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(54) **VAPOR COMPRESSION SYSTEM WITH CONDENSATE INTERCOOLING BETWEEN COMPRESSION STAGES**

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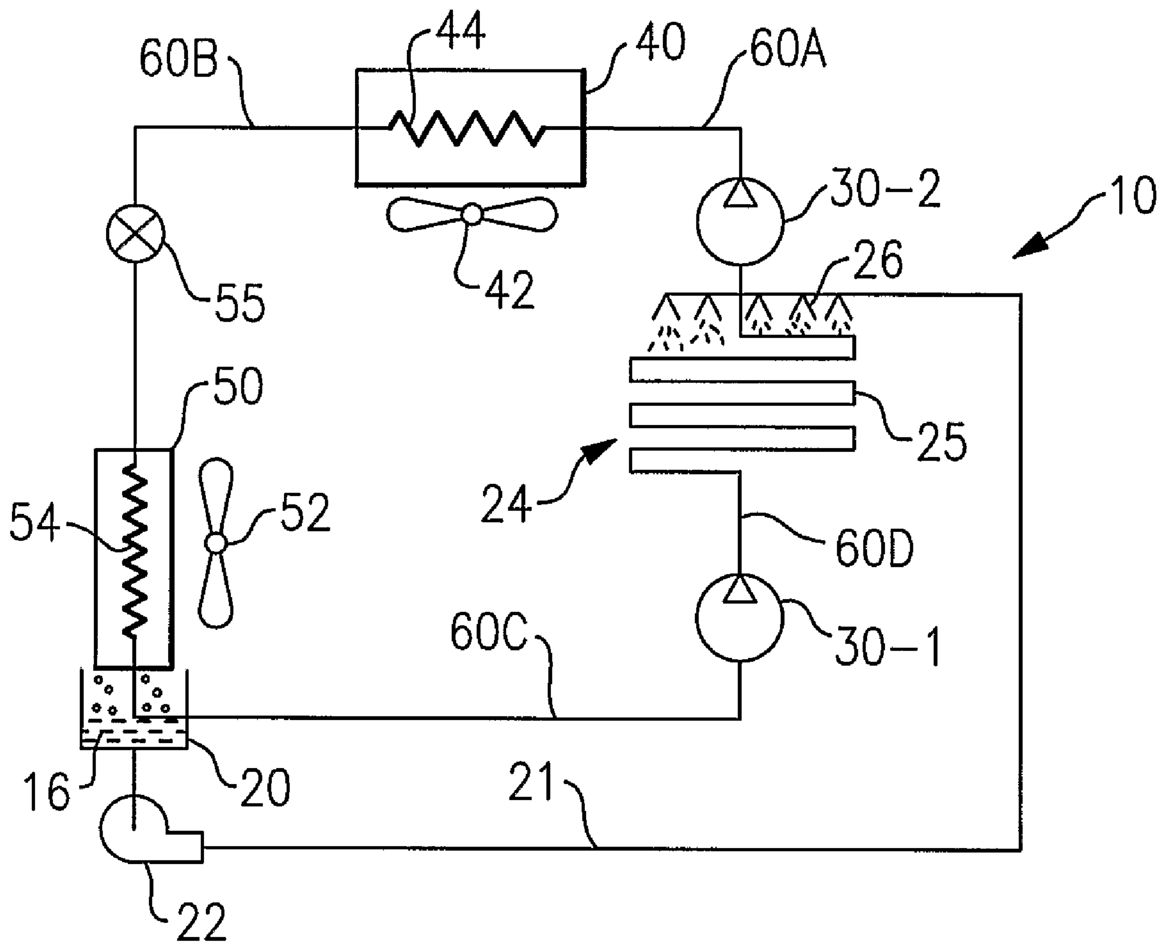
(57) **ABSTRACT**

A refrigerant vapor compression system includes a first compression device and a second compression device disposed in a refrigerant circuit in series relationship with respect to refrigerant flow and an intercooler adapted to cool the refrigerant passing from the first compression device to the second compression. An evaporator is provided in the refrigerant circuit wherein the refrigerant accepts heat from a moisture bearing gas such as air. Condensate formed of moisture condensing out of the gas is collected and supplied to the intercooler for cooling the refrigerant flowing from the first compression device to the second compression device.



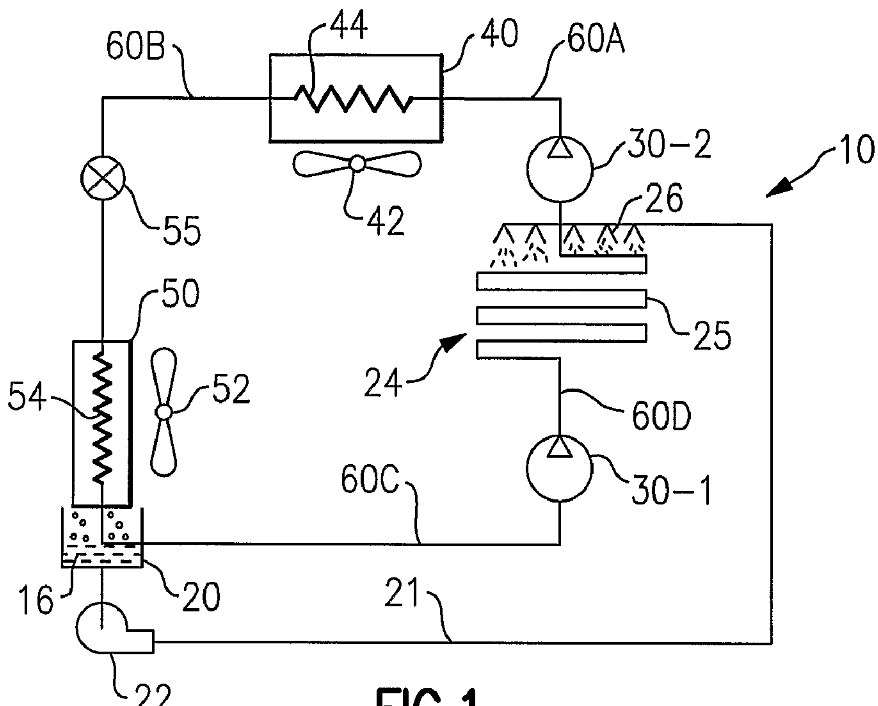

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FIG.1

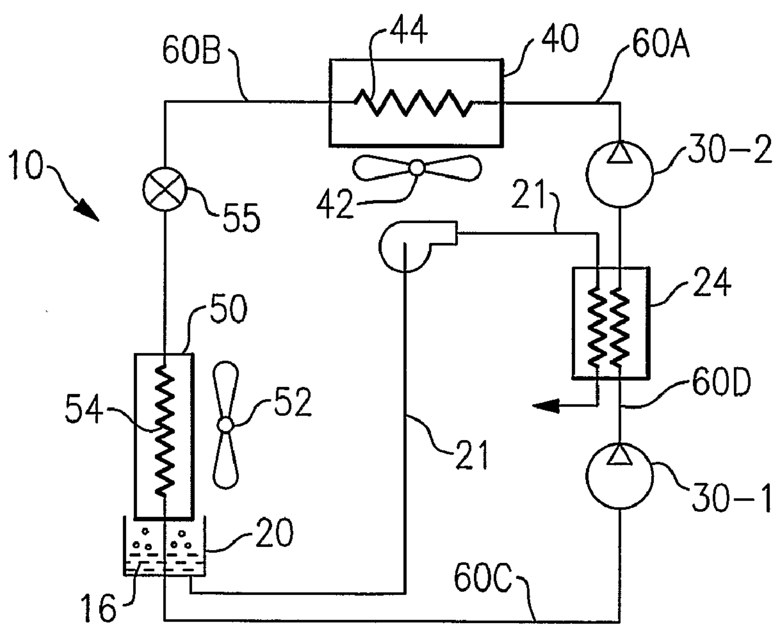
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FIG.2

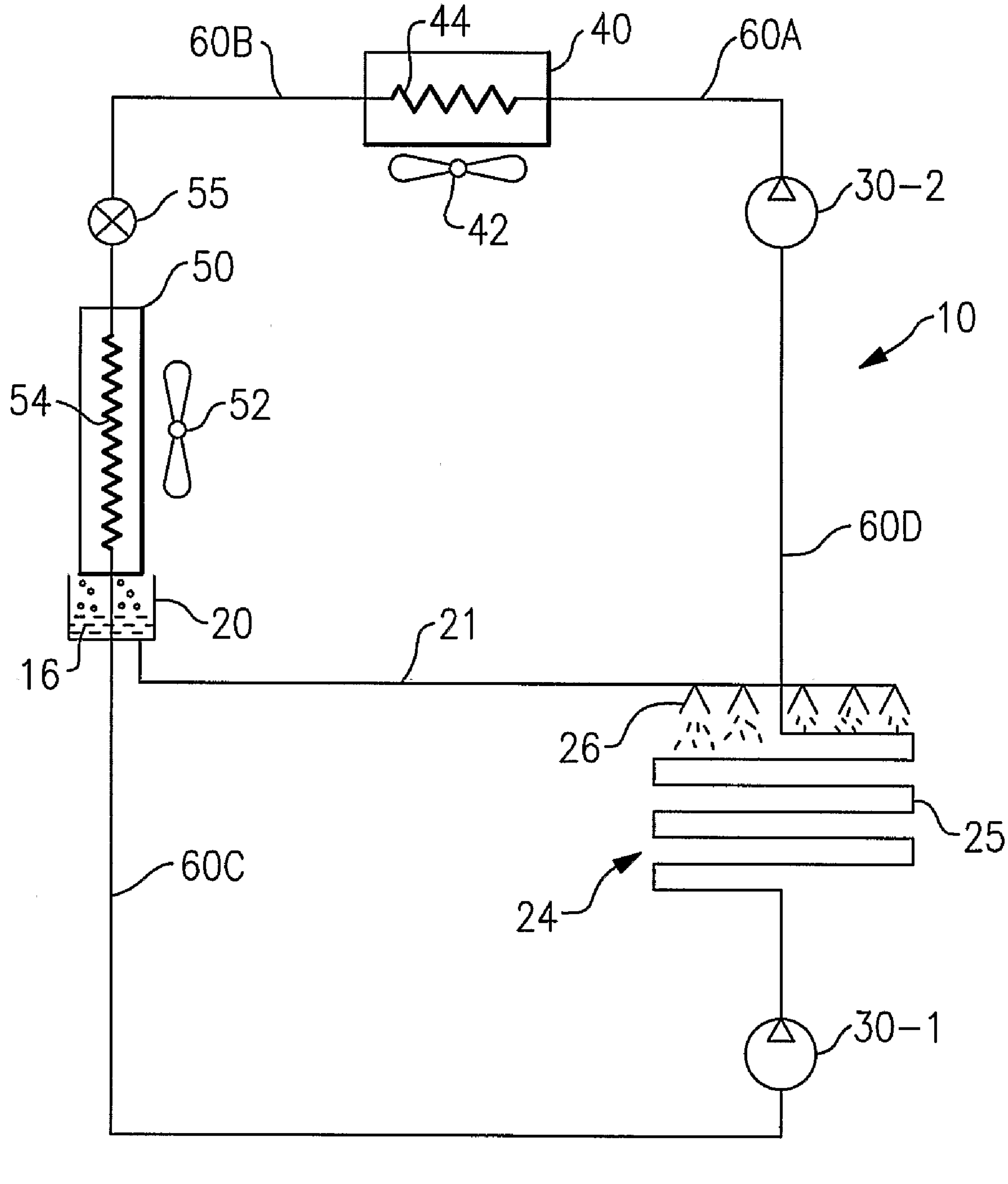


FIG.3

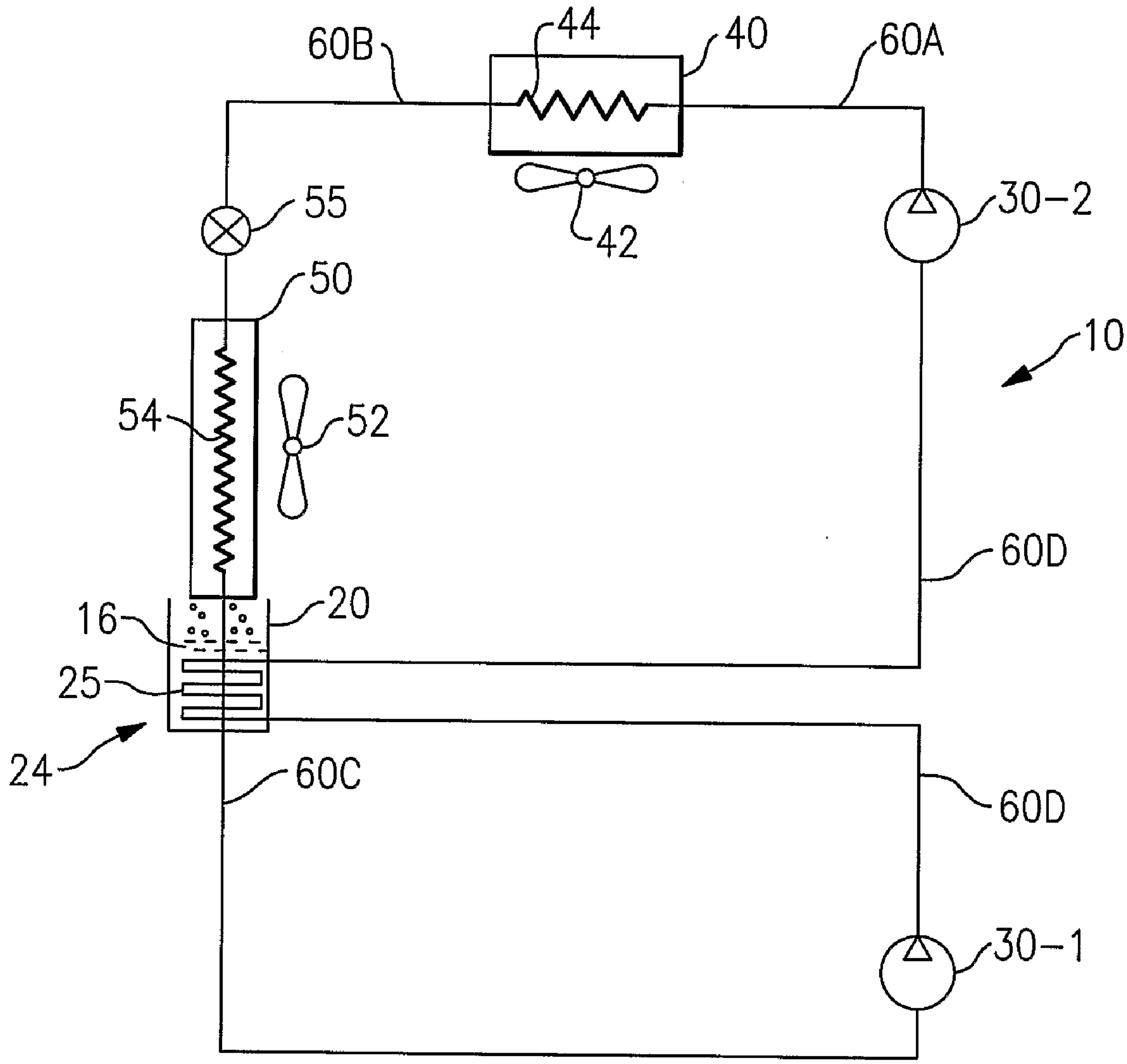


FIG.4

# VAPOR COMPRESSION SYSTEM WITH CONDENSATE INTERCOOLING BETWEEN COMPRESSION STAGES

## FIELD OF THE INVENTION

**[0001]** This invention relates generally to vapor compression systems having multiple compression stages and, more particularly, to the cooling of refrigerant vapor passing between an upstream compression stage and a downstream compression stage in a refrigerant vapor compression system.

## BACKGROUND OF THE INVENTION

**[0002]** Refrigerant vapor compression systems are well known in the art and commonly used for conditioning secondary fluid such as air to be supplied to a climate controlled comfort zone within a residence, office building, hospital, school, restaurant or other facility. Refrigerant vapor compression systems are also commonly used in transport and stationary refrigeration applications for refrigerating air supplied to a temperature controlled space of a truck, trailer, container, display case or the like for preserving perishable items. Traditionally, most of these refrigerant vapor compression systems operate at subcritical refrigerant pressures and typically include a compressor, a condenser, an evaporator, and an expansion device. Commonly, an expansion device is disposed upstream, with respect to refrigerant flow, of the evaporator and downstream of the condenser. These basic refrigerant system components are interconnected by refrigerant lines in a closed refrigerant circuit, arranged in accord with known refrigerant vapor compression cycles, and operated in the subcritical pressure range for the particular refrigerant in use. Refrigerant vapor compression systems operating in the subcritical range are commonly charged with fluorocarbon refrigerants such as, but not limited to, hydrochlorofluorocarbons (HCFCs), such as R**22**, and more commonly hydrofluorocarbons (HFCs), such as R134a, R410A and R407C.

**[0003]** Although HFC refrigerants are more environmentally friendly than the chlorine containing HCFC refrigerants that they replaced, "natural" refrigerants, such as carbon dioxide, are being turned to for use in air conditioning and refrigeration systems instead of HFC refrigerants. However, because carbon dioxide has a low critical point, a vast majority of refrigerant vapor compression systems charged with carbon dioxide as the refrigerant are designed for operation in the transcritical cycle. In refrigerant vapor compression systems operating in a transcritical cycle, the heat rejection heat exchanger operates at refrigerant pressures above the critical point, while the evaporator operates at refrigerant pressures in the subcritical range. Additionally, refrigerant vapor compression systems utilizing a low critical point refrigerant, such as carbon dioxide, frequently employ a multi-stage compression system, either multiple compressors disposed in series flow arrangement with respect to refrigerant flow or a single compressor having at least two compression stages. Typically, the pressure of the refrigerant vapor discharging from the final stage of the compression system, commonly referred to as the discharge pressure or the high-side pressure, is high enough that the refrigerant vapor does not condense as it traverses the heat rejection heat exchanger. Consequently, with respect to systems operating in a transcritical cycle, the heat rejection heat exchanger is commonly referred to as, and functions as, a gas cooler, not a condenser.

**[0004]** It is well appreciated by practitioners skilled in the art of vapor compression that it is desirable to insert an intercooler in the refrigerant circuit between compression stages in a multi-stage compression system charged with a low critical point refrigerant such as carbon dioxide. The vapor passing from the discharge of an upstream compression stage to the suction of a downstream compression stage flows in heat exchange relationship with a cooling medium as the vapor traverses the intercooler thereby cooling the vapor to improve the cycle performance and to decrease the refrigerant discharge temperature. In conventional transcritical vapor compression systems employing intercoolers, the cooling medium is generally a secondary cooling fluid external to the system, such as chilled water or ambient air, or a portion of the cold system refrigerant diverted from elsewhere within the refrigerant circuit.

**[0005]** U.S. Pat. No. 6,658,888 discloses a multi-stage compression refrigerant vapor compression system charged with carbon dioxide refrigerant and having an intercooler between stages of a multi-stage compressor. The refrigerant vapor passing between compression stages traverses the intercooler wherein it rejects heat to the same cooling fluid medium having previously passed through the gas cooler accepting heat from the refrigerant vapor discharged from the compressor. After traversing the intercooler, the heated cooling fluid medium exits the system. The cooling fluid medium may be room air, tap water or recirculated water, depending upon the application.

**[0006]** U.S. Pat. No. 6,698,234 also discloses a multi-stage compression refrigerant vapor compression system charged with carbon dioxide refrigerant and having an intercooler between stages of a multi-stage compression system. In an embodiment disclosed therein, a portion of the cold refrigerant downstream of the gas cooler bypasses the system evaporator and is diverted to pass through the intercooler in heat exchange relationship with the refrigerant vapor flowing between compression stages. The diverted refrigerant is expanded to a lower pressure and temperature prior to passing through the intercooler. As the two refrigerant streams pass in heat exchange relationship in the intercooler, the diverted refrigerant stream is heated and the refrigerant vapor flowing between compression stages is cooled. The heated diverted refrigerant is returned to the suction side of the refrigerant circuit downstream of the system evaporator.

**[0007]** It has to be noted that conventional subcritical multi-stage vapor compression systems also benefit from intercoolers, although these benefits are not as pronounced as for transcritical systems.

## SUMMARY OF THE INVENTION

**[0008]** It is an object of the invention to provide a multi-stage vapor compression system including an intercooler for cooling vapor passing between compression stages that use evaporator condensate water as the cooling medium in the intercooler.

**[0009]** The refrigerant vapor compression system of the invention includes a first compression device to compress a refrigerant to a first pressure, a second compression device to further compress the refrigerant from the first pressure to a second pressure, a heat accepting heat exchanger (e.g. evaporator) for passing the refrigerant in heat exchange relationship with a moisture bearing gas (e.g. air) whereby the heat is transferred from the gas to the refrigerant and at least some amount of moisture in the moisture bearing gas is condensed to form a condensate (water), and an intercooler wherein the condensate exchanges heat with and accepts heat from the refrigerant passing from said first compression device to the second compression device.

**[0010]** In an embodiment, the first compression device is a first compressor and the second compression device is a second compressor with the discharge outlet of the first compressor connected by a refrigerant line in refrigerant flow communication to the suction inlet of the second compressor. The refrigerant line connecting the discharge outlet of the first compressor to the suction inlet of the second compressor traverses the intercooler. In another embodiment, the first compression device is a first compression stage of a compressor and the second compression device is a second compression stage of the same compressor. The refrigerant being compressed in the compressor traverses the intercooler as it passes from the first compression stage to the second compression stage.

**[0011]** In an embodiment, the intercooler includes a refrigerant conveying passage having an exterior heat exchange surface, which can be enhanced for better heat transfer by one of the techniques known in the art, and at least one spray nozzle to spray the condensate condensed from the moisture bearing gas onto the exterior heat exchange surface of the refrigerant conveying passage. Alternatively, a heat exchanger construction may be provided for the intercooler, preferably having moisture and refrigerant flows arranged in a counterflow configuration. A condensate collector may be provided in operative association with the heat accepting heat exchanger for collecting the condensate condensed from the moisture bearing gas. Condensate may be gravity-fed from the condensate collector to the spray nozzle or nozzles if the condensate collector is disposed at a higher elevation than the intercooler. Alternatively, a pump may be provided to supply the condensate from the condensate collector to the intercooler.

**[0012]** In another aspect of the invention, a method is provided for increasing the capacity of a refrigerant vapor compression system by cooling the refrigerant between a first compression stage and a second compression stage via heat exchange with the condensate. The method of the invention includes the steps of: compressing the refrigerant to a first pressure in a first compression stage and to a second pressure in a second compression stage, passing the refrigerant in heat exchange relationship with a moisture bearing gas whereby the refrigerant accepts heat from the gas and at least a portion of the moisture condenses from the gas to form a condensate, and cooling the refrigerant between the first compression stage and the second compression stage via heat exchange with the condensate. The step of cooling the refrigerant passing between the first compression stage and the second compression stage via heat exchange with the condensate may comprise cooling the refrigerant between the first compression stage and the second compression stage via evaporating at least a portion of the condensate. The method may include the steps of passing the refrigerant flowing between the first compression stage and the second compression stage through a refrigerant conveying passage that may or may not have internal and external enhanced heat transfer surfaces and spraying the condensate onto the refrigerant conveying passage. Condensate delivery may be accomplished with assistance of gravity or mechanical means such as a condensate pump.

**[0013]** In a further aspect of the invention, a refrigerant vapor compression system includes a first compressor to compress a refrigerant to a first pressure, a second compressor to further compress the refrigerant to a second pressure, a refrigerant circuit including a first refrigerant line (or lines) passing through other refrigerant system components and connecting the discharge outlet of the second compressor in refrigerant flow communication with the suction inlet of the first compressor and a second refrigerant line connecting the discharge outlet of the first compressor with the suction inlet of the second compressor, a heat rejecting heat exchanger disposed in the first refrigerant line downstream with respect to refrigerant flow of the discharge outlet of said second compressor, a heat accepting heat exchanger disposed in the first refrigerant line downstream with respect to refrigerant flow of the heat rejecting heat exchanger for passing the refrigerant in heat exchange relationship with a moisture bearing gas whereby the refrigerant accepts heat from the gas and moisture in the gas is at least partially condensed to form a condensate, an expansion device operative to expand the refrigerant passing through the first refrigerant line from the heat rejecting heat exchanger to the heat accepting heat exchanger, and an intercooler disposed in the second refrigerant line wherein the refrigerant passing from the first compressor to the second compressor exchanges heat with the condensate whereby the refrigerant passing from the first compressor to the second compressor is cooled.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0014]** For a further understanding of these and other objects of the invention, reference will be made to the following detailed description of the invention which is to be read in connection with the accompanying drawing, where:

**[0015]** FIG. **1** is a schematic diagram illustrating a first exemplary embodiment of a refrigerant vapor compression system in accord with the invention;

**[0016]** FIG. **2** is a schematic diagram illustrating a second exemplary embodiment of a refrigerant vapor compression system in accord with the invention;

**[0017]** FIG. **3** is a schematic diagram illustrating a third exemplary embodiment of a refrigerant vapor compression system in accord with the invention; and

**[0018]** FIG. **4** is a schematic diagram illustrating a fourth exemplary embodiment of a refrigerant vapor compression system in accord with the invention.

## DETAILED DESCRIPTION OF THE INVENTION

**[0019]** Referring now to FIGS. **1-4**, as in conventional systems, the refrigerant vapor compression system **10** includes a compression device **30**, a refrigerant heat rejecting heat exchanger **40**, also referred to herein as a gas cooler or a condenser (depending on an application), a refrigerant heat absorbing heat exchanger **50**, also referred to herein as an evaporator, an expansion device **55**, illustrated as an expansion valve, operatively associated with the evaporator **50**, and various refrigerant lines **60**A, **60**B, **60**C and **60**D connecting the aforementioned components in a conventional refrigerant circuit. The compression device **30** functions to compress and circulate refrigerant throughout the refrigerant circuit as will be discussed in further detail hereinafter. The compression device **30** may be a scroll compressor, a screw compressor, a reciprocating compressor, a rotary compressor, a centrifugal compressor or any other type of compressor or a plurality of any such compressors. The compression device **30**, as depicted in FIGS. **1-4**, has a first compression stage **30-1** and a second compression stage **30-2**. The compression device **30** may be a pair of compressors **30-1** and **30-2**, for example a pair of scroll compressors, screw compressors, reciprocating compressors or rotary compressors connected in series, having a refrigerant line **60**D connecting the discharge outlet port of the first compressor **30-1**, which constitutes the first compression stage, in refrigerant flow communication with the suction inlet port of the second compressor **30-2**, which constitutes the second compression stage. Alternatively, the compression device **30** may be a single refrigerant compressor having a first compression stage and a second compression stage, for example a scroll compressor or a screw compressor having at least a pair of staged compression pockets **30-1**, **30-2**, or a reciprocating compressor having a first bank **30-1** and a second bank **30-2** of cylinders. Also, it has to be understood that although only two compression stages **30-1** and **30-2** are depicted in the FIGS. **1-4**, any number of compression stages connected in series is within the scope of this invention and can benefit from the invention. Further, one or more compression stage may consist of two or more compressors disposed in a so-called tandem arrangement, that is compressors operating in parallel and having at least one common manifold.

**[0020]** The refrigerant vapor compression system of the invention may be operated in either a subcritical cycle or a transcritical cycle. In a refrigerant vapor compression system operating in a subcritical cycle, the refrigerant heat rejecting heat exchanger **40** constitutes a refrigerant condensing heat exchanger through which hot, high pressure refrigerant vapor discharged from the compression device **30-2** passes in heat exchange relationship with a secondary cooling medium, most commonly ambient air in air conditioning systems or refrigeration systems. In a refrigerant vapor compression system operating in a transcritical cycle, the refrigerant heat rejecting heat exchanger **40** constitutes a gas cooler heat exchanger through which supercritical refrigerant vapor discharged from the compression device **30-2** passes in heat exchange relationship with a secondary cooling medium, again most commonly ambient air in air conditioning systems or refrigeration systems. In either case, the refrigerant passing through the heat exchanger **40** rejects heat as it passes in heat exchange relationship with a secondary cooling fluid, typically ambient air passed over the refrigerant conveying passages **44** by an air mover, such as one or more fans **42** operatively associated with the heat exchanger **40**.

**[0021]** Whether the system **10** is operating in a subcritical or a transcritical cycle, the refrigerant leaving the heat rejecting heat exchanger **40** passes through refrigerant line **60**B to the evaporator **50**. In doing so, the refrigerant traverses the expansion device **55** and expands to a lower pressure whereby the refrigerant typically enters the evaporator **50** as a lower temperature, lower pressure mixture of liquid and vapor. The evaporator **50** constitutes a refrigerant evaporating heat exchanger through which the liquid refrigerant passes in heat exchange relationship with a heating fluid whereby the liquid refrigerant is evaporated and typically superheated. The heating fluid (or the fluid to be cooled) passed in heat exchange relationship with the refrigerant in the evaporator **50** may be air passed over the evaporator external surfaces by an air mover, such as one or more fans **52**, and thereafter supplied to a climate controlled environment such as a comfort zone associated with an air conditioning system or a perishable product storage zone associated with a refrigeration unit. As the air passes over the refrigerant conveying passages **54** and other heat transfer enhancement elements (not shown) associated with the passages **54** of the evaporator **50**, at least a portion of moisture contained in the air condenses out onto the exterior surfaces of the evaporator and the condensed moisture, referred to as condensate **16**, then drains into a condensate collection device **20**, for example a drain pan.

**[0022]** The lower pressure refrigerant vapor exiting the evaporator **50** returns through refrigerant line **60**D to the suction port of the compression device **30-1**. The expansion device **55** may be a conventional thermostatic expansion valve (TXV) or electronic expansion valve (EXV) or a fixed restriction device such as an orifice, an accurator, a capillary tube, or the like. As in conventional refrigerant vapor compression systems, a sophisticated expansion device receives a signal indicative of the refrigerant temperature sensed by the temperature sensing element (not shown) associated with the outlet of the evaporator **50**, which may be a conventional temperature sensing element, such as a bulb for a TXV and a thermistor or a thermocouple, frequently coupled with a pressure sensor, for an EXV, and meters the refrigerant flow through the refrigerant line **60**C to maintain a desired level of superheat of the refrigerant vapor leaving the evaporator **50**. As in conventional practice, a suction accumulator (not shown) may be disposed in refrigerant line **60**C downstream with respect to refrigerant flow of the evaporator **50** and upstream with respect to refrigerant flow of the compression device **30-1** to remove and store any liquid refrigerant passing through refrigerant line **60**C, thereby ensuring that liquid refrigerant does not pass to the suction port of the compression device **30-1**. As known, suction accumulators are typically used in heat pump applications and employed in conjunction with fixed restriction expansion devices.

**[0023]** Additionally, the refrigerant vapor compression system **10** includes an intercooler **24** disposed in the refrigerant circuit between the first compression device **30-1** and the second compression device **30-2**. Refrigerant vapor passing from the evaporator **50** through refrigerant line **60**C enters the suction inlet of the first compression device **30-1**, wherein the refrigerant vapor is compressed to a higher intermediate pressure. The refrigerant vapor then passes from the discharge outlet of the first compression device **30-1** through refrigerant line **60**D to enter the suction inlet of the second compression device **30-2** wherein the refrigerant vapor is compressed to a still higher discharge pressure before passing from the discharge outlet of the second compression device **30-2** into refrigerant line **60**A. As the refrigerant vapor passes through refrigerant line **60**D, the refrigerant vapor traverses the intercooler **24** wherein the refrigerant vapor passing through the intercooler **24** is cooled via rejecting heat to the evaporator condensate **16**.

**[0024]** In the embodiment of the refrigerant vapor compression system **10** of the invention depicted in FIG. **1**, a pump **22** draws condensate **16** collecting in the evaporator drain pan **20** therefrom and passes the condensate **16** through condensate line **21** to a bank of spray nozzles **26**. The spray nozzles **26** are arrayed in operative association with a refrigerant conveying tube coil or passage **25** forming the intercooler **24** to spray condensate **16** received through condensate line **16** onto the exterior surfaces of the tubes of the coil **25**. As known in the art, the exterior surfaces of the tube coil or passage **25** can be extended and enhanced for better heat transfer. The refrigerant vapor traversing through the coil **25**

as it passes through refrigerant line **60**D from the first compression device **30-1** to the second compression device **30-2** is cooled as it rejects heat to heat and evaporate at least a portion of the condensate **16** sprayed onto the exterior of the coil **25**. To improve the evaporate cooling effect, the spray nozzles may comprise atomizers, such as atomizing nozzles or rotary atomizers, which produce a mist of relatively small size droplets of condensate onto the exterior of the coil **25**.

**[0025]** In the embodiment of the refrigerant vapor compression system **10** of the invention depicted in FIG. **2**, the pump **22** withdraws condensate **16** collecting in the evaporator drain pan **20** and passes the condensate **16** through condensate line **21** to and through the intercooler **24** in heat exchange relationship with the refrigerant passing through the intercooler **24**. As the refrigerant vapor traverses the intercooler **24**, the refrigerant vapor is cooled as it rejects heat to the condensate **16**. The intercooler **24** may comprise a plate-type heat exchanger, a tube-in-tube heat exchanger, an immersed coil heat exchanger or any other type of heat exchanger wherein the refrigerant vapor is passed in isolation from but in heat exchange relationship with the evaporator condensate. As the condensate passes in heat exchange relationship with the refrigerant vapor, the condensate **16** is heated and/or evaporated. As noted before, as known in the art, the exterior and interior surfaces of the intercooler **24** can be enhanced to provide better heat transfer characteristics. It has to be also noted that, in this case, the intercooler coil **25** can be integrated into the construction of the drain pan **20**, if desired.

**[0026]** In the embodiment of the refrigerant vapor compression system **10** of the invention depicted in FIG. **3**, the system is simplified by removing the pump **22** and disposing the evaporator **50** and its associated condensate drain pan **20** at a higher elevation than the intercooler **24**. Condensate **16** collecting in the evaporator drain pan **20** drains therefrom under the force of gravity through condensate line **21** to a plurality of spray nozzles **26**. As in the embodiment in FIG. **1**, the spray nozzles **26** are again arrayed in operative association with a refrigerant conveying tube coil or passage **25** forming the intercooler **24** to spray condensate **16** received through condensate line **21** onto the exterior surface of the tubes of the coil **25**. The refrigerant vapor traversing through the coil **25** as it passes through refrigerant line **60**D from the first compression device **30-1** to the second compression device **30-2** is cooled as it rejects heat to heat and at least partially evaporate the condensate **16** sprayed onto the exterior of the coil **25**. To improve the evaporate cooling effect, the spray nozzles may comprise atomizers, such as atomizing nozzles or rotary atomizers, which produce a mist of relatively small size droplets of condensate onto the exterior of the coil **25**.

**[0027]** In the embodiment of the refrigerant vapor compression system **10** of the invention depicted in FIG. **4**, the intercooler **24** is a refrigerant conveying tube coil or passage **25** immersed in the condensate **16** collecting in the condensate pan **20**. As noted before, the exterior surfaces of tube coils or passages **25** forming the intercooler **24** can be extended and enhanced for better heat transfer. The refrigerant vapor flowing through the intercooler **24** as it passes through refrigerant line **60**D from the first compression device **30-1** to the second compression device **30-2** is cooled as it rejects heat to heat and evaporate at least a portion of the condensate **16** collected in the condensate pan **20**. In this embodiment, the evaporated condensate must be vented to the ambient environment to ensure that the evaporated condensate does not re-enter the conditioned air stream leaving the evaporator **50**.

**[0028]** While the present invention has been particularly shown and described with reference to the preferred mode as illustrated in the drawings, it will be understood by one skilled in the art that various changes in detail may be effected therein without departing from the spirit and scope of the invention as defined by the claims. For example, those skilled in the art will recognize that many variations may be made to the exemplary embodiments described herein while still using the cooling capacity of the evaporator condensate to cool the refrigerant vapor passing between serially arranged compressors or compressor stages thereby utilizing cooling capacity that would otherwise be wasted.

We Claim:

**1**. A refrigerant vapor compression system comprising:

at least one compression device having a first compression stage to compress a refrigerant to a first pressure and a second compression stage to further compress the refrigerant from the first pressure to a second pressure;

a heat accepting heat exchanger for passing the refrigerant in heat exchange relationship with a moisture bearing gas whereby the heat is transferred to the refrigerant to cool moisture bearing gas and moisture in the moisture bearing gas is at least partially condensed to form a condensate; and

an intercooler wherein the condensate exchanges heat with and accepts heat from the refrigerant passing from the first compression stage to the second compression stage.

**2**. A refrigerant vapor compression system as recited in claim **1** wherein the first compression stage comprises a first compressor and the second compression stage comprises a second compressor, the first compressor having a discharge outlet connected by a refrigerant line in refrigerant flow communication to a suction inlet of the second compressor.

**3**. A refrigerant vapor compression system as recited in claim **2** wherein the refrigerant line connecting the discharge outlet of the first compressor to the suction inlet of the second compressor traverses the intercooler.

**4**. A refrigerant vapor compression system as recited in claim **1** wherein the first compression stage comprises a first compression stage of a compressor and the second compression stage comprises a second compression stage of the same compressor, the refrigerant being compressed in the compressor passes from the first compression stage to the second compression stage.

**5**. A refrigerant vapor compression system as recited in claim **4** wherein the refrigerant passing from the first compression stage to the second compression stage traverses the intercooler.

**6**. A refrigerant vapor compression system as recited in claim **1** further comprising a condensate collector operatively associated with the heat accepting heat exchanger for collecting the condensate condensed from the moisture bearing gas.

**7**. A refrigerant vapor compression system as recited in claim **6** further comprising a pump to supply the condensate from the condensate collector to the intercooler.

**8**. A refrigerant vapor compression system as recited in claim **1** wherein said intercooler comprises:

refrigerant conveying passages having an exterior heat exchange surface; and at least one spray nozzle to spray the condensate condensed from the moisture bearing gas onto the exterior heat exchange surface of the refrigerant conveying passages.

**9**. A refrigerant vapor compression system as recited in claim **8** wherein the at least one spray nozzle comprises an atomizing nozzle.

**10**. A refrigerant vapor compression system as recited in claim **8** wherein the at least one spray nozzle comprises a rotary atomizer.

**11**. A refrigerant vapor compression system as recited in claim **8** further comprising a condensate collector operatively associated with the heat accepting heat exchanger for collecting the condensate condensed from the moisture bearing gas.

**12**. A refrigerant vapor compression system as recited in claim **11** further comprising a pump to supply the condensate from the condensate collector to the at least one spray nozzle.

**13**. A refrigerant vapor compression system as recited in claim **1** wherein the refrigerant is carbon dioxide.

**14**. A refrigerant vapor compression system as recited in claim **1** wherein said intercooler comprises a heat exchange device incorporating refrigerant conveying passages having an exterior heat exchange surface in contact with the condensate.

**15**. A refrigerant vapor compression system as recited in claim **14** wherein the intercooler heat exchange device is selected from the group consisting of a plate heat exchanger, tubular heat exchanger and immersed coil heat exchanger.

**16**. A refrigerant vapor compression system as recited in claim **14** further comprising a condensate collector operatively associated with the heat accepting heat exchanger for collecting the condensate condensed from the moisture bearing gas.

**17**. A refrigerant vapor compression system as recited in claim **16** further comprising a pump to supply the condensate from the condensate collector to the intercooler.

**18**. A refrigerant vapor compression system as recited in claim **1** wherein the intercooler comprises a condensate collector operatively associated with the heat accepting heat exchanger for collecting the condensate condensed from the moisture bearing gas and the intercooler heat exchange device is a refrigerant conveying passage immersed in the condensate in said condensate collector.

**19**. A refrigerant vapor compression system as recited in claim **1**, wherein at least one of said first and second compression stages comprises at least a least a pair of compressors disposed in a tandem compressor configuration.

**20**. A method of improving performance of a refrigerant vapor compression system comprising the steps of:

compressing the refrigerant to a first pressure in a first compression stage and to a second pressure in a second compression stage;

passing the refrigerant in heat exchange relationship with a moisture bearing gas whereby the refrigerant accepts heat from the gas cooling the gas and at least a portion of the moisture condenses from the gas to form a condensate; and

cooling the refrigerant between the first compression stage and the second compression stage via heat exchange with the condensate.

**21**. A method as recited in claim **20** wherein the step of compressing the refrigerant to a first pressure in a first compression stage and to a second pressure in a second compression stage comprises compressing the refrigerant to a first pressure in a first compressor and compressing the refrigerant to a second pressure in a second compressor, the second compressor receiving refrigerant from the first compressor substantially at the first pressure.

**22**. A method as recited in claim **20** wherein the step of compressing the refrigerant to a first pressure in a first compression stage and to a second pressure in a second compression stage comprises compressing the refrigerant to a first pressure in a first stage of a compressor and compressing the refrigerant to a second pressure in a second stage of the same compressor.

**23**. A method as recited in claim **20** wherein the step of cooling the refrigerant passing between the first compression stage and the second compression stage via heat exchange with the condensate includes evaporating at least a portion of the condensate.

**24**. A method as recited in claim **23** further comprising the steps of:

passing the refrigerant flowing between the first compression stage and the second compression stage through at least one refrigerant conveying passage; and

spraying the condensate onto the at least one refrigerant conveying passage.

**25**. A method as recited in claim **23** further comprising the step of:

passing the refrigerant flowing between the first compression stage and the second compression stage through at least one refrigerant conveying passage immersed in the condensate.

**26**. A method as recited in claim **20** wherein the refrigerant is carbon dioxide.

**27**. A refrigerant vapor compression system comprising:

a first compressor to compress a refrigerant to a first pressure, said first compressor having a suction inlet and a discharge outlet;

a second compressor to further compress the refrigerant to a second pressure, the second compressor having a suction inlet and a discharge outlet;

a refrigerant circuit including a first refrigerant line connecting the discharge outlet of said second compressor in refrigerant flow communication with the suction inlet of said first compressor and a second refrigerant line connecting the discharge outlet of said first compressor with the suction inlet of said second compressor;

a heat rejecting heat exchanger for passing refrigerant in heat exchange relationship with a cooling fluid whereby the refrigerant rejects heat to the cooling fluid, said heat rejecting heat exchanger disposed in the first refrigerant line downstream with respect to refrigerant flow of the discharge outlet of said second compressor;

a heat accepting heat exchanger for passing the refrigerant in heat exchange relationship with a moisture bearing gas whereby the refrigerant accepts heat from the gas to cool the gas and moisture in the gas is at least partially condensed to form a condensate, said heat accepting heat exchanger disposed in the first refrigerant line downstream with respect to refrigerant flow of said heat rejecting heat exchanger;

an expansion device disposed in the refrigerant circuit downstream with respect to refrigerant flow of said heat rejecting heat exchanger and upstream with respect to refrigerant flow of said heat accepting heat exchanger, said expansion device operative to expand to lower pressure and temperature the refrigerant passing through the first refrigerant line from said heat rejecting heat exchanger to said heat accepting heat exchanger; and

an intercooler disposed in the second refrigerant line wherein the refrigerant passing from said first compressor to second compressor exchanges heat with the condensate whereby the refrigerant passing from said first compressor to said second compressor is cooled by the condensate.

**28**. A refrigerant vapor compression system as recited in claim **27** wherein the refrigerant is carbon dioxide.

**29**. A refrigerant vapor compression system as recited in claim **27** wherein said intercooler comprises a heat exchange device incorporating refrigerant conveying passages having an exterior heat exchange surface in contact with the condensate.

**30**. A refrigerant vapor compression system as recited in claim **29** wherein the intercooler heat exchange device is selected from the group consisting of a plate heat exchanger, tubular heat exchanger and immersed coil heat exchanger.

**31**. A refrigerant vapor compression system as recited in claim **27** further comprising a condensate collector operatively associated with the heat accepting heat exchanger for collecting the condensate condensed from the moisture bearing gas.

**32**. A refrigerant vapor compression system as recited in claim **27** further comprising a pump to supply the condensate from the condensate collector to the intercooler.

**33**. A refrigerant vapor compression system as recited in claim **27** wherein the intercooler comprises a condensate collector operatively associated with the heat accepting heat exchanger for collecting the condensate condensed from the moisture bearing gas and the intercooler heat exchange device is a refrigerant conveying passage immersed in the condensate in said condensate collector.

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