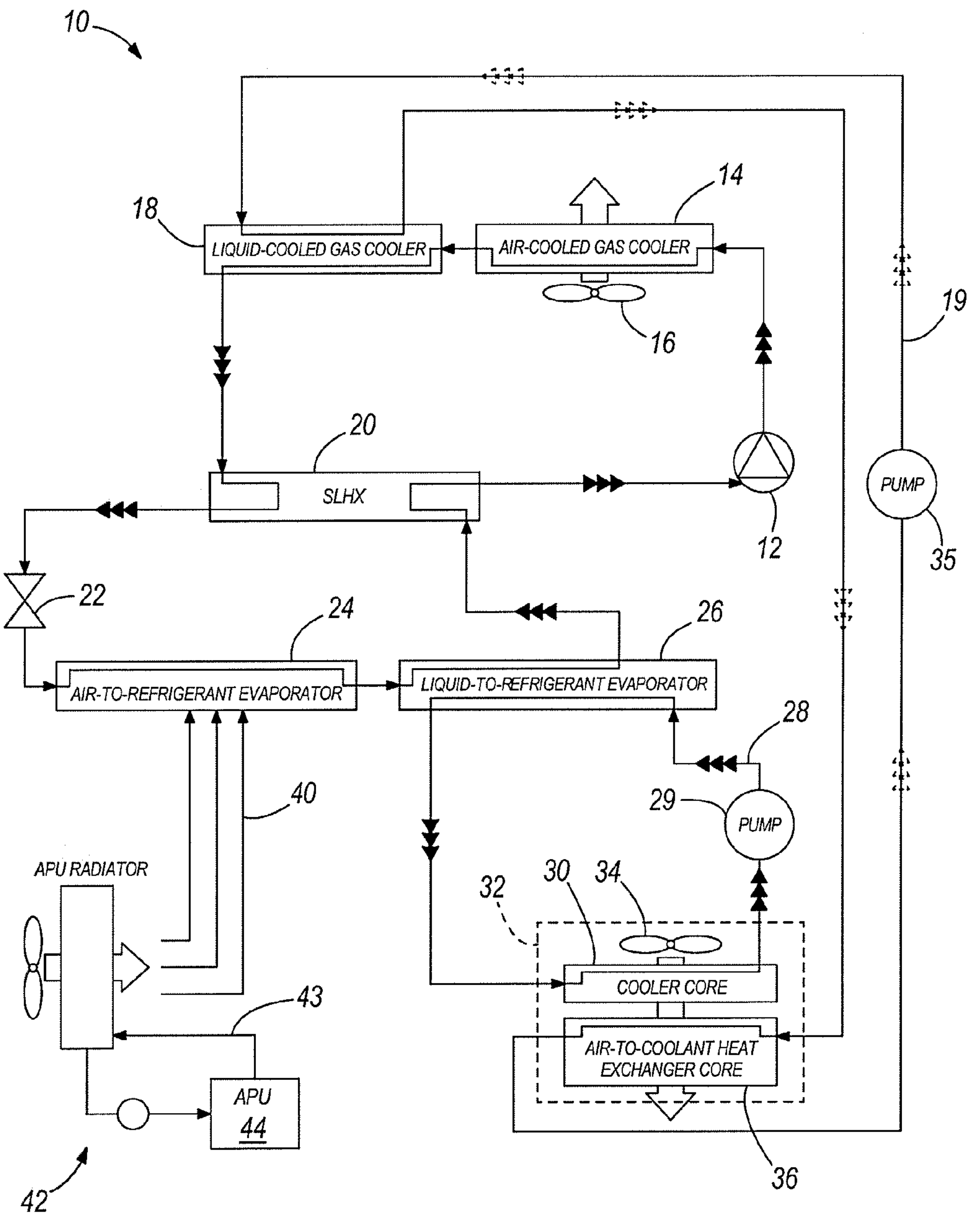
(51) **Int. Cl.**
F25B 1/00 (2006.01)
F25B 7/00 (2006.01)
F25B 27/00 (2006.01)
F25D 17/00 (2006.01)

(52) **U.S. Cl.** **62/115**; 62/335; 62/498; 62/238.7; 62/118

(57) **ABSTRACT**

The present invention provides a refrigeration system including a first refrigerant circuit including a first heat exchanger for transferring heat from refrigerant, a second refrigerant circuit including a second heat exchanger for transferring heat to refrigerant, and a third refrigerant circuit. The third refrigerant circuit includes a compressor, a condenser connected to the first refrigerant circuit such that heat exchange can occur between the refrigerants of the first and refrigerant circuits, an expansion device, and an evaporator connected to the second refrigerant circuit such that heat exchange can occur between the refrigerant of the second and third refrigerant circuits. The refrigerant can travel along the third refrigerant circuit in a common direction during operation in both heating and cooling modes. Refrigerant can be prevented from moving between first, second, and third refrigerant circuits during operation in heating and cooling modes.

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14
18
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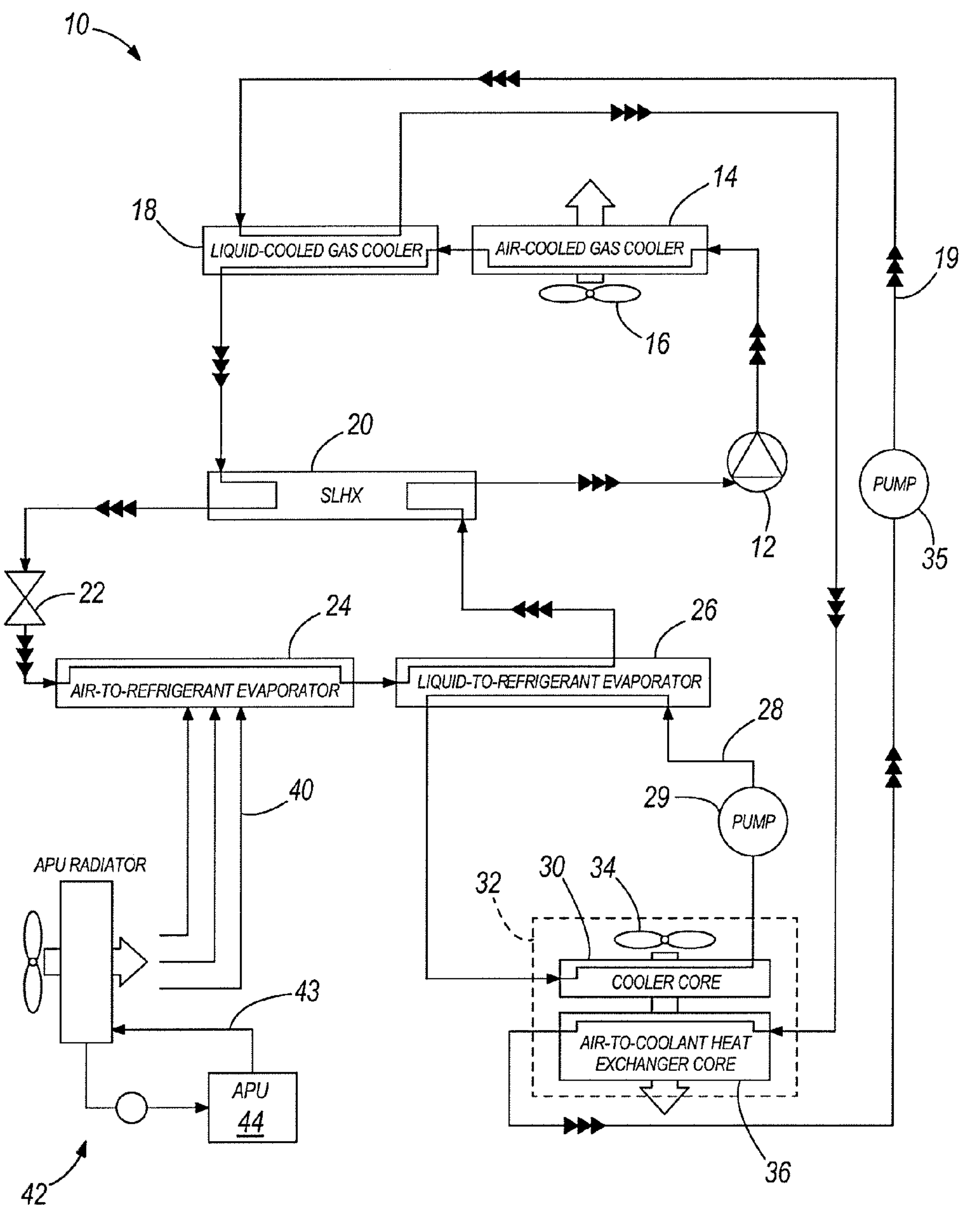
16
19
20
SLHX
12
PUMP
35
22
24
26
AIR-TO-REFRIGERANT EVAPORATOR
LIQUID-TO-REFRIGERANT EVAPORATOR
28
29
PUMP
40
APU RADIATOR
32
30
34
COOLER CORE
43
AIR-TO-COOLANT HEAT EXCHANGER CORE
APU
44
36
42

FIG. 1A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24
AIR-TO-REFRIGERANT EVAPORATOR
26
LIQUID-TO-REFRIGERANT EVAPORATOR
28
29
PUMP
40
APU RADIATOR
32
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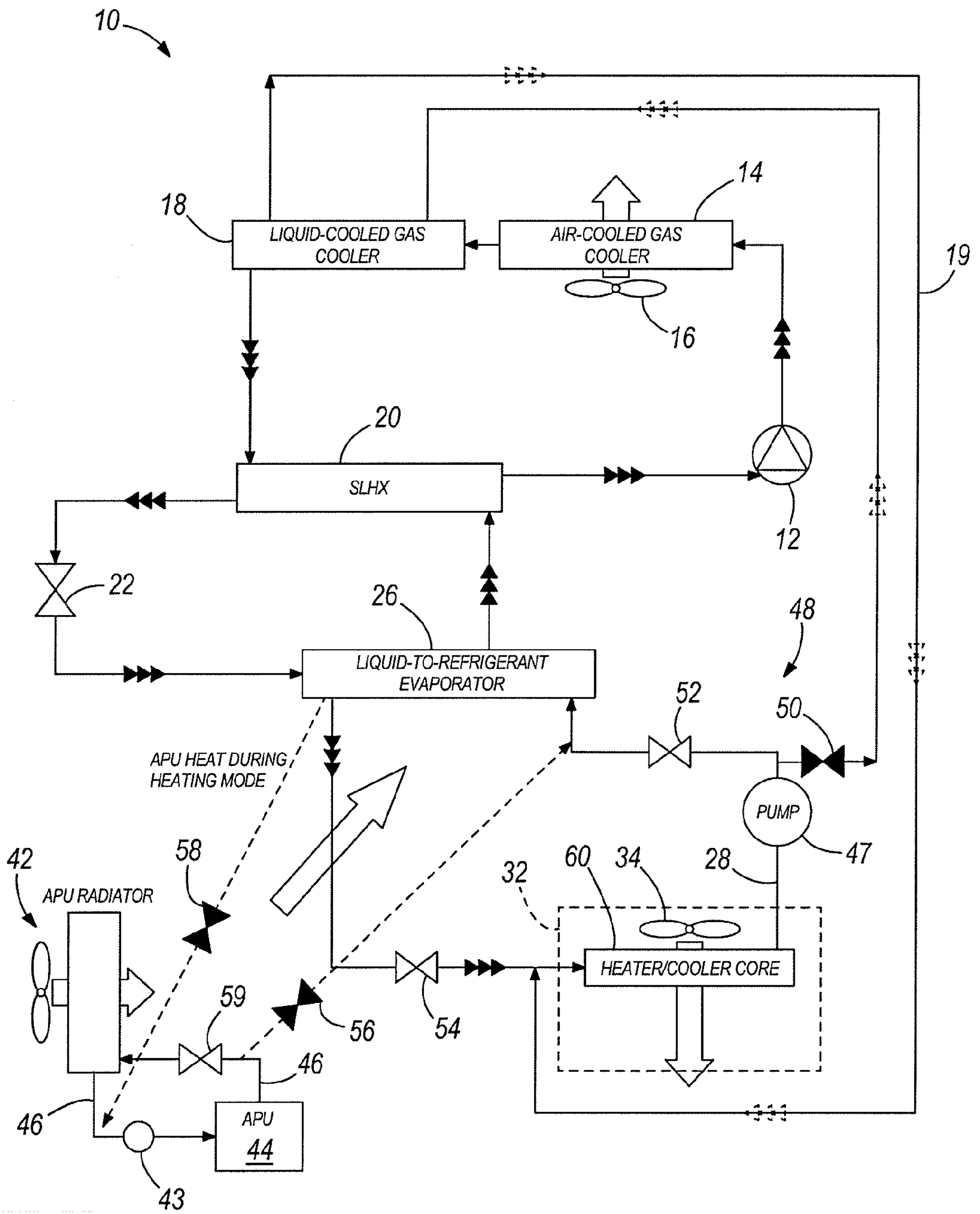
34
COOLER CORE
AIR-TO-COOLANT HEAT
EXCHANGER CORE
43
APU
44
36
42

FIG. 1B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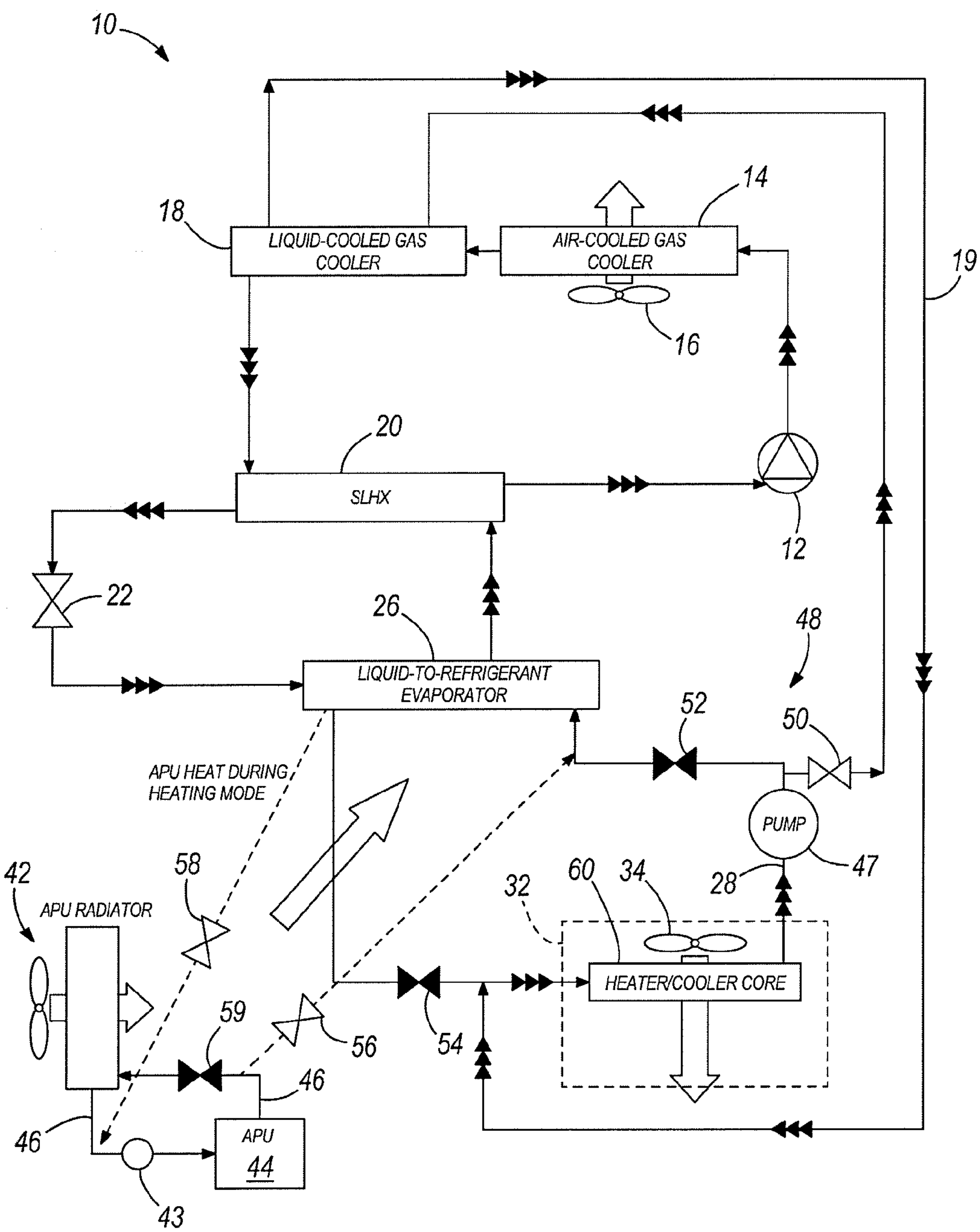
AIR-COOLED GAS COOLER
14
18
16
19
20
SLHX
12
22
26
LIQUID-TO-REFRIGERANT EVAPORATOR
48
52
50
APU HEAT DURING HEATING MODE
PUMP
47
42
58
60
34
28
32
APU RADIATOR
HEATER/COOLER CORE
59
56
54
46
APU
44
43

FIG. 2A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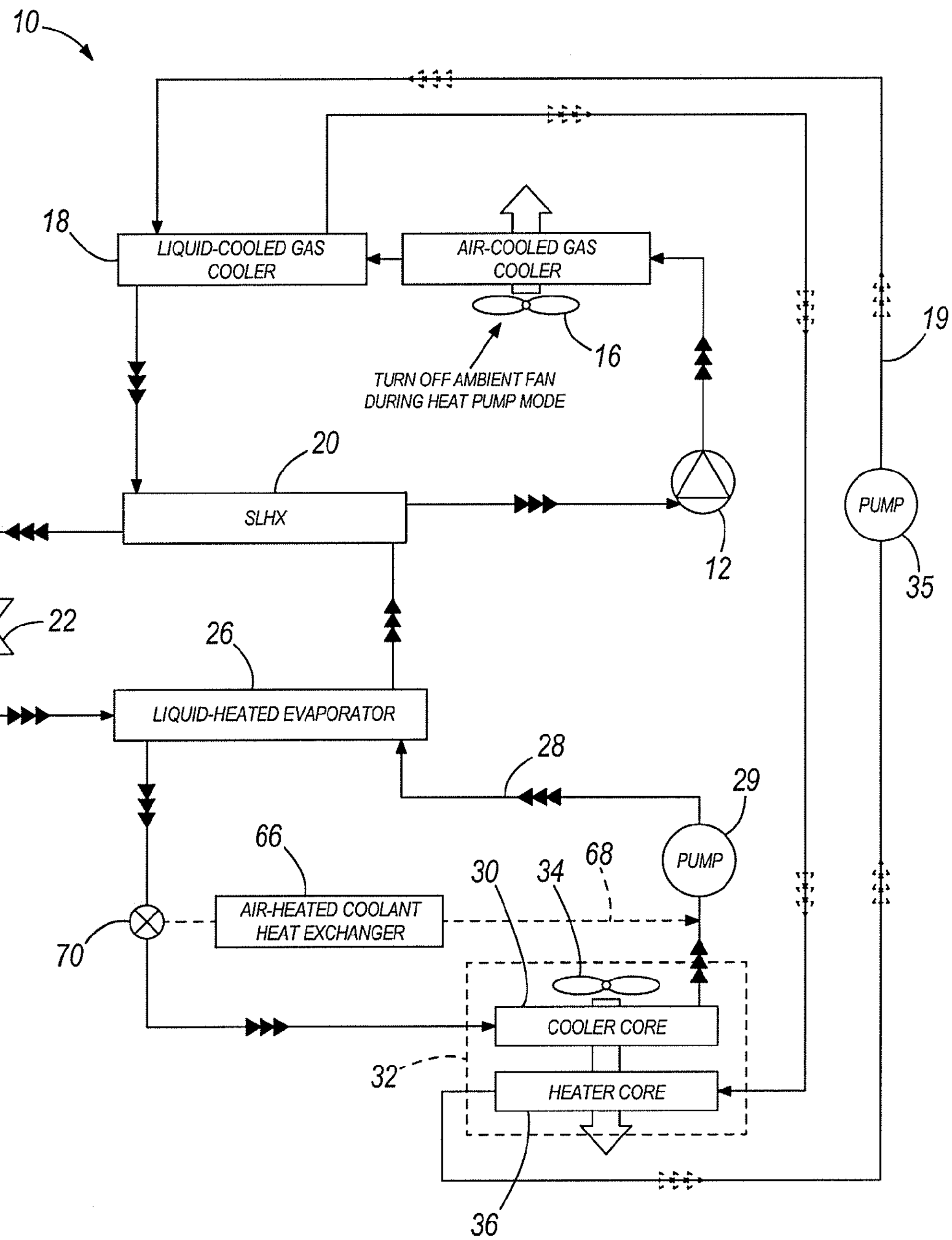
14
AIR-COOLED GAS COOLER
16
19
20
SLHX
12
22
26
LIQUID-TO-REFRIGERANT EVAPORATOR
48
52
50
APU HEAT DURING HEATING MODE
PUMP
47
42
APU RADIATOR
58
60
34
32
28
HEATER/COOLER CORE
59
56
54
46
APU
44
43

FIG. 2B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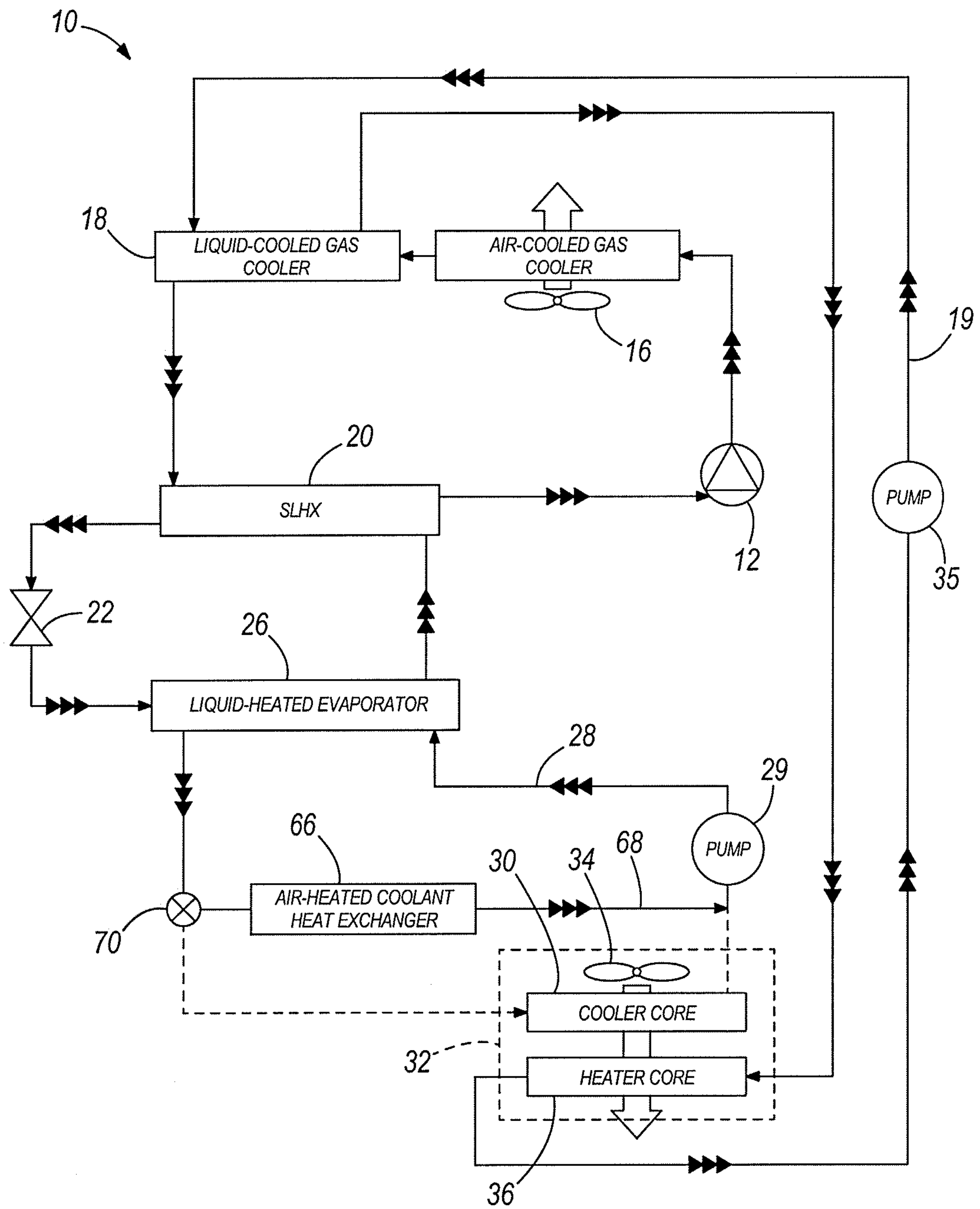
18
LIQUID-COOLED GAS COOLER
AIR-COOLED GAS COOLER
16
TURN OFF AMBIENT FAN DURING HEAT PUMP MODE
19
20
SLHX
12
PUMP
35
22
26
LIQUID-HEATED EVAPORATOR
28
29
PUMP
66
AIR-HEATED COOLANT HEAT EXCHANGER
30
34
68
70
COOLER CORE
32
HEATER CORE
36

FIG. 3A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LIQUID-COOLED GAS COOLER
AIR-COOLED GAS COOLER
16
19
20
SLHX
12
PUMP
35
22
26
LIQUID-HEATED EVAPORATOR
28
29
PUMP
66
30
34
68
AIR-HEATED COOLANT HEAT EXCHANGER
70
COOLER CORE
32
HEATER CORE
36

FIG. 3B

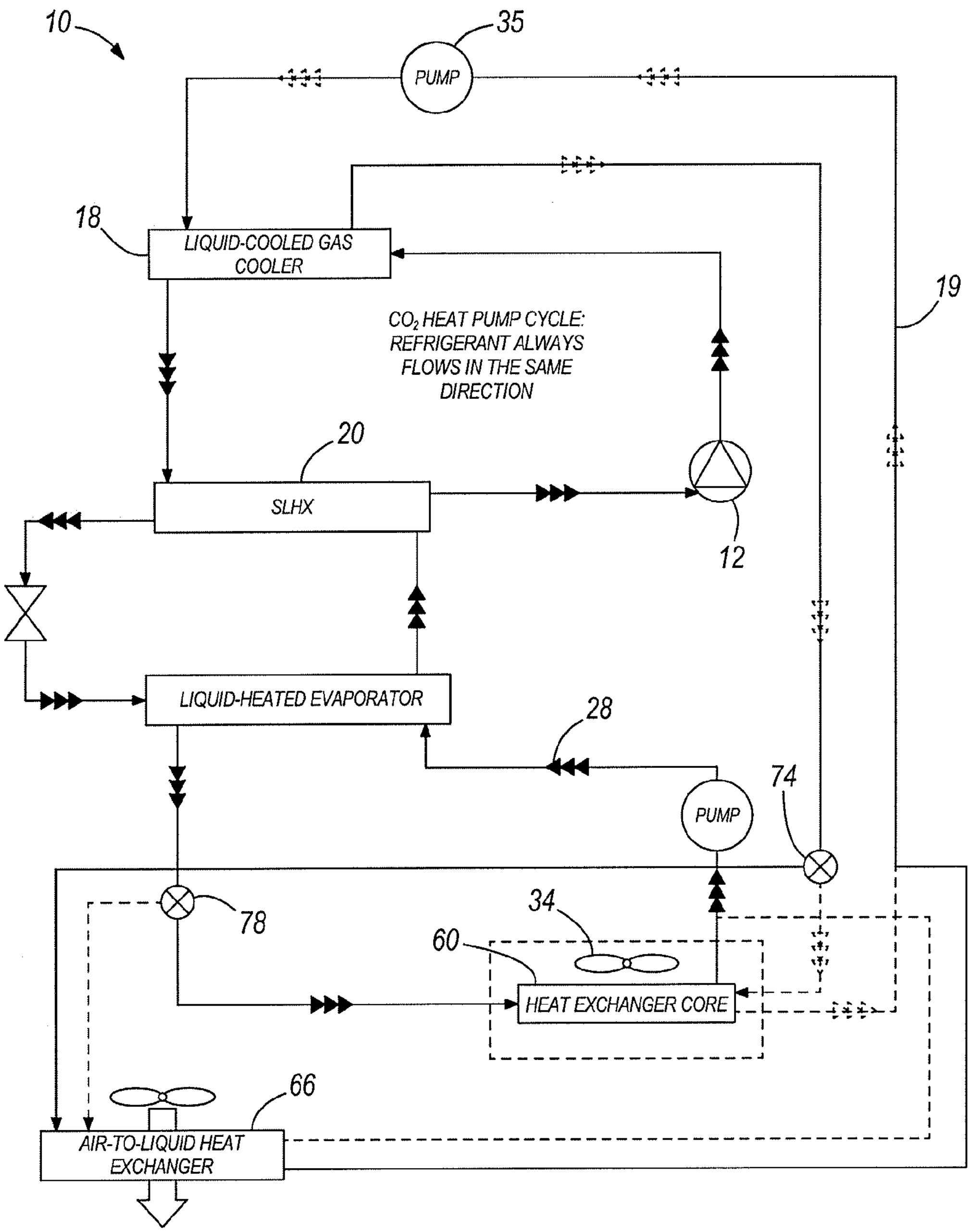
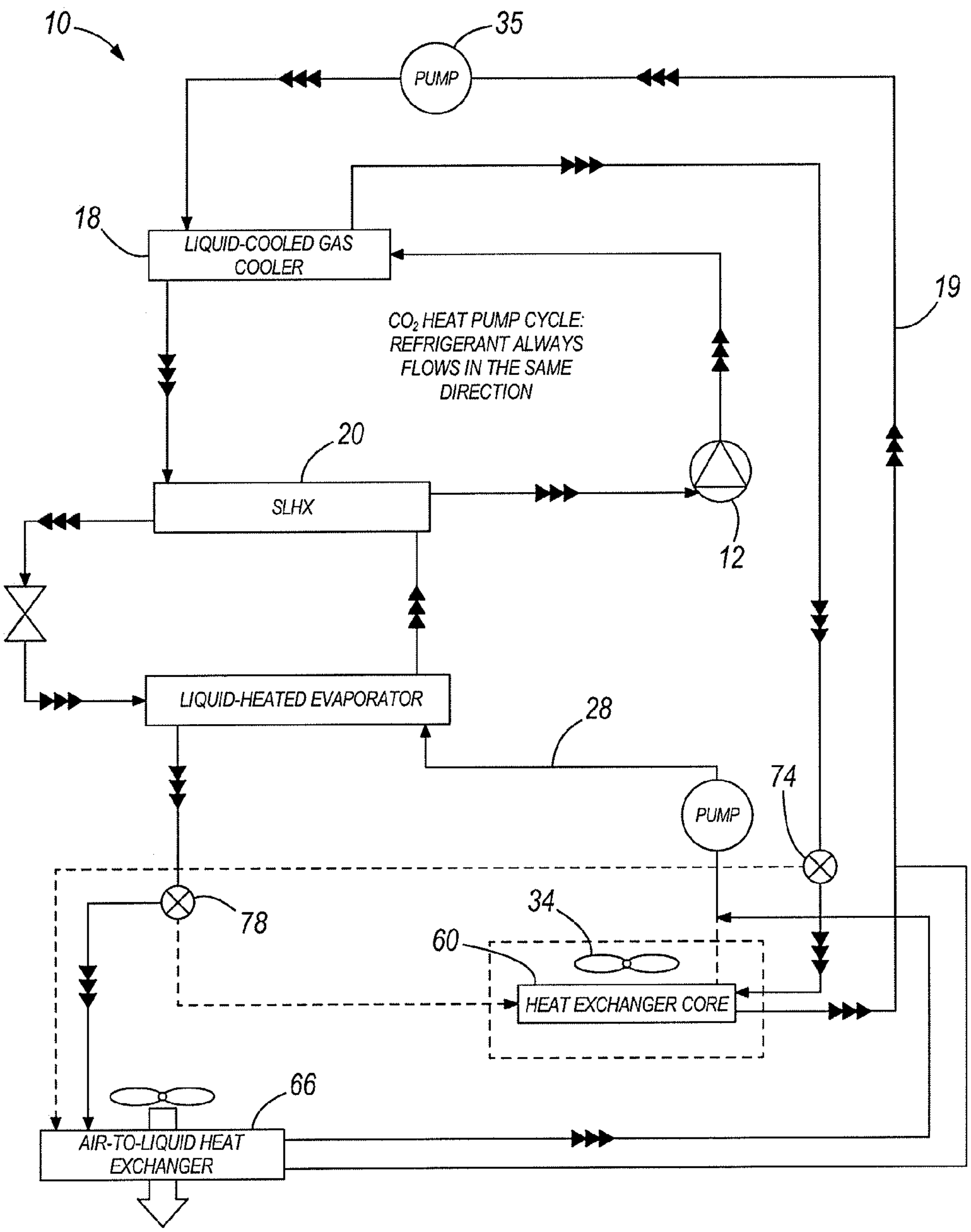

10
35
PUMP
18
LIQUID-COOLED GAS COOLER
19
CO_2 HEAT PUMP CYCLE: REFRIGERANT ALWAYS FLOWS IN THE SAME DIRECTION
20
SLHX
12
LIQUID-HEATED EVAPORATOR
28
74
PUMP
78
34
60
HEAT EXCHANGER CORE
66
AIR-TO-LIQUID HEAT EXCHANGER

FIG. 4A


10
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LIQUID-COOLED GAS COOLER
19
CO_2 HEAT PUMP CYCLE: REFRIGERANT ALWAYS FLOWS IN THE SAME DIRECTION
20
SLHX
12
LIQUID-HEATED EVAPORATOR
28
PUMP
74
78
34
60
HEAT EXCHANGER CORE
66
AIR-TO-LIQUID HEAT EXCHANGER

FIG. 4B

REFRIGERATION SYSTEM HAVING HEAT PUMP AND MULTIPLE MODES OF OPERATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to U.S. Provisional Patent Application Ser. No. 60/933,713, filed Jun. 8, 2007, the entire contents of which is hereby incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to a refrigeration system and a method of manufacturing a refrigeration system, and more particularly to a refrigeration system having both an air heating or heat pump mode and an air conditioning or cooling mode.

SUMMARY

[0003] In principal, a CO_2 heat pump system can be switched from a heat pump or heating mode (HP) to air conditioning or cooling (A/C) mode by changing the flow direction in the system cycle so that the A/C mode evaporator operates as a HP mode gas cooler, and the A/C mode gas cooler operates as an HP mode evaporator. However, there are some practical limitations to this method, which include, but are not limited to, the need for valves able to accommodate high pressure CO_2, appropriately sized accumulators, and heat exchangers in such a system able to withstand higher system pressures for a fully-reversible system.

[0004] In accordance with one feature of the present invention, a refrigeration system is provided that can be operated in both HP and A/C modes without changing the general direction of refrigerant flow through the system. This is done by employing two secondary coolant loops, and adding additional heat exchangers. One desirable application for this system is the cabin heating and cooling required for truck idle-off. In some embodiments, CO_2 can be used as a refrigerant in at least one refrigerant circuit.

[0005] In some embodiments, the invention provides a refrigeration system having both a heating mode for providing heat to a load space and a cooling mode for removing heat from the load space. The system can include a first refrigerant circuit including a first heat exchanger for transferring heat from refrigerant of the first refrigerant circuit to air, a second refrigerant circuit including a second heat exchanger for transferring heat from air to refrigerant of the second refrigerant circuit, and a third refrigerant circuit. The third refrigerant circuit can include a compressor for increasing pressure of refrigerant of the third refrigerant circuit, a condenser connected to the compressor for receiving refrigerant from the compressor and connected to the first refrigerant circuit such that heat exchange can occur between the refrigerant traveling through the first refrigerant circuit and the refrigerant traveling through the third refrigerant circuit, an expansion device for reducing the pressure of the refrigerant of the third refrigerant circuit, and an evaporator connected to the expansion device and connected to the second refrigerant circuit such that heat exchange can occur between the refrigerant traveling through the second refrigerant circuit and the refrigerant traveling through the third refrigerant circuit. The refrigerant can travel along the third refrigerant circuit in a common direction during operation in both the heating mode and the cooling mode. The refrigerant can be prevented from moving between the first refrigerant circuit, the second refrigerant circuit, and the third refrigerant circuit during operation in the heating and cooling modes.

[0006] In some embodiments, the present invention provides a refrigeration system having both a heating mode for providing heat to a load space and a cooling mode for removing heat from the load space. The refrigeration system can include a first refrigerant circuit extending between a compressor, an evaporator, an expansion device, and a condenser. The first refrigerant circuit can define a flow path for a refrigerant traveling in a direction along the refrigerant circuit during operation of the refrigeration system in the heating mode and the cooling mode. The refrigeration system can also include a second refrigerant circuit extending between the condenser and a heat exchanger, the second refrigerant circuit including a first refrigerant pump, and a third refrigerant circuit extending between the evaporator and the heat exchanger. The third refrigerant circuit can include a second refrigerant pump. The second refrigerant pump can be operational during operation in the heating mode and can be idle during operation in the cooling mode.

[0007] The present invention also provides a method of operating a refrigeration system. The method can include the acts of directing a refrigerant along a refrigerant circuit in a direction between a compressor, an evaporator, an expansion device, and a condenser during operation of the refrigeration system in a cooling mode, operating a first pump when the refrigeration system is operating in the cooling mode to circulate refrigerant through a heat exchanger, and transferring heat from a load space to the refrigerant in the refrigerant circuit when the refrigeration system is operating in the cooling mode. The method can also include the acts of stopping the first pump when the refrigeration system is operating in a heating mode, directing the refrigerant along the refrigerant circuit in the direction during operation of the refrigeration system in the heating mode, operating a second pump when the refrigeration system is operating in the heating mode to circulate refrigerant through the heat exchanger in heat exchange relation with the refrigerant of the refrigerant circuit, and transferring heat to the load space from the refrigerant in the refrigerant circuit when the refrigeration system is operating in the heating mode.

[0008] Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1**A is a schematic illustrating a refrigeration system according to some embodiments of the present invention and showing the refrigeration system operating in a cooling mode.

[0010] FIG. **1**B is a schematic illustrating the refrigeration system of FIG. **1**A and showing the refrigeration system operating in a heating mode.

[0011] FIG. **2**A is a schematic illustrating a refrigeration system according to an alternate embodiment of the present invention and showing the refrigeration system operating in a cooling mode.

[0012] FIG. **2**B is a schematic illustrating the refrigeration system of FIG. **2**A and showing the refrigeration system operating in a heating mode.

[0013] FIG. **3**A is a schematic illustrating a refrigeration system according to another alternate embodiment of the present invention and showing the refrigeration system operating in a cooling mode.

[0014] FIG. **3**B is a schematic illustrating the refrigeration system of FIG. **3**A and showing the refrigeration system operating in a heating mode.

[0015] FIG. **4**A is a schematic illustrating a refrigeration system according to a yet another alternate embodiment of the present invention and showing the refrigeration system operating in a cooling mode.

[0016] FIG. **4**B is a schematic illustrating the refrigeration system of FIG. **4**A and showing the refrigeration system operating in a heating mode.

DETAILED DESCRIPTION

[0017] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items.

[0018] Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

[0019] Also, it is to be understood that phraseology and terminology used herein with reference to device or element orientation (such as, for example, terms like "central," "upper," "lower," "front," "rear," and the like) are only used to simplify description of the present invention, and do not alone indicate or imply that the device or element referred to must have a particular orientation. In addition, terms such as "first", "second", and third" are used herein for purposes of description and are not intended to indicate or imply relative importance or significance.

[0020] FIGS. **1**A and **1**B show a schematic illustrating a refrigeration system **10** according to some embodiments of the present invention. During operation in an air conditioning or cooling (A/C) mode, refrigerant, such as, for example, CO_2 leaves a compressor **12** and enters a first evaporator, which, in the illustrated embodiment of FIGS. **1**A and **1**B, is an air-cooled gas cooler **14**. In the embodiment shown in FIG. **1**A, the flow of refrigerant is shown by three solid arrows. Depending on one or more of the operating conditions, the anticipated heating or cooling load, and the type of refrigerant employed, the refrigerant may exit the compressor in a super-critical state. While reference is made herein to the use of CO_2 as a refrigerant, in some embodiments, other refrigerants, including, but not limited to, water, R12, engine coolant, any other organic refrigerant, R245fa, glycol, air, and the like can also or alternatively be used. As shown in FIG. **1**A, a fan **16** can be positioned adjacent to or along an airflow path opening onto the air-cooled gas cooler **14** to reject heat from the gas cooler **14** to the ambient environment via transfer of heat from the refrigerant to an ambient air flow provided by the fan **16**.

[0021] The refrigerant can then enter a second evaporator, which, in the illustrated embodiment of FIG. **1**A, is a liquid-cooled gas cooler **18** that is cooled by a secondary, high temperature coolant loop **19**. In the illustrated embodiment of FIG. **1**A, liquid coolant flows through the loop **19** during A/C operation (possibly at a lower mass flow rate than refrigerant from the air-cooled gas cooler **14**) to further reduce the temperature of the refrigerant, however, compared to the air-cooled gas cooler **14**, the heat load of the liquid-cooled gas cooler **18** can be small. In other embodiments, the heat load of the liquid-cooled gas cooler **18** can be substantially equal to or larger than the heat load experienced by the air-cooled gas cooler **14**, depending upon one or more of the relative sizes and cooling capacities of the air-cooled gas cooler **14** and the liquid-cooled gas cooler **18**, the mass flow rates of refrigerant and coolant flows through and across the air-cooled gas cooler **14** and the liquid-cooled gas cooler **18**, the presence or absence of a fan **16** for the air-cooled gas cooler **14**, and the types and cooling capacities of the coolants used in the air-cooled gas cooler **14** and the liquid-cooled gas cooler **18**.

[0022] As shown in FIG. **1**A, from the liquid-cooled gas cooler, the refrigerant can enter the high pressure side of a suction line heat exchanger (SLHX) **20** for more cooling before going through an expansion device or valve **22**. After the refrigerant exits the expansion valve **22**, the refrigerant can enter an air-to-refrigerant evaporator **24**. A fan (not shown) can be positioned adjacent to or along an airflow path opening onto the evaporator **24**. In some embodiments, the fan can be turned off during periods of reduced cooling demand and/or to limit power consumption and improve efficiency of the refrigeration system **10**. In embodiments in which the fan can be turned off or operated at a reduced speed, the heat duty of the evaporator **24** can be limited to far less than the heat duty of a liquid-to-refrigerant evaporator **26** that receives the refrigerant from the heat exchanger **24**.

[0023] In the liquid-to-refrigerant evaporator **26**, the refrigerant can evaporate, receiving heat energy from and thereby cooling down a coolant (e.g., glycol, water, R12, engine coolant, any organic refrigerant, R245fa, air, and the like) flowing through the liquid-to-refrigerant evaporator **26** from another secondary, low temperature coolant loop **28**. It should be noted that the air-heated evaporator **24** can be placed either upstream or downstream of the liquid-heated evaporator **24** with respect to the flow of the refrigerant. The same can be said of the liquid-cooled gas cooler **18** with respect to the air-cooled gas cooler **14**. However, it can be desirable to avoid excess heating and/or boiling of the slow moving or stagnant liquid in the liquid-cooled gas cooler **18** during operation of the refrigeration system **10** in the A/C mode.

[0024] After traveling through the evaporator **26**, the refrigerant can reject heat to the high pressure refrigerant in the SLHX **20**. An accumulator (not shown in FIGS. **1**A-**2**B) can be positioned upstream of the SLHX **20** on the low-pressure-side. This accumulator can be a separate unit, or alternatively, can be directly integrated with the SLHX **20**.

[0025] In addition to the liquid-refrigerant evaporator **26**, the low temperature coolant loop **28** can include a pump **29** for moving liquid coolant through the liquid side of the evaporator **26**. While heat from the coolant is transferred to the refrigerant in the evaporator **26**, a heat exchanger cooler core **30**, which can be mounted in an inside space **32**, such as, for example, the cabin of a truck or another vehicle, can operate to transfer heat away from the low temperature coolant in the coolant loop **28**. The cooler core **30** can be accompanied by an air mover **34**, such as a fan or blower, and can cool down the air inside the space **32** and/or remove humidity from the air in the space **32**. In some embodiments, if the air stream through or across the heat exchanger **30** is cooled below the dew point, a small amount of liquid coolant can be circulated through the hot coolant loop **19** to reheat the air entering the cabin (as shown by three dashed arrows).

[0026] FIG. **1**B shows a schematic illustrating the refrigeration system **10** during operation in the heating (HP) mode. As shown by three solid arrows, the refrigerant flows through the system **10** in the same direction as described above with respect to operation in the A/C mode. However, the fan **16** adjacent to the air-cooled gas cooler **14** is deactivated and high temperature liquid coolant is pumped through the high temperature coolant loop **19** by a pump **35** to provide cooling to the refrigerant in the liquid-cooled gas cooler **18**. In the cold temperature loop **28**, the cold pump **29** is turned off and the air-to-refrigerant fan **34** can be activated. This allows for additional heating inside of the space **32** by the transfer of heat from the high temperature coolant to the air flow in an air-to-coolant heat exchanger heater core **36**. To increase the coefficient of performance (COP) of the system **10** while operating in HP mode during cold weather, a waste heat air stream **40** from a waste heat source **42**, such as a cooling system **43** for an auxiliary power unit **44** can be routed through the air-to-refrigerant evaporator **24**.

[0027] In other embodiments, the waste heat source **42** and/or a different waste heat source **42** can also or alternatively provide heat to a liquid-to-liquid heat exchanger evaporator or an integrated auxiliary power unit (APU) stack cooler and evaporator coolant loop. In the latter-case, the waste heat source **42** can remove the need for an extra air-heated evaporator, and the "cooler" core can add heat to the space air.

[0028] FIGS. **2**A and **2**B illustrate an alternate embodiment of a refrigeration system **10** according to the present invention. The refrigeration system shown in FIGS. **2**A and **2**B is similar in many ways to the illustrated embodiments of FIGS. **1**A and **1**B described above. Accordingly, with the exception of mutually inconsistent features and elements between the embodiment of FIGS. **2**A and **2**B and the embodiments of FIGS. **1**A and **1**B, reference is hereby made to the description above accompanying the embodiments of FIGS. **1**A and **1**B for a more complete description of the features and elements (and the alternatives to the features and elements) of the embodiment of FIGS. **2**A and **2**B.

[0029] FIG. **2**A illustrates a simpler version of the refrigeration system **10**. In this embodiment of the refrigeration system **10**, the low temperature fluid loop **28**, the high temperature loop **19**, and the coolant lines **46** of an APU coolant system **43** are directly plumbed into each other, and only one liquid pump **47** (not including the APU coolant loop pump) is required for the loops **19** and **28**.

[0030] As shown in FIG. **2**A, a matrix **48** of liquid valves **50**, **52**, **54**, **56**, **58** and **59** can be used to direct the coolant flows to the desired location during HP and A/C modes. This allows for the elimination of the air-to-refrigerant evaporator **24**, and for the functions of the cooler and heater cores **30** and **36** to be combined in one heat exchanger in the form of a heater/cooler core **60**.

[0031] For example, during operation in A/C mode, by opening valve **59** (shown unshaded), closing valves **56** and **58** (shown in solid), opening valves **52** and **54**, and closing valve **50**, the APU coolant will not enter the low temperature loop **28** (which is heating the evaporator **26**), and no coolant will pass to the liquid-cooled gas cooler **18** via the high temperature loop **19**, while the coolant in the low temperature loop **28** rejects heat to the refrigerant in the evaporator **26** and receives heat from the air stream passing through the heater/cooler core **60**. In some applications, it may be desirable for a small amount of cold liquid to pass through the valve **50** and the liquid-cooled gas cooler **18**. This can allow the refrigerant temperature to fall below the ambient temperature, thus potentially improving system COP.

[0032] As shown in FIG. **2**B, in HP mode, by closing or modulating the valve **59** (now shown in solid), opening the valves **56** and **58** (now shown unshaded), closing the valves **52** and **54** and opening the valve **50**, the APU coolant can be directed to the liquid-to-refrigerant evaporator **26**, and then circulated directly back to the APU **44** without passing through the combined heater/cooler core **60**, while the coolant in the high temperature loop **19** is circulated through the liquid-cooled gas cooler **18** to receive heat from the refrigerant and then through the heater/cooler core **60** to reject heat to the air stream passing therethrough.

[0033] FIGS. **3**A and **3**B illustrate an alternate embodiment of a refrigeration system **10** according to the present invention. The refrigeration system shown in FIGS. **3**A and **3**B is similar in many ways to the illustrated embodiments of FIGS. **1**A-**2**B described above. Accordingly, with the exception of mutually inconsistent features and elements between the embodiment of FIGS. **3**A and **3**B and the embodiments of FIGS. **1**A-**2**B, reference is hereby made to the description above accompanying the embodiments of FIGS. **1**A-**2**B for a more complete description of the features and elements (and the alternatives to the features and elements) of the embodiment of FIGS. **3**A and **3**B.

[0034] The refrigeration system **10** of FIGS. **3**A and **3**B differs from that of FIGS. **1**A and **1**B in that the air-to-refrigerant evaporator **24** has been eliminated and replaced with an air-heated coolant heat exchanger **66** that has been added to a bypass line **68** in the low temperature fluid loop **28**, with a three-way valve **70** (or series of two-way valves) controlling the flow of coolant through the cooler core **30** and the ambient air-heated coolant heat exchanger **66**.

[0035] As shown in FIG. **3**A, during operation in the A/C mode, the valve **70** can direct coolant through the cooler core **30**, rather than the heat exchanger **66**, so that the coolant flowing in the low temperature loop **28** can absorb heat from the air flow passing through the cooler core **30**. The operation of the high temperature loop can be substantially similar to the version of the system **10** in FIGS. **1**A and **1**B. It should be appreciated that the heat exchanger **66** could be replaced by any other type of heat exchanger that would utilize any other heat source, such as, for example, a liquid waste heat stream from a generator.

[0036] As shown in FIG. **3**B, during operation in the HP mode, the valve **70** is used to direct the coolant through the heat exchanger **66**, rather than through the cooler core **30**, so that heat from the ambient air passing through the heat exchanger **66** is transferred to the coolant flowing in the low temperature loop **28**.

[0037] FIGS. **4**A and **4**B illustrate an alternate embodiment of a refrigeration system **10** according to the present invention. The refrigeration system shown in FIGS. **4**A and **4**B is similar in many ways to the illustrated embodiments of FIGS. **1**A-**3**B described above. Accordingly, with the exception of mutually inconsistent features and elements between the embodiment of FIGS. **4**A and **4**B and the embodiments of FIGS. **1**A-**3**B, reference is hereby made to the description above accompanying the embodiments of FIGS. **1**A-**3**B for a more complete description of the features and elements (and the alternatives to the features and elements) of the embodiment of FIGS. **4**A and **4**B.

[0038] As shown in FIGS. **4**A and **4**B, this system **10** differs from that of FIGS. **1**A and **1**B in that the liquid-cooled gas cooler **14** and the air-to-refrigerant evaporator **24** have both been eliminated, the functions of the cooler and heater cores **30** and **36** are combined in a heater/cooler core **60** such as discussed in connection with FIGS. **2**A and **2**B, and an air-heated coolant heat exchanger **66**, such as discussed in connection with FIGS. **3**A and **3**B, has been plumbed into both the high temperature loop **19** and the low temperature loop **28** with a three-way valve **74** (or series of two-way valves) provided in the high temperature loop **19** and a three-way valve **78** provided in the low temperature loop **28** to control the coolant flow in both of the loops **19** and **20** through the heat exchangers **60** and **66**.

[0039] As shown in FIG. **4**A, during operation in the A/C mode, the valve **78** directs the coolant in the low temperature loop **19** through the core **60**, rather than through the heat exchanger **66**, to remove heat from the cabin **32**, and the valve **74** directs the coolant from the high temperature loop **19** through the heat exchanger **66**, rather than the core **60**, to reject heat absorbed by the coolant from the gas cooler **18** to the ambient air flow through the heat exchanger **66**.

[0040] As shown in FIG. **4**B, during operation in the HP mode, the coolant in the high temperature loop **19** is directed by the valve **74** through the heater/cooler core **60**, rather than through the heat exchanger **66**, while the valve **78** in the low temperature loop **28** directs coolant through the heat exchanger **66**, rather than the heater/cooler core **60**, so as to absorb heat from the ambient air flowing through the heat exchanger **68**.

[0041] The embodiments described above and illustrated in the figures are presented by way of example only and are not intended as a limitation upon the concepts and principles of the present invention. As such, it will be appreciated by one having ordinary skill in the art that various changes are possible.

1. A refrigeration system having both a heating mode for providing heat to a load space and a cooling mode for removing heat from the load space, the system comprising:

a first refrigerant circuit including a first heat exchanger for transferring heat from refrigerant of the first refrigerant circuit to air;

a second refrigerant circuit including a second heat exchanger for transferring heat from air to refrigerant of the second refrigerant circuit; and

a third refrigerant circuit including:

a compressor for increasing pressure of refrigerant of the third refrigerant circuit;

a third heat exchanger connected to the compressor for receiving refrigerant from the compressor, and connected to the first refrigerant circuit such that heat exchange can occur between the refrigerant traveling through the first refrigerant circuit and the refrigerant traveling through the third refrigerant circuit;

an expansion device for reducing the pressure of the refrigerant of the third refrigerant circuit; and

an evaporator connected to the expansion device, and connected to the second refrigerant circuit such that heat exchange can occur between the refrigerant traveling through the second refrigerant circuit and the refrigerant traveling through the third refrigerant circuit, the refrigerant traveling along the third refrigerant circuit in a common direction during operation in both the heating mode and the cooling mode;

wherein refrigerant is prevented from moving between the first refrigerant circuit, the second refrigerant circuit, and the third refrigerant circuit during operation in the heating and cooling modes.

2. The refrigeration system of claim **1**, wherein the third heat exchanger is a liquid-cooled gas cooler.

3. The refrigeration system of claim **2**, further comprising an air-cooled gas cooler connected in series with the liquid-cooled gas cooler and to at least one of the compressor and the expansion device.

4. The refrigeration system of claim **1**, wherein the evaporator is a liquid-heated evaporator.

5. The refrigeration system of claim **4**, further comprising an air-heated evaporator connected in series with the liquid heated evaporator and to at least one of the expansion device and the compressor.

6. The refrigeration system of claim **1**, further comprising a suction line heat exchanger connected to the third heat exchanger, the expansion valve, the evaporator, and the compressor along the third refrigerant circuit.

7. The refrigeration system of claim **1**, wherein the refrigerant of the third refrigerant circuit is carbon dioxide.

8. The refrigeration system of claim **1**, wherein the first heat exchanger and the second heat exchanger are combined in a single heat exchanger.

9. The refrigeration system of claim **1**, further comprising a heat source separate from the first, second, and third refrigerant circuits for providing heat to the refrigeration system during operation in the heating mode.

10. A refrigeration system having both a heating mode for providing heat to a load space and a cooling mode for removing heat from the load space, the refrigeration system comprising:

a first refrigerant circuit extending between a compressor, an evaporator, an expansion device, and a first heat exchanger, the first refrigerant circuit defining a flow path for a refrigerant traveling in a direction along the refrigerant circuit during operation of the refrigeration system in the heating mode and the cooling mode;

a second refrigerant circuit extending between the condenser and a second heat exchanger, the second refrigerant circuit including a first refrigerant pump; and

a third refrigerant circuit extending between the evaporator and the second heat exchanger, the third refrigerant circuit including a second refrigerant pump, the second refrigerant pump being operational during operation in the heating mode and being idle during operation in the cooling mode.

11. The refrigeration system of claim **10**, wherein the second refrigerant circuit is separated from the first refrigerant circuit such that refrigerant is prevented from moving between the first and second refrigerant circuits, the second refrigerant circuit extending through the first heat exchanger such that heat exchange can occur between the refrigerant traveling through the first refrigerant circuit and a refrigerant traveling through the second refrigerant circuit.

12. The refrigeration system of claim **10**, wherein the third refrigerant circuit is separated from the first refrigerant circuit such that refrigerant is prevented from moving between the first and third refrigerant circuits, the third refrigerant circuit extending through the evaporator such that heat exchange can occur between the refrigerant traveling through the first refrigerant circuit and a refrigerant traveling through the third refrigerant circuit.

13. The refrigeration system of claim **10**, wherein the first refrigerant circuit includes a suction line heat exchanger.

14. The refrigeration system of claim **10**, wherein the second heat exchanger includes a first heat exchanger core and a second heat exchanger core, the first heat exchanger core being associated with the second refrigerant circuit, the second heat exchanger core being associated with the third refrigerant circuit.

15. The refrigeration system of claim **10**, further comprising a heat source separate from the first, second, and third refrigerant circuits for providing heat to the refrigeration system during operation in the heating mode.

16. The refrigeration system of claim **10**, wherein the evaporator is a liquid-heated evaporator and the first heat exchanger is a liquid-cooled gas cooler.

17. The refrigeration system of claim **16**, further comprising an air-cooled gas cooler connected in series with the liquid-cooled gas cooler.

18. The refrigeration system of claim **16**, further comprising an air-heated evaporator connected in series with the liquid-heated evaporator.

19. A method of operating a refrigeration system, the method comprising the acts of:

directing a refrigerant along a refrigerant circuit in a direction between a compressor, an evaporator, an expansion device, and a first heat exchanger during operation of the refrigeration system in a cooling mode;

operating a first pump when the refrigeration system is operating in the cooling mode to circulate refrigerant through a second heat exchanger;

transferring heat from a load space to the refrigerant in the refrigerant circuit when the refrigeration system is operating in the cooling mode;

stopping the first pump when the refrigeration system is operating in a heating mode;

directing the refrigerant along the refrigerant circuit in the direction during operation of the refrigeration system in the heating mode;

operating a second pump when the refrigeration system is operating in the heating mode to circulate refrigerant through the second heat exchanger in heat exchange relation with the refrigerant of the refrigerant circuit; and

transferring heat to the load space from the refrigerant in the refrigerant circuit when the refrigeration system is operating in the heating mode.

20. The method of claim **19**, further comprising heating the refrigerant with a heat source separate from the refrigerant circuit when the refrigeration system is operating in the heating mode.

21. The method of claim **19**, further comprising cooling the refrigerant using a suction line heat exchanger included along the refrigerant circuit.

22. The method of claim **19**, further comprising heating the refrigerant with an air-heated evaporator and a liquid-heated evaporator when the refrigeration system is operating in the cooling mode.

23. The method of claim **19**, further comprising cooling the refrigerant with an air-cooled condenser and a liquid-cooled condenser when the refrigeration system is operating in the heating mode.

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