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(71) **Applicant** *(for all designated States except US)*: **CARRIER CORPORATION** [US/US]; Carrier Parkway, P.O. Box 4800, Syracuse, NY 13221 (US).

(72) **Inventor: BUSSJAGER, Ruddy, C.**; 7373 Lakeshore Road, Cicero, NY 13039 (US).

(74) **Agent: SZWERC, Christine, M.**; Carrier Corporation, Intellectual Property Department, Carrier Parkway, P.O.Box 4800, Syracuse, NY 13221 (US).

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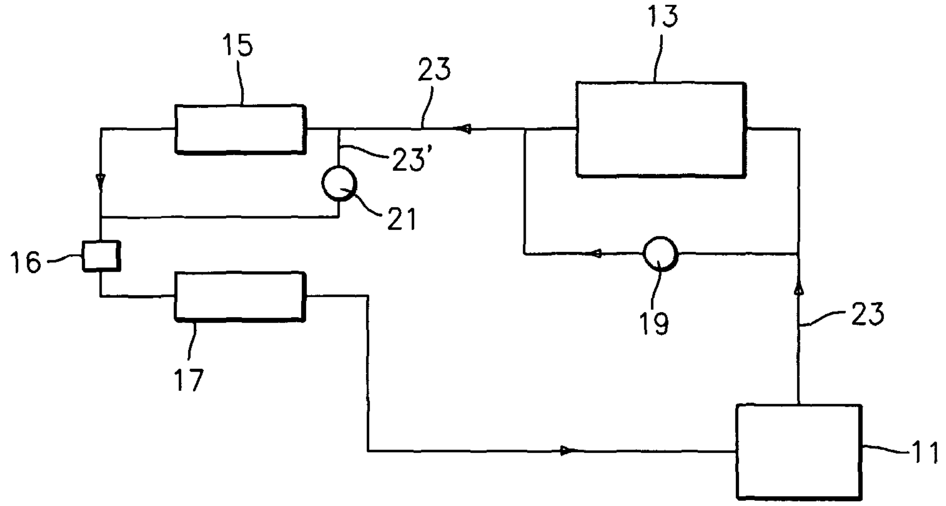
(54) **Title:** TWO PHASE OR SUBCOOLING REHEAT SYSTEM



(57) **Abstract:** An air conditioning apparatus comprising a continuous circuit through which a refrigerant flows from a compressor, through a condenser, through a heat exchanger, through an evaporator, and returning to the compressor, a bypass circuit through which a portion of the refrigerant flows from a point upstream of the condenser to mix with the refrigerant at a point downstream of the condenser, and a discharge gas valve for controlling the portion of the refrigerant flowing through the bypass circuit.

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TWO PHASE OR SUBCOOLING REHEAT SYSTEM

BACKGROUND OF THE INVENTION

(1) Field of the Invention

[0001] The invention relates to a method for increasing the flexibility of air conditioning systems that employ humidity removal.

(2) Description of the Related Art

[0002] Conventional air conditioning systems comprise three basic components which function in unison to provide cooling. These three system components include the compressor, the condenser, and the evaporator. With reference to Fig. 1, there is illustrated an air conditioning system 10 known in the art. The air conditioning system 10 moves a working fluid, or refrigerant, via a continuous closed network 23 through these operational components in a continuous cycle of operation. The refrigerant is typically composed of Freon but may consist of any fluid, such as alcohol or the like, capable of accepting and giving up heat energy as its temperature increases and decreases and as its state changes between a gas and a liquid.

[0003] Refrigerant enters the compressor 11 as a low pressure and temperature gas and is compressed. After compression, the refrigerant leaves the compressor 11 as a high temperature and pressure gas.

[0004] The refrigerant moves in its gaseous state to the condenser 13. At the condenser 13, the received refrigerant gas decreases in energy at a constant pressure and becomes totally subcooled as it leaves the condenser. Thereafter, the liquid refrigerant proceeds to the evaporator 17.

[0005] At the evaporator 17, the refrigerant pressure is reduced by expansion device 16. In the evaporator, energy is picked up from the air stream and the refrigerant leaves in a gaseous state. At the evaporator 17, the air to be cooled is, for example, initially at about 80 degrees Fahrenheit. Such air is moved by a fan through the evaporator 17 and becomes cooled to about 50 to 55 degrees Fahrenheit or lower.

[0006] Often times when the air requires greater dehumidification, heat exchanger 15 is provided to further subcool the refrigerant. The air passing over evaporator 17 exhibits more in latent and sensible cooling with the heat exchanger energized. However, the energy removed from the refrigerant by heat exchanger 15 is returned to the air stream after the air leaves evaporator 17. Thus, with heat exchanger 15 energized, the air leaving is at a higher dry bulb temperature (less sensible) and is low moisture centered (more latent), than with heat exchanger 15 unenergized.

SUMMARY OF THE INVENTION

[0007] Accordingly, it is an object of the present invention to provide a method for increasing the flexibility of an air conditioning systems that employ humidity removal.

[0008] In accordance with the present invention, an air conditioning apparatus comprises a continuous circuit through which a refrigerant flows from a compressor, through a condenser, through a heat exchanger, through an evaporator, and returning to the compressor, a bypass circuit through which a portion of the refrigerant flows from a point upstream of the condenser to mix with the refrigerant at a point downstream of the condenser, and a discharge gas valve for controlling the portion of the refrigerant flowing through the bypass circuit.

[0009] In further accordance with the present invention, a method for removing humidity from air comprises the steps of providing an air conditioning system comprising a continuous circuit through which a refrigerant flows from a compressor, through a condenser, through a heat exchanger, through an evaporator, and returning to the compressor, providing a bypass circuit through which a portion of the refrigerant flows from a point upstream of the condenser to mix with the refrigerant at a point downstream of the condenser, providing a discharge gas valve for controlling the portion of the refrigerant flowing through the bypass circuit, and providing at least one damper which may be opened in an economizer mode, and operating the air conditioning system to remove a portion of the humidity from the air.

[0010] The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 A diagram of an air conditioning system known in the art.

[0012] FIG. 2 A diagram of an air conditioning system of the present invention.

[0013] FIG. 3 A graph of pressure vs. enthalpy of the refrigerant flow of the prior art.

[0014] FIG. 4 A graph of pressure vs. enthalpy of the refrigerant flow of the present invention.

[0015] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0016] It is therefore a teaching of the present invention to provide a method, and a system for utilizing such method, for utilizing previously wasted heat in an air conditioning system to negate the undesirable effects of sensible cooling.

[0017] It is sometimes desirable to provide no sensible cooling and just remove moisture. In such a case, additional heat is added to the air by energizing valve 19 as illustrated with reference to FIG. 2 which bypasses a portion of the flow around condenser 13. In so doing, heat exchanger 15 becomes a condenser of the 2 phase mixture entering and a subcooler of refrigerant prior to its exit from heat exchanger 15.

[0018] Thus with this scheme various levels of moisture removal and sensible cooling is available.

[0019] With reference to figure 2, there is illustrated the air conditioning system of the present invention. Most notable is the inclusion of a circuit for partially bypassing a portion of the discharge gas from entering the condenser and a discharge gas valve 19 positioned along same. When open, discharge gas valve 19 allows for a portion of the hot gas leaving the compressor to bypass the condenser 13 which can provide enhanced flexibility when dehumidification is required. Dehumidification is often required when relative humidity in the space exceeds desired values. In a preferred embodiment, gas valve 19 is a solenoid valve.

[0020] As noted above, prior art implementations making use of a heat exchanger 15, wherein the heat exchanger 15 is configured to contain a sub-cool unit or coil as well, make use of a bypass valve to bypass the sub-cooler coil during normal operation during which there is no need for dehumidification. When a need for dehumidification arises, the normally open bypass valve 21, preferably a solenoid valve, is closed and the subcooling coil in the heat exchanger 15 is activated to yield increased latent capacity and less sensible capacity.

[0021] With reference to figure 3, there is illustrated a plot of enthalpy versus pressure of the refrigerant of a prior art system as it passes through the closed circuit of the air conditioning system 10. Point 4 indicates the entrance to the compressor 11. Traveling from point 4 to point 1, the refrigerant increases in pressure and energy. Moving from point 1 to point 2, the refrigerant moves through the condenser 13 and decreases in enthalpy while maintaining an approximately constant pressure. The pressure of the refrigerant is then lowered until entering the evaporator where the enthalpy increases while maintaining approximately constant pressure until returning to the compressor at point 4.

[0022] When solenoid 21 closes, the refrigerant is further cooled from point 2 to point 3 and enters the evaporator at a lower enthalpy. The evaporator then absorbs more energy from the air. However, this energy is returned to the air after it passes over the heat exchanger 15 and thus more latent and less sensible. As noted above, the present invention includes a discharge gas valve 19 which, when open, allows for a portion of the hot gas leaving the compressor to bypass the condenser 13. The bypass gas is mixed with the liquid refrigerant exiting the condenser. The resultant mixture, now two phase, enters the heat exchanger 15 and is condensed and subcooled.

[0023] With reference to figure 4, there is illustrated a plot of enthalpy versus pressure of the refrigerant as it travels the circuit of the present invention when the discharge gas valve 19 is open. Refrigerant enters and exits the compressor at point 5 and continues to point 1 where a portion of the refrigerant continues through the condenser while the remaining portion of the refrigerant bypasses the condenser and continues through discharge gas valve 19. This bypass gas moves from point 1 to point 3. The refrigerant passing through the condenser at point 1 exits the condenser at point 2, mixes with the bypass gas, and proceeds to point 3 at which point, condensing and sub-cooling of the refrigerant and reheat of the air is performed. The refrigerant then proceeds to enter and exit the evaporator and return to the condenser.

[0024] As a result, the addition of mixing the hot gas refrigerant with the refrigerant exiting the condenser 13 increases the distance from point 3 to point 4 in figure 4 to be greater than the distance from point 2 to point 3 in figure 3. The addition of heat to the refrigerant in the present invention negates sensible cooling. Preferably, the amount of refrigerant flowing though discharge gas valve 19 is controlled to yield zero sensible capacity, that is the dry bulb temperature entering the evaporator is equal to the dry bulb temperature leaving the evaporator.

[0025] The decision to open, or activate, discharge gas valve 19 depends primarily upon the need for dehumidification in the space to be cooled, the outside air temperature, and the ability to perform subcooling in the heat exchanger 15. When dehumidification is desired with no need for cooling, the air conditioning system 10 operates with discharge gas valve 19 opened to provide for bypass. If dehumidification and cooling is desired and the outside air temperature is low, one must ascertain the availability of an economizer mode whereby dampers are opened to bring in cool outside air. If an economizer is available, it is activated with discharge gas valve 19 opened to provide for bypass. If dehumidification and cooling is desired and the outside air temperature is warm, discharge gas valve 19 is closed, the economizer is closed, and the heat exchanger 15 is operated in the subcooling mode. When dehumidification is not required, discharge gas valve 19 is closed. By "cool" and "warm", it is meant that the outside air is below or above, respectively, the desired temperature or enthalpy of the air to be cooled by the air conditioning system 10.

[0026] One or more embodiments of the present invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Accordingly, other embodiments are within the scope of the following claims.

CLAIMS

What is claimed is:

1. An air conditioning apparatus comprising:

a continuous circuit through which a refrigerant flows from a compressor, through a condenser, through a heat exchanger unit, through an evaporator, and returning to said compressor;

a bypass circuit through which a portion of said refrigerant flows from a point upstream of said condenser to mix with said refrigerant at a point downstream of said condenser; and

a discharge gas valve for controlling said portion of said refrigerant flowing through said bypass circuit.

2. The air conditioning system of claim 1 wherein said discharge gas valve is a solenoid valve.

3. The air conditioning system of claim 1 comprising at least one damper which may be opened in an economizer mode.

4. The air conditioning system of claim 1 wherein said discharge gas valve is opened and closed in response to a temperature of said air.

5. A method for removing humidity from air comprising the steps of:

providing an air conditioning system comprising a continuous circuit through which a refrigerant flows from a compressor, through a condenser, through a heat exchanger, through an evaporator, and returning to said compressor;

providing a bypass circuit through which a portion of said refrigerant flows from a point upstream of said condenser to mix with said refrigerant at a point downstream of said condenser;

providing a discharge gas valve for controlling said portion of said refrigerant flowing through said bypass circuit; and

operating said air conditioning system to remove a portion of said humidity from said air.

6. The method of claim 5 comprising the additional step of opening said discharge gas valve in to remove said portion of humidity wherein said air is not to be cooled.

7. The method of claim 5 comprising the additional steps of opening said discharge gas valve and opening said at least one damper to remove said portion of humidity wherein said air is to be cooled and said air is cool.

8. The method of claim 5 comprising the additional steps of closing said discharge gas valve, opening said at least one damper, and operating heat exchanger to remove said portion of humidity wherein said air is to be cooled and said air is warm.

9. The method of claim 5 further comprising the step of flowing said portion of said refrigerant through said bypass circuit so as to provide a two-phase flow to said heat exchanger.

10. The method of claim 5 comprising the additional step of providing at least one damper which may be opened in an economizer mode.

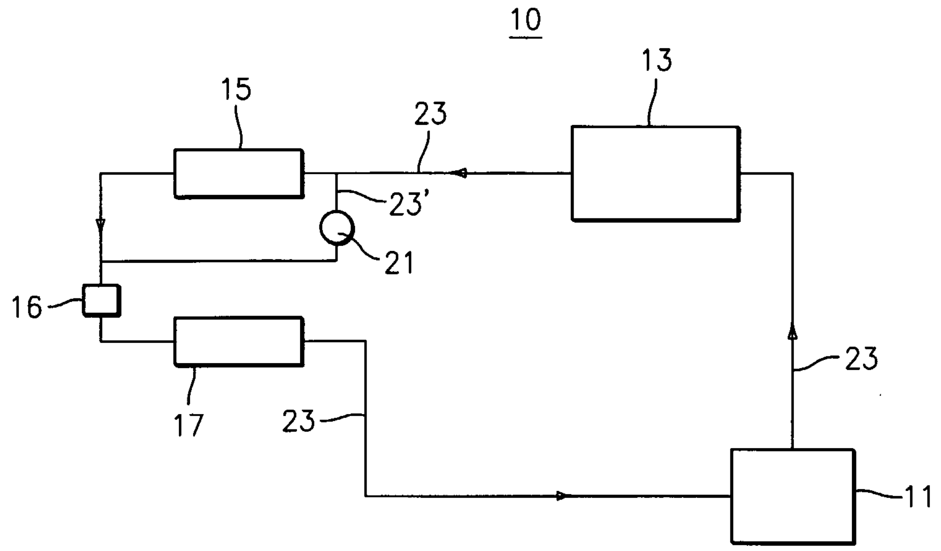

FIG. 1
(PRIOR ART)

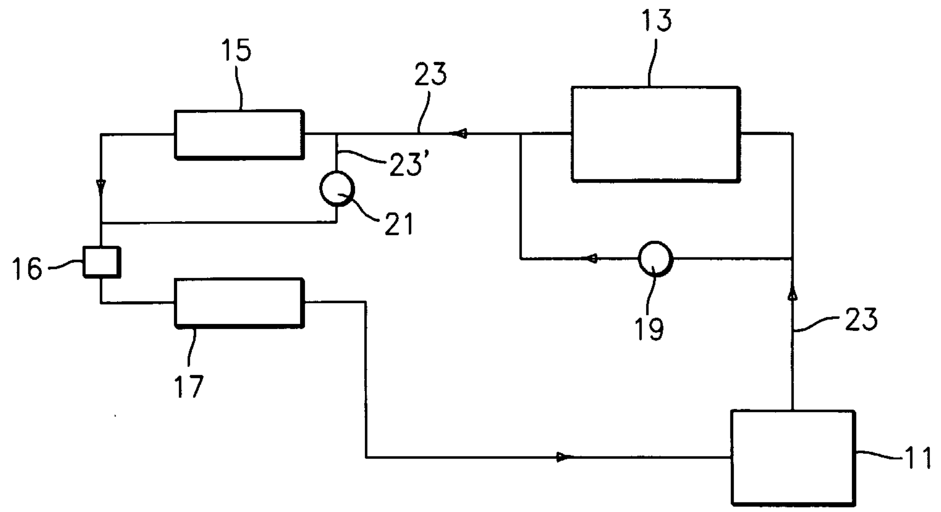

FIG. 2

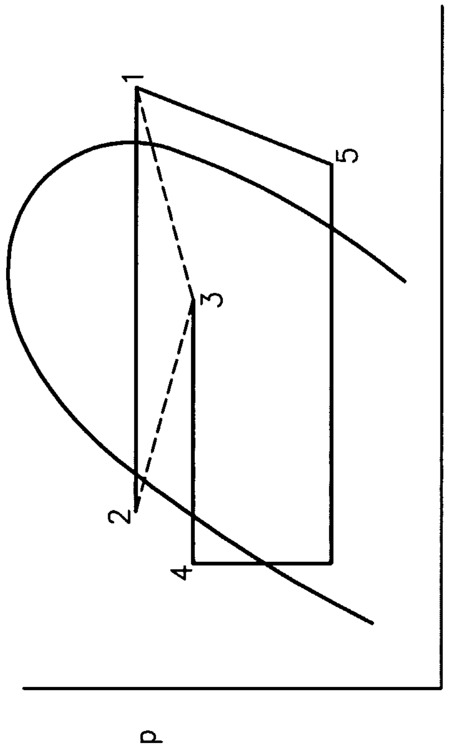

FIG. 4

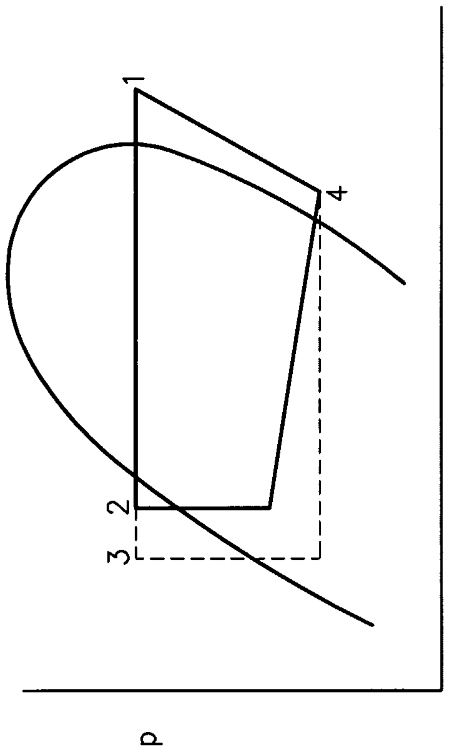

FIG. 3

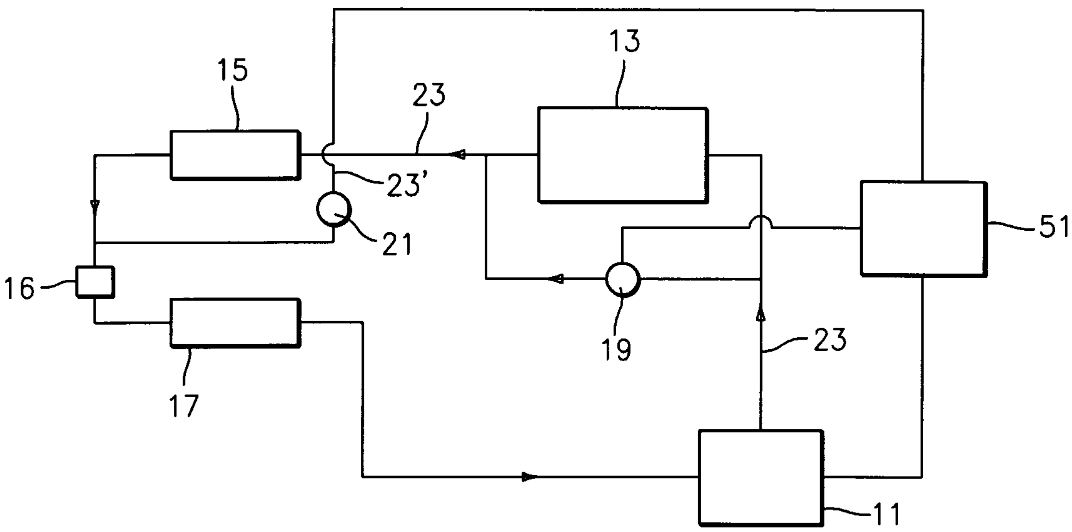

FIG. 5