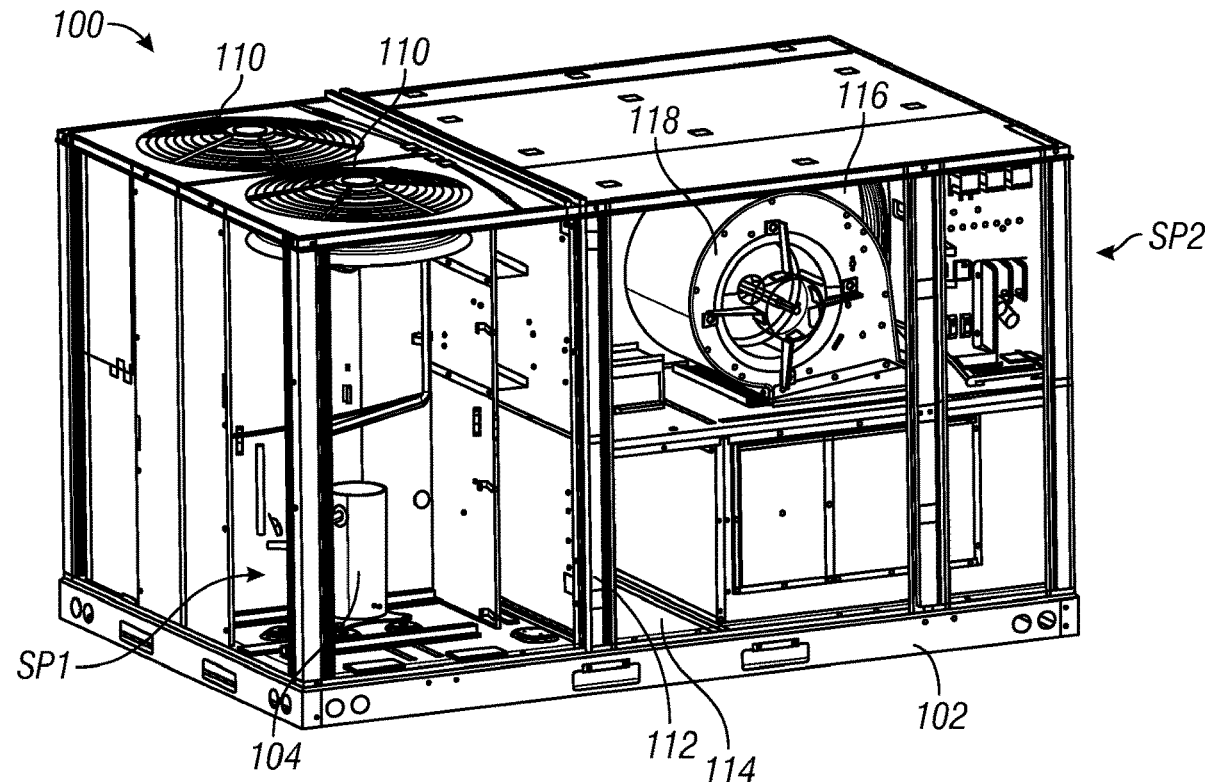




US 20230152013A1

(19) **United States**(12) **Patent Application Publication** (10) **Pub. No.: US 2023/0152013 A1**
(43) **Pub. Date: May 18, 2023**(54) **HEAT PUMP SYSTEM WITH BI-FLOW
EXPANSION DEVICE**(52) **U.S. Cl.**
CPC *F25B 41/20* (2021.01); *F25B 13/00*
(2013.01)(71) Applicant: **Goodman Manufacturing Company,
L.P.**, Waller, TX (US)(72) Inventors: **Michael F. Taras**, The Woodlands, TX
(US); **David L. Boyea**, Houston, TX
(US); **Walter Edgar Davis, II**,
Houston, TX (US)(73) Assignee: **Goodman Manufacturing Company,
L.P.**, Waller, TX (US)(21) Appl. No.: **17/455,429**(22) Filed: **Nov. 18, 2021****Publication Classification**(51) **Int. Cl.**
F25B 41/20 (2006.01)
F25B 13/00 (2006.01)(57) **ABSTRACT**

A reversible heat pump system with one bi-flow expansion device. A four-way valve in the refrigerant circuit may be configured in either a cooling mode or a heating mode. In the cooling mode, a compressor is operable to flow a refrigerant out a compressor outlet and through the bi-flow expansion device in a first direction. In the heating mode, the compressor is operable to flow the refrigerant out the compressor outlet and through the bi-flow expansion device in a second direction, opposite the first direction. Thus, only one thermal expansion device is needed for a reversible heat pump heating, ventilation, and air conditioning (HVAC) system without the need for bypass lines and check valves around the bi-flow expansion device. Further, if an accumulator is included before the compressor, the bi-flow expansion device may be controlled to store at least some refrigerant in the accumulator, thus allowing the evaporator superheat to be lower than if the accumulator were not used.



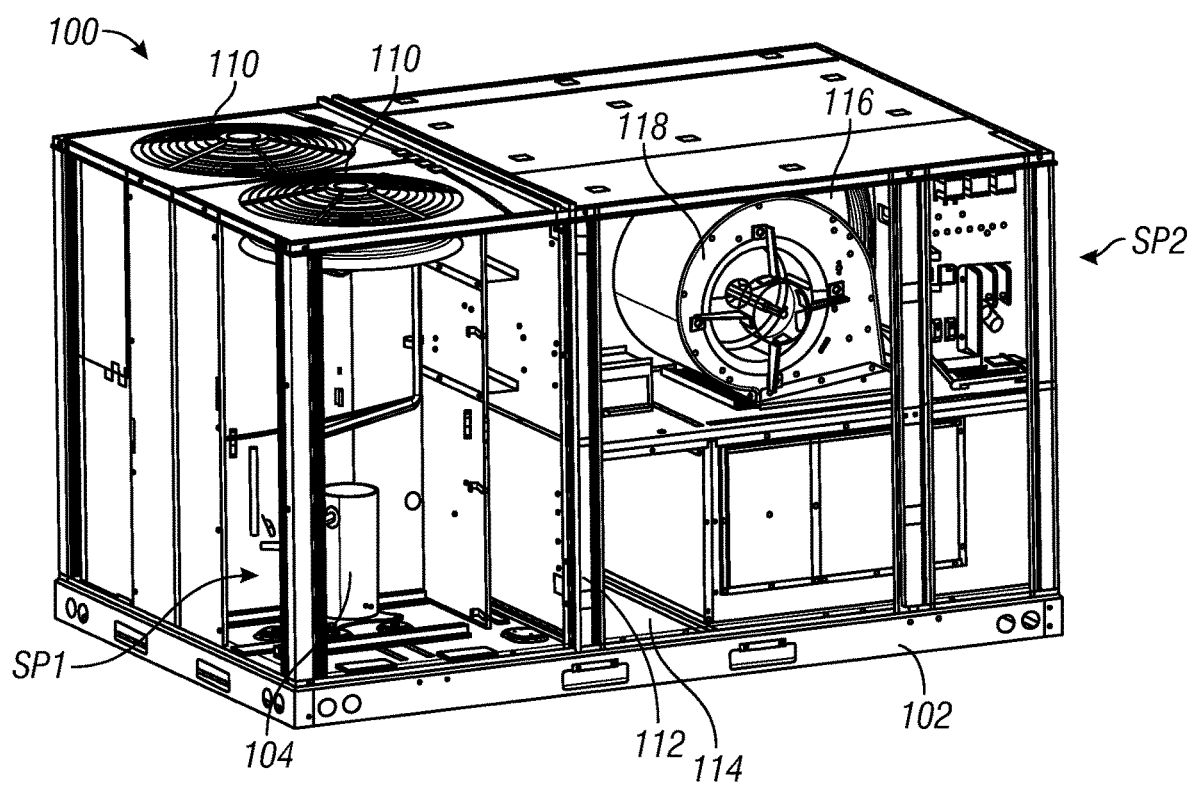


FIG. 1A

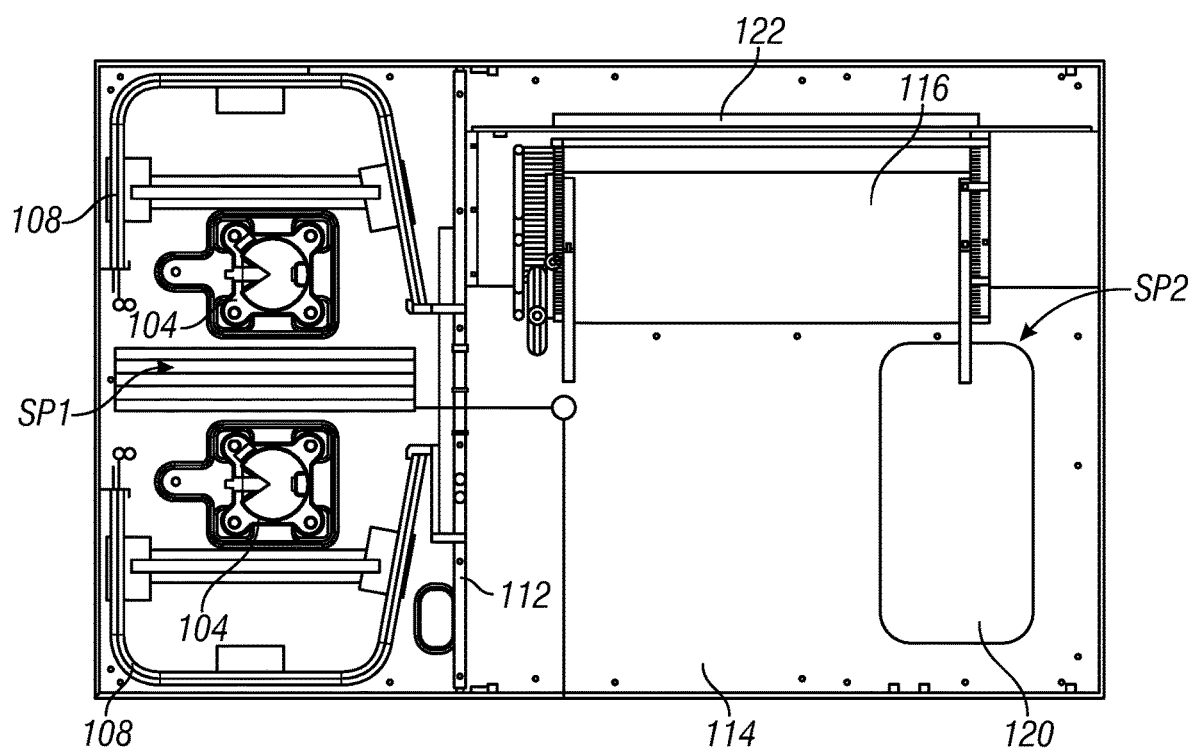


FIG. 1B

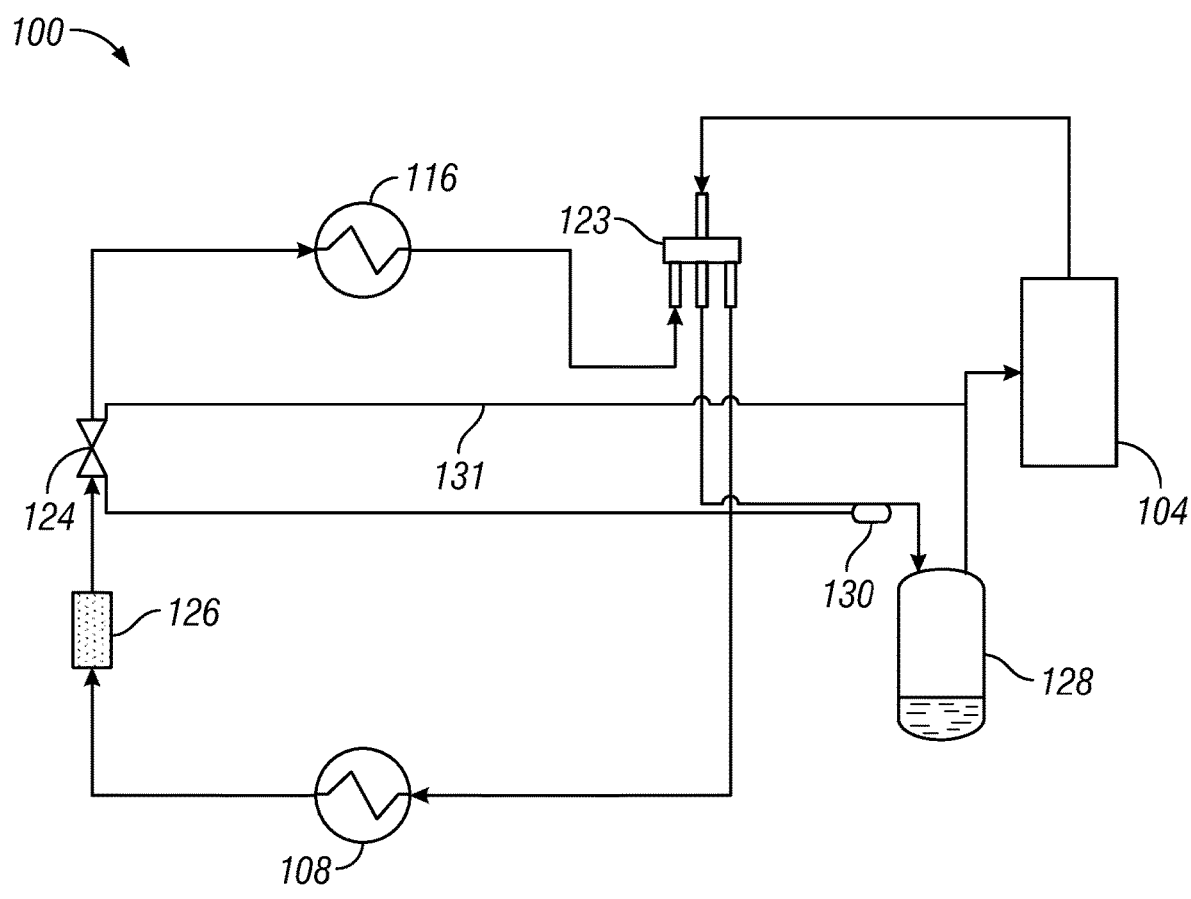


FIG. 2

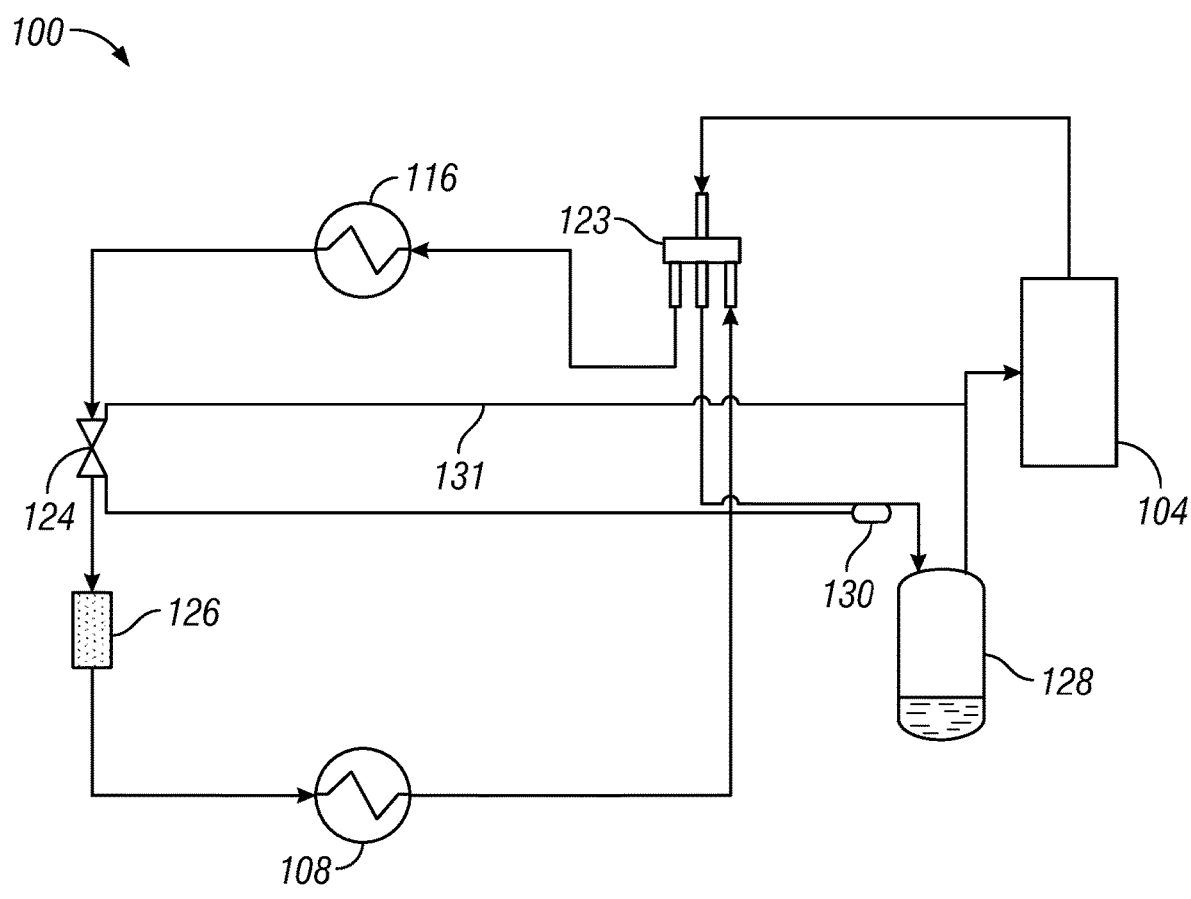


FIG. 3

HEAT PUMP SYSTEM WITH BI-FLOW EXPANSION DEVICE

BACKGROUND

[0001] This section is intended to provide relevant background information to facilitate a better understanding of the various aspects of the described embodiments. Accordingly, these statements are to be read in this light and not as admissions of prior art.

[0002] Refrigerant systems are utilized to control the temperature and humidity of air in various indoor environments to be conditioned.

[0003] A heat pump is a refrigerant system that is typically operable in both cooling and heating modes. While air conditioners are familiar examples of heat pumps, the term “heat pump” is more general and applies to many heating, ventilating, and air conditioning (HVAC) devices used for space heating or space cooling. When a heat pump is used for heating, it employs the same basic refrigeration-type cycle used by an air conditioner or a refrigerator, but in the opposite direction, releasing heat into the conditioned space rather than the surrounding environment. In this use, heat pumps generally draw heat from cooler external air, water, or from the ground.

[0004] In a cooling mode, a heat pump operates like a typical air conditioner, i.e., a refrigerant is compressed in a compressor and delivered to a condenser (or an outdoor heat exchanger). In the condenser, heat is exchanged between a medium such as outside air, water, or the like and the refrigerant. From the condenser, the refrigerant passes to an expansion device, at which the refrigerant is expanded to a lower pressure and temperature, and then to an evaporator (or an indoor heat exchanger). In the evaporator, heat is exchanged between the refrigerant and the indoor air, to condition the indoor air. When the refrigerant system is operating, the evaporator cools the air that is being supplied to the indoor environment. In addition, as the temperature of the indoor air is lowered, moisture usually is also taken out of the air. In this manner, the humidity level of the indoor air can also be controlled.

[0005] Reversible heat pumps work in either direction to provide heating or cooling to the internal space as mentioned above. Reversible heat pumps employ a reversing valve to reverse the flow of refrigerant from the compressor through the condenser and evaporation coils. In heating mode, the outdoor coil is an evaporator, while the indoor coil is a condenser. The refrigerant flowing from the evaporator (outdoor coil) carries the thermal energy from outside air (or source such as water, soil, etc.) indoors. Vapor temperature is augmented within the pump by compressing it. The indoor coil then transfers thermal energy (including energy from the compression) to the indoor air, which is then moved around the inside of the building by an air handler. The refrigerant is then allowed to expand, cool, and absorb heat from the outdoor temperature in the outside evaporator, and the cycle repeats. This is a standard refrigeration cycle, save that the “cold” side of the refrigerator (the evaporator coil) is positioned so it is outdoors where the environment is colder.

[0006] Typically, however, some reversible heat pump HVAC systems require two, uni-flow expansion devices, each directed to allow flow in only one direction and opposite from the other. Bypass piping and flow control valves are then used to direct flow through only one uni-flow expansion device at a time, depending on whether the HVAC

system is in cooling mode or heating mode. Alternatively, some reversible heat pump HVAC systems will use a device with two fixed orifices to meter refrigerant flow. Fixed orifices however are not efficient with partial load operation. Multiple uni-flow expansion devices are more efficient with partial load operation but, with the increase in parts, are most costly and difficult to implement within a limited design footprint, especially with multi-circuit designs. Single tandem compressors within a single refrigeration circuit could be used to reduce the number of metering devices. However, single tandem compressors suffer from a lack of redundancy that a multi-circuit system offers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Embodiments of the heat pump system with bi-flow expansion device are described with reference to the following figures. The same or sequentially similar numbers are used throughout the figures to reference like features and components. The features depicted in the figures are not necessarily shown to scale. Certain features of the embodiments may be shown exaggerated in scale or in somewhat schematic form, and some details of elements may not be shown in the interest of clarity and conciseness.

[0008] FIGS. 1A and 1B are a perspective and cross-section views of a heating ventilation and air conditioning (HVAC) system, according to one or more embodiments;

[0009] FIG. 2 is a schematic of an embodiment of a refrigeration circuit of an HVAC system operating in a cooling mode; and

[0010] FIG. 3 is a schematic of an embodiment of a refrigeration circuit of an HVAC system operating in a heating mode.

DETAILED DESCRIPTION

[0011] The present disclosure describes a reversible heat pump system with one bi-flow expansion device. A four-way valve in the refrigerant circuit may be configured in either a cooling mode or a heating mode. In the cooling mode, a compressor is operable to flow a refrigerant out a compressor outlet and through the bi-flow expansion device in a first direction. In the heating mode, the compressor is operable to flow the refrigerant out the compressor outlet and through the bi-flow expansion device in a second direction, opposite the first direction. Thus, only one expansion device is needed for a reversible heat pump heating, ventilation, and air conditioning (HVAC) system without the need for bypass lines, incorporating the check valves, around or inside the bi-flow expansion device. Further, if an accumulator is included before the compressor, the bi-flow expansion device may be controlled to store at least some refrigerant in the accumulator, thus allowing the evaporator superheat to be lower than if the accumulator were not used.

[0012] Turning now to the figures, FIGS. 1A and 1B show an external appearance of an HVAC system 100 when seen from obliquely above the HVAC system 100 as well as a cross-section view of the HVAC system 100 from a top view perspective. Although not shown, it should be appreciated that the HVAC system 100 includes additional panel covers for covering and protecting the equipment of the HVAC system 100. The example HVAC system 100 shown is a so-called “light” commercial package unit and shall be described in terms of a cooling operation, although it should be appreciated that the HVAC system 100 could also be used

for heating and can be representing residential packaged, residential split, light commercial split, or commercial applied applications. The HVAC system **100** includes both an “outdoor” section SP1 and an “indoor” section SP2 mounted on a common frame **102**. Further, the HVAC system **100** may be a “rooftop” system where the entire system is installed on the rooftop of a structure such as a building. Further, the HVAC system **100** may be a variable refrigerant flow heat pump system.

[0013] The outdoor section SP1 includes one or more compressors **104**. As noted above, the outdoor section SP1 may include other HVAC system components, such as accumulators, receivers, charge compensators, flow control devices, air movers, pumps, and filter driers secured within and attached to the structure of HVAC system **100**. Also included are one or more outdoor heat exchangers **108** and outdoor fans **110** that move air into the outdoor section SP1 across the outdoor heat exchanger **108** and to the outside of the HVAC system **100**. FIG. 1A is shown without the additional outdoor heat exchanger **108** and outdoor fan **110** to be able to view additional structure and equipment. However, FIG. 1B shows the additional outdoor heat exchanger **108** and it should be appreciated that an additional outdoor fan **110** would be included as well. The outdoor fans **110** may be any suitable type of fan, for example, a propeller fan. The outdoor heat exchangers **108** may include a plurality of heat-transfer tubes (not shown), in which a refrigerant flows, and a plurality of heat-transfer fins (not shown), in which air flows between gaps thereof. The plurality of heat-transfer tubes may be arranged in an up-down direction (hereunder may be referred to as “row direction”), and each heat-transfer tube may extend in a direction substantially orthogonal to the up-down direction (in a substantially horizontal direction). At an end portion of the outdoor heat exchangers **108**, for example, the heat-transfer tubes are connected to each other by being bent into a U-shape or by using a U-shaped return bends so that the flow of a refrigerant from a certain column to another column and/or a certain row to another row is turned back. The plurality of heat-transfer fins that extend, so as to be oriented in the up-down direction, are arranged side by side in a direction in which the heat-transfer tubes extend with a predetermined interval between the plurality of heat-transfer fins. The plurality of heat-transfer fins and the plurality of heat-transfer tubes are assembled to each other so that each heat-transfer fin extends through the plurality of heat-transfer tubes. The plurality of heat-transfer fins are also disposed in a plurality of columns.

[0014] Due to the structure of the outdoor heat exchangers **108**, a flow path of outdoor air that enters the outdoor section SP1 passes through the outdoor heat exchanger **108**, where the outdoor air exchanges heat with a refrigerant that flows in the outdoor heat exchangers **108**. Air, after the heat exchange in the outdoor heat exchanger **108**, is discharged to the outside of the outdoor section SP1 by the outdoor fans **110**. Even though the heat exchanger **108** is described as a round tube and plate fin heat exchanger, other heat exchanger types, such as for instance a microchannel heat exchanger, are within the scope of the disclosure. Not shown but described below, the outdoor section SP1 includes one bi-flow expansion device. The bi-flow expansion device may alternatively be located in the indoor section SP2.

[0015] The outdoor section SP1 and the indoor section SP2 are separated by a partition plate **112**. Outdoor air flows

to the outdoor section SP1 and indoor air flows to the indoor section SP2. By separating the outdoor section SP1 and the indoor section SP2 by the partition plate **112**, the airflow bypass between the outdoor section SP1 and the indoor section SP2 is blocked. Therefore, in an ordinary state, the indoor air and the outdoor air do not mix and do not communicate with each other within or via the HVAC system **100**. It has to be noted, that there exist the airside economizers that allow mixing indoor and outdoor air, however there are not discussed in relation to this invention.

[0016] The indoor section SP2 also includes an indoor heat exchanger **116** and an indoor blower **118**, which may be, for example, a centrifugal fan. The indoor section SP2 also optionally includes a combustion heat exchanger. The indoor heat exchanger **116** may also include a plurality of heat-transfer tubes, in which a refrigerant flows, and a plurality of heat-transfer fins, in which air flows between gaps thereof. The plurality of heat-transfer tubes may be arranged in an up-down direction (row direction), and each heat-transfer tube may extend in a direction substantially orthogonal to the up-down direction (in the second embodiment, in a left-right direction). At an end portion of the indoor heat exchanger **116**, for example, the heat-transfer tubes are connected to each other by being bent into a U-shape or by using a U-shaped return bends so that the flow of a refrigerant from a certain column to another column and/or a certain row to another row is turned back. The plurality of heat-transfer fins and the plurality of heat-transfer tubes may be assembled so that each heat-transfer fin extends through the plurality of heat-transfer tubes. As for the indoor heat exchanger **116**, even though the heat exchanger **116** is described as a round tube and plate fin heat exchanger, other heat exchanger types, such as for instance a microchannel heat exchanger, are within the scope of the invention.

[0017] The indoor heat exchanger **116** divides the indoor section SP2 into a space on an upstream side with respect to the indoor heat exchanger **116** and a space on a downstream side with respect to the indoor heat exchanger **116**. All air that flows to the downstream side from the upstream side with respect to the indoor heat exchanger **116** passes through the indoor heat exchanger **116**. The indoor blower **118** is disposed in the space on the downstream side with respect to the indoor heat exchanger **116** and causes an airflow that passes through the indoor heat exchanger **116** to be generated. Although not shown, supply air and return air ducts are connected to the indoor section SP2 through a bottom plate **114** in the bottom of the HVAC system **100** (note that the side air supply and discharge are also feasible). Alternatively, the horizontal, instead of downward, supply and return air ducts can be provided, and the down-shot air duct configurations are also within the scope of the disclosure. The blower **118** is disposed above a supply air opening **120** in the bottom plate **114** for providing supply air to the indoor space being conditioned. A return air opening **122** in the bottom plate **114** provides return air from the indoor space being conditioned to flow through the indoor heat exchanger **116** and the indoor blower **118**.

[0018] The HVAC system **100** also includes a refrigerant circuit that includes the indoor heat exchanger **116** and the outdoor heat exchangers **108** for circulating a refrigerant between the indoor heat exchanger **116** and the outdoor heat exchangers **108**. In the refrigerant circuit, when, in a cooling operation or a heating operation, a vapor compression refrig-

eration cycle is performed, heat is exchanged at the indoor heat exchanger 116 and the outdoor heat exchangers 108. The refrigerant circuit includes the compressors 104, the outdoor heat exchangers 108, the bi-flow expansion device, the indoor heat exchanger 116, and a configurable 4-way valve (not shown but discussed below). However, no bypass piping around the bi-flow expansion device, or an internal bypass complemented by a check valve allowing for a refrigerant flow in a single direction, is needed. The refrigerant circuit may also include an accumulator and a filter drier.

[0019] In a cooling mode, the refrigerant is compressed by the compressors 104 and is sent through the four-way valve to the outdoor heat exchangers 108. The refrigerant dissipates heat to outdoor air at the outdoor heat exchangers 108 and is sent to the bi-flow expansion device. At the bi-flow expansion device, the refrigerant expands and its pressure and temperature are reduced. The refrigerant then flows to the indoor heat exchanger 116. A refrigerant having a low temperature and a low pressure sent from the bi-flow expansion device exchanges heat at the indoor heat exchanger 116, absorbing heat from indoor air. The air cooled by having its heat taken away at the indoor heat exchanger 116 is supplied to the indoor space being conditioned. The refrigerant after the heat exchange at the indoor heat exchanger 116 is evaporated into a gaseous state and then travels back through the four-way valve and is then sucked into the compressors 104 to repeat the cycle. Thus, in a cooling mode, the indoor heat exchanger 116 operates as an evaporator.

[0020] In a heating mode, the refrigerant is compressed by the compressors 104 and is sent through the four-way valve to the indoor heat exchanger 116. The refrigerant dissipates heat to indoor air at the indoor heat exchanger 116 and is sent to the bi-flow expansion device. The air, heated by the heat exchange with the indoor heat exchanger 116, is supplied to the indoor space being heated. At the bi-flow expansion device, the refrigerant expands and its pressure and temperature are reduced. The refrigerant then flows to the outdoor heat exchangers 108. A refrigerant having a low temperature and a low pressure sent from the bi-flow expansion device exchanges heat at the outdoor heat exchangers 108, absorbing heat from outdoor air. The refrigerant after the heat exchange at the outdoor heat exchangers 108 is evaporated into a gaseous state and then travels back through the four-way valve and is then sucked into the compressors 104 to repeat the cycle. Thus, in a heating mode, the outdoor heat exchanger 108 operates as an evaporator.

[0021] The equipment of the refrigerant circuit, and thus flow of the refrigerant through the circuit may be controlled by a main controller that controls the HVAC system 100. The main controller may also be configured to be capable of communicating with a remote controller. A user can send, for example, a set values of indoor temperatures of rooms in the indoor space being conditioned to the main controller from the remote controller. For controlling the HVAC system 100, a plurality of temperature sensors for measuring the temperature of a refrigerant at each portion of the refrigerant circuit and/or a pressure sensor that measures the pressure of each portion and a temperature sensor for measuring the air temperature of each location may be provided.

[0022] The main controller performs at least on/off control of the compressors 104, on/off control of the outdoor fans

110, and on/off control of the indoor blower 118. When any or all of the compressors 104, the outdoor fans 110, and the indoor blowers 118 include a motor of a type whose number of rotations is changeable, the main controller may be configured to be capable of controlling the number of rotations of the motor or motors whose number of rotations is changeable among the motors of the compressors 104, the outdoor fans 110, and the indoor blowers 118. In this case, the main controller can control the circulation amount of the refrigerant that flows through the refrigerant circuit by changing the number of rotations of the motor of the compressors 104. The main controller can change the flow rate of outdoor air that flows between the heat-transfer fins of the outdoor heat exchangers 108 by changing the number of rotations of the motor of the outdoor fans 110. The main controller can change the flow rate of indoor air that flows between the heat-transfer fins of the indoor heat exchanger 116 by changing the number of rotations of the motor of the indoor blower 118.

[0023] The main controller may be realized by, for example, a computer. The computer that constitutes the main controller includes a control calculation device and a storage device. For the control calculation device, a processor such as a CPU or a GPU may be used. The control calculation device reads a program that is stored in the storage device and performs a predetermined image processing operation and a computing processing operation in accordance with the program. Further, the control calculation device writes a calculated result to the storage device and reads information stored in the storage device in accordance with the program. However, the main controller may be formed by using an integrated circuit (IC) that can perform control similar to the control that is performed by using a CPU and a memory. Here, IC includes, for example, LSI (large-scale integrated circuit), ASIC (application-specific integrated circuit), a gate array, and FPGA (field programmable gate array).

[0024] Turning now to FIG. 2, FIG. 2 illustrates a schematic of an embodiment of a refrigeration circuit of an HVAC system 100 described above operating in a cooling mode. Flow of the refrigerant through the refrigerant circuit is designated by arrows that represent flow lines. For simplicity, the outdoor fans and indoor blowers are not represented but are understood to be included. The HVAC system 100 refrigeration circuit includes a compressor 104, an outdoor heat exchanger 108, and an indoor heat exchanger 116. Also located in the refrigeration circuit are a four-way valve 123, one adjustable bi-flow expansion device 124, and an optional refrigerant filter drier 126 and an accumulator 128. The bi-flow expansion device 124 may either be a thermostatic expansion valve (TXV) or an electronic expansion valve (EXV). If the bi-flow expansion device 124 is a TXV, the TXV may include a bleed port, which is an internal bypass line that does not include a check valve, for flowing the refrigerant in both directions. The bleed port is typically used for more precise and stable control for the TXV, as well pressure equalization between the high pressure side and low pressure side of the HVAC system 100. No other bypass lines, external or internal, are needed for bi-flow operation of the TXV.

[0025] In operation in a cooling mode, a vapor compression refrigeration cycle is performed. The compressor 104 is operable to flow the refrigerant out of a compressor outlet and to the four-way valve 123. The four-way valve 123 is configured to receive the refrigerant from the compressor

104 and direct the refrigerant to the outdoor heat exchanger **108**. The refrigerant dissipates heat to outdoor air at the outdoor heat exchanger **108** and is sent to the bi-flow expansion device **124**. At the bi-flow expansion device **124**, the refrigerant expands, and its pressure and temperature are reduced. The refrigerant then flows to the indoor heat exchanger **116**. A refrigerant, having a low temperature and a low pressure, sent from the bi-flow expansion device **124** exchanges heat at the indoor heat exchanger **116**, absorbing heat from indoor air. The air, cooled by having its heat taken away at the indoor heat exchanger **116**, is supplied to the indoor space being conditioned. The refrigerant, after the heat exchange at the indoor heat exchanger **116**, is evaporated into a gaseous state and then travels back through the four-way valve **123** and is then sucked into the compressor **104** through a compressor suction line **129** to repeat the cycle. Thus, in a cooling mode, the indoor heat exchanger **116** operates as an evaporator.

[0026] When the bi-flow expansion device **124** is a TXV, the TXV is controlled using a temperature sensing bulb **130** and an equalizer line **131**, with the equalizer line **131** typically brazed downstream of the sensing bulb **130** in the refrigerant circuit. The temperature sensing bulb **130** may be placed on the compressor suction line **129** upstream the compressor **104** and downstream the four-way valve **123**, with respect to the refrigerant flow. If an accumulator **128** is used, the bulb may be placed in the compressor suction line **129** upstream or downstream the accumulator **128**, with respect to the refrigerant flow, and the output of the sensing bulb **130** is adjusted to account for in the liquid amount in the refrigerant within the accumulator **128**. The location of the sensing bulb **130** may be selected to optimize vapor compression refrigeration cycle, depending on user preferences for the HVAC system **100**. Additionally, the HVAC system **100** may include an equalization line **131** in communication with the pressures in the indoor heat exchanger **116** and the outdoor heat exchanger **108** at a location similar to the bulb **130**. In cooling mode for example, the indoor heat exchanger **116** is the evaporator and the pressure of the refrigerant leaving the indoor heat exchanger **116** is communicated to the TXV through the equalizer line **131**. Pressure communicated through the equalizer line **131** is used to balance the pressure communicated to the expansion device **124** from the sensing bulb **130** to operate the TXV. The TXV is set to maintain a compressor superheat while optimizing whichever of the indoor heat exchanger or outdoor heat exchanger is operating as the evaporator. Controlling the TXV with this method allows the evaporator superheat to be maintained at more efficient levels. Further, the expansion device **124** may include an internal bleed port to maintain a more accurate and stable control, as well as equalize the high side pressure and low side pressure during the off-cycle. Further, the TXV may also be a so-called balanced port design with the pressure of the refrigerant at the condenser balanced across the valve.

[0027] If the accumulator **128** is used in the compressor suction line **129**, the accumulator **128** allows for the collection of some refrigerant, before the refrigerant flows to the compressor **104**. This provides the benefit of separating some non-vaporized refrigerant before passing to the compressor **104**. Further, the bi-flow expansion device **124** is also configurable to control the flow of refrigerant to store some refrigerant in the accumulator **128** if there is a refrigerant charge imbalance in the refrigeration circuit. In doing

so, the bi-flow expansion device **124** may be configured to lower a superheat of the evaporator, which in the cooling mode is the indoor heat exchanger **116**, compared to not including the accumulator in the HVAC system **100**. This allows a lower capacity evaporator to be used for the load of the HVAC system **100**. As an example, the bi-flow expansion device **124** is configurable to control flow of the refrigerant through the evaporator such that a superheat of the evaporator is as close to zero as possible while maintaining a superheat control at the compressor **104**.

[0028] Although FIG. 2 illustrates the sensing bulb **130** and equalizer line **131** for the control of a TXV, it should be appreciated that if the bi-flow expansion device **124** is an EXV, such controls would not be included. Instead, if the bi-flow expansion device **124** is an EXV, a pair of temperature or temperature/pressure sensors connected to the main controller provide measurement data for the control of the EXV operation. The temperature and/or pressure sensors are positioned to sense temperature and/or pressure in the compressor suction line **129** before the compressor **104** and after the four-way valve **123**. If an accumulator **128** is used, the temperature and/or pressure sensors may be placed in the compressor suction line **129** upstream or downstream the accumulator **128**, with respect to the refrigerant flow. The main controller processes the measurement data and provides control commands to the EXV to operate the HVAC system **100** similarly to the TXV operation discussed above.

[0029] In addition, the HVAC system **100** may also include the refrigerant filter drier **126** located within the refrigeration circuit. The filter drier **126** is shown located between the bi-flow expansion device **124** and the indoor heat exchanger, but the filter drier **126** may be located in another portion of the refrigeration circuit, depending on the desired operation of the HVAC system **100** and proper refrigerant charge rebalancing between the cooling and heating mode of operation. The filter drier **126** functions to filter particulate contamination and copper shavings and capture any moisture present in the refrigerant circuit, thus drying the refrigerant.

[0030] As shown in FIG. 3, FIG. 3 illustrates a schematic of an embodiment of the refrigeration circuit of the HVAC system **100** described above operating in a heating mode. In the heating mode, the refrigerant is compressed by the compressor **104** and is sent to the four-way valve **123**, which is configured to direct the refrigerant to the indoor heat exchanger **116**. The refrigerant dissipates heat to indoor air at the indoor heat exchanger **116** and is then sent to the bi-flow expansion device **124**. The air heated by the heat exchange with the indoor heat exchanger **116** is supplied to the indoor space being heated. At the bi-flow expansion device **124**, refrigerant is allowed to flow through the same bi-flow expansion device but in the opposite direction as in the cooling mode. As such, the refrigerant expands, and its pressure and temperature are reduced. The refrigerant then flows to the outdoor heat exchanger **108**. A refrigerant, having a low temperature and a low pressure sent from the bi-flow expansion device **124**, exchanges heat at the outdoor heat exchanger **108**, absorbing heat from outdoor air. The refrigerant after the heat exchange at the outdoor heat exchanger **108** is evaporated into a gaseous state, then travels back through the four-way valve **123**, and is then sucked into the compressor **104** to repeat the cycle. Thus, in a heating mode, the outdoor heat exchanger **108** operates as an evaporator.

[0031] When the bi-flow expansion device **124** is a TXV, the sensing bulb **130** and equalizer line **131** may be used to operate the TXV as explained above. Similarly, if the bi-flow expansion device **124** is an EXV, the pressure and/or temperature sensors may be used to operate the EXV as explained above. Similarly to the HVAC system **100** discussed in FIG. 2, the HVAC system **100** may include an optional accumulator **128** and refrigerant filter drier **126**, which operate in the same manner as discussed above.

[0032] For the embodiments and examples above, a non-transitory computer readable medium can comprise instructions stored thereon, which, when performed by a machine, cause the machine to perform operations, the operations comprising one or more features similar or identical to features of methods and techniques described above. The physical structures of such instructions may be operated on by one or more processors. A system to implement the described algorithm may also include an electronic apparatus and a communications unit. The system may also include a bus, where the bus provides electrical conductivity among the components of the system. The bus can include an address bus, a data bus, and a control bus, each independently configured. The bus can also use common conductive lines for providing one or more of address, data, or control, the use of which can be regulated by the one or more processors. The bus can be configured such that the components of the system can be distributed. The bus may also be arranged as part of a communication network allowing communication with control sites situated remotely from system.

[0033] In various embodiments of the system, peripheral devices such as displays, additional storage memory, and/or other control devices that may operate in conjunction with the one or more processors and/or the memory modules. The peripheral devices can be arranged to operate in conjunction with display unit(s) with instructions stored in the memory module to implement the user interface to manage the display of the anomalies. Such a user interface can be operated in conjunction with the communications unit and the bus. Various components of the system can be integrated such that processing identical to or similar to the processing schemes discussed with respect to various embodiments herein can be performed.

[0034] While compositions and methods are described herein in terms of “comprising” various components or steps, the compositions and methods can also “consist essentially of” or “consist of” the various components and steps.

[0035] Unless otherwise indicated, all numbers expressing quantities are to be understood as being modified in all instances by the term “about.” Accordingly, unless indicated to the contrary, the numerical parameters are approximations that may vary depending upon the desired properties sought to be obtained by the embodiments of the present invention.

[0036] The embodiments disclosed should not be interpreted, or otherwise used, as limiting the scope of the disclosure, including the claims. It is to be fully recognized that the different teachings of the embodiments discussed may be employed separately or in any suitable combination to produce desired results. In addition, one skilled in the art will understand that the description has broad application, and the discussion of any embodiment is meant only to be

exemplary of that embodiment, and not intended to suggest that the scope of the disclosure, including the claims, is limited to that embodiment.

1. A heating, ventilation, and air conditioning (HVAC) system comprising:

an outdoor heat exchanger operable as an evaporator in a heating mode;

an indoor heat exchanger operable as the evaporator in a cooling mode;

one bi-flow expansion device;

a compressor operable to flow a refrigerant through the outdoor heat exchanger, the indoor heat exchanger and the bi-flow expansion device in a refrigerant circuit; and

a four-way valve in the refrigerant circuit and configurable such that the compressor is operable to flow a refrigerant out a compressor outlet and through the bi-flow expansion device in a first direction in the cooling mode and configurable such that the compressor is operable to flow the refrigerant out the compressor outlet and through the bi-flow expansion device in a second direction, opposite the first direction, in the heating mode.

2. The HVAC system of claim **1**, wherein the HVAC system is a rooftop HVAC system.

3. The HVAC system of claim **1**, wherein the HVAC system is a variable refrigerant flow heat pump system.

4. The HVAC system of claim **1**, further comprising a filter drier located in the refrigerant circuit located on either side of the bi-flow expansion device.

5. The HVAC system of claim **1**, further comprising an accumulator in the refrigerant circuit before the compressor inlet.

6. The HVAC system of claim **5**, wherein the accumulator allows collection of the liquid refrigerant such that the bi-flow expansion device may be configured to lower a superheat of the evaporator compared to not including the accumulator.

7. The HVAC system of claim **5**, wherein the bi-flow expansion device is configurable to store refrigerant in the accumulator if there is a refrigerant charge imbalance in the refrigerant circuit.

8. The HVAC system of claim **1**, further comprising an outdoor section comprising the outdoor heat exchanger and the bi-flow expansion device.

9. The HVAC system of claim **1**, further comprising an indoor section comprising the indoor heat exchanger and the bi-flow expansion device.

10. The HVAC system of claim **1**, wherein the bi-flow expansion device comprises a thermostatic expansion valve (TXV).

11. The HVAC system of claim **10**, wherein the TXV comprises a bleed port.

12. The HVAC system of claim **10**, wherein the TXV comprises a balanced port design.

13. The HVAC system of claim **10**, further comprising a sensing bulb and an equalizer line in communication with the TXV.

14. The HVAC system of claim **1**, wherein the bi-flow expansion device is configurable to control flow of the refrigerant through the evaporator such that a superheat of the evaporator is as close to zero as possible while maintaining a superheat control at the compressor.

15. The HVAC system of claim **1**, wherein the bi-flow expansion device comprises an electronic expansion valve (EXV).

16. The HVAC system of claim **15**, further comprising at least one of a temperature sensor or a pressure sensor operable to provide temperature and pressure measurement data usable to control the EXV.

17. A method of operating a heating, ventilation, and air conditioning (HVAC) system, comprising:

configuring a four-way valve and operating a compressor in a cooling mode to flow a refrigerant out a compressor outlet and through an outdoor heat exchanger, one bi-flow expansion device, and an indoor heat exchanger in a first direction in a refrigerant circuit with the indoor heat exchanger operating as an evaporator; and

configuring the four-way valve and operating the compressor in a heating mode to flow the refrigerant out the compressor outlet and through the indoor heat exchanger, the one bi-flow expansion device, and the outdoor heat exchanger in a second direction, opposite the first direction, in the refrigerant circuit with the outdoor heat exchanger operating as the evaporator.

18. The method of claim **17**, wherein the HVAC system is a rooftop HVAC system.

19. The method of claim **17**, wherein the HVAC system is a variable refrigerant flow heat pump system.

20. The method of claim **17**, further comprising filtering and drying the refrigerant in the refrigerant circuit using a filter drier located on either side of the bi-flow expansion device.

21. The method of claim **17**, further comprising collecting refrigerant in an accumulator located in the refrigerant circuit before the compressor.

22. The method of claim **21**, further comprising collecting refrigerant in the accumulator to lower a superheat of the evaporator compared to not including the accumulator.

23. The method of claim **20**, further comprising configuring the bi-flow expansion device to store refrigerant in the accumulator if there is a refrigerant charge imbalance in the refrigerant circuit.

24. The method of claim **17**, further comprising controlling refrigerant flow through the evaporator using the bi-flow expansion device such that a superheat of the evaporator is as close to zero as possible while maintaining a superheat control at the compressor.

25. The method of claim **17**, wherein the bi-flow expansion device comprises a thermostatic expansion valve (TXV)

26. The method of claim **25**, wherein the TXV comprises bleed port.

27. The method of claim **25**, wherein the TXV comprises a balanced port design.

28. The method of claim **25**, further comprising controlling the operation of the TXV using a sensing bulb and an equalizer line.

29. The method of claim **17**, wherein the bi-flow expansion device comprises an electronic expansion valve (EXV).

30. The method of claim **29**, further comprising controlling the EXV using at least one of temperature data from a temperature sensor or pressure data from a pressure sensor.

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