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(54) COUNTER-CURRENT FLOW IN BOTH AC AND HP MODES FOR PART LOAD OPTIMIZATION

(57) An HVAC system (100) having an indoor heat exchanger (310) having a first refrigerant passage (110) extending in a first direction and a second refrigerant passage (210) extending in a second direction opposite from the first direction, a first refrigerant circuit (102) comprising a first compressor (104), a first expansion valve (106), a first outdoor heat exchanger (108), the first refrigerant passage (110), and a first reversing valve (112) operable to control a direction of first refrigerant (114) in the first refrigerant circuit (102), and a second refrigerant circuit (202) comprising a second compressor (204), a second expansion valve (206), a second outdoor heat exchanger (208), the second refrigerant passage (210), and a second reversing valve (212) operable to control a direction of second refrigerant (214) in the second refrigerant circuit (202).

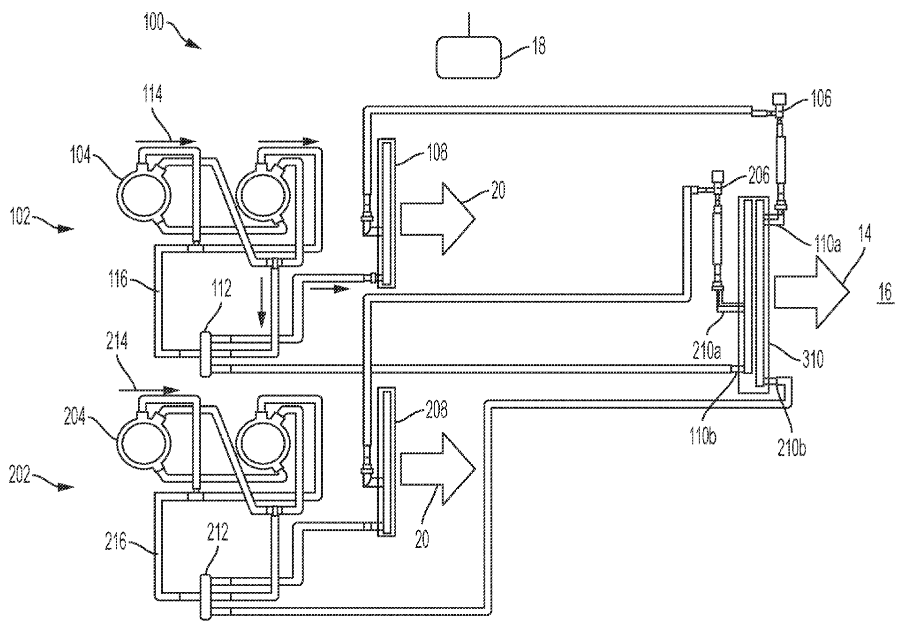

FIG. 1

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Description

TECHNICAL FIELD

[0001] This application relates generally to heating, ventilation, and air conditioning (HVAC) systems and more particularly, but not by way of limitation, to implementing, in a two or more thermodynamic circuit HVAC system, part load optimization and full load best compromise.

BACKGROUND

[0002] This section provides background information to facilitate a better understanding of the various aspects of the disclosure. It should be understood that the statements in this section of this document are to be read in this light, and not as admissions of prior art.

[0003] Thermodynamic vapor-compression systems are used to regulate environmental conditions within an enclosed space. Typically, such systems have a circulation fan that pulls air from the enclosed space through ducts and pushes the air back into the enclosed space through additional ducts after conditioning the air (*e.g.*, heating or cooling). A refrigerant may flow in a circuit between two heat exchangers, typically coils. One heat exchanger may be "inside" the structure (the "indoor heat exchanger" or "indoor coil") and the other heat exchanger may be outside the structure (the "outdoor heat exchanger" or "outdoor coil"). For heating, the refrigerant may absorb heat as it passes through the outdoor heat exchanger and release heat as it passes through the indoor heat exchanger. For air conditioning, the refrigerant may absorb heat as it passes through the indoor heat exchanger and release heat as it passes through the outdoor heat exchanger. Heat pumps can reverse the direction of refrigerant flow, to change between heating and air conditioning. A reversing valve typically controls the direction of refrigerant flow.

[0004] State-of-the-art HVAC rooftop systems utilize two thermodynamic circuits, each thermodynamic circuit has a dedicated outdoor coil and shares an indoor coil with the other thermodynamic circuit. These state-of-the-art systems are designed for highest efficiency in either the cooling, air-conditioning (AC), mode or heating, heat pump (HP), mode. The state-of-the-art HVAC systems do not accommodate a configuration where the highest level of efficiency is reached in part-load for both air-conditioning and heat pump modes. Part load working conditions may be the most important for regulations and impact rooftop efficiency.

SUMMARY

[0005] This summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not necessarily intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of claimed subject matter.

[0006] An exemplary HVAC system operable in a cooling (AC) mode and a heat pump (HP) mode, the HVAC system including an indoor heat exchanger having a first refrigerant passage extending in a first direction and a second refrigerant passage extending in a second direction opposite from the first direction, a first refrigerant circuit comprising a first compressor, a first expansion valve, a first outdoor heat exchanger, the first refrigerant passage, and a first reversing valve operable to control a direction of first refrigerant in the first refrigerant circuit, and a second refrigerant circuit comprising a second compressor, a second expansion valve, a second outdoor heat exchanger, the second refrigerant passage, and a second reversing valve operable to control a direction of second refrigerant in the second refrigerant circuit.

[0007] In an exemplary embodiment, the first refrigerant circuit is AC mode optimized whereby the first outdoor heat exchanger and the first refrigerant passage are counter-current flow in the AC mode and co-current flow in the HP mode, and the second refrigerant circuit is HP mode optimized whereby the second outdoor heat exchanger and the second refrigerant passage are counter-current flow in the HP mode and co-current flow in the AC mode.

[0008] An exemplary method includes operating an HVAC system in a cooling mode or a heating mode, the HVAC system including an indoor heat exchanger having a first refrigerant passage extending in a first direction and a second refrigerant passage extending in a second direction opposite from the first direction, wherein fresh air flows generally in the second direction across the indoor heat exchanger, a first refrigerant circuit comprising a first refrigerant, a first compressor, a first outdoor heat exchanger, and the first refrigerant passage, and a second refrigerant circuit comprising a second refrigerant, a second compressor, a second outdoor heat exchanger, and the second refrigerant passage. In an exemplary embodiment, the first refrigerant circuit is AC optimized whereby, in the AC mode, the first refrigerant is in counter-current flow in the first outdoor heat exchanger and the indoor heat exchanger, and the second refrigerant circuit is HP optimized whereby, in the HP mode, the second refrigerant is in counter-current flow in the second outdoor heat exchanger and the indoor heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The disclosure is best understood from the following detailed description when read with the accompanying figures. It is emphasized that, in accordance with standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of various features may be arbitrarily increased or reduced for clarity of discussion.

FIGURE 1 is a block diagram of an exemplary HVAC system that implements counter-current flow in both cooling and heating modes for part load optimization;

FIGURE 2 schematically illustrates a portion of an exemplary indoor heat exchanger implementing first and second refrigerant passages;

FIGURE 3 is a block diagram of an exemplary HVAC system operating in cooling mode part load;

FIGURE 4 is a block diagram of an exemplary HVAC system operating in cooling mode full load;

FIGURE 5 is a block diagram of an exemplary HVAC system operating in heating mode part load; and

FIGURE 6 is a block diagram of an exemplary HVAC system operating in heating mode full load.

DETAILED DESCRIPTION

[0010] Various embodiments will now be described more fully with reference to the accompanying drawings. The disclosure may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein.

[0011] Figure 1 is a schematic illustration of an exemplary HVAC system 100. HVAC system 100 is a vapor-compression system comprising a first refrigerant circuit 102 that can implement a thermodynamic heat recovery process in the cooling (AC) mode and the heating (HP) mode and a second refrigerant circuit 202 that can implement a thermodynamic heat recovery process in the cooling mode and the heating mode. HVAC system 100 may be implemented for example as a rooftop unit. One of the first refrigerant circuit and the second refrigerant circuit is optimized for the cooling mode and the other refrigerant circuit is optimized for the heating mode. The full load performance of system 100 is a compromise between an AC designed unit and a HP designed unit and the highest level of efficiency will be reached in part load. Part load working conditions are the most important for eco-design regulations and will impact rooftop seasonal efficiency (SEER, SCOP).

[0012] With additional reference to FIG. 2, HVAC system 100 includes an indoor heat exchanger 310 that has a first refrigerant passage 110 and a second refrigerant passage 210 that extend in opposite directions through indoor heat exchanger 310. Each first passage 110, represented by an arrow, has a first inlet 110a and a first outlet 110b and each second passage 210, represented by an arrow, has a second inlet 210a and a second outlet 210b. Refrigerant is illustrated passing, in the AC mode, through first passage 110 in a first direction 10 and through second passage 210 in a second direction 12 opposite the first direction. First and second directions 10, 12 are reversed in HP mode. Relative to the direction of airflow 14, e.g., blown air, across indoor heat exchanger, first direction 10 is counter-current flow in AC mode and second direction 12 is co-current flow in AC mode. Inlet and outlet are used to generically identify respective passage ports, for example when the circuits are in the AC mode, for ease and clarity of description.

[0013] First refrigerant circuit 102, e.g., conduit 116, includes a first compressor 104, a first expansion valve 106, a first outdoor heat exchanger 108, first passage 110 (FIG. 2) of indoor heat exchanger 310, and a first reversing valve 112 (e.g., 4-way valve) operable between a cooling mode to direct first refrigerant 114 in the direction from the first compressor to the first outdoor heat exchanger and then to the first passage of the indoor heat exchanger, and a heating mode to direct the first refrigerant in the direction from the first compressor to the first passage of the indoor heat exchanger and then to the first outdoor heat exchanger. In this example, first refrigerant circuit 102 is optimized for the AC mode, whereby first refrigerant 114 is in counter-current flow in first outdoor heat exchanger 108 and indoor heat exchanger 310 when in the AC mode, and first refrigerant 114 is in co-current flow in first outdoor heat exchanger 108 and indoor heat exchanger 310 when in the HP mode.

[0014] Second refrigerant circuit 202, e.g., conduit 216, includes a second compressor 204, a second expansion valve 206, a second outdoor heat exchanger 208, second passage 210 (FIG. 2) of indoor heat exchanger 310, and a second reversing valve 212 (e.g., 4-way valve) operable between a cooling mode to direct second refrigerant 214 in the direction from the second compressor to the second outdoor heat exchanger and then to the second passage of the indoor heat exchanger, and a heating mode to direct the second refrigerant in the direction from the second compressor to the second passage of the indoor heat exchanger and then to the second outdoor heat exchanger. In this example, second refrigerant circuit 202 is optimized for the HP mode, whereby second refrigerant 214 is in counter-current flow in second outdoor heat exchanger 208 and indoor heat exchanger 310 when in the HP mode, and second refrigerant 214 is in co-current flow in second outdoor heat exchanger 208 and indoor heat exchanger 310 when in the AC mode.

[0015] Indoor heat exchanger 310 may be positioned in a fresh air inlet, e.g., duct, to the conditioned space 16, e.g., enclosure). An electronic controller 18 comprising computer-readable storage medium may be in communication for example with the compressors, reversing valves, dampers, blowers, and various valves to operate the HVAC system in various modes including without limitation, a cooling part load, a cooling full load, a heating part load, and a heating full load mode. For example, in the AC mode refrigerant passes through the refrigerant passage from the inlet to the outlet and the refrigerant flow is reversed in the HP mode to flow through the refrigerant passage from the outlet to the inlet.

[0016] Figure 3 illustrates HVAC system 100 operating in AC mode part load, for example during warm moderate ambient temperatures. First refrigerant circuit 102, which is AC optimized, is operated in AC mode and second refrigerant circuit 202, which is HP optimized, is not operated. One or more of first compressors 104 of first refrigerant circuit 102 are operated. First refrigerant 114 flows from one or more first compressors 104 to first reversing valve 112 and then first outdoor heat exchanger 108. First refrigerant 114 is in counter-current flow in first outdoor heat exchanger 108, passing in the opposite direction of ambient airflow 20. First refrigerant 114 flows from first outdoor heat exchanger 108 through first expansion valve 106 to inlets 110a of first passage 110 (FIG. 2) of indoor heat exchanger 310. First refrigerant 114 is in counter-current flow in indoor heat exchanger 310, flowing in the opposite direction of airflow 14. First refrigerant 114 exists outlets 110b and returns to compressors 104.

[0017] Figure 4 illustrates HVAC system 100 operating in AC mode full load, for example during hot ambient temperatures. In AC mode full load, first refrigerant circuit 102 and second refrigerant circuit 202 are operated in AC mode. First refrigerant circuit 102, which is AC optimized, operates as illustrated in Figure 3, with first refrigerant 114 in counter-current flow in first outdoor heat exchanger 108 and indoor heat exchanger 310. In AC mode, second refrigerant circuit 202 is in co-current flow through second outdoor heat exchanger 208 and indoor heat exchanger 310. Second refrigerant 214 flows from one or more of second compressors 204 through reversing valve 212 to second outdoor heat exchanger 208. Second refrigerant 214 is in co-current flow in second outdoor heat exchanger 208, passing in the same direction as ambient airflow 20. Second refrigerant 214 flows from second outdoor heat exchanger 208 through expansion valve 206 to inlets 210a of second passage 210 (FIG. 2) of indoor heat exchanger 310. Second refrigerant 214 is in co-current flow in indoor heat exchanger 310, flowing in the same direction as airflow 14.

[0018] Figure 5 illustrates HVAC system 100 operating in HP mode part load, for example during cool moderate ambient temperatures. Second refrigerant circuit 202, which is HP optimized, is operated in HP mode and first refrigerant circuit 102, which is AC optimized, is not operated. Second refrigerant 214 flows from one or more of second compressors 204 through reversing valve 212 to outlets 201b of second passage 210 (FIG. 2) of indoor heat exchanger 310. Second refrigerant 214 is in counter-current flow in indoor heat exchanger 310, flowing in the opposite direction as airflow 14. Second refrigerant 214 exits inlets 210a and flows through second outdoor heat exchanger 208 and returns to second compressors 204. Second refrigerant 214 is in counter-current flow in second outdoor heat exchanger 208, flowing in the opposite direction of ambient airflow 20.

[0019] Figure 6 illustrates HVAC system 100 operating in HP mode full load, for example during cold ambient temperatures. In HP mode full load, first refrigerant circuit 102 and second refrigerant circuit 202 are operated in HP mode. Second refrigerant circuit 202 operates as illustrated in Figure 5, with second refrigerant 214 in counter-current flow in second outdoor heat exchanger 208 and indoor heat exchanger 310. First refrigerant circuit 102 is operated in HP mode, directing first refrigerant 114 from first compressors 104 to outlet 110b of first passage 110 (FIG. 2) of indoor heat exchanger 310. First refrigerant 114 is in co-current flow in indoor heat exchanger 310, flowing it the same direction as airflow 14. First refrigerant 114 exits inlets 110a and flows through first expansion valve 106 and then first outdoor heat exchanger 108. First refrigerant 114 is in co-current flow through first outdoor heat exchanger 108, flowing in the same direction as ambient airflow 20.

[0020] The state-of-the-art HVAC systems do not accommodate counter-current flow in the indoor heat exchanger in the AC mode and in the HP mode. State-of-the-art HVAC systems are designed: 1) Full AC Optimized (CCF AC Mode) with counter-current flow (CCF) in the AC mode in the indoor coil and the outdoor coils, and co-current flow in the HP mode in the indoor coil and the outdoor coils; 2) AC Oriented (In CCF AC/Out CCF HP) with CCF in indoor coil in the AC mode and CCF in the outdoor coils in HP mode; 3) HP Oriented (In CCF HP/Out CCF AC) with CCF in the indoor coil in the HP mode and CCF in the outdoor coils in the AC mode; and 4) Full HP Optimized (CCF HP Mode) with CCF in the HP mode in the indoor coil and the outdoor coils and co-current flow in the HP mode in the indoor coil and the outdoor coils. Calculated efficiency of HVAC system 100 has identified unexpected improvements over the state-of-the-art HVAC systems in particular in the important seasonal energy efficiency ratio (SEER) and the seasonal coefficient of performance (SCOP), as illustrated in Tables 1 and 2 below.

[0021] Table 1 tabulates calculated European cooling capacity at full load and the seasonal energy efficiency ratio (SEER) calculated by combining full and part load operating energy efficiency ratios for different ambient temperatures, for an exemplary HVAC system 100 and state-of-the-art HVAC systems.

TABLE 1 (AC Mode)			
HVAC System	**Optimization**	**Eur. Cool Cap. (Kw)**	**SEER**
CCF AC MODE	Full AC Optimized	110.0	171.9
In CCF AC/ Out CCF HP	AC Oriented	109.7	168.9
In CCF HP/Out CCF AC	HP Oriented	107.8	169.3
CCF HP MODE	Full HP Optimized	107.6	166.7
HVAC System 100	Part Load Optimized	108.8	**171.2**

[0022] Table 1 illustrates that HVAC system 100 shows the best compromise for operating in the cooling mode. The SEER of 171.2 for HVAC system 100 is substantially equivalent to the state-of-the-art full AC optimized system (CCF AC Mode) and is an improvement over the AC oriented, HP oriented, and Full HP optimized other state-of-the-art systems.

[0023] Table 2 tabulates calculated European heating capacity at full load and the seasonal coefficient of performance (SCOP) ratio calculated by combining full and part load efficiency ratios for different ambient temperatures, for an exemplary HVAC system 100 and state-of-the-art HVAC systems.

TABLE 2 (HP Mode)			
HVAC System	**Optimization**	**Eur. Heat Cap. (kW)**	**SCOP**
CCF AC MODE	Full AC Optimized	104.2	117.5
In CCF AC/ Out CCF HP	AC Oriented	104.3	118.0
In CCF HP/Out CCF AC	HP Oriented	106.8	128.1
CCF HP MODE	Full HP Optimized	107.4	128.5
HVAC System 100	Part Load Optimized	105.8	126.3

[0024] Table 2 illustrates that HVAC system 100 shows the best compromise for operating in the heating mode. The SCOP of 126.3 for HVAC system 100 is in the range of the Full HP optimized and the HP oriented state-of-the-art systems and a significant improvement over the full AC optimized and AC oriented state-of-the-art systems.

[0025] Accordingly, HVAC system 100 is indicative of a full load best compromise providing substantially similar seasonal efficiency as the full AC optimized prior art systems in cooling mode and competitive seasonal performance relative to the full HP optimized prior art systems in the heating mode. HVAC system 100 also greater seasonal efficiency than the AC oriented and the HP oriented prior art systems in both the cooling and the heating mode.

[0026] The term "substantially" is defined as largely but not necessarily wholly what is specified (and includes what is specified; e.g., substantially 90 degrees includes 90 degrees and substantially parallel includes parallel), as understood by a person of ordinary skill in the art. In any disclosed embodiment, the terms "substantially," "approximately," "generally," and "about" may vary from the stated value, for example, by 0.1, 0.5, 1, 2, 3, 4, 5, 10, or 15 percent understood by a person of ordinary skill in the art.

[0027] For purposes of this disclosure, the term computer-readable storage medium encompasses one or more tangible computer-readable storage media possessing structures. As an example and not by way of limitation, a computer-readable storage medium may include a semiconductor-based or other integrated circuit (IC) (such as, for example, a field-programmable gate array (FPGA) or an application-specific IC (ASIC), a hard disk, an HDD, a hybrid hard drive (HHD), an optical disc, an optical disc drive (ODD), a magneto-optical disc, a magneto-optical drive, a floppy disk, a floppy disk drive (FDD), magnetic tape, a holographic storage medium, a solid-state drive (SSD), a RAM-drive, a SECURE DIGITAL card, a SECURE DIGITAL drive, a flash memory card, a flash memory drive, or any other suitable tangible computer-readable storage medium or a combination of two or more of these, where appropriate.

[0028] Particular embodiments may include one or more computer-readable storage media implementing any suitable storage. In particular embodiments, a computer-readable storage medium implements one or more portions of a controller as appropriate. In particular embodiments, a computer-readable storage medium implements RAM or ROM. In particular embodiments, a computer-readable storage medium implements volatile or persistent memory. In particular embodiments, one or more computer-readable storage media embody encoded software.

[0029] In this patent application, reference to encoded software may encompass one or more applications, bytecode, one or more computer programs, one or more executables, one or more instructions, logic, machine code, one or more scripts, or source code, and vice versa, where appropriate, that have been stored or encoded in a computer-readable storage medium. In particular embodiments, encoded software includes one or more application programming interfaces (APIs) stored or encoded in a computer-readable storage medium. Particular embodiments may use any suitable encoded software written or otherwise expressed in any suitable programming language or combination of programming languages stored or encoded in any suitable type or number of computer-readable storage media. In particular embodiments, encoded software may be expressed as source code or object code. In particular embodiments, encoded software is expressed in a higher-level programming language, such as, for example, C, Python, Java, or a suitable extension thereof. In particular embodiments, encoded software is expressed in a lower-level programming language, such as assembly language (or machine code). In particular embodiments, encoded software is expressed in JAVA. In particular embodiments, encoded software is expressed in Hyper Text Markup Language (HTML), Extensible Markup Language (XML), or other suitable markup language.

[0030] Depending on the embodiment, certain acts, events, or functions of any of the algorithms described herein can be performed in a different sequence, can be added, merged, or left out altogether (e.g., not all described acts or events are necessary for the practice of the algorithms). Moreover, in certain embodiments, acts or events can be performed concurrently, *e.g.*, through multi-threaded processing, interrupt processing, or multiple processors or processor cores or on other parallel architectures, rather than sequentially. Although certain computer-implemented tasks are described as being performed by a particular entity, other embodiments are possible in which these tasks are performed by a different entity.

[0031] Conditional language used herein, such as, among others, "can," "might," "may," "e.g.," and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or states. Thus, such conditional language is not generally intended to imply that features, elements and/or states are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without author input or prompting, whether these features, elements and/or states are included or are to be performed in any particular embodiment.

[0032] While the above detailed description has shown, described, and pointed out novel features as applied to various embodiments, it will be understood that various omissions, substitutions, and changes in the form and details of the devices or algorithms illustrated can be made without departing from the spirit of the disclosure. As will be recognized, the processes described herein can be embodied within a form that does not provide all of the features and benefits set forth herein, as some features can be used or practiced separately from others. The scope of protection is defined by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

Claims

1. A heating, ventilation, and air conditioning, HVAC, system (100) operable in a cooling, AC, mode and a heat pump, HP, mode, the HVAC system (100) comprising:

   an indoor heat exchanger (310) having a first refrigerant passage (110) extending in a first direction and a second refrigerant passage (210) extending in a second direction opposite from the first direction;
   a first refrigerant circuit (102) comprising a first compressor (104), a first expansion valve (106), a first outdoor heat exchanger (108), the first refrigerant passage (110), and a first reversing valve (112) operable to control a direction of first refrigerant in the first refrigerant circuit (102); and
   a second refrigerant circuit (202) comprising a second compressor (204), a second expansion valve (206), a second outdoor heat exchanger (208), the second refrigerant passage (210), and a second reversing valve (212) operable to control a direction of second refrigerant in the second refrigerant circuit (202).

2. The HVAC system (100) of claim 1, wherein in the AC mode the first direction is a counter-current flow relative to an intended direction of air flow across the indoor heat exchanger (310).

3. The HVAC system (100) of claim 1 or claim 2, wherein the first refrigerant circuit (102) is configured to be AC mode optimized and the second refrigerant circuit (202) is configured to be HP mode optimized.

4. The HVAC system (100) of any one of claims 1 to 3, wherein in the AC mode:

   the first refrigerant circuit (102) is configured with the first refrigerant passage (110) in counter-current flow; and
   the second refrigerant circuit (202) is configured with the second refrigerant passage (210) in co-current flow.

5. The HVAC system (100) of claim 4, wherein in the HP mode the first refrigerant circuit (102) is configured with the first refrigerant passage (110) in co-current flow and the second refrigerant circuit (202) is configured with the second refrigerant passage (210) in counter-current flow.

6. The HVAC system (100) of any one of claims 1 to 5, wherein in the AC mode:

the first refrigerant circuit (102) is configured with the first outdoor heat exchanger (310) and the first refrigerant passage (110) in counter-current flow; and
the second refrigerant circuit (202) is configured with the second outdoor heat exchanger (208) and the second refrigerant passage (210) in co-current flow.

7. A heating and/or cooling method, the method comprising:
operating a heating, ventilation, and air conditioning, HVAC, system (100) in a cooling, AC, mode or a heating, HP, mode, the HVAC system (100) comprising:

an indoor heat exchanger (310) having a first refrigerant passage (110) extending in a first direction and a second refrigerant passage (210) extending in a second direction opposite from the first direction, wherein fresh air flows generally in the second direction across the indoor heat exchanger (310);
a first refrigerant circuit (102) comprising a first refrigerant (114), a first compressor (104), a first outdoor heat exchanger (108), and the first refrigerant passage (110); and
a second refrigerant circuit (202) comprising a second refrigerant (214), a second compressor (204), a second outdoor heat exchanger (208), and the second refrigerant passage (210).

8. The method of claim 7, wherein operating in the AC mode comprises directing the first refrigerant (114) in a direction from the first compressor (104) through the first outdoor heat exchanger (108) and then the first refrigerant passage (110), wherein the first refrigerant (114) is in counter-current flow through the first outdoor heat exchanger (108) and the first refrigerant passage (110), the method optionally further comprising only operating the first refrigeration circuit (110).

9. The method of claim 7 or claim 8, wherein operating in the AC mode comprises:

directing the first refrigerant in a direction from the first compressor (104) through the first outdoor heat exchanger (108) and then the first refrigerant passage (110), wherein the first refrigerant (114) is in counter-current flow through the first outdoor heat exchanger (108) and the first refrigerant passage (110); and
directing the second refrigerant (214) in a direction from the second compressor (204) through the second outdoor heat exchanger (208) and then the second refrigerant passage (210), wherein the second refrigerant (214) is in co-current flow in the second outdoor heat exchanger (208) and in the second refrigerant passage (210).

10. The method of any one of claims 7 to 9, wherein operating in the HP mode comprises:
directing the second refrigerant (214) in a direction from the second compressor (204) through the second refrigerant passage (210) and then the second outdoor heat exchanger (208), wherein the second refrigerant (214) is in counter-current flow in the second outdoor heat exchanger (208) and in the second refrigerant passage (210), the method optionally further comprising only operating the second refrigeration circuit (202).

11. The method of any one of claims 7 to 10, wherein operating in the HP mode comprises:

directing the second refrigerant (214) in a direction from the second compressor (204) through the second refrigerant passage (210) and then the second outdoor heat exchanger (208), wherein the second refrigerant (214) is in counter-current flow in the second outdoor heat exchanger (208) and in the second refrigerant passage (210); and
directing the first refrigerant (114) in a direction from the first compressor (104) through the first refrigerant passage (110) and then the first outdoor heat exchanger (108), wherein the first refrigerant (114) is in co-current flow in the first outdoor heat exchanger (108) and in the first refrigerant passage (110).

12. The HVAC system (100) or method of any preceding claim, wherein the first compressor (104) comprises one or more first compressors (104) and the second compressor (204) comprises one or more second compressors (204).

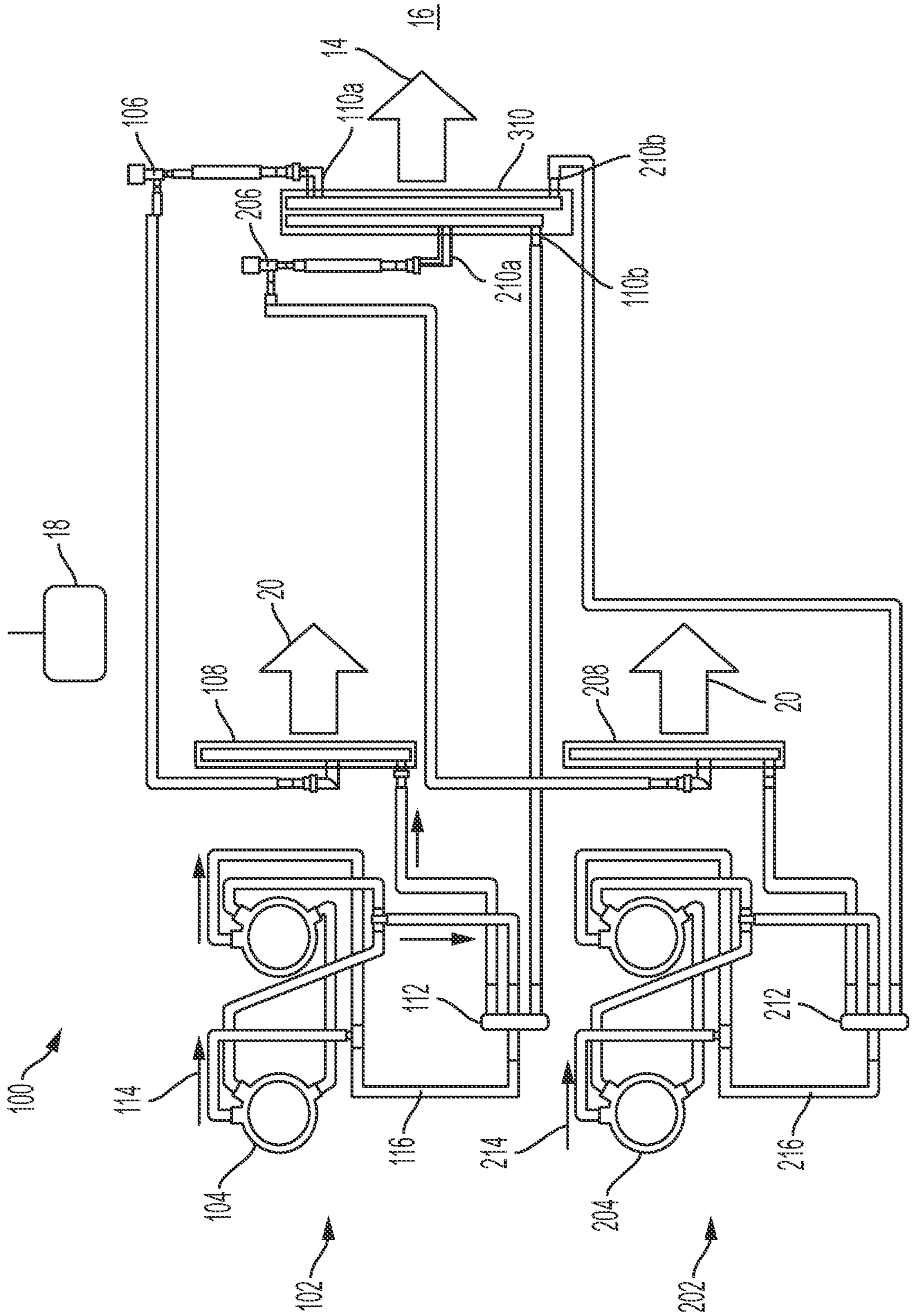
13. The HVAC system (100) or method of any preceding claim, wherein the HVAC system (100) is a rooftop unit.

14. The method of claim 13, wherein operating in the AC mode comprises:

directing the first refrigerant (114) in a direction from the first compressor (104) through the first outdoor heat exchanger (108) and then the first refrigerant passage (110), wherein the first refrigerant (114) is in counter-current flow through the first outdoor heat exchanger (108) and the first refrigerant passage (110); and
directing the second refrigerant (214) in a direction from the second compressor (204) through the second outdoor heat exchanger (208) and then the second refrigerant passage (210), wherein the second refrigerant (214) is in co-current flow in the second outdoor heat exchanger (208) and in the second refrigerant passage (210).

15. The method of claim 14, wherein operating in the HP mode comprises:

directing the second refrigerant (214) in a direction from the second compressor (204) through the second refrigerant passage (210) and then the second outdoor heat exchanger (208), wherein the second refrigerant (214) is in counter-current flow in the second outdoor heat exchanger (208) and in the second refrigerant passage (210); and
directing the first refrigerant (114) in a direction from the first compressor (104) through the first refrigerant passage (110) and then the first outdoor heat exchanger (108), wherein the first refrigerant (114) is in co-current flow in the first outdoor heat exchanger (108) and in the first refrigerant passage (110).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14
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110a
310
210b
206
210a
110b
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208
20
100
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204
216
212
102
202

FIG. 1

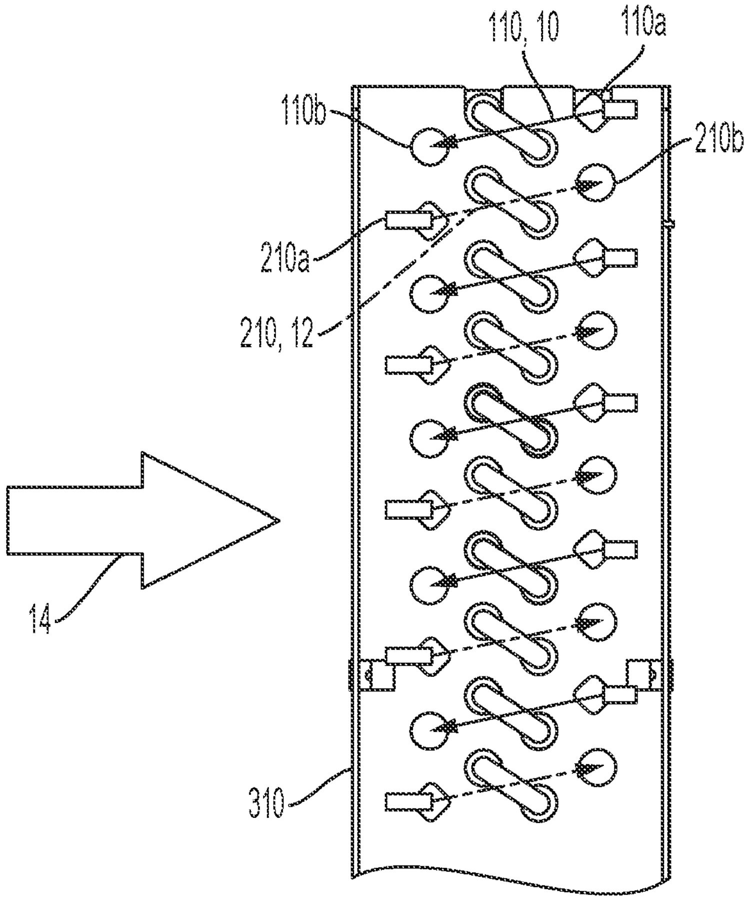

FIG. 2

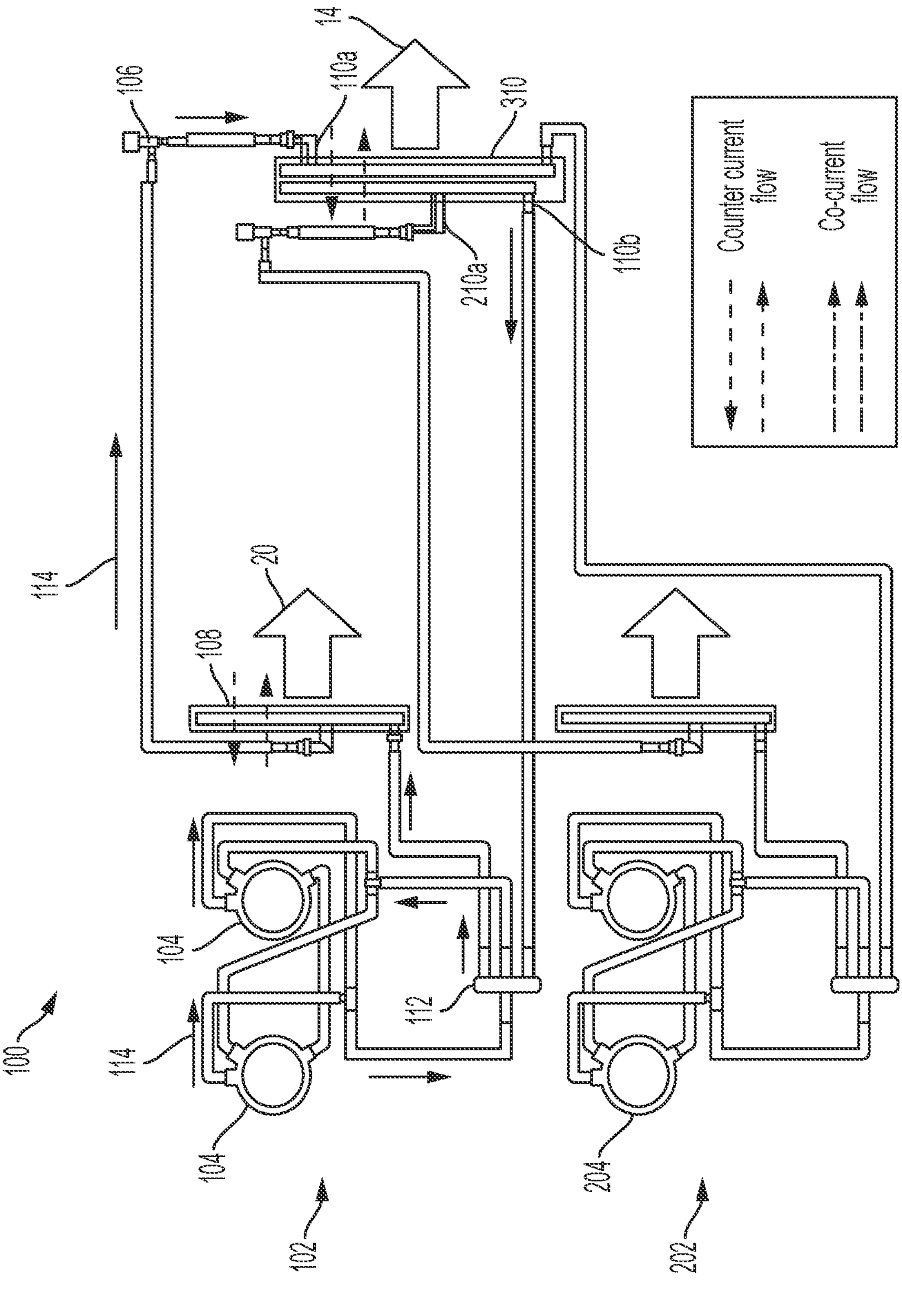
106
14
110a
310
210a
110b
Counter current flow
Co-current flow
114
20
108
100
104
104
114
112
102
204
202

FIG. 3

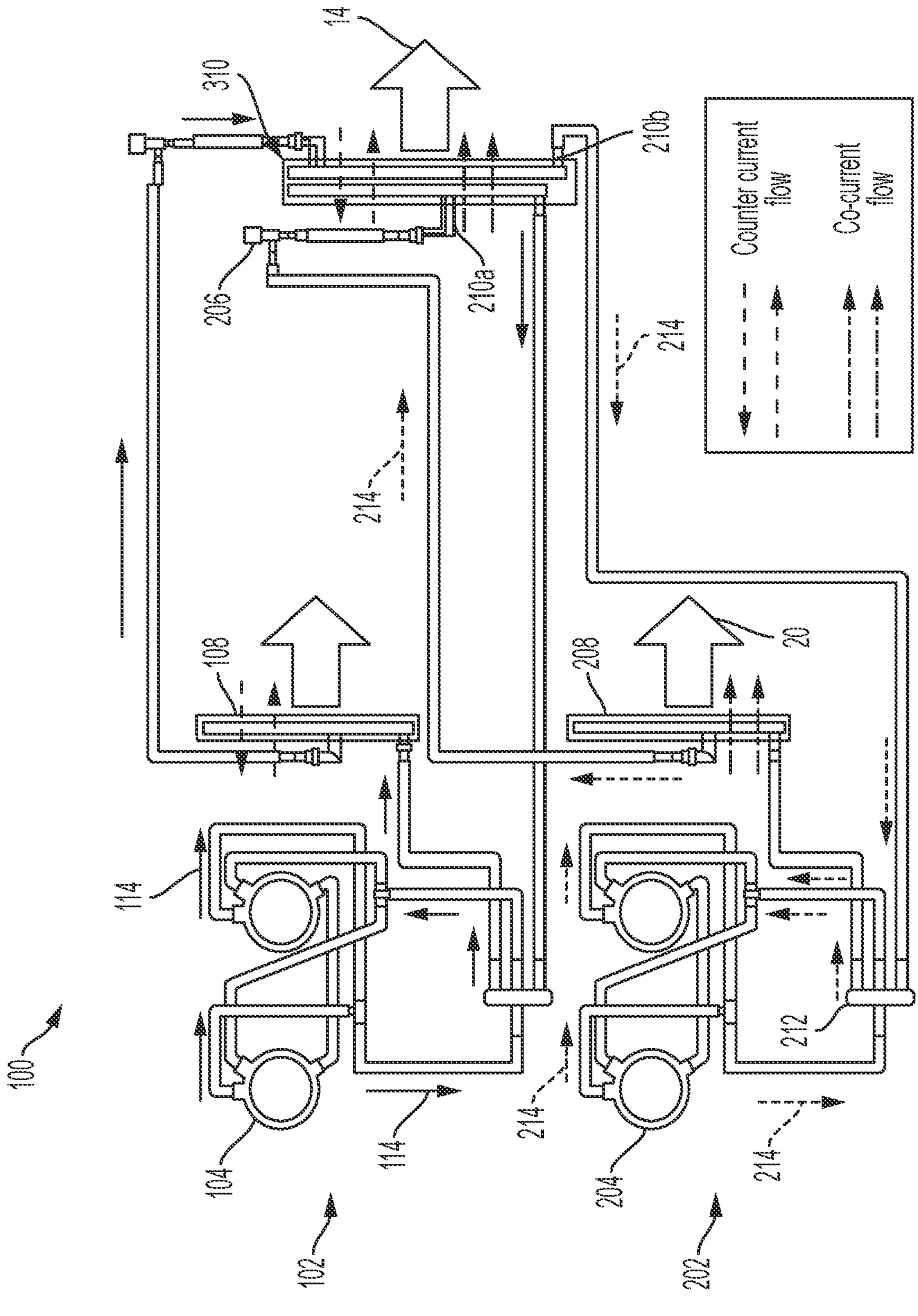
100
102
104
114
114
108
206
310
14
210a
210b
214
214
214
214
214
202
204
208
212
20
Counter current flow
Co-current flow

FIG. 4

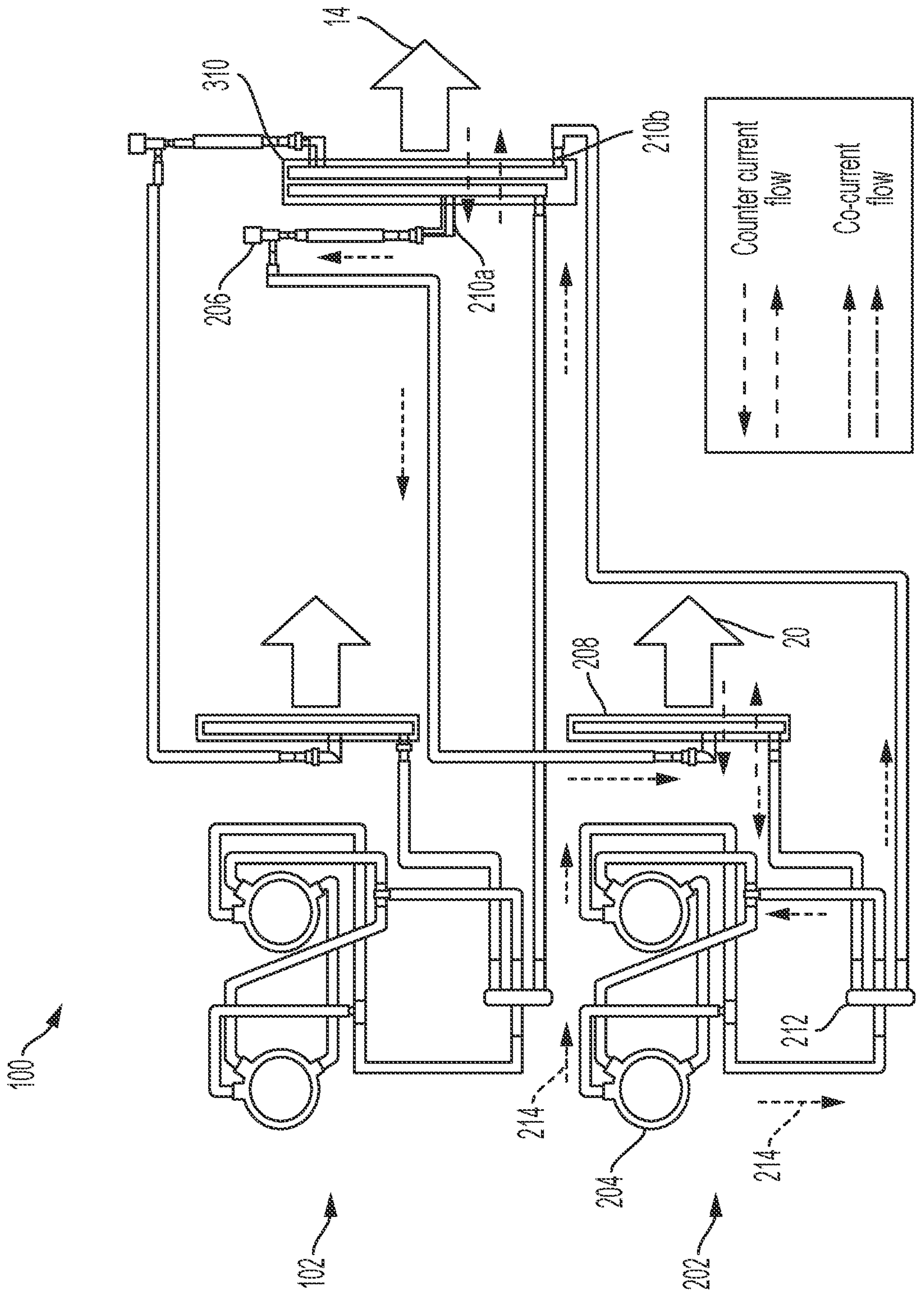
100
102
202
204
206
208
210a
210b
212
214
214
310
14
20
Counter current flow
Co-current flow

FIG. 5

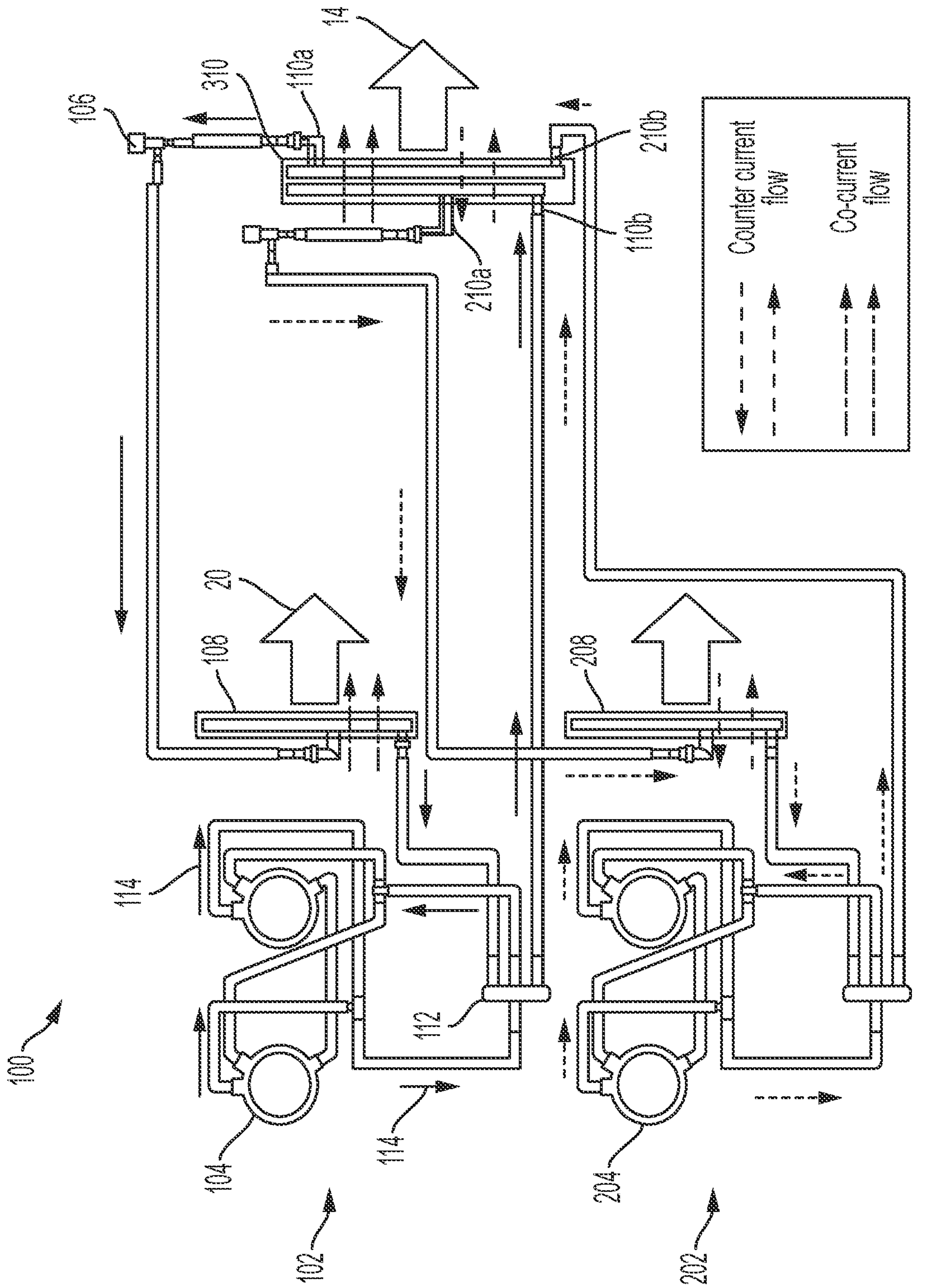
106
310
110a
14
210b
110b
210a
Counter current flow
Co-current flow
20
108
208
114
100
112
114
104
204
102
202

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 22 17 5454

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Place of search	Date of completion of the search	Examiner
Munich	10 October 2022	Szilagyi, Barnabas

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