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(54) **FLUID FLOW REVERSING DEVICE FOR HEAT EXCHANGERS**

(57) A flow reversing device is provided for a heating, ventilation, air conditioning, and refrigeration (HVACR) system having a heat exchanger (50). The flow reversing device included a first flow control device (10), a second flow control device (20), a third flow control device (30), and a fourth flow control device (40), each flow control device being a two-way flow control device. When the first flow control device and the fourth flow control device are opened and the second flow control device and the third flow control device are closed, a first flow is formed. When the second flow control device and the third flow control device are opened and the first flow control device and the fourth flow control device are closed, a second flow is formed. The first flow and the second flow are in opposite directions.

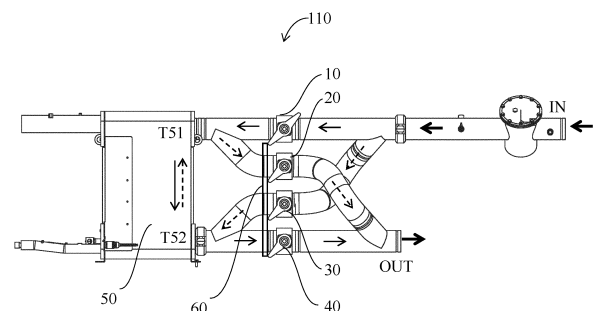


FIG. 3

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Description

RELATED APPLICATION

[0001] The present application claims priority to the Chinese Patent Application No. 202410004237.0 filed on January 2, 2024 and entitled "FOUR-WAY REVERSING DEVICE AND HEAT PUMP UNIT", the entirety of which is incorporated herein by reference.

FIELD

[0002] The embodiments described herein pertain generally to systems and methods for fluid flow control of a heating, ventilation, air conditioning, and refrigeration (HVACR) system. More specifically, the embodiments described herein pertain to a fluid flow reversing device for a heat exchanger in an HVACR system such as a heat pump.

BACKGROUND

[0003] An HVACR system typically includes a compressor, a condenser, an expander, and an evaporator, forming a refrigeration circuit. In a cooling cycle or cooling mode, refrigerant vapor is generally compressed by the compressor, and then condensed to liquid refrigerant in the condenser. The liquid refrigerant can then be directed through the expander to reduce the temperature and become a liquid/vapor refrigerant mixture (two-phase refrigerant mixture). The two-phase refrigerant mixture can be directed into the evaporator to exchange heat with, for example, air or water moving across the evaporator. The two-phase refrigerant mixture can be vaporized to refrigerant vapor in the evaporator.

[0004] Some HVACR systems may be able to operate in a heating cycle. These HVACR systems are typically called heat pumps. During a heating cycle or heating mode, the process is generally reversed from the process in the cooling cycle. In the heating cycle, the evaporator in the cooling cycle functions as a condenser, and the condenser functions as an evaporator. After being compressed by the compressor, the compressed refrigerant vapor is typically directed to the evaporator first to release heat to, for example, the indoor air, which also condenses the refrigerant vapor to liquid refrigerant. The liquid refrigerant is then typically directed to the condenser through the expander to become a two-phase refrigerant mixture.

[0005] When the heat pump transits e.g., from a cooling cycle to a heating cycle, the flow direction of the working fluid (e.g., refrigerant or the like) circuit may be changed; for example, the working fluid flow direction may be changed to an opposite (e.g., reversed) direction compared with the working fluid flow direction e.g., in the cooling cycle. Typically, the flow direction of the process fluid (e.g., water or the like) is designed to be in a counter direction to the flow direction of the working fluid (e.g., in

the cooling cycle) for efficient heat exchanging, in order to ensure the energy efficiency of refrigeration system. When transiting to the heating cycle, since the flow direction of the working fluid is reversed (compared with the working fluid flow direction in the cooling cycle), the process fluid flow direction may be no longer in the counter direction to the working fluid flow direction, which may cause a lower logarithmic average temperature difference, resulting in a lower coefficient of performance, a lower heating performance, a higher discharge pressure, a higher condensation temperature, a larger power consumption, and/or a limited leaving water temperature.

SUMMARY

[0006] To solve the above technical problem, changes to the flow direction of the working fluid circuit may be performed when transiting e.g., from a cooling cycle to the heating cycle; however, such solution may not be optimal for heat exchanging under the condensation condition. Features in the embodiments disclosed herein may provide a solution to switch, change, or reverse the process fluid flow direction e.g., when transiting from a cooling cycle to the heating cycle, so that the flow direction of the process fluid can be in a counter direction to the flow direction of the working fluid in both cycles. Compared with switching the process fluid flow direction using e.g. a (single) four-way valve, which may have a relatively high cost, features in the embodiments disclosed herein may provide a fluid flow reversing device for e.g., a heat pump unit, to switch or reverse the process fluid flow direction at low cost without substantially impacting on the existing structure of the system.

[0007] In an example embodiment, a flow reversing device is provided for a heating, ventilation, air conditioning, and refrigeration (HVACR) system having a heat exchanger. The flow reversing device includes a first flow control device, a second flow control device, a third flow control device, and a fourth flow control device. Each of the flow control devices is a two-way flow control device. A first port of the first flow control device and a first port of the third flow control device connect to a fluid inlet. A first port of the second flow control device and a first port of the fourth flow control device connect to a fluid outlet. A second port of the first flow control device and a second port of the second flow control device connect to a first port of the heat exchanger. A second port of the third flow control device and a second port of the fourth flow control device connect to a second port of the heat exchanger. When the first flow control device and the fourth flow control device are opened and the second flow control device and the third flow control device are closed, a first flow is formed from the fluid inlet, the first port and the second port of the first flow control device, the first port and the second port of the heat exchanger, the second port and the first port of the fourth flow control device, to the fluid outlet. When the second flow control device and the third flow control device are opened and the first flow

control device and the fourth flow control device are closed, a second flow is formed from the fluid inlet, the first port and the second port of the third flow control device, the second port and the first port of the heat exchanger, the second port and the first port of the second flow control device, to the fluid outlet.

[0008] It is to be understood that the fluid flow reversing device disclosed herein can achieve the reversing function by using four two-way flow control devices, thereby implementing the reversing circuit, having advantages of low cost, low pressure-drop, space-saving, and the like.

[0009] In another example embodiment, a heat pump unit is provided. The heat pump unit includes the above disclosed fluid flow reversing device and the heat exchanger. The heat exchanger has a first heat exchange side (or circuit) and a second heat exchange side (or circuit). The first heat exchange side is a working fluid side (or circuit). The fluid flow reversing device is located at the second heat exchange side. When the heat pump unit is in the cooling mode, the flow reversing device forms the first flow. When the heat pump unit is in the heating mode, the flow reversing device forms the second flow, which is in an opposite direction to the first flow.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The accompanying drawings illustrate various embodiments of systems, methods, and embodiments of various other aspects of the disclosure. Any person with ordinary skills in the art will appreciate that the illustrated element boundaries (e.g. boxes, groups of boxes, or other shapes) in the figures represent one example of the boundaries. It may be that in some examples one element may be designed as multiple elements or that multiple elements may be designed as one element. In some examples, an element shown as an internal component of one element may be implemented as an external component in another, and vice versa. Non-limiting and non-exhaustive descriptions are described with reference to the following drawings. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating principles. In the detailed description that follows, embodiments are described as illustrations only since various changes and modifications may become apparent to those skilled in the art from the following detailed description.

FIG. 1 illustrates a schematic diagram of an HVACR system including a refrigerant circuit, arranged in accordance with at least some embodiments described herein.

FIG. 2 illustrates a schematic diagram of a flow reversing device, arranged in accordance with at least some embodiments described herein.

FIG. 3 is a perspective view of a flow reversing device, arranged in accordance with a first embodiment described herein.

FIG. 4 is a perspective view of a flow reversing

device, arranged in accordance with a second embodiment described herein.

FIG. 5 is a perspective view of a flow reversing device, arranged in accordance with a third embodiment described herein.

FIG. 6 is a perspective view of a flow reversing device, arranged in accordance with a fourth embodiment described herein.

FIG. 7 is a perspective view of a flow reversing device, arranged in accordance with a fifth embodiment described herein.

FIG. 8 is a perspective view of a flow reversing device, arranged in accordance with a sixth embodiment described herein.

FIG. 9 is a perspective view of a flow reversing device, arranged in accordance with a seventh embodiment described herein.

FIG. 10 is a perspective view of a flow reversing device, arranged in accordance with an eighth embodiment described herein.

FIG. 11 is a perspective view of a flow reversing device, arranged in accordance with a ninth embodiment described herein.

DETAILED DESCRIPTION

[0011] In the following detailed description, particular embodiments of the present disclosure are described herein with reference to the accompanying drawings, which form a part of the description. In this description, as well as in the drawings, like-referenced numbers represent elements that may perform the same, similar, or equivalent functions, unless context dictates otherwise. Furthermore, unless otherwise noted, the description of each successive drawing may reference features from one or more of the previous drawings to provide clearer context and a more substantive explanation of the current example embodiment. Still, the example embodiments described in the detailed description, drawings, and claims are not intended to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein and illustrated in the drawings, may be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0012] It is to be understood that the disclosed embodiments are merely examples of the disclosure, which may be embodied in various forms. Well-known functions or constructions are not described in detail to avoid obscuring the present disclosure in unnecessary detail. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present disclosure in virtually any appropriately detailed

structure.

[0013] Additionally, the present disclosure may be described herein in terms of functional block components and various processing steps. It is to be understood that such functional blocks may be realized by any number of hardware and/or software components configured to perform the specified functions.

[0014] The scope of the disclosure should be determined by the appended claims and their legal equivalents, rather than by the examples given herein. For example, the steps recited in any method claims may be executed in any order and are not limited to the order presented in the claims. Moreover, no element is essential to the practice of the disclosure unless specifically described herein as "critical" or "essential".

[0015] As referenced herein, a "two-way" flow control device is a term of art that may refer to a flow control device having an inlet port and an outlet port. A two-way flow control device can be controlled to either stop or allow fluid flow, effectively acting as e.g., an on/off switch for fluids. A two-way flow control device can control the flow of fluid (e.g., liquid, gas, etc.) in one direction at a time through a passage (e.g., a conduit, a pipe, a tube, a duct, etc.). It is to be understood that a flow control device can be a valve (e.g., a solenoid valve, a check valve, a butterfly valve, a ball valve, or the like), a damper, a pump, or the like. It is also to be understood that when a two-way flow control device is opened or in an open state, fluid is allowed to pass through the two-way flow control device (e.g., from its inlet or inlet port to its outlet or outlet port). When the two-way flow control device is closed or in a close state, fluid flow is blocked and fluid is prevented from passing through the two-way flow control device.

[0016] As referenced herein, a "three-way" flow control device is a term of art that may refer to a flow control device having a first inlet port, a second inlet port, and an outlet port. It is to be understood that a three-way flow control device can have a first outlet port, a second outlet port, and an inlet port, depending on the direction of fluid flow. A three-way flow control device can be controlled to shut off fluid flow in one passage while opening fluid flow in another passage.

[0017] As referenced herein, a "four-way" flow control device is a term of art that may refer to a (single or integral) flow control device that can control the direction of fluid flow, e.g., allowing an HVACR system to switch between heating and cooling modes by reversing the fluid flow depending on the desired operation. It is to be understood that a four-way flow control device can enable the HVACR system to provide both heating and cooling functions by changing the direction of the fluid (e.g., the refrigerant) through the system.

[0018] As referenced herein, "directly" upstream or "directly" downstream may refer to that no other components of a fluid circuit, other than fluid lines/connections/pipes for conveying the fluid are provided between such directly related elements. As referenced herein, "up-

stream" and "downstream" may refer to the direction of flow of the fluid or a component thereof through the fluid circuit.

[0019] The terminology used in the present application is for the purpose of describing particular embodiments only and is not intended to limit the present application. Unless otherwise defined, all technical and scientific terms used herein have the meanings as commonly understood by one of ordinary skill in the art to which this application belongs. The terms "first", "second", and similar words used in the specification and claims of this application do not indicate any order, quantity, or importance, but are merely used to distinguish different components. Likewise, similar words such as "a" or "an" do not denote a quantity limitation but indicate that there is at least one. "A plurality of" or "some" means two or more. Unless stated otherwise, terms such as "front", "rear", "horizontal", "vertical", "lower", and/or "upper" are merely used for ease of description and are not limited to one position or one spatial orientation. Similar words such as "comprise" or "include" mean that an element or object before "comprise" or "include" encompasses the element or object listed after "comprise" or "include" and the equivalent thereof and does not exclude other elements or objects. Similar words such as "connect" or "link" are not limited to physical or mechanical connections, and may include electrical connections, whether direct or indirect. As used in the specification and in the claims, the singular forms "a", "an", and "the" are also intended to include plural forms, unless the context clearly indicates other meanings. It is also to be understood that the term "and/or" as used herein refers to and includes any or all possible combinations of one or more associated listed items.

[0020] FIG. 1 illustrates a schematic diagram of an HVACR system including a refrigerant circuit 1000, arranged in accordance with at least some embodiments described herein.

[0021] In an example embodiment, the refrigerant circuit 1000 can include a compressor 1200, a condenser 1400, an expander 1600, and an evaporator 1800. The refrigerant circuit 1000 may also include a controller (not shown) configured to control the operations of the compressor 1200, the condenser 1400, the expander 1600, the evaporator 1800, and/or other components (e.g., actuator, flow control device, or the like) of the HVACR system.

[0022] In an example embodiment, the refrigerant circuit 1000 can generally be applied in a variety of systems used to control an environmental condition (e.g., temperature, humidity, air quality, or the like) in a conditioned space. The conditioned space can be a space within an office building, a commercial building, a factory, a laboratory, a data center, a residential building, or the like. In an embodiment, the refrigerant circuit 1000 can be configured to be a cooling system (e.g., an air conditioning system) capable of operating in a cooling mode. In an embodiment, the refrigerant circuit 1000 can be config-

ured to be a heat pump that can operate in a heating/defrost mode. It is appreciated that the refrigerant circuit 1000 can be configured to operate in a cooling mode and/or a heating/defrosting mode. In an example embodiment, an HVACR system can include a refrigerant circuit 1000 to heat or cool a process fluid (e.g., air, water and/or glycol, or the like). A working fluid (e.g., one or more refrigerants) can flow through the refrigerant circuit 1000 and be utilized to heat or cool the process fluid.

[0023] In an example embodiment, the compressor 1200, the condenser 1400, the expander 1600, and the evaporator 1800 can be fluidly connected. An "expander" as described herein may also be referred to as an expansion device. In an embodiment, the expander 1600 can be an expansion valve, expansion plate, expansion vessel, orifice, or the like, or other such types of expansion mechanisms. It is to be understood that the expander 1600 may be any suitable type of expander used in the field for expanding a working fluid to cause the working fluid to decrease in pressure and temperature.

[0024] It is to be understood that the refrigerant circuit 1000 is an example and can be configured to include more or less components. For example, in an embodiment, the refrigerant circuit 1000 can include other components such as, but not limited to, an economizer heat exchanger, one or more flow control devices (e.g., a valve, a pump, etc.), a receiver tank, a dryer, a suction-liquid heat exchanger, or the like.

[0025] In an example embodiment, the refrigerant circuit 1000 can operate according to generally known principles. The refrigerant circuit 1000 can be configured to heat and/or cool a liquid process fluid. The liquid process fluid can be a heat transfer fluid or medium (e.g., a liquid such as, but not limited to, water or the like). The refrigerant circuit 1000 may be generally representative of a liquid chiller system. The refrigerant circuit 1000 can alternatively be configured to heat and/or cool a gaseous process fluid (e.g., a heat transfer medium or fluid (e.g., a gas such as, but not limited to, air or the like), in which case the refrigerant circuit 1000 may be generally representative of an air conditioner and/or heat pump.

[0026] In an example embodiment, the refrigerant circuit 1000 can operate as a vapor-compression circuit such that the compressor 1200 compresses a working fluid (e.g., a heat transfer fluid such as, but not limited to, refrigerant, water, solution, glycol fluid, fluorine, or the like) from a relatively lower pressure gas to a relatively higher-pressure gas. The relatively higher-pressure gas is at a relatively higher temperature, being discharged from the compressor 1200 and flowing through the condenser 1400. In accordance with generally known principles, the working fluid flows through the condenser 1400 and rejects heat to the process fluid (e.g., water, solution, air, or the like), thereby cooling the working fluid. The cooled working fluid, which is now in a liquid form, flows to the expander 1600 that can reduce the pressure of the working fluid. As a result, a portion of the working

fluid is converted to a gaseous form. The working fluid, which is now in a mixed liquid and gaseous form flows to the evaporator 1800. The working fluid flows through the evaporator 1800 and absorbs heat from the process fluid (e.g., a heat transfer medium such as, but not limited to, water, a solution, air, fluorine, or the like, etc.), heating the working fluid, and converting it to a gaseous form. The gaseous working fluid then returns to the compressor 1200. The above-described process continues while the heat transfer circuit is operating, for example, in a cooling mode (e.g., while the compressor 1200 is enabled).

[0027] FIG. 2 illustrates a schematic diagram of a flow reversing device 100, arranged in accordance with at least some embodiments described herein.

[0028] As shown in FIG. 2, the flow reversing device 100 includes a first flow control device 10, a second flow control device 20, a third flow control device 30, and a fourth flow control device 40. Each of the flow control devices (10, 20, 30, 40 in FIGS. 2-11) can be a two-way flow control device (e.g., a valve such as a butterfly valve, a ball valve, etc., or the like) and has a first port and a second port. Fluid flow can pass through the flow control device from the first port (the inlet port) to the second port (the outlet port), or from the second port (the inlet port) to the first port (the outlet port), when the flow control device is opened. The first port T11 of the first flow control device 10 and the first port T31 of the third flow control device 30 connect to a fluid inlet IN. The first port T21 of the second flow control device 20 and the first port T41 of the fourth flow control device 40 connect to a fluid outlet OUT. The second port T12 of the first flow control device 10 and the second port T22 of the second flow control device 20 connect to the first port T51 of the heat exchanger 50. The second port T32 of the third flow control device 30 and the second port T42 of the fourth flow control device 40 connect to the second port T52 of the heat exchanger 50. Fluid flow can pass the heat exchanger 50 from its first port T51 to its second port T52, or from its second port T52 to its first port T51, depending on the direction of the fluid flow.

[0029] As indicated by the solid arrow in FIG. 2, when the first flow control device 10 and the fourth flow control device 40 are opened, and when the second flow control device 20 and the third flow control device 30 are closed, a first flow is formed from the fluid inlet IN, the first port T11 and the second port T12 of the first flow control device 10, the first port T51 and the second port T52 of the heat exchanger 50, the second port T42 and the first port T41 of the fourth flow control device 40, to the fluid outlet OUT.

[0030] As indicated by the dashed arrow in FIG. 2, when the second flow control device 20 and the third flow control device 30 are opened, and when the first flow control device 10 and the fourth flow control device 40 are closed, a second flow is formed from the fluid inlet IN, the first port T31 and the second port T32 of the third flow control device 30, the second port T52 and the first port T51 of the heat exchanger 50, the second port T22 and the first port T21 of the second flow control device 20, to

the fluid outlet OUT.

[0031] It is shown via the solid arrows and the dashed arrows in FIG. 2 that the heat exchange directions (or the flow directions) of the first flow and the second flow are opposite to each other when the fluid flow passing through the heat exchanger 50. It is to be understood that the heat exchanger 50 has a first heat exchange side (a first fluid circuit such as the working fluid circuit) and a second heat exchange side (a second fluid circuit such as the process fluid circuit), and that FIGS. 2-11 only show one side (e.g., the process fluid side or the working fluid side).

[0032] In some embodiments, the flow reversing device 100 may be adopted to a process fluid (e.g., water or the like) side (or circuit) of an HVACR system such as a heat pump unit. For example, when the heat pump unit is in the cooling mode or cycle, the process fluid side may adopt a first flow (which is in a counter direction to a direction of working fluid), and the cooling resistance is not affected. When the heat pump unit is in the heating mode or cycle, the process fluid side may adopt the second flow (which is still in a counter direction to the direction of working fluid since the working fluid flow direction is changed/reversed in the heating mode). Therefore, the switching or reversing of the process fluid flow direction when transitioning from the cooling mode to the heating mode, or when transitioning from the heating mode to the cooling mode, can be achieved.

[0033] The flow reversing device 100 can achieve the function of flow reversing by using four two-way flow control devices, which can achieve switching or reversing the fluid circuit, and the cost can be significantly reduced compared with using a single flow control device (e.g., a single four-way flow control device such as a single four-way valve).

[0034] FIGS. 3-11 are perspective views of flow reversing devices, arranged in accordance with at least some embodiments described herein. In FIGS. 3-11, the thick solid arrow indicates a common path of the first flow and the second flow, the thin solid arrow indicates a path of the first flow, and the thin dashed arrow indicates a path of the second flow.

First Embodiment

[0035] FIG. 3 is a perspective view of a flow reversing device 110, arranged in accordance with a first embodiment described herein. As shown in the flow reversing device 110 of FIG. 3, the rod of the first flow control device 10, the rod of the second flow control device 20, the rod of the third flow control device 30, and the rod of the fourth flow control device 40 are disposed or located on the same plane (e.g., a horizontal plane or a vertical plane) and are connected together through a connecting rod mechanism 60. It is to be understood that the rod (e.g., a valve rod) can be controlled (e.g., via the connecting rod mechanism 60) to move (or rotate) to close or open the flow control device(s).

[0036] With the configuration of FIG. 3 (e.g., the positions of the rods), when the first flow control device 10 and the fourth flow control device 40 are opened, the second flow control device 20 and the third flow control device 30 are closed. When the second flow control device 20 and the third flow control device 30 are opened, the first flow control device 10 and the fourth flow control device 40 are closed.

[0037] The flow reversing device 110 can achieve simultaneous driving control of the first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40 e.g., through a single connecting rod mechanism 60, so that switching or reversing the fluid circuit can be achieved, with simple structure and low cost.

[0038] In some embodiments, the first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40 may be switched or controlled by a single actuator (not shown). The actuator can simultaneously control the switching of the states (e.g., open and/or close states) of the first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40 through e.g., the connecting rod mechanism 60 and/or the rods of the flow control devices. Therefore, the number of actuators can be reduced, the cost can be further reduced, and the structure can be further simplified. In other embodiments, the switching of the states (e.g., open and/or close states) of the first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40 can be achieved by manually operating the connecting or linkage mechanism 60.

[0039] As shown in FIG. 3, the rod of the first flow control device 10, the rod of the second flow control device 20, the rod of the third flow control device 30, and the rod of the fourth flow control device 40 extend in a direction that is at or about 45 degrees to a horizontal direction. In such configuration, in an initial state, two of the four two-way flow control devices are normally closed, and the other two flow control devices are normally open. For example, in such configuration, in an initial state, the first flow control device 10 and the fourth flow control device 40 are normally closed, and the second flow control device 20 and the third flow control device 30 are normally open; or, the first flow control device 10 and the fourth flow control device 40 are normally open, and the second flow control device 20 and the third flow control device 30 are normally closed. When the actuator or the manual controlling the connecting rod mechanism 60 enables or controls the rods of the four two-way flow control devices to rotate e.g., by at or about 90 degrees (so that the rods extends in a direction at or about 45 degrees to the other side of the horizontal direction), the states (open and/or close states) of the four two-way flow control devices can be switched (e.g., from open to close or from close to open, respectively).

[0040] As shown in the flow reversing device 110 of

FIG. 3, the directions from the first port to the second port of the first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40 are in a horizontal direction. The first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40 are arranged or disposed in a vertical direction.

[0041] In the flow reversing device 110 of FIG. 3, the structure of the first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40 can be compact, and the pressure drop can be significantly reduced.

[0042] As shown in FIG. 3, when the flow reversing device 110 is adopted to the process fluid path side of the heat pump unit, and when the heat pump unit is in the cooling mode, as shown by the thin solid arrow in FIG. 3, the first flow control device 10 and the fourth flow control device 40 are opened, the second flow control device 20 and the third flow control device 30 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its first port T51 to its second port T52. When the heat pump unit is in the heating mode, as shown by the thin dashed arrow in FIG. 3, the second flow control device 20 and the third flow control device 30 are opened, the first flow control device 10 and the fourth flow control device 40 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its second port T52 to its first port T51, which is a direction opposite to the direction in the cooling mode.

Second Embodiment

[0043] FIG. 4 is a perspective view of a flow reversing device 120, arranged in accordance with a second embodiment described herein. As shown in FIG. 4, the flow reversing device 120 has some features the same as the flow reversing device 110. In the flow reversing device 120, the rod of the first flow control device 10, the rod of the second flow control device 20, the rod of the third flow control device 30, and the rod of the fourth flow control device 40 are located or disposed on a same plane (e.g., a horizontal plane or a vertical plane) and are connected together through a connecting rod mechanism 60. When the first flow control device 10 and the fourth flow control device 40 are opened, the second flow control device 20 and the third flow control device 30 are closed. When the second flow control device 20 and the third flow control device 30 are opened, the first flow control device 10 and the fourth flow control device 40 are closed. In some embodiments, open and/or close states of the first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40 may be switched or controlled by a single actuator. In an initial state, the rod of the first flow control device 10, the rod of the second flow control device 20, the rod of the third flow control device 30, and the rod of the fourth flow control device 40 extend in a direction that

is at or about 45 degrees to a horizontal direction.

[0044] The differences between the flow reversing device 120 and the flow reversing device 110 include the arrangement of the first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40. In the flow reversing device 120, the directions from the first port T11 to the second port T12 of the first flow control device 10 and from the first port T31 to the second port T32 of the third flow control device 30 are in a vertical direction. The directions from the first port T21 to the second port T22 of the second flow control device 20 and from the first port T41 to the second port T42 of the fourth flow control device 40 are in a horizontal direction. The first flow control device 10 and the third flow control device 30 are arranged in series in the vertical direction. The second flow control device 20 and the fourth flow control device 40 are respectively located on two opposite sides (or ends) of the combined device (the first flow control device 10 and the third flow control device 30 connecting in series).

[0045] As shown in FIG. 4, when the flow reversing device 120 is adopted to the process fluid path side of the heat pump unit, and when the heat pump unit is in the cooling mode, as shown by the thin solid arrow in FIG. 4, the first flow control device 10 and the fourth flow control device 40 are opened, the second flow control device 20 and the third flow control device 30 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its first port T51 to its second port T52. When the heat pump unit is in the heating mode, as shown by the thin dashed arrow in FIG. 4, the second flow control device 20 and the third flow control device 30 are opened, the first flow control device 10 and the fourth flow control device 40 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its second port T52 to its first port T51, which is a direction opposite to the direction in the cooling mode.

Third Embodiment

[0046] FIG. 5 is a perspective view of a flow reversing device 130, arranged in accordance with a third embodiment described herein. As shown in the flow reversing device 130 of FIG. 5, the first flow control device 10 and the third flow control device 30 can form a first three-way flow control device through a first connector 81. The second flow control device 20 and the fourth flow control device 40 can form a second three-way flow control device through the second connector 82. Each of the connectors (81, 82) can be e.g. a T-shaped three-way connector (or pipe), and can have a first end (or port), a second end (or port), and a third end (or port). The first end and the second end extend in the same direction, and the third end extends in a direction different from directions in which the first port and the second port extend. That is, fluid flows between the first end and the second

end in a straight or substantial straight direction. Fluid flows between the first (or second) end and the third end first in a straight or substantial straight direction and then turns at or about 90 degrees.

[0047] The first end of the first connector 81 connects to the fluid inlet IN. The first flow control device 10 and the third flow control device 30 respectively connect to the second end and the third end of the first connector 81. The first end of the second connector 82 connects to the fluid outlet OUT. The second flow control device 20 and the fourth flow control device 40 respectively connect to the third end and the second end of the second connector 82.

[0048] As shown in the flow reversing device 130 of FIG. 5, the first flow control device 10 and the fourth flow control device 40 respectively connect to the first port T51 and the second port T52 of the heat exchanger 50 through the first three-way pipeline (or pipe) 71 and the second three-way pipeline 72. The first three-way pipeline 71 and the second flow control device 20 are connected through the first bent pipe 73. The second three-way pipeline 72 and the third flow control device 30 are connected through the second bent pipe 74. The first elbow 73 and/or the second elbow 74 are not in a plane where the fluid inlet IN and the fluid outlet OUT are located.

[0049] In the flow reversing device 130, the first bent pipe 73 and the second bent pipe 74 can adopt the same bent pipe structure, and a single type of bent pipe part can be shared.

[0050] In some embodiments, the rod of the first flow control device 10 and the rod of the third flow control device 30 connect together through a connecting rod mechanism (not shown), such that when the first flow control device 10 is opened, the third flow control device 30 is closed; and such that when the third flow control device 30 is opened, the first flow control device 10 is closed. The rod of the second flow control device 20 and the rod of the fourth flow control device 40 connect together through another connecting rod mechanism (not shown), such that when the second flow control device 20 is opened, the fourth flow control device 40 is closed; and such that when the fourth flow control device 40 is opened, the second flow control device 20 is closed.

[0051] In some embodiments, open and/or close states of the first flow control device 10 and the third flow control device 30 may be switched by a first actuator; and open and/or close states of the second flow control device 20 and the fourth flow control device 40 may be switched by a second actuator.

[0052] As shown in FIG. 5, when the flow reversing device 130 is adopted to the process fluid path side of the heat pump unit, and when the heat pump unit is in the cooling mode, as shown by the thin solid arrow in FIG. 5, the first flow control device 10 and the fourth flow control device 40 are opened, the second flow control device 20 and the third flow control device 30 are closed, the fluid at

the process fluid path side flows in a direction passing the heat exchanger 50 from its first port T51 to its second port T52. When the heat pump unit is in the heating mode, as shown by the thin dashed arrow in FIG. 5, the second flow control device 20 and the third flow control device 30 are opened, the first flow control device 10 and the fourth flow control device 40 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its second port T52 to its first port T51, which is a direction opposite to the direction in the cooling mode.

Fourth Embodiment

[0053] FIG. 6 is a perspective view of a flow reversing device 140, arranged in accordance with a fourth embodiment described herein. As shown in FIG. 6, the flow reversing device 140 has some features the same as the flow reversing device 130. The first flow control device 10 and the third flow control device 30 form a first three-way flow control device through a first connector 81. The second flow control device 20 and the fourth flow control device 40 form a second three-way flow control device through a second connector 82. The first end of the first connector 81 connect to the fluid inlet IN. The first flow control device 10 and the third flow control device 30 respectively connect to the second end and the third end of the first connector 81. The first end of the second connector 82 connects to the fluid outlet OUT. The second flow control device 20 and the fourth flow control device 40 respectively connect to the third end and the second end of the second connector 82.

[0054] The differences between the flow reversing device 140 and the flow reversing device 130 include that in the flow reversing device 140, the first flow control device 10 and the fourth flow control device 40 respectively connect to the first port T51 and the second port T52 of the heat exchanger 50 through the first three-way pipeline 71 and the second three-way pipeline 72. The first three-way pipeline 71 and the second flow control device 20 are connected through the first bent pipe 73. The second three-way pipeline 72 and the third flow control device 30 are connected through the second bent pipe 74. The first bent pipe 73 is not in the plane where the fluid inlet IN and the fluid outlet OUT are located. The second bent pipe 74 is located in the plane where the fluid inlet IN and the fluid outlet OUT are located.

[0055] In the flow reversing device 140, since the second bent pipe 74 is located in the plane where the fluid inlet IN and the fluid outlet OUT are located, and the first bent pipe 73 is located on a side of such plane, the space/size of the flow reversing device 140 can be reduced.

[0056] As shown in FIG. 6, when the flow reversing device 140 is adopted to the process fluid path side of the heat pump unit, and when the heat pump unit is in the cooling mode, as shown by the thin solid arrow in FIG. 6, the first flow control device 10 and the fourth flow control device 40 are opened, the second flow control device 20

and the third flow control device 30 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its first port T51 to its second port T52. When the heat pump unit is in the heating mode, as shown by the dashed arrow in FIG. 6, the second flow control device 20 and the third flow control device 30 are opened, the first flow control device 10 and the fourth flow control device 40 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its second port T52 to its first port T51, which is a direction opposite to the direction in the cooling mode.

Fifth Embodiment

[0057] FIG. 7 is a perspective view of a flow reversing device 150, arranged in accordance with a fifth embodiment described herein. As shown in FIG. 7, the flow reversing device 150 has some features the same as the flow reversing device 130. The first flow control device 10 and the third flow control device 30 form a first three-way flow control device through a first connector 81. The second flow control device 20 and the fourth flow control device 40 form a second three-way flow control device through a second connector 82. The first end of the first connector 81 connect to the fluid inlet IN. The first flow control device 10 and the third flow control device 30 respectively connect to the second end and the third end of the first connector 81. The first end of the second connector 82 connects to the fluid outlet OUT. The second flow control device 20 and the fourth flow control device 40 respectively connect to the third end and the second end of the second connector 82.

[0058] The differences between the flow reversing device 150 and the flow reversing device 130 include that in the flow reversing device 150, the first end of the first connector 81 extends in a direction different from a direction in which the fluid inlet IN extends, and the first end of the second connector 82 extends in a same (or parallel) direction in which the fluid outlet OUT extends.

[0059] Compared with the flow reversing device 130, in the flow reversing device 150, the direction from the fluid inlet IN to the inlet end (or port) of the first connector 81 is changed.

[0060] As shown in FIG. 7, when the flow reversing device 150 is adopted to the process fluid path side of the heat pump unit, and when the heat pump unit is in the cooling mode, as shown by the thin solid arrow in FIG. 7, the first flow control device 10 and the fourth flow control device 40 are opened, the second flow control device 20 and the third flow control device 30 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its first port T51 to its second port T52. When the heat pump unit is in the heating mode, as shown by the thin dashed arrow in FIG. 7, the second flow control device 20 and the third flow control device 30 are opened, the first flow control device 10 and the fourth flow control device 40 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger

50 from its second port T52 to its first port T51, which is a direction opposite to the direction in the cooling mode.

Sixth Embodiment

[0061] FIG. 8 is a perspective view of a flow reversing device 160, arranged in accordance with a sixth embodiment described herein. As shown, in the flow reversing device 160 of FIG. 8, the first flow control device 10 and the third flow control device 30 form the first three-way flow control device through the first connector 81. The second flow control device 20 and the fourth flow control device 40 form the second three-way flow control device through the second connector 82.

[0062] The third end of the first connector 81 connects to the fluid inlet IN. The first flow control device 10 and the third flow control device 30 symmetrically connect to the first end and the second end of the first connector 81 respectively. The third end of the second connector 82 connects to the fluid outlet OUT. The second flow control device 20 and the fourth flow control device 40 symmetrically connect to the first end and the second end of the second connector 82 respectively.

[0063] As shown in FIG. 8, in the flow reversing device 160, the first flow control device 10 and the second flow control device 20 symmetrically connect to the first port T51 of the heat exchanger 50 through the first pipe (e.g., a Y-shaped three-way pipeline) 91. The third flow control device 30 and the fourth flow control device 40 symmetrically connect to the second port T52 of the heat exchanger 50 through the second pipe (e.g., a Y-shaped three-way pipeline) 92.

[0064] In some embodiments, the rod of the first flow control device 10 and the rod of the third flow control device 30 connect together through a connecting rod mechanism (not shown), such that when the first flow control device 10 is opened, the third flow control device 30 is closed; and such that when the third flow control device 30 is opened, the first flow control device 10 is closed. The rod of the second flow control device 20 and the rod of the fourth flow control device 40 connect together through another connecting rod mechanism (not shown), such that when the second flow control device 20 is opened, the fourth flow control device 40 is closed; and such that when the fourth flow control device 40 is opened, the second flow control device 20 is closed.

[0065] In some embodiments, open and/or states of the first flow control device 10 and the third flow control device 30 may be switched via a first actuator (not numbered) by e.g., driving the rods or the connecting rod mechanism. Open and/or states of the second flow control device 20 and the fourth flow control device 40 may be switched via a second actuator (not numbered) by e.g., driving the rods or the connecting rod mechanism.

[0066] As shown in FIG. 8, when the flow reversing device 160 is adopted to the process fluid path side of the heat pump unit, and when the heat pump unit is in the

cooling mode, as shown by the thin solid arrow in FIG. 8, the first flow control device 10 and the fourth flow control device 40 are opened, the second flow control device 20 and the third flow control device 30 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its first port T51 to its second port T52. When the heat pump unit is in the heating mode, as shown by the thin dashed arrow in FIG. 8, the second flow control device 20 and the third flow control device 30 are opened, the first flow control device 10 and the fourth flow control device 40 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its second port T52 to its first port T51, which is a direction opposite to the direction in the cooling mode.

Seventh Embodiment

[0067] FIG. 9 is a perspective view of a flow reversing device 170, arranged in accordance with a seventh embodiment described herein. As shown in FIG. 9, the flow reversing device 170 has some features the same as the flow reversing device 160. In the flow reversing device 170, the first flow control device 10 and the third flow control device 30 form a first three-way flow control device through the first connector 81. The second flow control device 20 and the fourth flow control device 40 form a second three-way flow control device through the second connector 82. The third end of the first connector 81 connects to the fluid inlet IN. The first flow control device 10 and the third flow control device 30 symmetrically connect to the first end and the second end of the first connector 81 respectively. The third end of the second connector 82 connects to the fluid outlet OUT. The second flow control device 20 and the fourth flow control device 40 symmetrically connect to the first end and the second end of the second connector 82 respectively.

[0068] The differences between the flow reversing device 170 and the flow reversing device 160 include that in the flow reversing device 170, the first flow control device 10 and the second flow control device 20 connect to the first port T51 of the heat exchanger 50 through the first pipe (e.g., an F-shaped three-way pipeline) 93. The third flow control device 30 and the fourth flow control device 40 connect to the second port T52 of the heat exchanger 50 through the second pipe (e.g., an F-shaped three-way pipeline) 94. The first pipe 93 and the second pipe 94 are located or disposed in a same plane.

[0069] In the flow reversing device 170, the first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40 are located in a same plane as the first port T51 and the second port T52 of the heat exchanger 50. The connecting pipes of the first pipe 93 and of the second pipe 94 have a smooth (or curved) transition, thereby further reducing the pressure drop.

[0070] As shown in FIG. 9, when the flow reversing device 170 is adopted to the process fluid path side of the heat pump unit, and when the heat pump unit is in the

cooling mode, as shown by the thin solid arrow in FIG. 9, the first flow control device 10 and the fourth flow control device 40 are opened, the second flow control device 20 and the third flow control device 30 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its first port T51 to its second port T52. When the heat pump unit is in the heating mode, as shown by the thin dashed arrow in FIG. 9, the second flow control device 20 and the third flow control device 30 are opened, the first flow control device 10 and the fourth flow control device 40 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its second port T52 to its first port T51, which is a direction opposite to the direction in the cooling mode.

Eighth Embodiment

[0071] FIG. 10 is a perspective view of a flow reversing device 180, arranged in accordance with an eighth embodiment described herein. As shown in the flow reversing device 180 of FIG. 10, the first flow control device 10 and the second flow control device 20 form the first three-way flow control device through the first connector 81. The third flow control device 30 and the fourth flow control device 40 form the second three-way flow control device through the second connector 82. The first flow control device 10 and the third flow control device 30 are connected through the third connector 83. It is to be understood that same as or similar to connectors (81, 82), the connector 83 can be e.g. a T-shaped three-way connector (or pipe), and can have a first end (or port), a second end (or port), and a third end (or port). The first end and the second end extend in the same direction, and the third end extends in a direction different from directions in which the first port and the second port extend. That is, fluid flows between the first end and the second end in a straight or substantial straight direction. Fluid flows between the first (or second) end and the third end first in a straight or substantial straight direction and then turns at or about 90 degrees.

[0072] The first flow control device 10 and the second flow control device 20 respectively connect to the third end and the first end of the first connector 81. The second end of the first connector 81 connects to the first port T51 of the heat exchanger 50. The third flow control device 30 and the fourth flow control device 40 respectively connect to the third end and the first end of the second connector 82. The second end of the second connector 82 connects to the second port T52 of the heat exchanger 50. The first flow control device 10 and the third flow control device 30 symmetrically connect to the first end and the second end of the third connector 83 respectively. The third end of the third connector 83 connects to the fluid inlet IN. The second flow control device 20 and the fourth flow control device 40 connect to the fluid outlet OUT.

[0073] In some embodiments, the rod of the first flow control device 10 and the rod of the second flow control device 20 connect together through a connecting rod

mechanism (not shown), such that when the first flow control device 10 is opened, the second flow control device 20 is closed; and such that when the second flow control device 20 is opened, the first flow control device 10 is closed. The rod of the third flow control device 30 and the rod of the fourth flow control device 40 connect together through another connecting rod mechanism (not shown), such that when the third flow control device 30 is opened, the fourth flow control device 40 is closed; and such that when the fourth flow control device 40 is opened, the third flow control device 30 is closed.

[0074] In some embodiments, open and/or close states of the first flow control device 10 and the second flow control device 20 may be switched via a first actuator (not numbered) by e.g., driving the rods or the connecting rod mechanism. Open and/or close states of the third flow control device 30 and the fourth flow control device 40 may be switched via a second actuator (not numbered) by e.g., driving the rods or the connecting rod mechanism.

Ninth Embodiment

[0075] FIG. 11 is a perspective view of a flow reversing device 190, arranged in accordance with an eighth embodiment described herein. The flow reversing device 190 is the same as or similar to the flow reversing device 180 except for orientations of some components such as connectors. As shown in the flow reversing device 190 of FIG. 11, the first flow control device 10 and the second flow control device 20 form the first three-way flow control device through the first connector 81. The third flow control device 30 and the fourth flow control device 40 form the second three-way flow control device through the second connector 82. The first flow control device 10 and the third flow control device 30 are connected through the third connector 83.

[0076] The first flow control device 10 and the second flow control device 20 respectively connect to the third end and the first end of the first connector 81. The second end of the first connector 81 connects to the first port T51 of the heat exchanger 50. The third flow control device 30 and the fourth flow control device 40 respectively connect to the third end and the first end of the second connector 82. The second end of the second connector 82 connects to the second port T52 of the heat exchanger 50. The first flow control device 10 and the third flow control device 30 connect to the second end and the third end of the third connector 83 respectively. The first end of the third connector 83 connects to the fluid inlet IN. The second flow control device 20 and the fourth flow control device 40 connect to the fluid outlet OUT.

[0077] In some embodiments, the rod of the first flow control device 10 and the rod of the second flow control device 20 connect together through a connecting rod mechanism (not shown), such that when the first flow control device 10 is opened, the second flow control device 20 is closed; and such that when the second flow

control device 20 is opened, the first flow control device 10 is closed. The rod of the third flow control device 30 and the rod of the fourth flow control device 40 connect together through another connecting rod mechanism (not shown), such that when the third flow control device 30 is opened, the fourth flow control device 40 is closed; and such that when the fourth flow control device 40 is opened, the third flow control device 30 is closed.

[0078] In some embodiments, open and/or close states of the first flow control device 10 and the second flow control device 20 may be switched via a first actuator (not numbered) by e.g., driving the rods or the connecting rod mechanism. Open and/or close states of the third flow control device 30 and the fourth flow control device 40 may be switched via a second actuator (not numbered) by e.g., driving the rods or the connecting rod mechanism.

[0079] As shown in FIG. 11, when the flow reversing device 190 is adopted to the process fluid path side of the heat pump unit, and when the heat pump unit is in the cooling mode, as shown by the thin solid arrow in FIG. 9, the first flow control device 10 and the fourth flow control device 40 are opened, the second flow control device 20 and the third flow control device 30 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its first port T51 to its second port T52. When the heat pump unit is in the heating mode, as shown by the thin dashed arrow in FIG. 11, the second flow control device 20 and the third flow control device 30 are opened, the first flow control device 10 and the fourth flow control device 40 are closed, the fluid at the process fluid path side flows in a direction passing the heat exchanger 50 from its second port T52 to its first port T51, which is a direction opposite to the direction in the cooling mode.

[0080] Features in the embodiments disclosed herein may further provide a heat pump or heat pump unit. Referring to FIGS. 2-11, the heat pump unit may include the heat exchanger 50 and the flow reversing device 100-190 described in the foregoing embodiments. The heat exchanger 50 has a first heat exchange side (or fluid circuit) and a second heat exchange side (or fluid circuit). In an example embodiment, the first heat exchange side can be a working fluid side or circuit. The flow reversing device(s) 100-190 can be located at the second heat exchange side. When the heat pump unit is in a cooling mode, the flow reversing device(s) 100-190 can form a first flow; and when the heat pump unit is in a heating mode, the flow reversing device(s) 100-190 can form a second flow, which is in a direction opposite to the direction of the first flow.

[0081] In some embodiments, all of the first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40 can be butterfly valves. The second heat exchange side can be a process fluid (e.g., water or the like) side. The flow reversing device(s) 100-190 can be implemented using four butterfly valves, thereby reducing the cost.

[0082] In some other embodiments, all of the first flow control device 10, the second flow control device 20, the third flow control device 30, and the fourth flow control device 40 can be ball valves. The second heat exchange side can be a process fluid (e.g., fluorine or the like) side. The flow reversing device(s) 100-190 can be implemented using four ball valves and can be adopted to a large-scale air-cooled heat pump unit or a water source heat pump unit.

[0083] The flow reversing device 100 (including the flow reversing device(s) 110-190) can achieve the flow reversing function by using four two-way flow control devices, thereby switching or reversing the direction of the flow circuit, and can have the advantages of low cost, low pressure drop, space saving, and the like. It is to be understood that the flow reversing device 100 can be adopted at the first heat exchange side and/or the second heat exchange side.

[0084] The flow reversing device and the heat pump unit are provided in the embodiments disclosed herein with specific examples. It is to be understood that the description of the embodiments is used to help understand the core idea of the present application only and is not intended to limit the present application. It is also to be understood that, for a person of ordinary skill in the art, several improvements and modifications may be made to this application without departing from the spirit and principle of this application, and these improvements and modifications shall fall within the protection scope of the claims of this application.

ASPECTS:

[0085] It is to be understood that any one of aspects can be combined with each other.

[0086] Aspect 1 A flow reversing device for a heating, ventilation, air conditioning, and refrigeration (HVACR) system having a heat exchanger, the flow reversing device comprising: a first flow control device, a second flow control device, a third flow control device, and a fourth flow control device, each flow control device being a two-way flow control device; wherein a first port of the first flow control device and a first port of the third flow control device connect to a fluid inlet, a first port of the second flow control device and a first port of the fourth flow control device connect to a fluid outlet, a second port of the first flow control device and a second port of the second flow control device connect to a first port of the heat exchanger, a second port of the third flow control device and a second port of the fourth flow control device connect to a second port of the heat exchanger, when the first flow control device and the fourth flow control device are opened and the second flow control device and the third flow control device are closed, a first flow is formed from the fluid inlet, the first port and the second port of the first flow control device, the first port and the second port of the heat exchanger, the second port and the first port of the fourth flow control device, to the fluid outlet, when the

second flow control device and the third flow control device are opened and the first flow control device and the fourth flow control device are closed, a second flow is formed from the fluid inlet, the first port and the second port of the third flow control device, the second port and the first port of the heat exchanger, the second port and the first port of the second flow control device, to the fluid outlet.

[0087] Aspect 2. The flow reversing device of aspect 1, wherein a rod of the first flow control device, a rod of the second flow control device, a rod of the third flow control device, and a rod of the fourth flow control device are disposed on a same plane and are connected through a connecting mechanism, such that when the first flow control device and the fourth flow control device are opened, the second flow control device and the third flow control device are closed, and such that when the second flow control device and the third flow control device are opened, the first flow control device and the fourth flow control device are closed.

[0088] Aspect 3. The flow reversing device of aspect 2, wherein open and close states of the first flow control device, the second flow control device, the third flow control device, and the fourth flow control device are switched by an actuator.

[0089] Aspect 4. The flow reversing device of aspect 2 or aspect 3, wherein the rod of the first flow control device, the rod of the second flow control device, the rod of the third flow control device, and the rod of the fourth flow control device extend in a direction that is at or about 45 degrees to a horizontal direction.

[0090] Aspect 5. The flow reversing device of any one of aspects 2-4, wherein directions from the first port to the second port of the first flow control device, the second flow control device, the third flow control device, and the fourth flow control device are in a horizontal direction, and the first flow control device, the second flow control device, the third flow control device, and the fourth flow control device are arranged in a vertical direction.

[0091] Aspect 6. The flow reversing device of any one of aspects 2-5, wherein directions from the first port to the second port of the first flow control device and the third flow control device are in a vertical direction, the first flow control device and the third flow control device are arranged in series along a vertical direction, directions from the first port to the second port of the second flow control device and the fourth flow control device are in a horizontal direction, the second flow control device and the fourth flow control device are respectively disposed at opposite sides of the first flow control device and the third flow control device that are arranged in series.

[0092] Aspect 7. The flow reversing device of any one of aspects 1-6, wherein the first flow control device and the third flow control device form a first three-way flow control device through a first three-way connector, the second flow control device and the fourth flow control device form a second three-way flow control device through a second three-way connector, each of the first

three-way connector and the second three-way connector includes a first end, a second end, and a third end, the first end and the second end extend in a same direction different from a direction in which the third end extends, the first end of the first three-way connector connects to the fluid inlet, and the first flow control device and the third flow control device respectively connect to the second end and the third end of the first three-way connector; the first end of the second three-way connector connects to the fluid outlet, and the second flow control device and the fourth flow control device respectively connect to the third end and the second end of the second three-way connector.

[0093] Aspect 8. The flow reversing device of aspect 7, wherein the first flow control device and the fourth flow control device respectively connect to the first port and the second port of the heat exchanger through a first three-way pipeline and a second three-way pipeline, the first three-way pipeline and the second flow control device are connected through a first bent pipe, and the second three-way pipeline and the third flow control device are connected through a second bent pipe, wherein the first bent pipe and the second bent pipe are not in a plane where the fluid inlet and the fluid outlet are located.

[0094] Aspect 9. The flow reversing device of aspect 7, wherein the first flow control device and the fourth flow control device respectively connect to the first port and the second port of the heat exchanger through a first three-way pipeline and a second three-way pipeline, the first three-way pipeline and the second flow control device are connected through a first bent pipe, the second three-way pipeline and the third flow control device are connected through a second bent pipe, the first bent pipe is not in a plane where the fluid inlet and the fluid outlet are located, and the second bent pipe is located in the plane where the fluid inlet and the fluid outlet are located.

[0095] Aspect 10. The flow reversing device of any one of aspects 7-9, wherein the first end of the first three-way connector extends in a direction different from a direction in which the fluid inlet extends, and the first end of the second three-way connector extends in a same direction in which the fluid outlet extends.

[0096] Aspect 11. The flow reversing device of any one of aspects 1-10, wherein the first flow control device and the third flow control device form a first three-way flow control device through a first three-way connector, the second flow control device and the fourth flow control device form a second three-way flow control device through a second three-way connector, each of the first three-way connector and the second three-way connector includes a first end, a second end, and a third end, the first end and the second end extend in a same direction different from a direction in which the third end extends, the third end of the first three-way connector connects to the fluid inlet, and the first flow control device and the third flow control device symmetrically connect to the first end and the second end of the first three-way connector

respectively; the third end of the second three-way connector connect to the fluid outlet, and the second flow control device and the fourth flow control device symmetrically connect to the first end and the second end of the second three-way connector respectively.

[0097] Aspect 12. The flow reversing device of aspect 11, wherein the first flow control device and the second flow control device symmetrically connect to the first port of the heat exchanger through a first Y-shaped three-way pipeline, and the third flow control device and the fourth flow control device symmetrically connect to the second port of the heat exchanger through a second Y-shaped three-way pipeline.

[0098] Aspect 13. The flow reversing device of aspect 11, wherein the first flow control device and the second flow control device connect to the first port of the heat exchanger through a first F-shaped three-way pipeline, the third flow control device and the fourth flow control device connect to the second port of the heat exchanger through a second F-shaped three-way pipeline, and the first F-shaped three-way pipeline and the second F-shaped three-way pipeline are located in a same plane.

[0099] Aspect 14. The flow reversing device of any one of aspects 7-13, wherein a rod of the first flow control device and a rod of the third flow control device connect together through a connecting rod mechanism, such that when the first flow control device is opened, the third flow control device is closed, and such that when the third flow control device is opened, the first flow control device is closed; a rod of the second flow control device and a rod of the fourth flow control device connect together through another connecting rod mechanism, such that when the second flow control device is opened, the fourth flow control device is closed, and such that when the fourth flow control device is opened, the second flow control device is closed.

[0100] Aspect 15. The flow reversing device of aspect 14, wherein open and close states of the first flow control device and the third flow control device are switched via a first actuator, and open and close states of the second flow control device and the fourth flow control device are switched via a second actuator.

[0101] Aspect 16. The flow reversing device of any one of aspects 1-15, wherein the first flow control device and the second flow control device form a first three-way flow control device through a first three-way connector, the third flow control device and the fourth flow control device form a second three-way flow control device through a second three-way connector, the first flow control device and the third flow control device connect through a third three-way connector, the first three-way connector, the second three-way connector and the third three-way connector each includes a first end, a second end and a third end, the first end and the second end extend in a same direction different from a direction in which the third end extends, the first flow control device and the second flow control device respectively connect to the third end and the first end of the first three-way connector, and the

second end of the first three-way connector connect to the first port of the heat exchanger; the third flow control device and the fourth flow control device respectively connect to the third end and the first end of the second three-way connector, and the second end of the second three-way connector connect to the second port of the heat exchanger; the first flow control device and the third flow control device symmetrically connect to the first end and the second end of the third three-way connector respectively, and the third end of the third three-way connector connects to the fluid inlet; the second flow control device and the fourth flow control device connect to the fluid outlet.

[0102] Aspect 17. The flow reversing device of aspect 16, wherein a rod of the first flow control device and a rod of the second flow control device connect together through a connecting rod mechanism, such that when the first flow control device is opened, the second flow control device is closed, and such that when the second flow control device is opened, the first flow control device is closed; a rod of the third flow control device and a rod of the fourth flow control device connect together through another connecting rod mechanism, such that when the third flow control device is opened, the fourth flow control device is closed, and such that when the fourth flow control device is opened, the third flow control device is closed.

[0103] Aspect 18. The flow reversing device of aspect 17, wherein open and close states of the first flow control device and the second flow control device are switched via a first actuator, and open and close states of the third flow control device and the fourth flow control device are switched via a second actuator.

[0104] Aspect 19. The flow reversing device of any one of aspects 1-18, wherein the first flow control device and the second flow control device form a first three-way flow control device through a first three-way connector, the third flow control device and the fourth flow control device form a second three-way flow control device through a second three-way connector, the first flow control device and the third flow control device connect through a third three-way connector, the first three-way connector, the second three-way connector and the third three-way connector each includes a first end, a second end and a third end, the first end and the second end extend in a same direction different from a direction in which the third end extends, the first flow control device and the second flow control device respectively connect to the third end and the first end of the first three-way connector, and the second end of the first three-way connector connect to the first port of the heat exchanger; the third flow control device and the fourth flow control device respectively connect to the third end and the first end of the second three-way connector, and the second end of the second three-way connector connect to the second port of the heat exchanger; the first flow control device and the third flow control device connect to the first end and the third end of the third three-way connector respectively, and the

second end of the third three-way connector connects to the fluid inlet; the second flow control device and the fourth flow control device connect to the fluid outlet.

[0105] Aspect 20. A heat pump unit, comprising: the flow reversing device of any one of aspects 1-19; and the heat exchanger, wherein the heat exchanger has a first heat exchange side and a second heat exchange side, the first heat exchange side is a working fluid side, the flow reversing device is located at the second heat exchange side, when the heat pump unit is in a cooling mode, the flow reversing device forms the first flow; and when the heat pump unit is in a heating mode, the flow reversing device forms the second flow.

[0106] Aspect 21. The heat pump unit of aspect 20, wherein all of the first flow control device, the second flow control device, the third flow control device, and the fourth flow control device are butterfly valves or ball valves, and the second heat exchange side is a process fluid side.

[0107] With regard to the preceding description, it is to be understood that changes may be made in detail, especially in matters of the construction materials employed and the shape, size, and arrangement of parts without departing from the scope of the present disclosure. This specification and the embodiments described are exemplary only, with the true scope and spirit of the disclosure being indicated by the claims that follow.

Claims

1. A flow reversing device for a heating, ventilation, air conditioning, and refrigeration (HVACR) system having a heat exchanger, the flow reversing device comprising:

a first flow control device, a second flow control device, a third flow control device, and a fourth flow control device, each flow control device being a two-way flow control device;

wherein a first port of the first flow control device and a first port of the third flow control device connect to a fluid inlet, a first port of the second flow control device and a first port of the fourth flow control device connect to a fluid outlet, a second port of the first flow control device and a second port of the second flow control device connect to a first port of the heat exchanger, a second port of the third flow control device and a second port of the fourth flow control device connect to a second port of the heat exchanger, when the first flow control device and the fourth flow control device are opened and the second flow control device and the third flow control device are closed, a first flow is formed from the fluid inlet, the first port and the second port of the first flow control device, the first port and the second port of the heat exchanger, the second port and the first port of the fourth flow control

- device, to the fluid outlet,
when the second flow control device and the third flow control device are opened and the first flow control device and the fourth flow control device are closed, a second flow is formed from the fluid inlet, the first port and the second port of the third flow control device, the second port and the first port of the heat exchanger, the second port and the first port of the second flow control device, to the fluid outlet.
2. The flow reversing device of claim 1, wherein a rod of the first flow control device, a rod of the second flow control device, a rod of the third flow control device, and a rod of the fourth flow control device are disposed on a same plane and are connected through a connecting mechanism, such that when the first flow control device and the fourth flow control device are opened, the second flow control device and the third flow control device are closed, and such that when the second flow control device and the third flow control device are opened, the first flow control device and the fourth flow control device are closed.
 3. The flow reversing device of claim 2, wherein directions from the first port to the second port of the first flow control device, the second flow control device, the third flow control device, and the fourth flow control device are in a horizontal direction, and the first flow control device, the second flow control device, the third flow control device, and the fourth flow control device are arranged in a vertical direction.
 4. The flow reversing device of any one of claims 2-3, wherein directions from the first port to the second port of the first flow control device and the third flow control device are in a vertical direction, the first flow control device and the third flow control device are arranged in series along a vertical direction, directions from the first port to the second port of the second flow control device and the fourth flow control device are in a horizontal direction, the second flow control device and the fourth flow control device are respectively disposed at opposite sides of the first flow control device and the third flow control device that are arranged in series.
 5. The flow reversing device of any one of claims 1-4, wherein the first flow control device and the third flow control device form a first three-way flow control device through a first three-way connector, the second flow control device and the fourth flow control device form a second three-way flow control device through a second three-way connector, each of the first three-way connector and the second three-way connector includes a first end, a second end, and a third end, the first end and the second end extend in a same direction different from a direction in which the third end extends,
the first end of the first three-way connector connects to the fluid inlet, and the first flow control device and the third flow control device respectively connect to the second end and the third end of the first three-way connector;
the first end of the second three-way connector connects to the fluid outlet, and the second flow control device and the fourth flow control device respectively connect to the third end and the second end of the second three-way connector.
 6. The flow reversing device of claim 5, wherein the first flow control device and the fourth flow control device respectively connect to the first port and the second port of the heat exchanger through a first three-way pipeline and a second three-way pipeline, the first three-way pipeline and the second flow control device are connected through a first bent pipe, and the second three-way pipeline and the third flow control device are connected through a second bent pipe, wherein the first bent pipe and the second bent pipe are not in a plane where the fluid inlet and the fluid outlet are located.
 7. The flow reversing device of claim 5, wherein the first flow control device and the fourth flow control device respectively connect to the first port and the second port of the heat exchanger through a first three-way pipeline and a second three-way pipeline, the first three-way pipeline and the second flow control device are connected through a first bent pipe, the second three-way pipeline and the third flow control device are connected through a second bent pipe, the first bent pipe is not in a plane where the fluid inlet and the fluid outlet are located, and the second bent pipe is located in the plane where the fluid inlet and the fluid outlet are located.
 8. The flow reversing device of any one of claims 5-7, wherein the first end of the first three-way connector extends in a direction different from a direction in which the fluid inlet extends, and the first end of the second three-way connector extends in a same direction in which the fluid outlet extends.
 9. The flow reversing device of any one of the preceding claims, wherein the first flow control device and the third flow control device form a first three-way flow control device through a first three-way connector, the second flow control device and the fourth flow control device form a second three-way flow control device through a second three-way connector, each of the first three-way connector and the second three-way connector includes a first end, a second end, and a third end, the first end and the second end

extends in a same direction different from a direction in which the third end extends,

the third end of the first three-way connector connects to the fluid inlet, and the first flow control device and the third flow control device symmetrically connect to the first end and the second end of the first three-way connector respectively;
the third end of the second three-way connector connect to the fluid outlet, and the second flow control device and the fourth flow control device symmetrically connect to the first end and the second end of the second three-way connector respectively.

10. The flow reversing device of claim 9, wherein the first flow control device and the second flow control device symmetrically connect to the first port of the heat exchanger through a first Y-shaped three-way pipeline, and the third flow control device and the fourth flow control device symmetrically connect to the second port of the heat exchanger through a second Y-shaped three-way pipeline.
11. The flow reversing device of claim 9, wherein the first flow control device and the second flow control device connect to the first port of the heat exchanger through a first F-shaped three-way pipeline, the third flow control device and the fourth flow control device connect to the second port of the heat exchanger through a second F-shaped three-way pipeline, and the first F-shaped three-way pipeline and the second F-shaped three-way pipeline are located in a same plane.
12. The flow reversing device of any one of the preceding claims, wherein a rod of the first flow control device and a rod of the third flow control device connect together through a connecting rod mechanism, such that when the first flow control device is opened, the third flow control device is closed, and such that when the third flow control device is opened, the first flow control device is closed;
a rod of the second flow control device and a rod of the fourth flow control device connect together through another connecting rod mechanism, such that when the second flow control device is opened, the fourth flow control device is closed, and such that when the fourth flow control device is opened, the second flow control device is closed.
13. The flow reversing device of any one of claims 1-4, wherein the first flow control device and the second flow control device form a first three-way flow control device through a first three-way connector, the third flow control device and the fourth flow control device form a second three-way flow control device through

a second three-way connector, the first flow control device and the third flow control device connect through a third three-way connector, the first three-way connector, the second three-way connector and the third three-way connector each includes a first end, a second end and a third end, the first end and the second end extend in a same direction different from a direction in which the third end extends,

the first flow control device and the second flow control device respectively connect to the third end and the first end of the first three-way connector, and the second end of the first three-way connector connect to the first port of the heat exchanger;
the third flow control device and the fourth flow control device respectively connect to the third end and the first end of the second three-way connector, and the second end of the second three-way connector connect to the second port of the heat exchanger;
the first flow control device and the third flow control device symmetrically connect to the first end and the second end of the third three-way connector respectively, and the third end of the third three-way connector connects to the fluid inlet;
the second flow control device and the fourth flow control device connect to the fluid outlet.

14. The flow reversing device of any one of claims 1-4, wherein the first flow control device and the second flow control device form a first three-way flow control device through a first three-way connector, the third flow control device and the fourth flow control device form a second three-way flow control device through a second three-way connector, the first flow control device and the third flow control device connect through a third three-way connector, the first three-way connector, the second three-way connector and the third three-way connector each includes a first end, a second end and a third end, the first end and the second end extend in a same direction different from a direction in which the third end extends,

the first flow control device and the second flow control device respectively connect to the third end and the first end of the first three-way connector, and the second end of the first three-way connector connect to the first port of the heat exchanger;
the third flow control device and the fourth flow control device respectively connect to the third end and the first end of the second three-way connector, and the second end of the second three-way connector connect to the second port of the heat exchanger;
the first flow control device and the third flow

control device connect to the first end and the third end of the third three-way connector respectively, and the second end of the third three-way connector connects to the fluid inlet; the second flow control device and the fourth flow control device connect to the fluid outlet. 5

15. A heat pump unit, comprising:

the flow reversing device of any one of claims 1-14; and 10
the heat exchanger,
wherein the heat exchanger has a first heat exchange side and a second heat exchange side, the first heat exchange side is a working fluid side, the flow reversing device is located at the second heat exchange side, 15
when the heat pump unit is in a cooling mode, the flow reversing device forms the first flow; and
when the heat pump unit is in a heating mode, 20
the flow reversing device forms the second flow.

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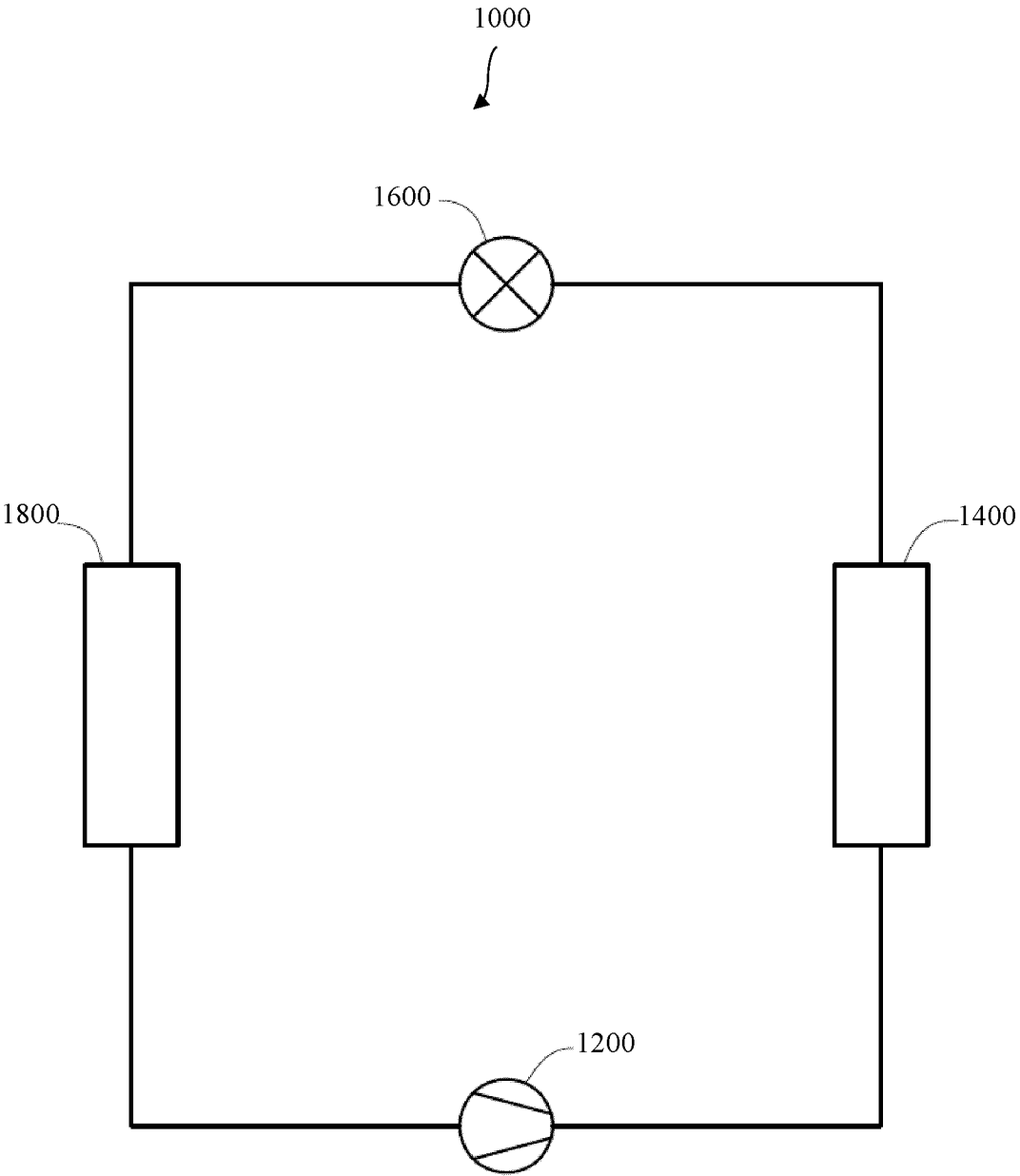


FIG. 1

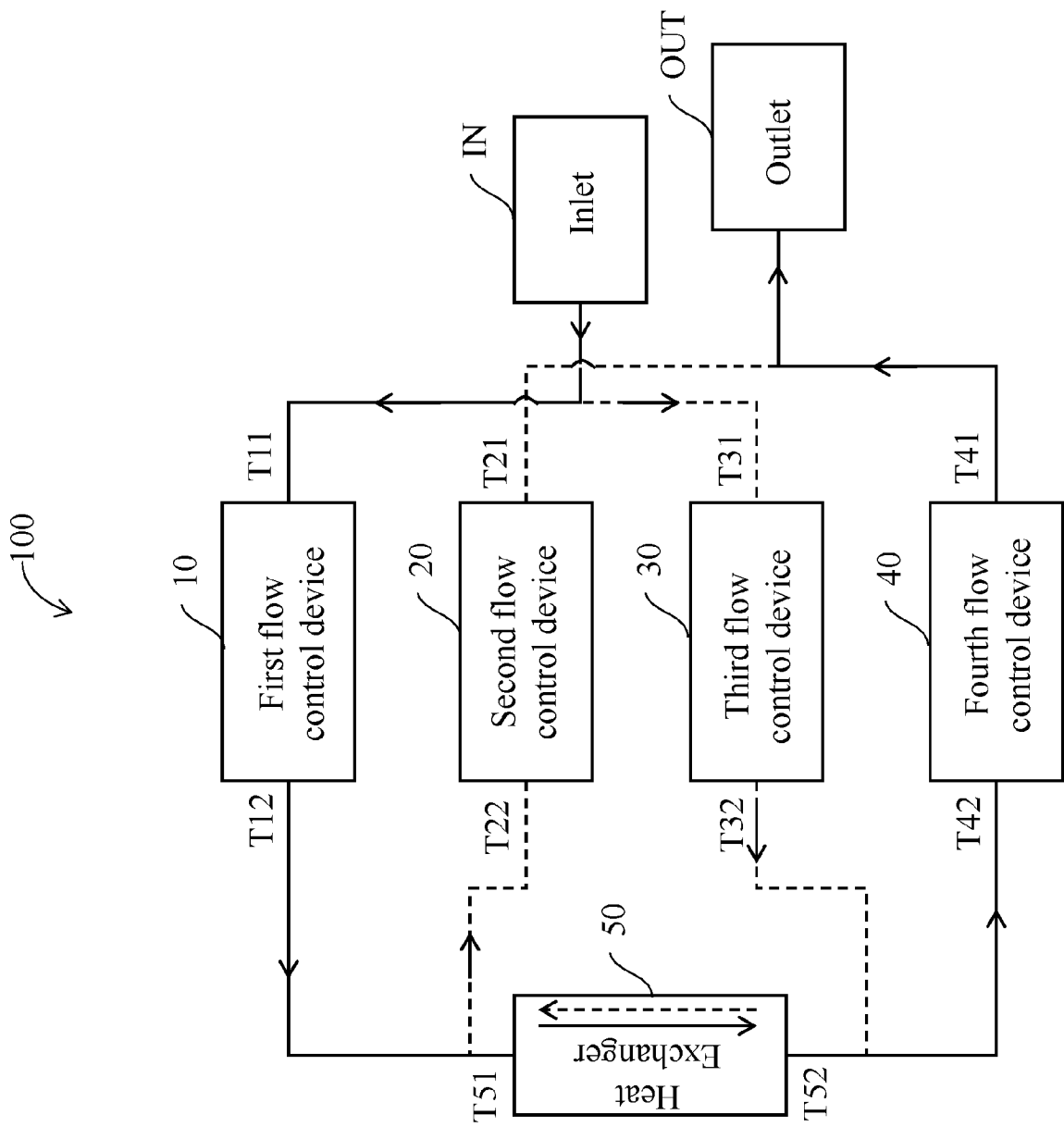


FIG. 2

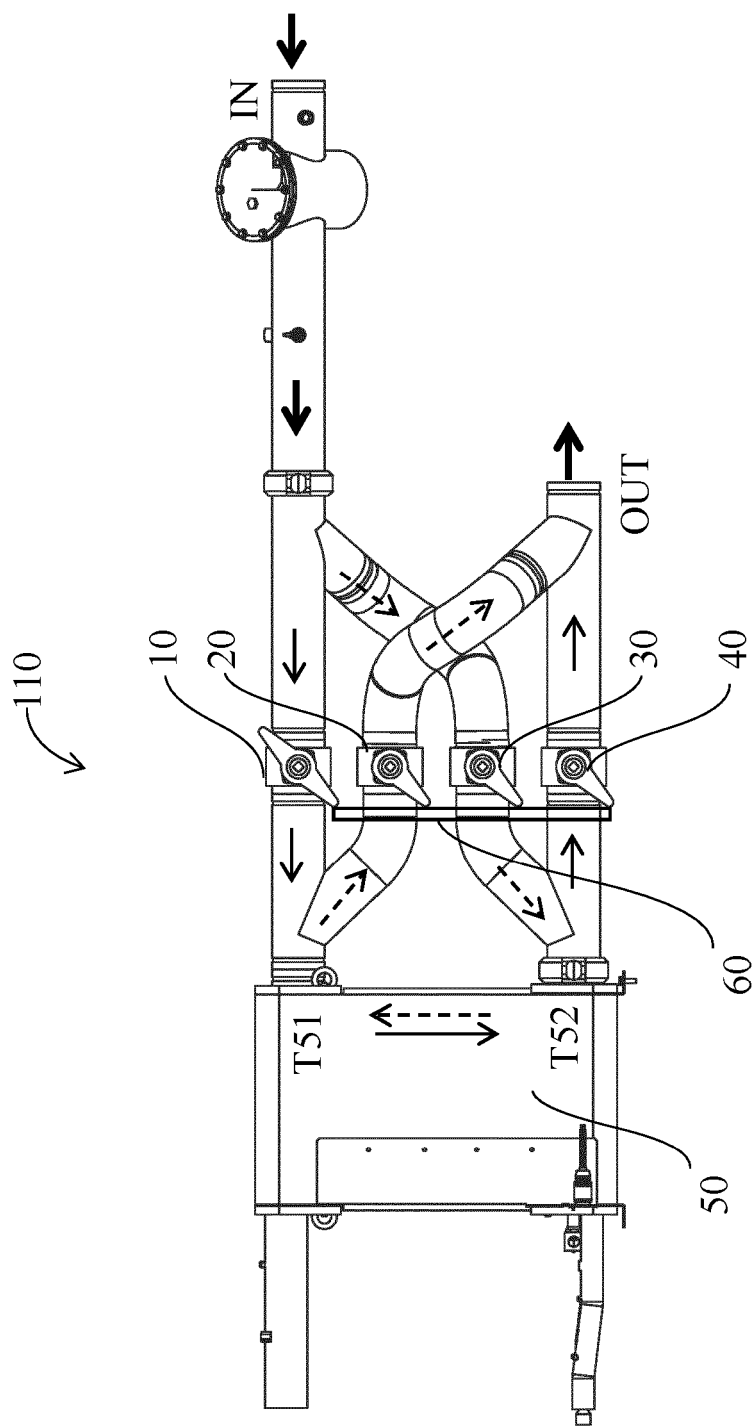
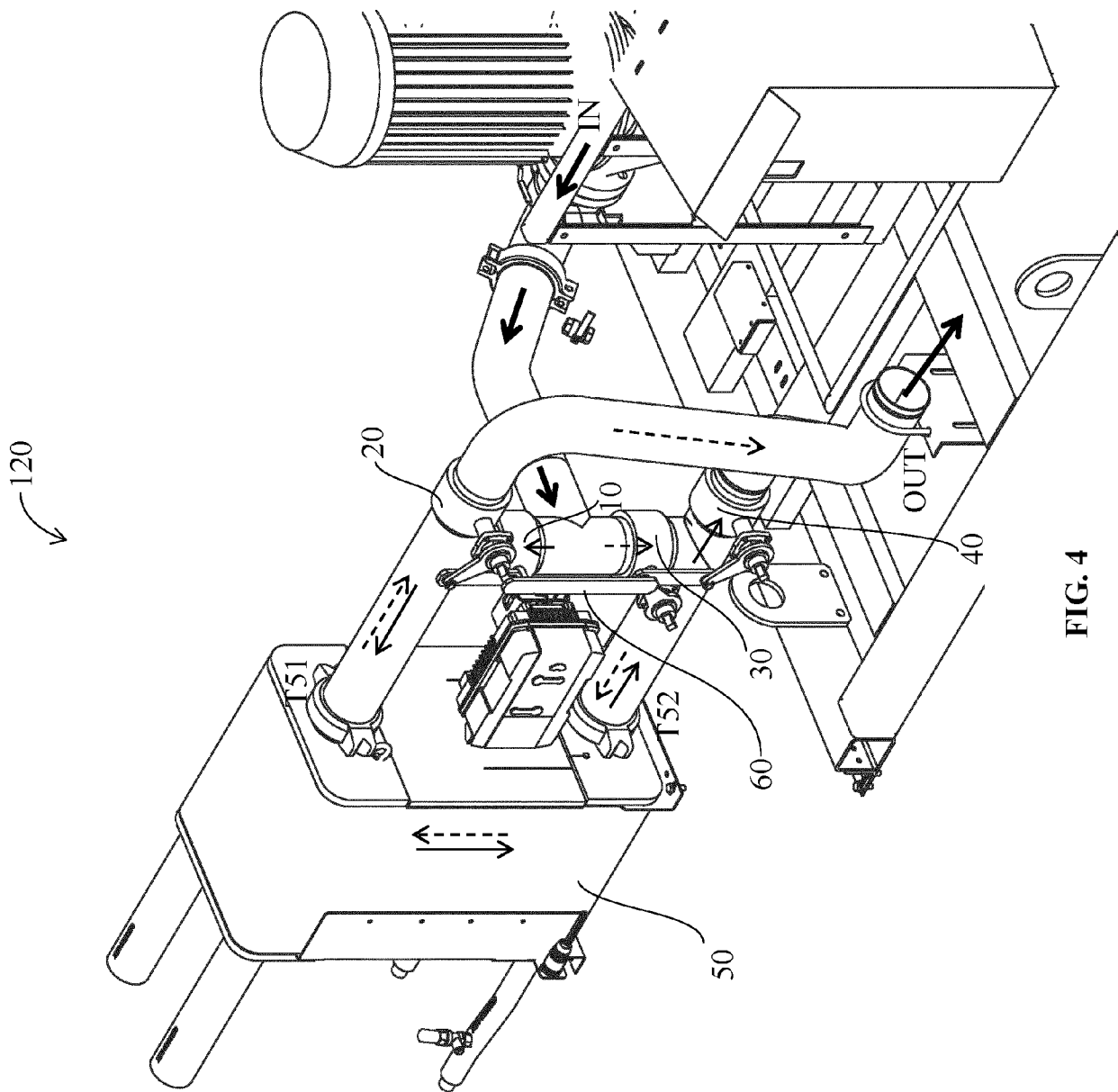


FIG. 3



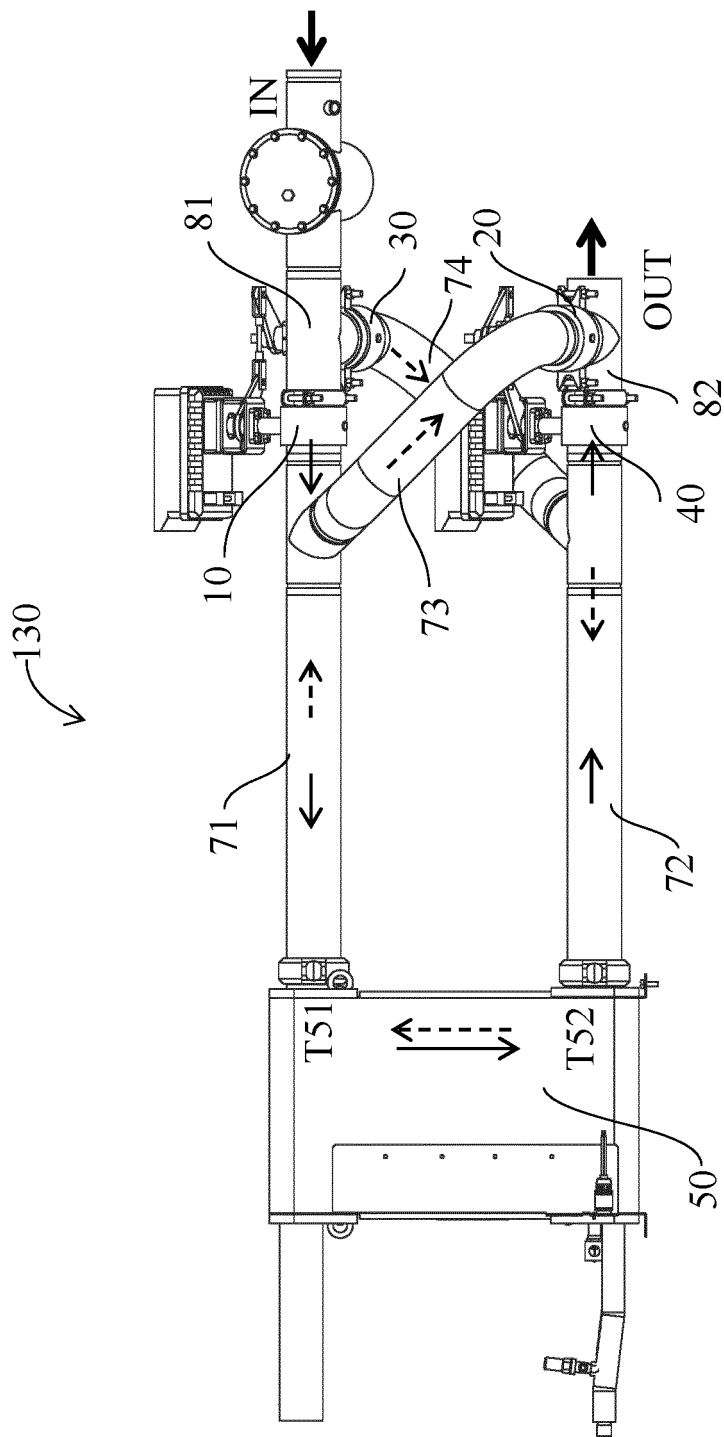


FIG. 5

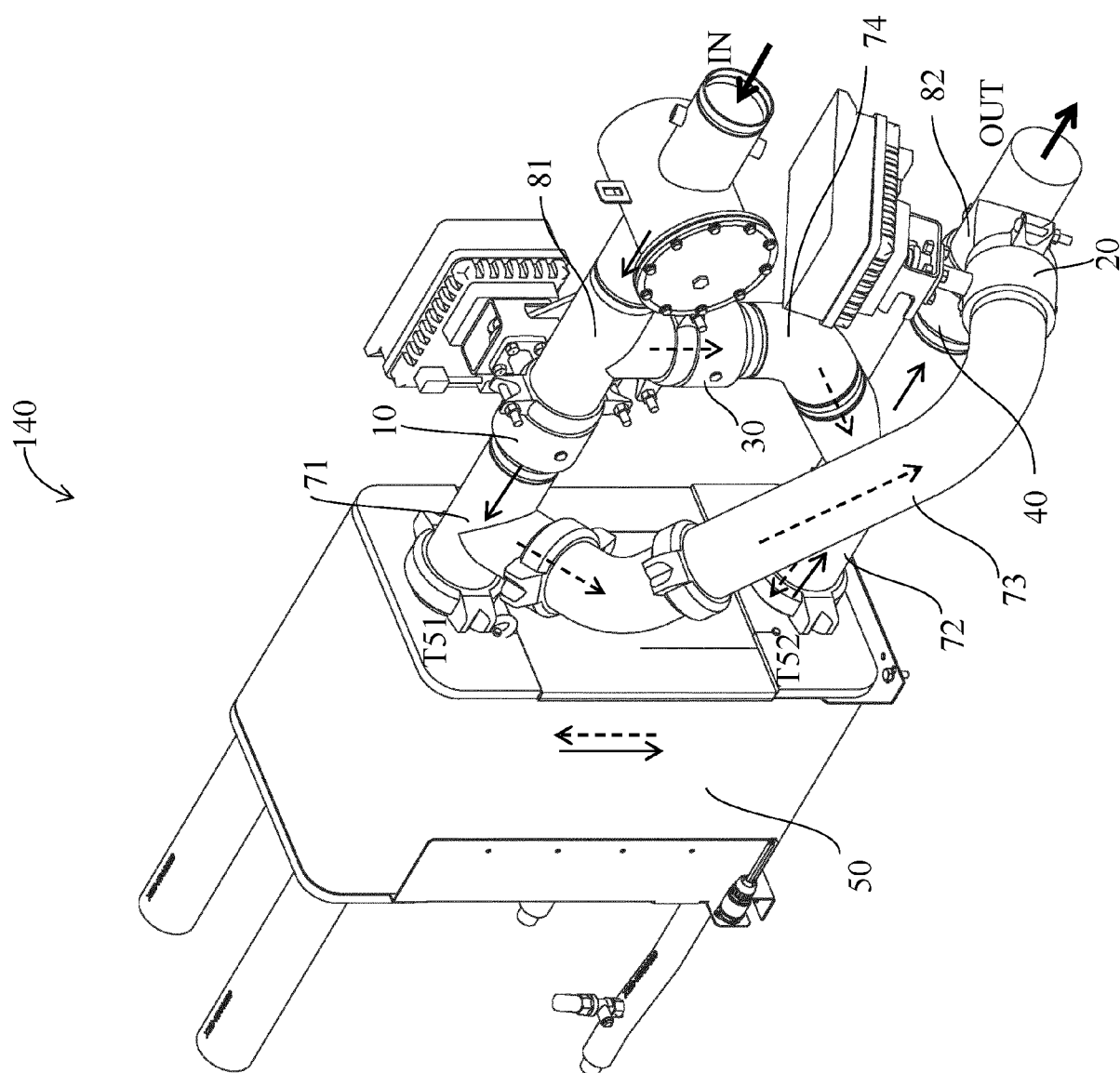


FIG. 6

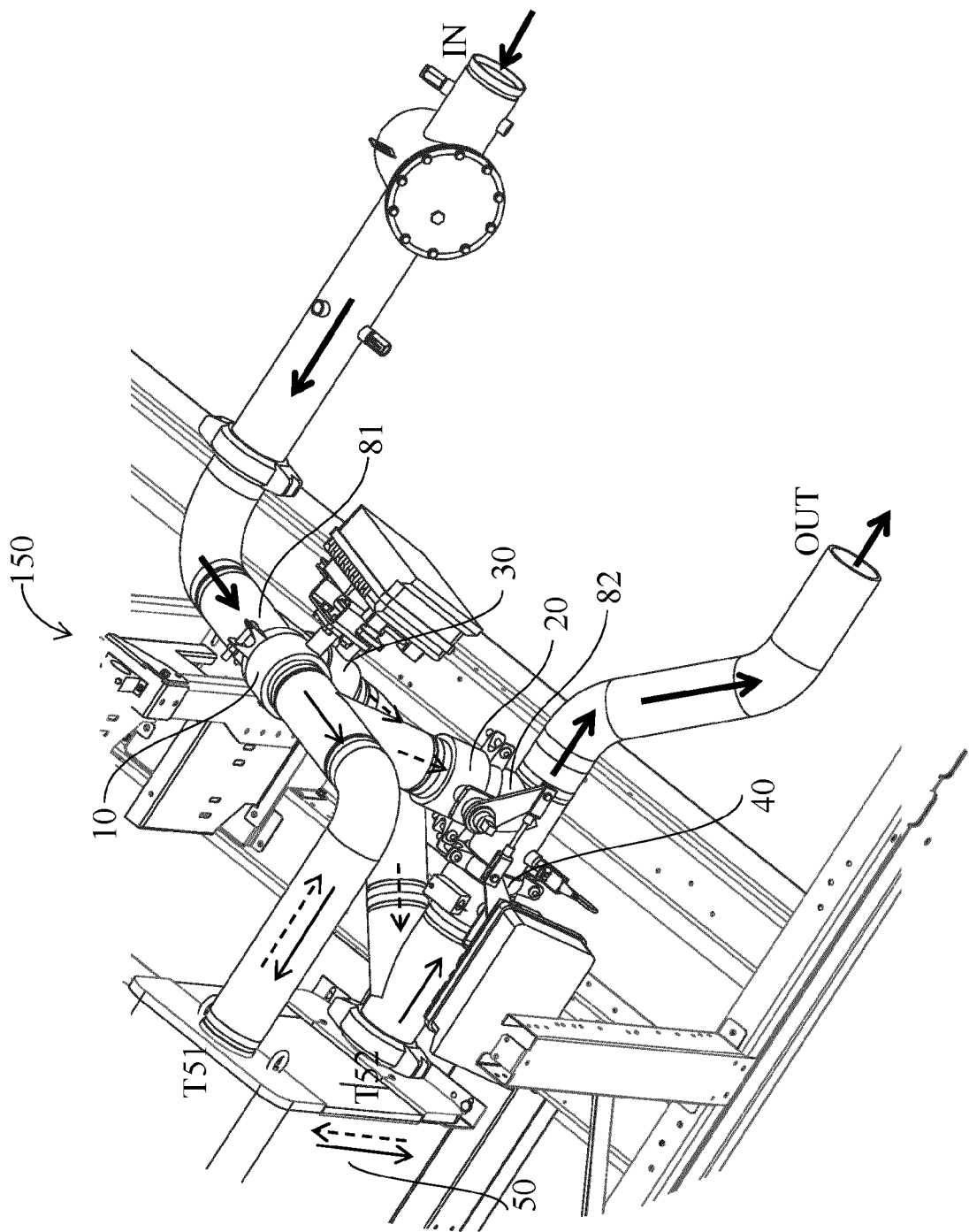


FIG. 7

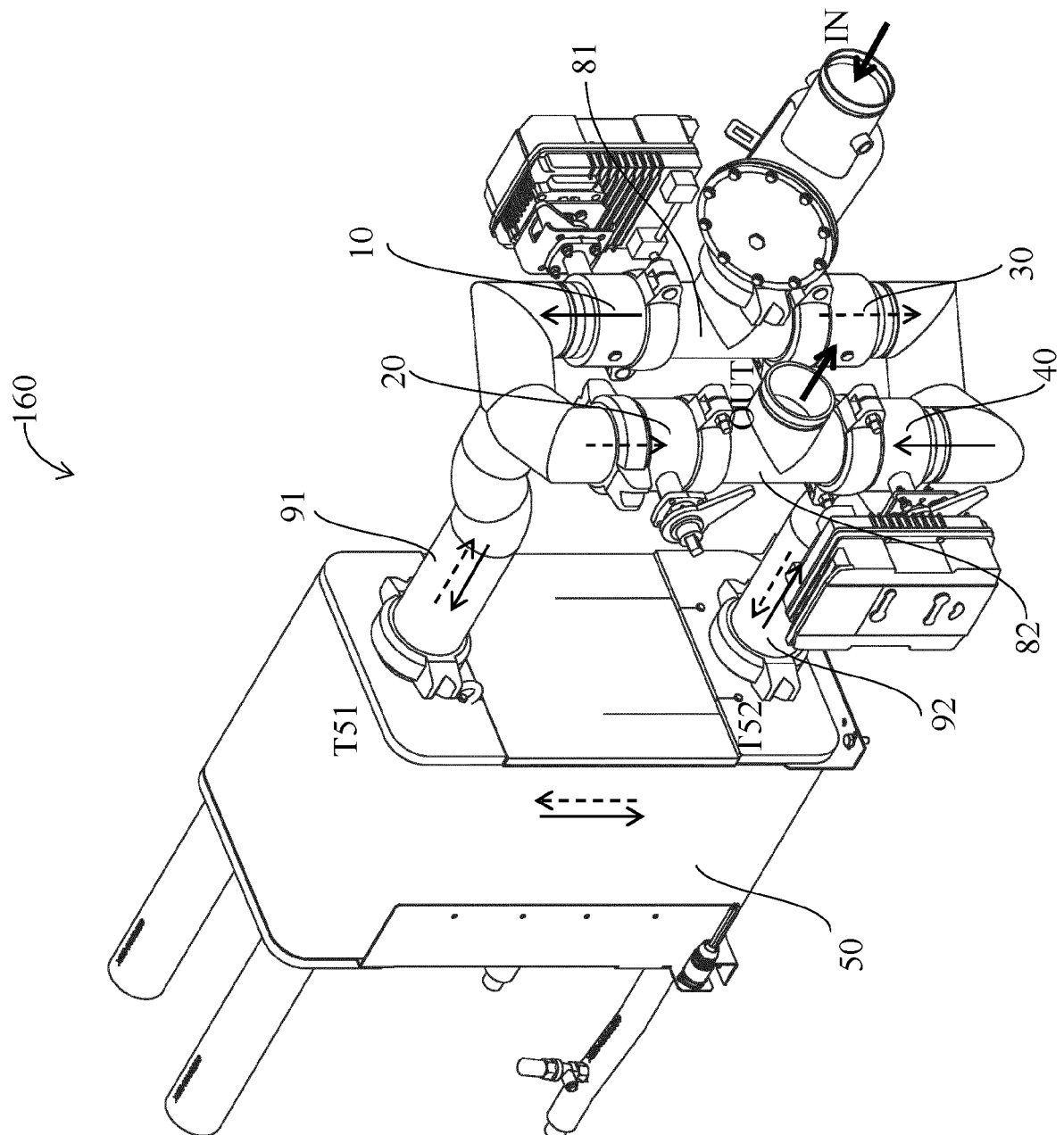


FIG. 8

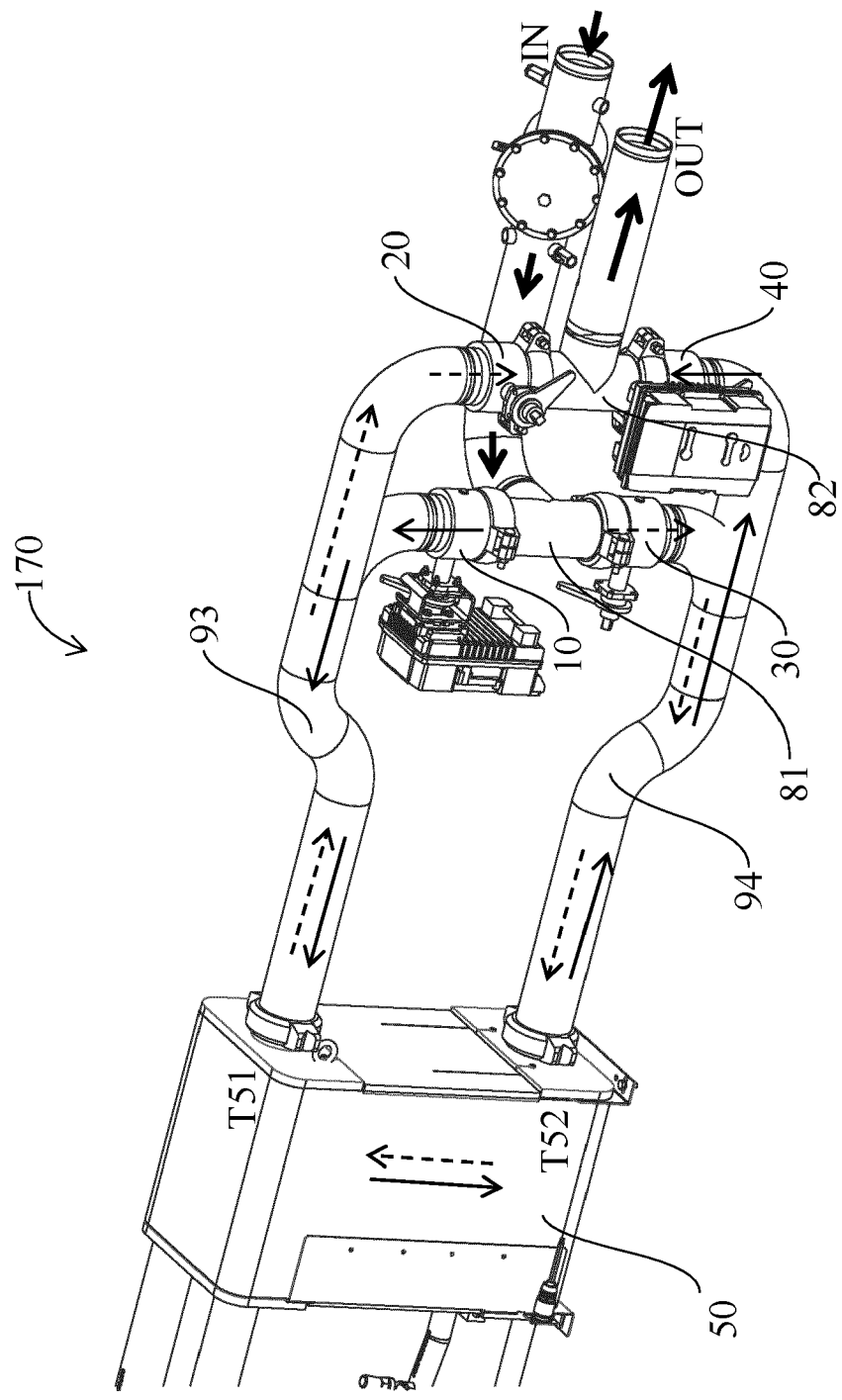


FIG. 9

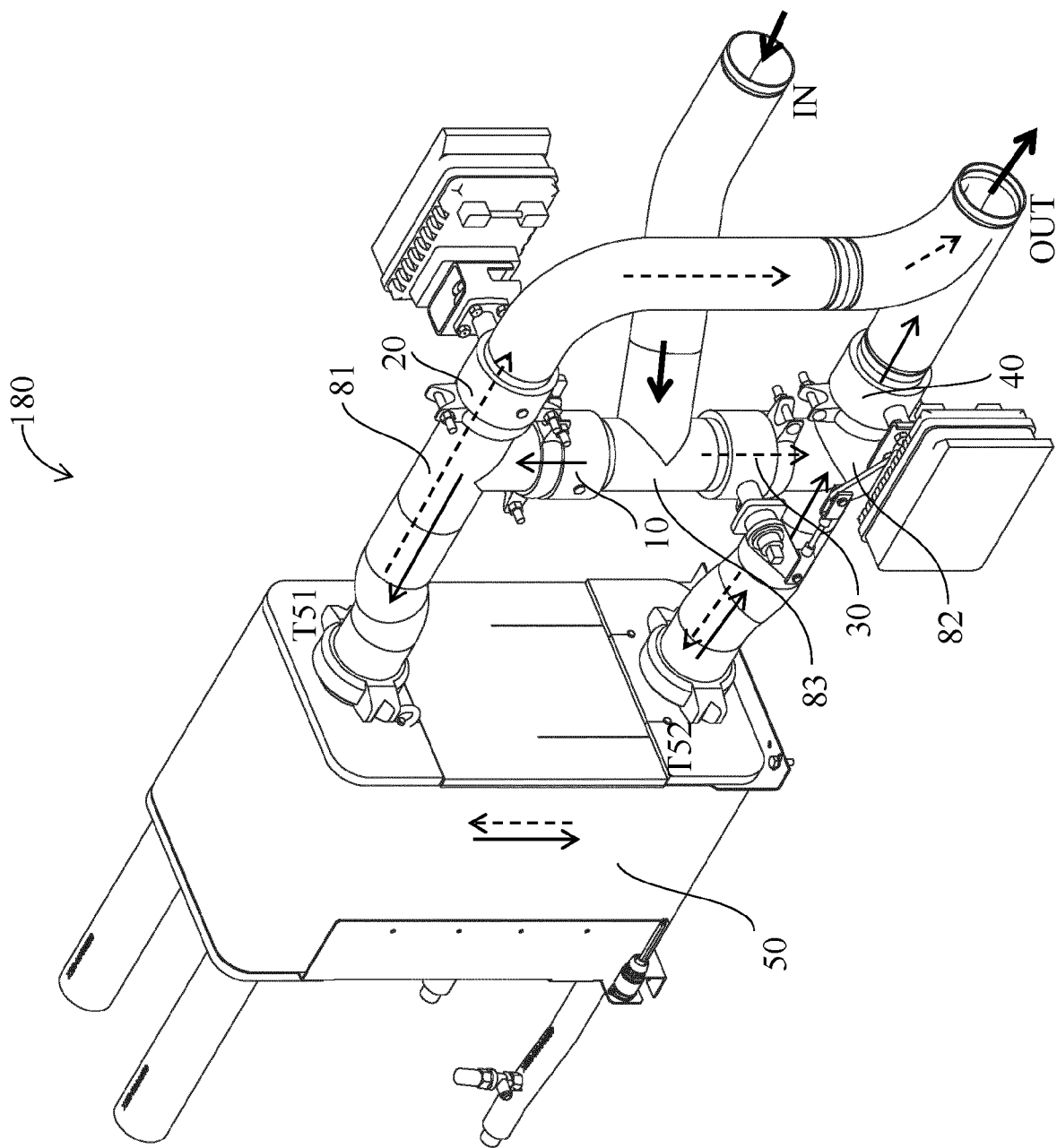


FIG. 10

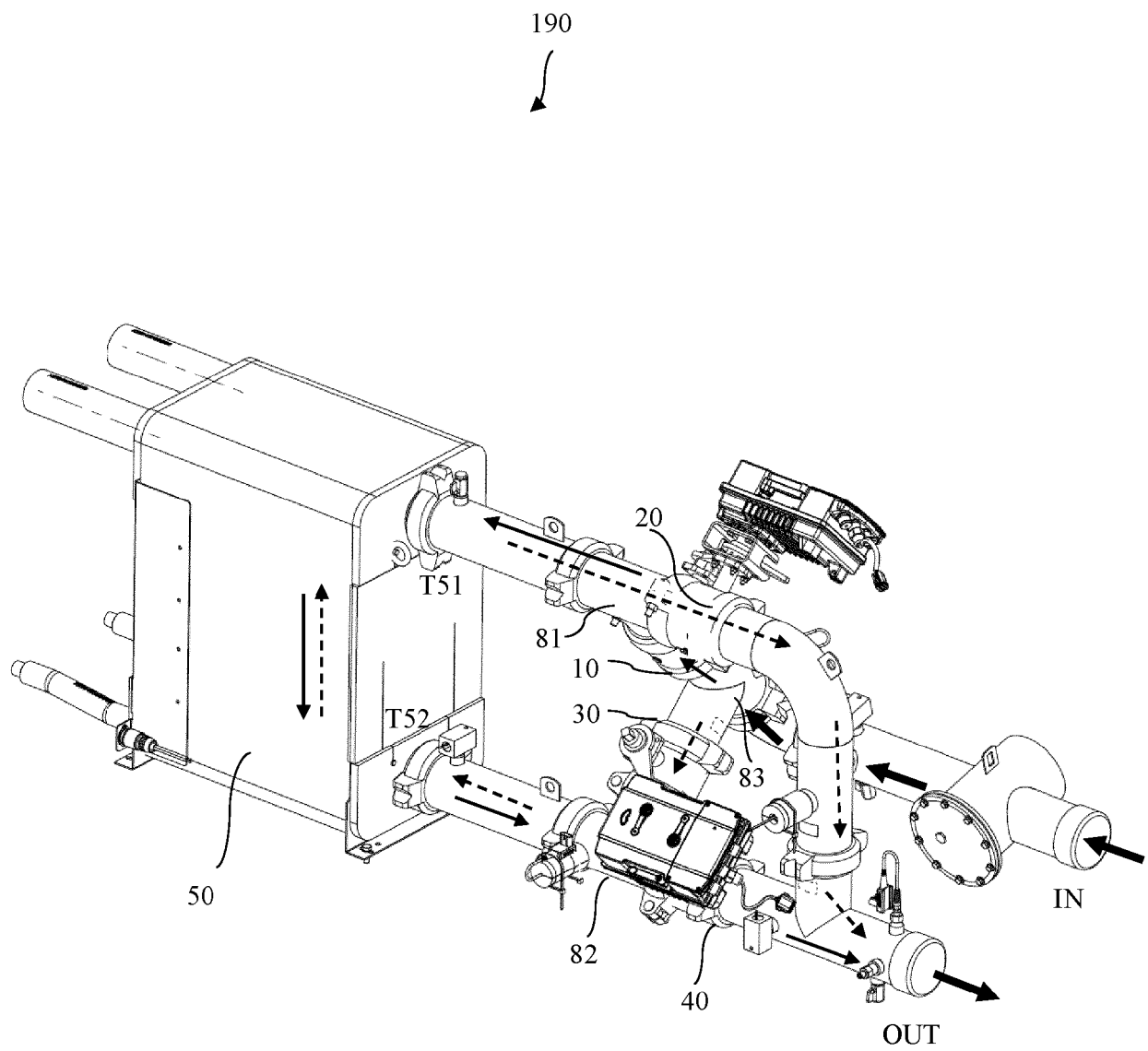


FIG. 11



EUROPEAN SEARCH REPORT

Application Number

EP 25 15 0049

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Place of search		Date of completion of the search	Examiner
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