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(54) REFRIGERANT FLOW MANAGEMENT FOR MODULATING REHEAT SYSTEM

(57) A heating, ventilation, and air conditioning (HVAC) system includes a housing, a plurality of compressors, a condenser, a reheater, and an evaporator arranged in fluid communication. The condenser and the reheater are arranged in parallel and the plurality of compressors are arranged in parallel. A fluid management system is operable to actively manage a flow of a fluid within the HVAC system provided to the reheater.

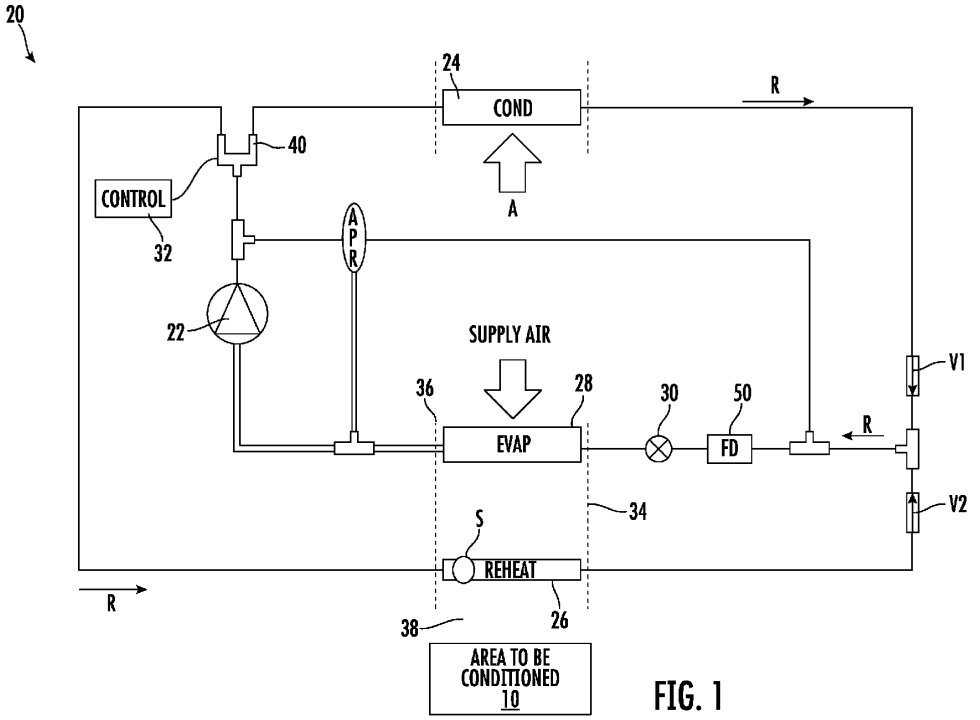

FIG. 1

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Description

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/495,361 filed on April 11, 2023, which is incorporated by reference herein in its entirety.

[0002] Exemplary embodiments of the present disclosure generally pertain to a dedicated outdoor air system (DOAS), and more particularly, to a system and method for controlling a fluid flow through a DOAS.

[0003] As a result of the increasing need for fresh air in buildings, the demand for a heating, ventilation, and air conditioning system that can handle and condition solely outdoor air has increased. However, a system that uses only outdoor air typically has challenges associated with managing the flow of refrigerant therein.

[0004] According to a first aspect of the invention, there is provided a heating, ventilation, and air conditioning (HVAC) system including a housing, a plurality of compressors, a condenser, a reheater, and an evaporator arranged in fluid communication. The condenser and the reheater are arranged in parallel and the plurality of compressors are arranged in parallel. A fluid management system is operable to actively manage a flow of a fluid within the HVAC system provided to the reheater.

[0005] Optionally, the HVAC system comprises a filter drier arranged downstream from and in fluid communication with the condenser and the reheater, the filter drier being arranged within the housing.

[0006] Optionally, the plurality of compressors includes a first compressor and a second compressor, the first compressor having a first capacity and the second compressor having a second capacity different from the first capacity.

[0007] Optionally, the housing includes an access panel and the filter drier is positioned adjacent to the access panel.

[0008] Optionally, the fluid management system further comprises a modulating valve movable to direct the fluid output from the plurality of compressors to at least one of the condenser and the reheater.

[0009] Optionally, the HVAC system further comprises a plurality of flow loops, and the fluid management system is operable to control a portion of the fluid provided to each of the plurality of flow loops.

[0010] Optionally, the plurality of flow loops includes a first fluid loop and a second fluid loop, the condenser being arranged within the first fluid loop and the reheater being arranged within the second fluid loop.

[0011] Optionally, the fluid management system further comprises a first valve arranged within the first fluid loop downstream from the condenser, the first valve being configured to allow the fluid to flow in only a first direction; and a second valve arranged within the second fluid loop downstream from the reheater, the second valve being configured to allow the fluid to flow in only a second direction.

[0012] Optionally, at least one of the first valve and the second valve is passive.

[0013] Optionally, at least one of the first valve and the second valve is a check valve.

[0014] Optionally, the system further comprises a controller and at least one of the first valve and the second valve is actively controlled by the controller.

[0015] Optionally, the fluid management system further comprises a controller operably coupled to at least one sensor, the controller being configured to operable to actively manage the flow of fluid through the HVAC system in response to the at least one sensor.

[0016] Optionally, the at least one sensor is associated with the reheater.

[0017] Optionally, the at least one sensor is configured to monitor a temperature of a flow of supply air at or downstream from the reheater.

[0018] According to a second aspect of the invention, there is provided a method of operating a heating, ventilation, and air conditioning (HVAC) system including providing a heating, ventilation, and air conditioning (HVAC) system including a plurality of compressors, an evaporator, a condenser, and a reheater, the plurality of compressors being arranged in parallel and the condenser and the reheater being arranged in parallel to define a plurality of fluid flow loops, receiving information about at least one parameter of the HVAC system, selecting at least one of the plurality of compressors in response to the information about the at least one parameter of the HVAC system, determining a position of a modulating valve of a refrigerant management system of the HVAC system in response to the information about the at least one parameter of the HVAC system, and moving the modulating valve to the determined position to control a fluid flow through the plurality of fluid flow loops.

[0019] Optionally, the information about the at least one parameter of the HVAC system is collected by a sensor.

[0020] Optionally, the sensor is operable to monitor a temperature of a supply air output from the reheater.

[0021] Optionally, the at least one parameter of the HVAC system includes an operational mode of the HVAC system.

[0022] Optionally, the at least one parameter of the HVAC system includes an on/off status of the HVAC system.

[0023] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments the plurality of fluid flow loops includes a first fluid loop and a second fluid loop, the method further comprising: blocking a fluid within the second fluid loop from entering the first fluid loop via a first valve and blocking a fluid within the first fluid loop from entering the second fluid loop via a second valve.

[0024] The method according to the second aspect of the invention may comprise providing and/or using the system according to the first aspect of the invention, and may comprise providing and/or using any of the features of the system described herein. The system according

to the first aspect of the invention may be configured to perform the method according to the second aspect of the invention, and may be configured to perform any of the features of the method described herein.

[0025] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

FIG. 1 is a schematic diagram of a heating, ventilation, and air conditioning (HVAC) system according to an embodiment;

FIG. 2 is a schematic diagram of another HVAC system according to an embodiment; and

FIG. 3 is a perspective view of a filter drier of a HVAC system according to an embodiment.

[0026] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0027] Referring now to the Figures, an improved heating, ventilation, and air conditioning (HVAC) system 20 is illustrated. In an embodiment, the system 20 is a dedicated outdoor air system (DOAS). The system 20 is configured to partly or fully condition a flow of air supplied to an area to be conditioned 10, such as one or more rooms within a building for example.

[0028] In the illustrated, non-limiting embodiment of FIG. 1, the system 20 includes a compressor 22, a first heat exchanger 24, a second heat exchanger 26, a thermal expansion device 30, and a third heat exchanger 28. In an embodiment, the first and second heat exchangers 24, 26 are configured as condensers (also referred to herein as a condenser and reheater, respectively) within which heat is rejected from a fluid, such as refrigerant R for example, circulating through the system 20. The third heat exchanger 28 may be configured as an evaporator within which heat is absorbed by the fluid R circulating through the system 20. The third heat exchanger 28 may be arranged directly upstream from an inlet of the compressor 22.

[0029] With reference now to FIG. 2, in an embodiment, the system 20 includes a plurality of compressors arranged in parallel downstream from the outlet of the third heat exchanger 28. In the illustrated, non-limiting embodiment, the plurality of compressors includes a first compressor 22a and a second compressor 22b. However, embodiments having any number of compressors, such as more than two compressors for example, are also contemplated herein. To optimize the functionality of the system 20, the capacity of the first compressor 22a may be different than the capacity of the second compressor 22b. By providing two compressors 22a, 22b with different capacities, the fluid R output from the third heat exchanger 28 may be configured to flow entirely through the first compressor 22a, entirely through the second compressor 22b, or through both the first and second compressor 22a, 22b simultaneously.

[0030] With continued reference to FIGS. 1 and 2, as shown, the first heat exchanger 24 and the second heat exchanger 26 are arranged in parallel downstream from the one or more compressor outlets. As a result, the system 20 has two distinct fluid loops through which the refrigerant R may be configured to circulate. At least one compressor 22, the first heat exchanger 24, the expansion device 30, and the third heat exchanger 28 cooperate to define a first fluid loop. Similarly, the at least one compressor 22, the second heat exchanger 26, the expansion device 30, and the third heat exchanger 28 may similarly cooperate to define a second fluid loop. As will be described in more detail below, during operation of the system 20, the fluid circulating within the system 20 may be configured to flow through the first fluid loop, the second fluid loop, or simultaneously through the first and second fluid loops.

[0031] In an embodiment, a first flow control valve V1 is arranged downstream from the first heat exchanger 24 and upstream from the third heat exchanger 28 and the intersection between the first and second fluid loops. Similarly, a second flow control valve V2 may be arranged downstream from the second heat exchanger 26 and upstream from the third heat exchanger 28 and the intersection between the first and second fluid loops. The first flow control valve V1 is configured to prevent the fluid output from the second heat exchanger 26 from flowing into the first fluid loop, towards the first heat exchanger 24 and the second flow control valve V2 is operable to prevent the fluid output from the first heat exchanger 24 from flowing into the second fluid loop, towards the second heat exchanger 26. The first and second flow control valves V1, V2 may have similar or different configurations. In an embodiment, at least one of the first and second flow control valves V1, V2 is a passive valve, such as a check valve for example. In another embodiment, at least one of the first and second flow control valves V1, V2 is an actively controlled valve, such as a solenoid valve for example, controlled by the controller 32.

[0032] The system 20 additionally includes a supply air flow path 34 having an inlet 36 and an outlet 38. A flow of supply air, such as outside air for example, may be directed via the supply air flow path 34 to the area to be conditioned 10. Supply air may be drawn into the inlet 36 and/or may be moved through the supply air flow path 34 by one or more fans (not shown). In the illustrated, non-limiting embodiment, the second heat exchanger 26 and the third heat exchanger 28 are arranged within the supply air flow path 34. Accordingly, the supply air is conditioned as it passes over one or more of the second and third heat exchangers 26, 28 prior to being provided to the area to be conditioned 10. The supply air is typically cooled and/or dehumidified as it passes over the third heat exchanger 28 and is heated as it flows over the second heat exchanger 26. A secondary flow of air, indicated by arrow A, is configured to pass over the first

heat exchanger 24 before being exhausted to the atmosphere external to the system 20. The secondary flow of air A is configured to absorb heat from the fluid within the first heat exchanger 24.

[0033] The refrigerant R circulating within the system 20 is configured to flow through one or both of the first and second fluid loops depending on the mode of operation of the system 20. For example, when the system 20 is in a first mode of operation, also referred to herein as a "full cooling" mode, the refrigerant R is configured to circulate the first fluid loop. Accordingly, in the full cooling mode, any refrigerant R within the second fluid loop is not actively circulating through the system 20. In such embodiments, the supply air is cooled as it passes over the third heat exchanger 28. Although the cooled supply air is configured to pass over the second heat exchanger or reheater 26 prior to being delivered to the area to be conditioned 10, the limited and stationary refrigerant R within the second heat exchanger 26, will not substantially alter the temperature of the supply air. As a result, the temperature of the supply air remains generally constant as it flows from the third heat exchanger 28 to the outlet 38 of the supply air flow path 34.

[0034] In a second mode of operation, also referred to herein as a "full reheat" mode, the refrigerant R is configured to circulate through only the second fluid loop. In the reheat mode, any refrigerant within the first fluid loop is not actively circulating through the system 20. In such embodiments, the supply air is cooled and/or dehumidified as it passes over the third heat exchanger 28 and is further reheated as it passes over the second heat exchanger 26.

[0035] In a third "combination" mode of operation, a first portion of the refrigerant R output from the compressor 22 is configured to flow through the first fluid loop and a second portion of the refrigerant R output from the compressor 22 is configured to flow through the second fluid loop in parallel, such that both the first and second heat exchangers 24, 26 are utilized. In such embodiments, the supply air within the supply air flow path 34 is cooled and/or dehumidified as it passes over the third heat exchanger 28 and is reheated as it passes over the second heat exchanger 26, in series.

[0036] The system 20 may further include a refrigerant management system operable to control the flow of refrigerant within the system 20. In an embodiment, the refrigerant management system includes a valve 40, such as a modulating valve for example, that is arranged downstream from the outlet of the at least one compressor 22. Further, the valves V1 and V2 previously described herein may, but need not be considered part of the refrigerant management system. A position of the modulating valve 40 may be adjustable to direct a flow of refrigerant R output from the at least one compressor 22 into at least one of the first fluid loop and the second fluid loop. Operation of the modulating valve 40 to control the flow of compressor discharge gas provided to the second heat exchanger 26 in turn controls the temperature of the resulting supply air that is delivered to the area to be conditioned 10.

[0037] The controller 32 is operably coupled to the modulating valve 40 and is configured to adjust the position of the modulating valve 40 to actively manage the flow of refrigerant through the system 20, such as based on one or more conditions of the system 20. For example, the controller 32 may generate a command to adjust the position of the modulating valve 40 as the system 20 is starting up or being shut down, and/or to transition the system 20 between the full cooling, reheat, and combination modes of operation. In an embodiment, the controller 32 may be used to control the rate at which the flow of refrigerant through the system 20 is redirected as the system 20 transitions between modes of operation.

[0038] The system 20 may be designed to operate across a wide range of outdoor air temperatures, such as from about 60°F to about 115°F. As the temperature and humidity of the outdoor air changes, the cooling demand of the system 20 will vary. Accordingly, in embodiments where the system 20 has a plurality of compressors 22, the refrigeration management system may be configured to control which compressor(s) is/are operational. This control of the compressors 22 may be used to control the temperature of the fluid at the third heat exchanger 28 which will increase and/or decrease the latent capacity of the system 20.

[0039] The system 20 may additionally include one or more sensors S for monitoring a parameter of the system 20. In an embodiment, at least one sensor S is associated with operation of one of the condensers. For example, at least one sensor S may be configured to monitor a temperature of the supply air at or downstream from the second heat exchanger 26. However, embodiments where one or more sensors S are alternatively or additionally operable to monitor another parameter associated with the second heat exchanger 26 or with another component of the system 20 are also contemplated herein.

[0040] The flow of refrigerant R through the system 20 may be controlled in response to the information measured by the one or more sensors S. In an embodiment, the controller 32 is configured to automatically adjust the position of the modulating valve 40 in response to the sensor information to control or manage the amount of refrigerant R provided to each of the first and second fluid loops. This adjustment of the modulating valve 40 may be used to optimize operation of the system 20 by providing the required amount of refrigerant R to each of the fluid loops. This control may occur when the system 20 is in only the combination mode, or alternatively, may be implemented during all modes of operation.

[0041] As shown in the FIGS., a filter drier 50 may be located downstream from the first and second valves V1, V2 and upstream from the third heat exchanger 28 and in some embodiments, from the expansion device 30. As is known in the art, a filter drier 50 is configured to not only adsorb system contaminants, such as water for ex-

ample, but also provide physical filtration to the refrigerant R circulating through the system 20. Over time, the filter drier 50 requires replacement to maintain proper operation of and prevent damage to the system 20. By actively managing the flow of refrigerant R within the system 20, such as via the inclusion of the modulating valve 40 and valves V1, V2, the requirements of the filter drier 50 for the system 20 may be reduced. For example, in an embodiment, the system 20 requires only a single filter drier 50 instead of multiple filter driers. In addition, the filter drier 50 can be strategically positioned within an interior of a system housing, directly adjacent to an access panel of the system housing (see FIG. 3), allowing for easy access during a maintenance operation. Further, by managing the refrigerant flow within of the system 20, the performance, reliability, and serviceability of the system 20 are increased while also reducing overall cost.

[0042] The term "about" is intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application.

[0043] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

[0044] While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

Claims

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

   a housing;
   a plurality of compressors, a condenser, a reheater, and an evaporator in fluid communication, the condenser and the reheater being arranged in parallel, and the plurality of compressors being arranged in parallel; and
   a fluid management system operable to actively manage a flow of a fluid within the HVAC system provided to the reheater.

2. The HVAC system of claim 1, further comprising a filter drier arranged downstream from and in fluid communication with the condenser and the reheater, the filter drier being arranged within the housing.

3. The HVAC system of claim 1 or 2, wherein the plurality of compressors includes a first compressor and a second compressor, the first compressor having a first capacity and the second compressor having a second capacity different from the first capacity.

4. The HVAC system of claim 1, 2 or 3, wherein the housing includes an access panel and the filter drier is positioned adjacent to the access panel.

5. The HVAC system of any preceding claim, wherein the fluid management system further comprises a modulating valve movable to direct the fluid output from the plurality of compressors to at least one of the condenser and the reheater.

6. The HVAC system of any preceding claim, further comprising a plurality of flow loops, and the fluid management system is operable to control a portion of the fluid provided to each of the plurality of flow loops.

7. The system of claim 6, wherein the plurality of flow loops includes a first fluid loop and a second fluid loop, the condenser being arranged within the first fluid loop and the reheater being arranged within the second fluid loop.

8. The system of claim 7, wherein the fluid management system further comprises:

   a first valve arranged within the first fluid loop downstream from the condenser, the first valve being configured to allow the fluid to flow in only a first direction; and
   a second valve arranged within the second fluid loop downstream from the reheater, the second valve being configured to allow the fluid to flow in only a second direction.

9. The system of claim 8, wherein at least one of the first valve and the second valve is passive; and/or wherein at least one of the first valve and the second valve is a check valve.

10. The system of claim 8, wherein the system further comprises a controller and at least one of the first valve and the second valve is actively controlled by

the controller.

11. The system of any preceding claim, wherein the fluid management system further comprises a controller operably coupled to at least one sensor, the controller being configured to operable to actively manage the flow of fluid through the HVAC system in response to the at least one sensor; optionally

wherein the at least one sensor is associated with the reheater; and/or
wherein the at least one sensor is configured to monitor a temperature of a flow of supply air at or downstream from the reheater.

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

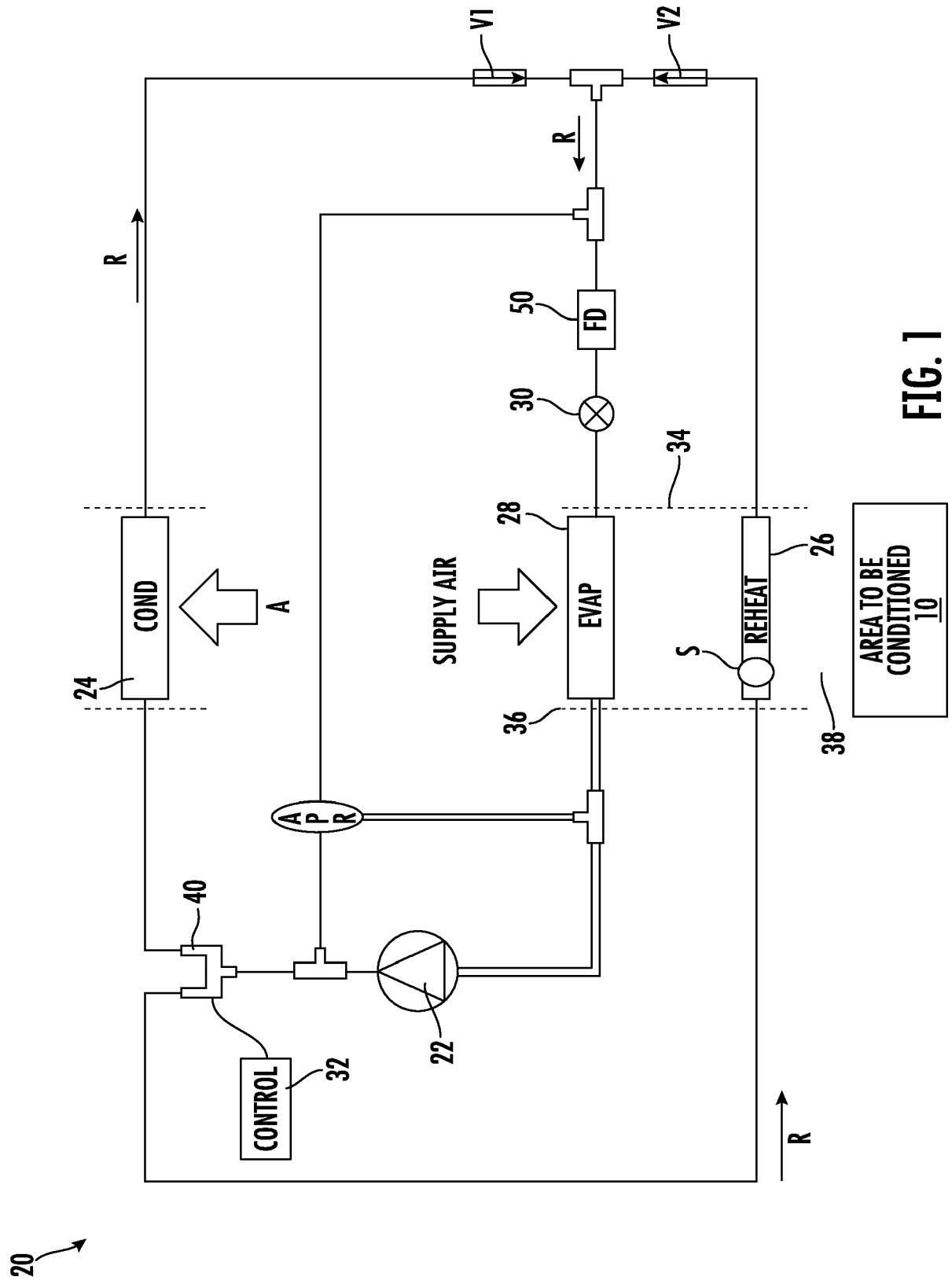
providing a HVAC system including a plurality of compressors, an evaporator, a condenser, and a reheater, the plurality of compressors being arranged in parallel and the condenser and the reheater being arranged in parallel to define a plurality of fluid flow loops;
receiving information about at least one parameter of the HVAC system;
selecting at least one of the plurality of compressors in response to the information about the at least one parameter of the HVAC system;
determining a position of a modulating valve of a refrigerant management system of the HVAC system in response to the information about the at least one parameter of the HVAC system; and
moving the modulating valve to the determined position to control a fluid flow through the plurality of fluid flow loops.

13. The method of claim 12, wherein the information about the at least one parameter of the HVAC system is collected by a sensor; optionally
wherein the sensor is operable to monitor a temperature of a supply air output from the reheater.

14. The method of claim 12 or 13, wherein the at least one parameter of the HVAC system includes an operational mode of the HVAC system; and/or
wherein the at least one parameter of the HVAC system includes an on/off status of the HVAC system.

15. The method of claim 12, 13 or 14, wherein the plurality of fluid flow loops includes a first fluid loop and a second fluid loop, the method further comprising:

blocking a fluid within the second fluid loop from entering the first fluid loop via a first valve; and
blocking a fluid within the first fluid loop from entering the second fluid loop via a second valve.


V1
V2
R
R
50
FD
30
34
28
EVAP
SUPPLY AIR
26
REHEAT
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AREA TO BE CONDITIONED
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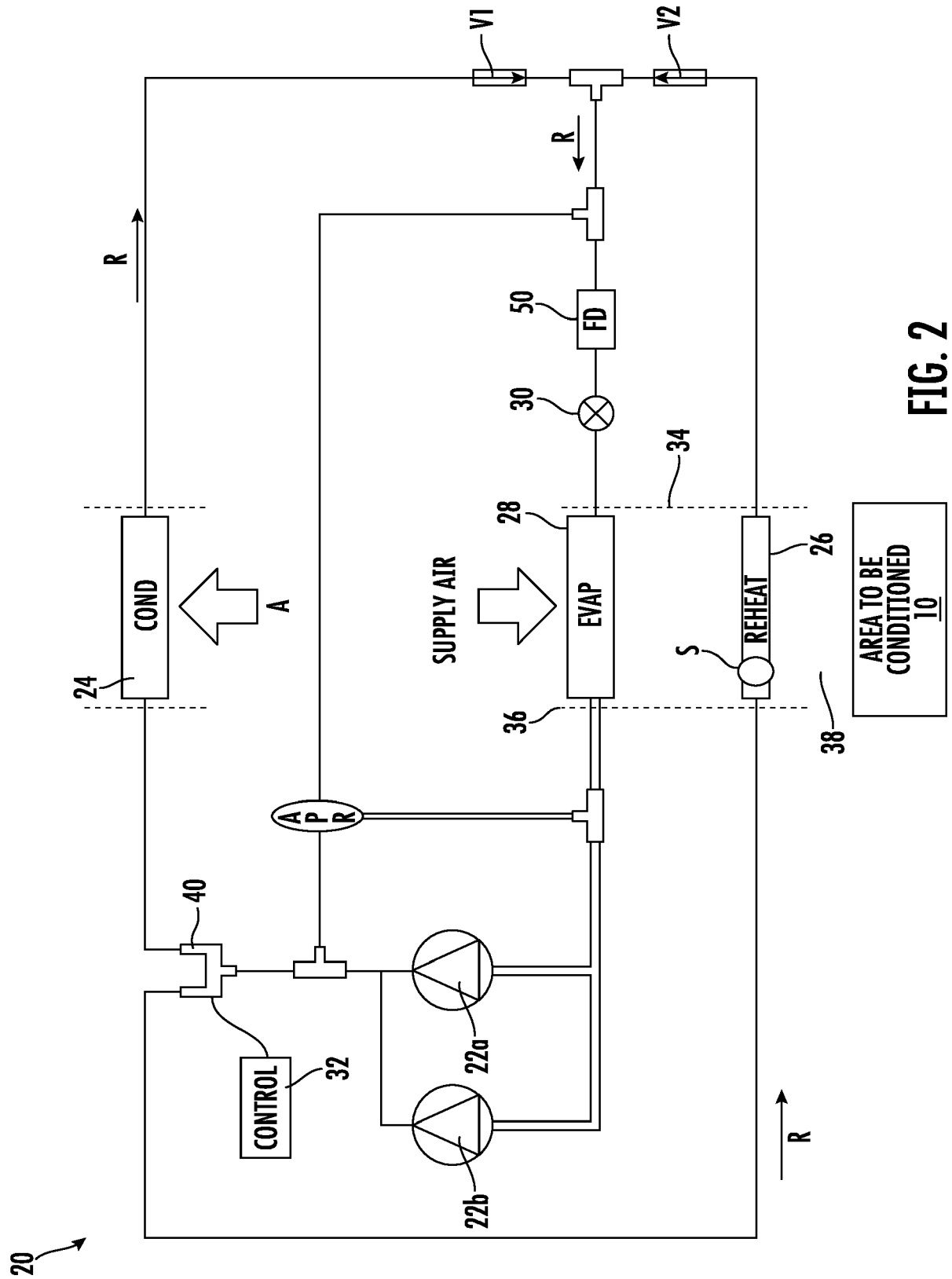
38
36
COND
A
24
APR
40
22
CONTROL
32
R
20

FIG. 1


V1
V2
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R
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FD
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34
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26
COND
A
SUPPLY AIR
EVAP
REHEAT
S
AREA TO BE CONDITIONED 10
24
36
38
APR
40
CONTROL
32
22a
22b
R
20

FIG. 2

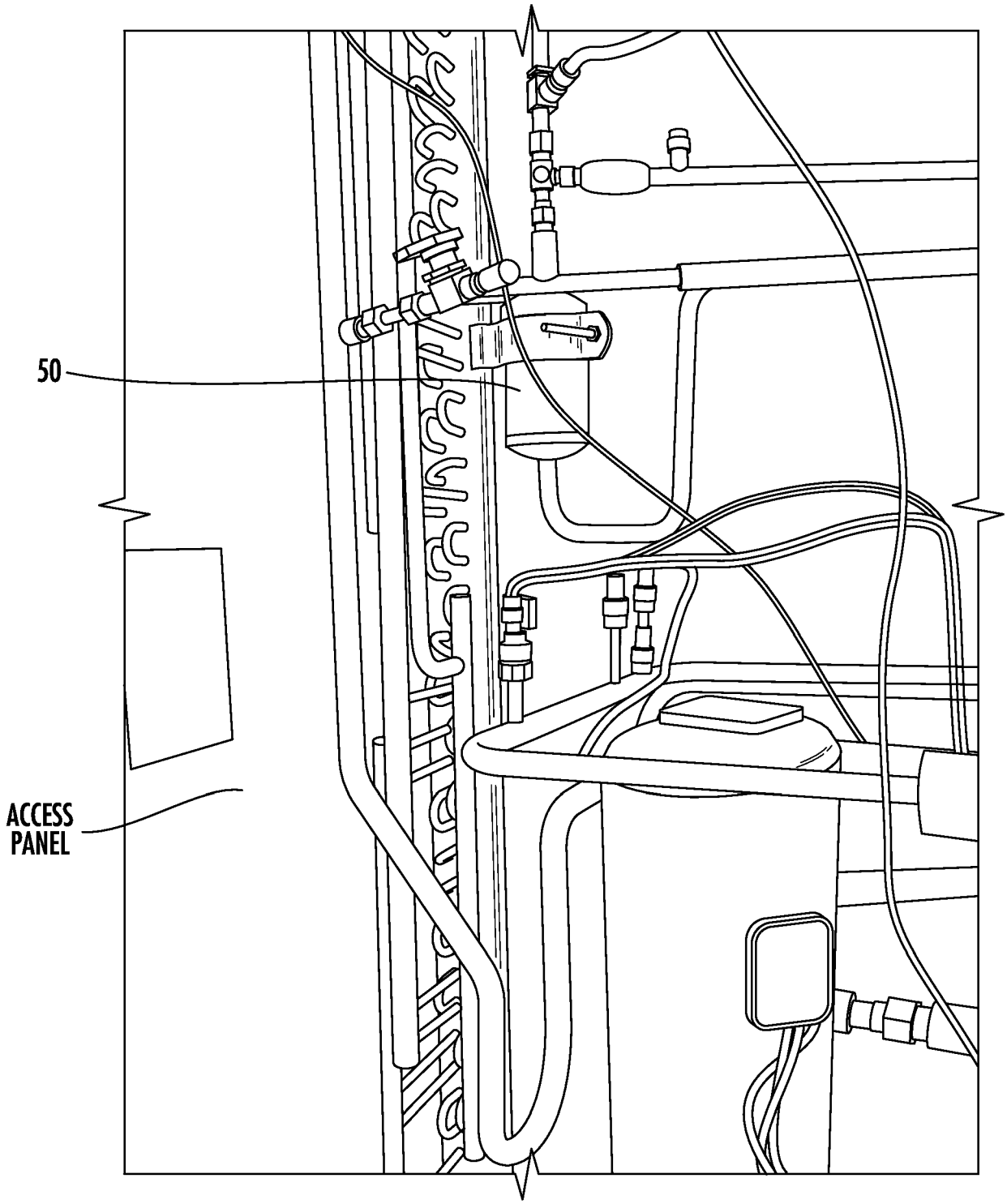

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 24 16 9529

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2015/013356 A1 (KARKHANIS RAJIV [US] ET AL) 15 January 2015 (2015-01-15) * paragraphs [0019] - [0037]; figures 2,3,6 *	1,5-15 2-4	INV. F25B6/02
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			TECHNICAL FIELDS SEARCHED (IPC)
			F25B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 August 2024	Weisser, Meinrad

CATEGORY OF CITED DOCUMENTS

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26-08-2024

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REFERENCES CITED IN THE DESCRIPTION

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