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(54) **REFRIGERANT DEHUMIDIFICATION SYSTEM WITH VARIABLE CONDENSER UNLOADING**

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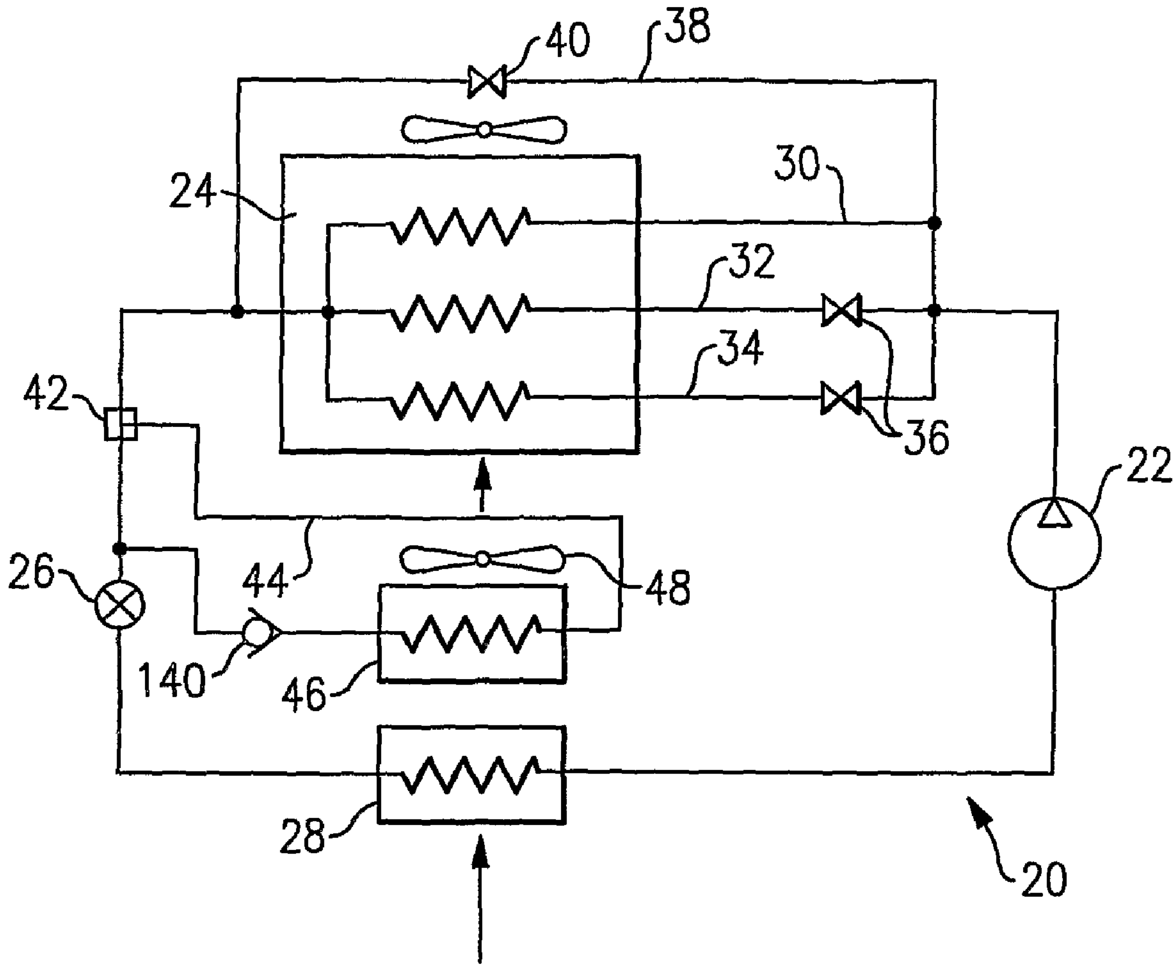
(57) **ABSTRACT**

A condenser in a refrigerant system is provided with a plurality of refrigerant circuits, with at least one of the plurality of circuits being equipped with a shut off device. A reheat coil is also incorporated into the refrigerant system to provide enhanced dehumidification functionality. By selectively shutting off at least one of the active refrigerant circuits in the condenser, the amount of heat rejected by the condenser as well as by the reheat coil can be controlled shifting the heat load between the condenser and reheat coil. In this manner, and in combination with operation of the reheat cycle, incremental dehumidification and cooling/heating can be provided and humidity and temperature can be precisely controlled.



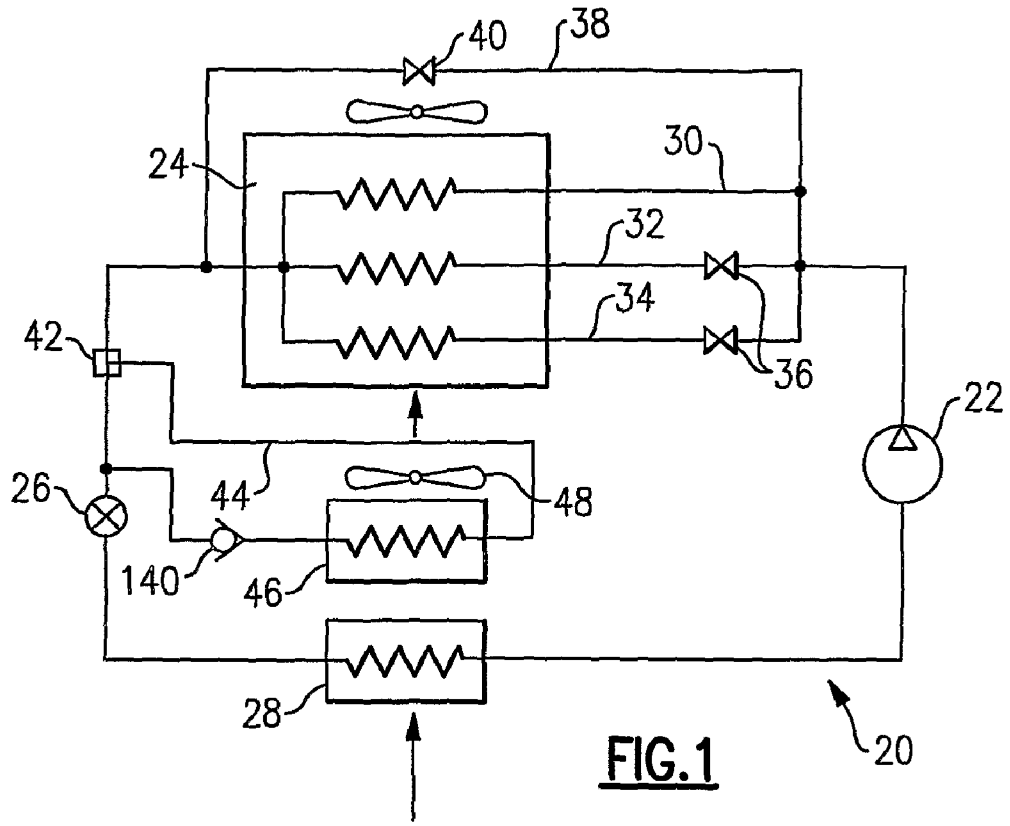

40
38
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FIG. 1

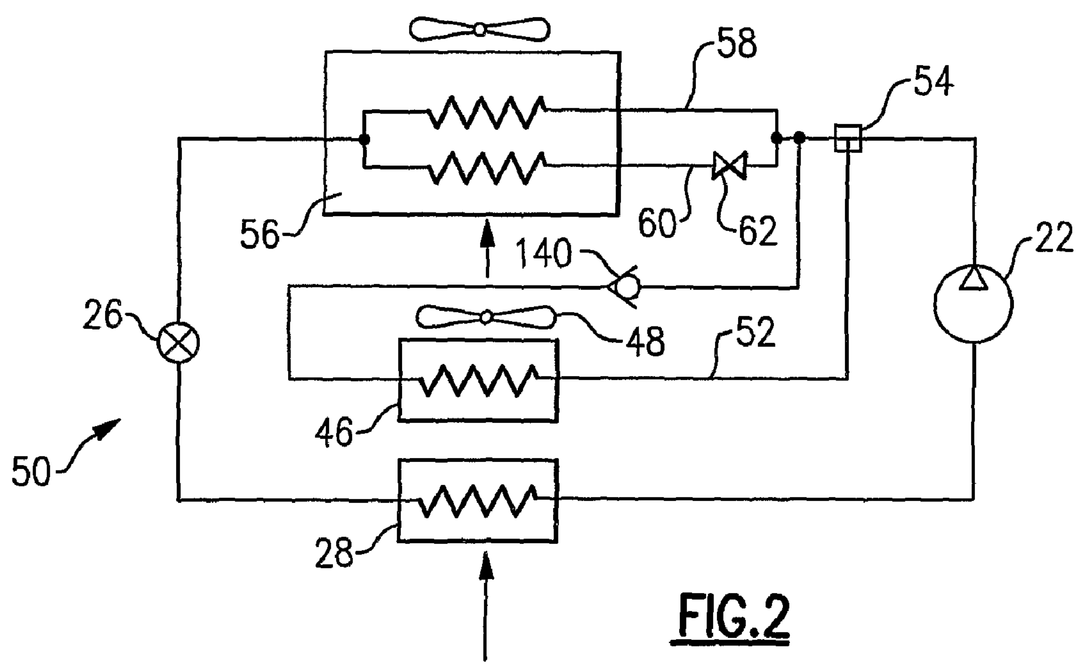
58
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FIG. 2

REFRIGERANT DEHUMIDIFICATION SYSTEM WITH VARIABLE CONDENSER UNLOADING

BACKGROUND OF THE INVENTION

[0001] This invention relates to a refrigerant system incorporating a reheat function and a condenser comprising a number of refrigerant passages, with at least some of the passages being selectively shut off to control the total heat rejection distribution between the condenser (outdoor section) and reheat coil (indoor section).

[0002] Refrigerant systems are utilized to control the temperature and humidity of air in various indoor environments to be conditioned. In a typical refrigerant system operating in the cooling mode, a refrigerant is compressed in a compressor and delivered to a condenser (or an outdoor heat exchanger in this case). In the condenser, heat is exchanged between outside ambient air and the refrigerant. From the condenser, the refrigerant is passed to an expansion device, at which the refrigerant is expanded to a lower pressure and temperature, and then to an evaporator (or an indoor heat exchanger). In the evaporator, heat is exchanged between the refrigerant and the indoor air, to condition the indoor air. When the refrigerant system is operating, the evaporator cools the air that is being supplied to the indoor environment. In addition, as the temperature of the indoor air is lowered, moisture usually is taken out of the air as well. In this manner, the humidity level of the indoor air can also be controlled.

[0003] Another way of controlling an environment in the conditioned space with a refrigerant system is the utilization of a reheat coil. Typically, a reheat coil is provided in the path of air that has been blown over the evaporator. The air passes over the reheat coil to regain heat from a refrigerant that is at a temperature higher than the temperature of air leaving the evaporator. The reheat coil is thus able to raise the temperature of the air leaving the evaporator. Hence, the air is dehumidified and overcooled in the evaporator and then is reheated back to a comfortable temperature level in the reheat coil.

[0004] Another option with known refrigerant systems is to use a bypass line to reroute the refrigerant flow around the condenser. In this manner, at least a portion of refrigerant may bypass the condenser, which will lower its cooling potential as it approaches the evaporator. The condenser bypass has been employed in the prior art systems in combination with the reheat coil to control the thermodynamic state of the refrigerant entering the reheat coil. On the other hand, the condenser passages are typically sized to handle the normal volume of refrigerant flowing through the condenser, and how much refrigerant passes through each circuit should be carefully managed at a wide spectrum of environmental and operating conditions for proper system functionality and reliable operation. Further, pulsating flow in the bypass line (in case pulse width modulation method is used) may introduce some undesired instabilities within the refrigerant circuit that may be difficult to control. Consequently, the condenser bypass alone has a restricted range of applications limited by efficiency, head pressure control, oil holdup and other considerations.

[0005] Thus, there is a need in a refrigerant dehumidification system that would have a variable reheat capacity and provide reliable and efficient operation without further complexity and at marginal cost.

SUMMARY OF THE INVENTION

[0006] In a disclosed embodiment of this invention, a condenser, within a refrigerant system incorporating a reheat function, has a plurality of refrigerant passages with at least some of these passages being provided with shut off devices. Thus, as fewer passages are open to allow refrigerant flow through the main condenser, less heat is rejected by the condenser and more reheat capacity is provided at the reheat coil.

[0007] This increase in the reheat capacity can be accomplished by selectively turning off some of the condenser circuits. Thus, the condenser size and condenser load can be reduced in stages in accordance with application requirements and design constraints.

[0008] Another side benefit of this proposed concept is that a head pressure control is naturally provided by varying the number of active refrigerant circuits in the condenser, regardless of the mode of operation. Obviously, the pressure drop through the condenser has to be maintained within design guidelines, and in one disclosed embodiment, a bypass line around the condenser may be included for additional operational flexibility. The bypass line could also have an application in combination with the reheat cycle.

[0009] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** shows a first schematic incorporating the present invention.

[0011] FIG. **2** shows an alternate schematic.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] A refrigerant system **20** is illustrated in FIG. **1** including a compressor **22** compressing refrigerant and delivering it to a downstream condenser **24**. An expansion device **26** is located downstream of the condenser **24**, and an evaporator **28** is positioned downstream of the expansion device **26**. The refrigerant returns from the evaporator **28** to the compressor **22**. As shown, a number of parallel refrigerant passages (or circuits) **30**, **32** and **34** pass through the condenser **24**. Shutoff devices such as valves **36** are placed on two of the three circuits **32** and **34**. A control operates to open or close the shutoff valves **36**, as will be explained below. A bypass line **38** includes a valve **40** for selectively allowing bypass at least a portion of refrigerant around the condenser **24**.

[0013] A three-way valve **42** selectively routes refrigerant into a line **44** and through a reheat heat exchanger **46**. A fan **48** pulls air over the evaporator **28** and then over the reheat heat exchanger **46**. Also, a check valve **140** is placed downstream of the reheat heat exchanger **46** within the reheat loop.

[0014] As is known, the reheat loop is utilized when dehumidification is desired. Essentially, the evaporator is controlled to cool air to a temperature level lower than the temperature that would be desired by an occupant of a space to be conditioned by the refrigerant system **20** in order to remove sufficient amount of moisture from the air stream. This cold and dehumidified air then passes over the reheat coil **46**, which will be at a higher temperature (while in operation) than the air exiting the evaporator **28**. The reheat coil thus reheats the air up toward the temperature desired by the occupant of the space to be conditioned. The control of the reheat coil is known.

[0015] At times, it may be desirable to vary the amount of cooling and/or dehumidification being provided. By limiting the number of refrigerant circuits passing through the condenser **24**, the amount of heat rejected by the main condenser **24** and reheat provided by the reheat coil **46** can be controlled. In the refrigerant system **20**, the incremental steps of reheat control can be achieved by either shutting the valves **36**, opening the valve **40**, or both. In this manner, the amount of heat load placed on the condenser as well as the amount of refrigerant circulating through the condenser can be varied, and the total heat rejected can be shifted between the main condenser **24** and the reheat coil **46**. By decreasing the amount of heat exchanged in the condenser **24**, the amount of cooling and dehumidification achieved in the evaporator **28** can also be adjusted.

[0016] For instance, if a higher air temperature is desired downstream of the reheat heat exchanger **46** then some of the refrigerant circuits **36** passing through the main condenser **24** will be shut off or taken off-line. As a result, a smaller heat transfer surface will be utilized in the condenser **24**, and the pressure differential of the refrigerant circulating through the remaining circuits **30** may simultaneously increase. Consequently, although condensation temperature (or discharge pressure) will rise, the net effect would be such that heat rejected by the main condenser **24** will diminish. Since the temperature difference in the reheat coil **46** will increase and the refrigerant leaving the main condenser **24** may have higher enthalpy, the heat rejected in the reheat coil **46** will rise providing the desired higher temperature of the air supplied to the conditioned environment. Further, the valve **40** could be used in combination with the valves **36** to assure precise control as well as safe and reliable operation. Finally, the number of circuits incorporating shutoff devices **36** may vary and is determined by the equipment type and practical considerations.

[0017] Thus, a control in this invention operates the valves **36** and **40** in combination with the valve **42** to achieve desired levels of cooling and dehumidification, while the refrigerant system **20** is operating in the reheat mode.

[0018] A worker of ordinary skill in the art would recognize under what conditions these several valves mentioned above should be opened and/or closed. Another side benefit of this invention is that a head pressure control is naturally provided by varying the number of active refrigerant circuits in the main condenser, regardless of the mode of operation.

[0019] FIG. **2** shows another system **50** wherein a reheat line **52** taps refrigerant from a three-way valve **54**, and returns the refrigerant through a reheat heat exchanger **46** and a check valve **140** back to a main refrigerant circuit upstream of a condenser **56** (as well as upstream of a pair of refrigerant circuits **58** and **60** passing through the condenser **56**). A shut off valve **62** is shown only on the circuit **60**. Once again, a number of circuits incorporating valves **62** may vary.

[0020] This refrigerant system is controlled similarly to the refrigerant system **20**. Essentially, the valve **62** is opened and closed to change the heat load on the condenser **56** and consequently on the reheat coil **46**.

[0021] While two basic reheat concepts are shown in FIGS. **1** and **2**, a multitude of other system configurations can equally benefit from this invention.

[0022] Although preferred embodiments of this invention have been disclosed, a worker of ordinary skill in the art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.

We claim:

1. A refrigerant system comprising:

a compressor, said compressor delivering a refrigerant to a downstream condenser through a discharge line, said discharge line communicating with a plurality of parallel flow paths passing through said condenser, and at least one of said plurality of flow paths having a shut-off device;

a line communicating downstream of said condenser to an expansion device, and downstream of said expansion device to an evaporator, and a line communicating from said evaporator back to said compressor; and

a reheat circuit incorporated into said refrigerant system, said reheat circuit receiving a refrigerant, and passing said received refrigerant through a reheat heat exchanger, and from said reheat heat exchanger back into a main refrigerant circuit, an air-moving device for moving air over said evaporator, and over said reheat heat exchanger, and a control for selectively opening said shutoff device to achieve desired control in combination with said reheat circuit.

2. The refrigerant system as set forth in claim **1**, wherein a bypass line allows selective bypass of at least a portion of refrigerant around said condenser, and said bypass line also includes a bypass valve, with said control selectively controlling said bypass valve.

3. The refrigerant system as set forth in claim **1**, wherein said reheat circuit taps refrigerant from a location downstream of said condenser.

4. The refrigerant system as set forth in claim **1**, wherein said reheat circuit taps refrigerant from a location upstream of said condenser.

5. The refrigerant system as set forth in claim **4**, wherein said discharge line from said compressor branches into said plurality of parallel flow paths, and said reheat circuit taps refrigerant from a location upstream of a branching point.

6. The refrigerant system as set forth in claim **1**, wherein there are at least three of said flow paths, and at least two of said at least three flow paths having shut-off devices.

7. The refrigerant system as sot forth in claim **1**, wherein said control operating said shut-off device to block flow of refrigerant through said at least one of said plurality of flow paths when less cooling is desired.

8. The refrigerant system as set forth in claim **7**, wherein said control operates said shut-off device to block the flow of refrigerant through said at least one of said plurality of flow paths to achieve a desired amount of dehumidification, with lesser cooling, when less cooling is desired.

9. The refrigerant system as set forth in claim **1**, wherein said control shuts said shut-off device to block flow of refrigerant through at least one of said plurality of flow paths, while still allowing flow through at least one other of said plurality of flow paths to reduce the cooling load provided by refrigerant passing through the condenser.

10. A method of controlling a refrigerant system comprising:

providing a compressor, said compressor delivering a compressed refrigerant to a downstream condenser through a discharge line, said discharge line communicating with a plurality of parallel flow paths passing through said condenser, and at least one of said plurality of flow paths having a shut off device;

communicating refrigerant downstream of said condenser to an expansion device, and downstream or said expansion device to an evaporator, and communicating refrigerant from said evaporator back to said compressor; and

a reheat circuit incorporated into said refrigerant system, said reheat circuit receiving a refrigerant, and passing said received refrigerant through a reheat heat exchanger, and from said reheat heat exchanger back into a main refrigerant circuit, an air-moving device moving air over said evaporator, and over said reheat heat exchanger, and a control selectively opening said shutoff device to achieve desired control in combination with said reheat circuit.

11. The method as set forth in claim **10** wherein a bypass line allows selective bypass of at least a portion of refrigerant around said condenser, and said bypass line also includes a bypass valve, with said control selectively controlling said bypass valve.

12. The method as set forth in claim **10**, wherein said reheat circuit taps refrigerant from a location downstream of said condenser.

13. The method as set forth in claim **10**, wherein said reheat circuit taps refrigerant from a location upstream of said condenser.

14. The method as set forth in claim **13**, wherein said discharge line from said compressor branches into said plurality of parallel flow paths, and said reheat circuit taps refrigerant from a location upstream of a branching point.

15. The method as set forth in claim **10**, wherein there are at least three of said flow paths, and at least two of said at least three flow paths having shut off devices.

16. The method as set forth in claim **10**, wherein said control operating said shut-off valve device to block flow of refrigerant through said at least one of said plurality of flow paths when less cooling is desired.

17. The method as set forth in claim **10**, wherein said control operating said shut-off device to block flow of refrigerant through said at least one of said plurality of flow paths when less cooling is desired.

18. The method as set forth in claim **10**, wherein said control operates said shut-off device to block the flow of refrigerant through said at least one of said plurality of flow paths to achieve a desired amount of dehumidification, with lesser cooling, when less cooling is desired.

19. The method as set forth in claim **10**, wherein said control shuts said shut-off device to block flow of refrigerant through at least one of said plurality of flow paths, while still allowing flow through at least one other of said plurality of flow paths to reduce the cooling load provided by refrigerant passing through the condenser.

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