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McFarlan

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[54] **AIR CONDITIONING SYSTEM AND METHOD UTILIZING HUMIDIFICATION OF THE AIR**

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[63] Continuation of Ser. No. 177,415, Sept. 2, 1971, abandoned.

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[51] **Int. Cl.** **F24f 3/14**

[58] **Field of Search** 62/335, 510; 165/2, 20, 165/21, 22

[56] **References Cited**

UNITED STATES PATENTS

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3,354,943	11/1967	McFarlan	165/22 X
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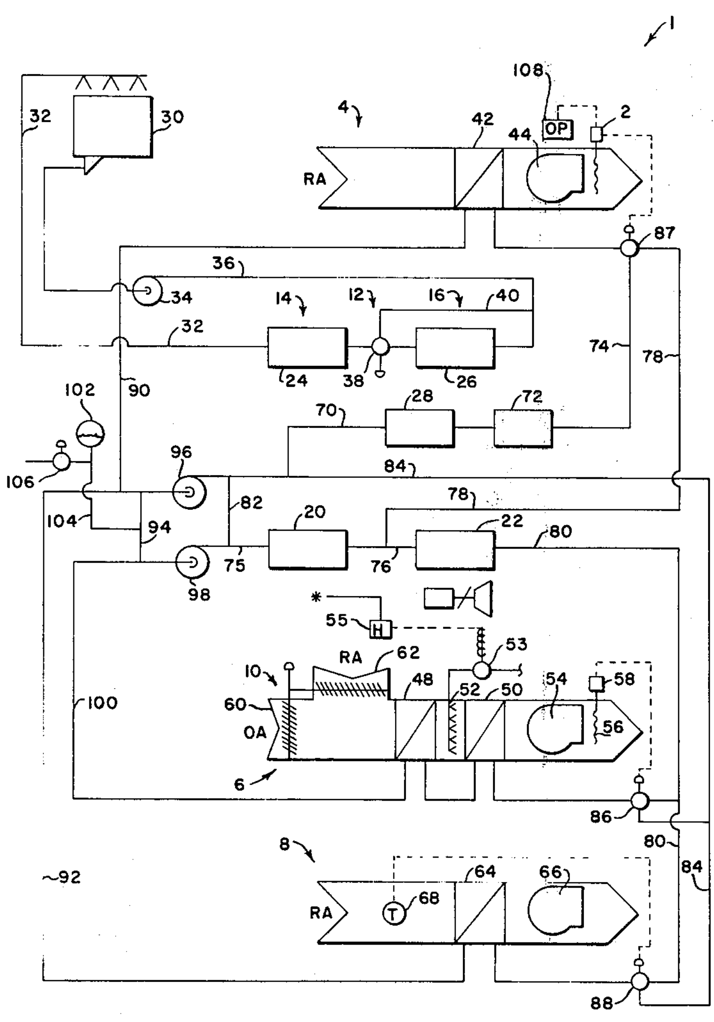
[57] **ABSTRACT**

An air conditioning system utilizing excess heat which would otherwise be discharged from the system to vaporize water and humidify the air. The system utilizes heat produced internally of the system to make up for heat losses so that heat is discharged from the system only when there is an excess of heat in the entire system, and auxillary heat is added to the system only when there is a deficiency of heat in the system. When there is an excess of heat in the system water is sprayed and vaporized into the air for the conditioned space. The vaporization acts to reduce the load on the refrigeration equipment, and the heat of vaporization remains in the system.

5 Claims, 1 Drawing Figure



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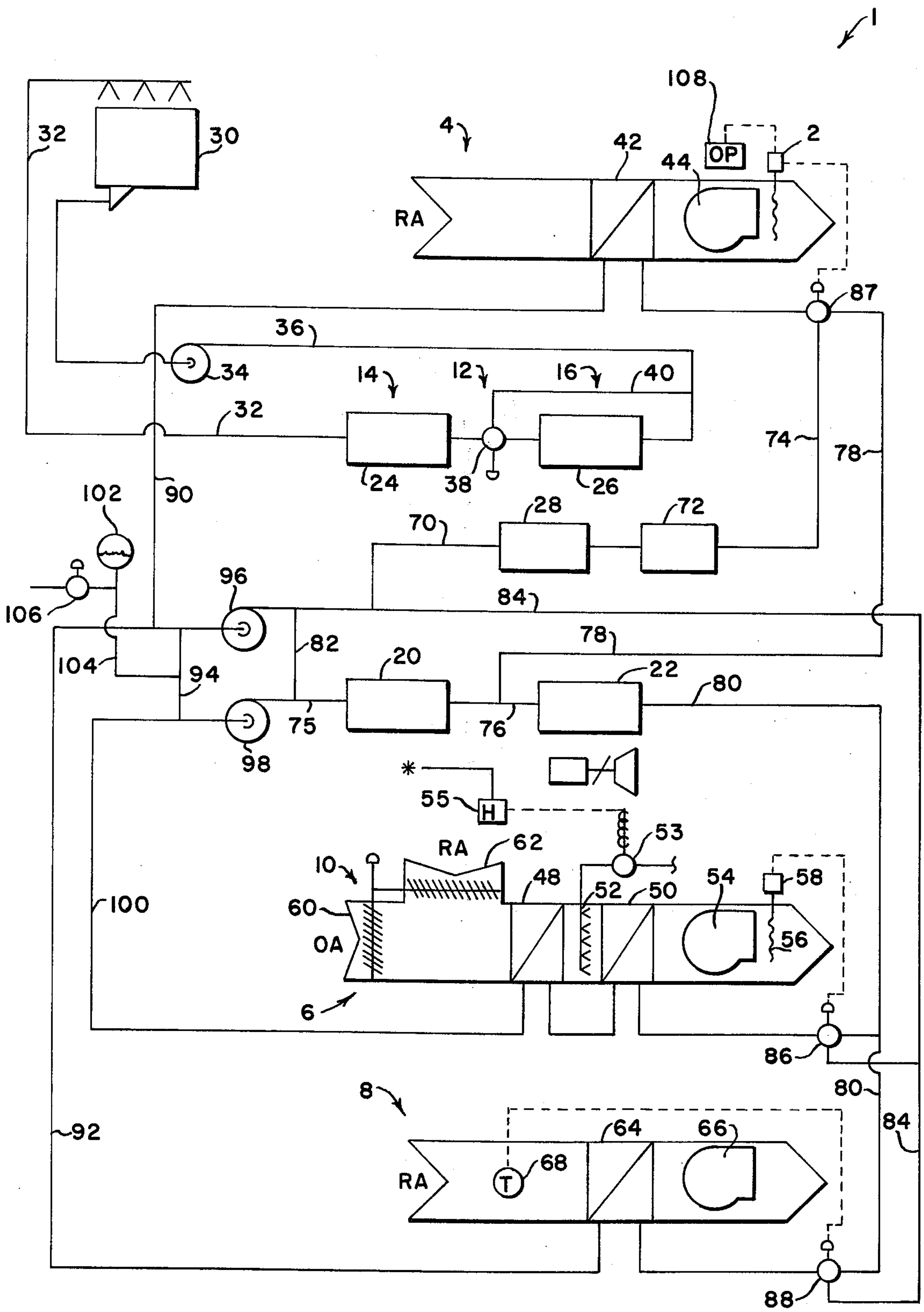

AIR CONDITIONING SYSTEM AND METHOD UTILIZING HUMIDIFICATION OF THE AIR

This is a continuation of application Ser. No. 177,415, filed Sept. 2, 1971 and now abandoned.

This invention relates to air conditioning systems and methods, and more in particular to providing improved operation in the humidification of the air in the zones and spaces which are served.

Most air conditioning systems serve zones or spaces where a substantial amount of "internal heat" is produced, for example, by lights, electric machines, occupants and the refrigeration equipment. That heat can be utilized in a properly designed air conditioning system to compensate for heat losses during the cold weather. Accordingly, systems have been developed for recovering the heat removed from the internal space of the building, and for distributing that heat to the periphrey of the building and for heating the air supplied for ventilation.

With such an arrangement and for any particular set of operating conditions, there is a "break-even temperature" at which the internally produced heat of the system exactly equals the heat losses. Above that temperature, heat must be discharged from the system and below that temperature auxillary heat must be added to the system. In many instances the climate is such that the outside temperature is below the desired temperature within the building, but it is above the break-even temperature, i.e., the exterior of the building and the air for ventilation must be heated, but heat must still be discharged from the system. Under this condition it has been common practice to discard excess internal heat by increasing the quantity of cold outside air above the minimum required for ventilation only.

When outside cold air is heated it also requires humidification, and the necessary heat of vaporization must be provided as part of the heating load. Bringing in excessive outside air increases the demand for humidification and produces a correspondingly increased heating load. It is an object of the present invention to improve the efficiency of operation of systems of this type where humidification is desirable. It is a further object to provide improved methods and controls for such systems. These and other objects will be in part obvious and in part pointed out below.

In the drawings, the single FIGURE illustrates schematically one embodiment of the invention.

Referring to the drawing, a system **1** is adapted to provide heating and cooling for a plurality of zones under the control of a heat balance detector or controller **2.** That basic heating and cooling system is disclosed in U.S. Pat. No. 3,354,943, patented Nov. 28, 1967, and reference should also be had to U.S. Pat. No. 3,628,600, patented Dec. 21, 1971, which incorporates the basic refrigeration system and control features of the present invention. Both of said patents issued to A. I. McFarlan. As will be explained more fully below, controller **2** exerts overall control upon the various components of the system and maintains a desirable heat level in the system. It causes heat to be discharged from or added to the system in accordance with the requirements. The system includes three return air-treating units **4, 6** and **8** which supply conditioned air for the various zones. Unit **6** receives controlled portions of return air and outside air under the control of an air-mixing damper assembly **10,** while units **4** and **8** receive only return air. A refrigeration system **12** is of the type disclosed in U.S. Pat. No. 3,628,600, and has two refrigeration units **14** and **16,** with evaporator-chillers **20** and **22,** respectively, condensers **24** and **26,** respectively, compressors and standard control and operating components not shown. Unit **16** has a second condenser **28** which is a water-heating or double condenser in parallel with condenser **26,** as shown in U.S. Pat. No. 3,628,600. A cooling tower **30** receives condenser-cooling water from condensers **24** and **26** through a line **32,** and is circulated by pump **34** in the return line **36** from the cooling tower. Condenser **26** has a bypass valve **38** and a line **40** by which water from line **36** may be bypassed around the condenser at a variable rate, whereby all or any part of the stream of water passes from line **36** directly to condenser **24** so as to render condenser **26** ineffective.

Air-treating unit **4** has an air-treating coil **42** and a blower **44,** and a temperature sensing element **46** of controller **2** and is positioned in the path of the discharge air. Unit **6** has two coils **48** and **50,** a sprayer **52** positioned between the coils in the air stream, a blower **54,** and a temperature sensing element **56** of a control unit **58** is positioned in the path of the discharge air. As indicated above, damper assembly **10** controls the proportion of air entering through the outside air inlet **60** and the return air inlet **62.** Sprayer **52** is supplied with tap water through a solenoid valve **53** which is under the control of a humidistat **55** in the stream of return air flowing to unit **6.** As will be explained more fully below, controller **2** also exerts overriding control on humidistat **55** and valve **53** so as to control the operation of sprayer **52.** Unit **8** has an air-treating coil **64** and a blower **66,** and a thermostat **68** is positioned in the path of the return air.

The system provides heat transfer liquid in the form of water at four different temperatures; namely, moderate temperature and low temperature chilled water, heated water and return water. The stream of heated water flows from a line **70** through condenser **28** and an auxillary heater **72** to a hot water line **74.** Chilled water flows through a line **75,** evaporator chiller **20** and a line **76** and thence either to a moderate-temperature chilled water line **78** or through chiller **22** to a low-temperature chilled water line **80.** Return water flows from a supply header line **82** through to a return-water line **84.**

Lines **74** and **78** extend to a mixing valve **87** for coil **42** of unit **4,** so that coil is supplied with either moderate-temperature chilled water or heated water, or a mixture of the two, as required by controller **2.** Lines **80** and **84** extend to a mixing valve **86** for coils **50** and **48** of unit **6,** and also to a mixing valve **88** for coil **64** of unit **8,** so that units **6** and **8** may receive either return water or low-temperature chilled water or a mixture of the two. Valve **86** is regulated by controller **58,** and valve **88** is controlled by thermostat **68.** Water returns from coil **42** through a line **90** and joins a return water line **92** from coil **64** at a common connection with common return header line **94** and in alignment with a pump **96.** A pump **98** is connected in parallel with pump **96** between header lines **94** and **82,** and the pumps are of the constant head-pressure type, even with differences in the flow rates through them.

Water supplied to unit **6** flows through coils **50** and **48** in series and thence through a return line **100** to header line **94,** with a connection in alignment with the inlet to pump **98**. Hence, there is a tendency for pump **98** to handle water from line **100** and direct it through the chilled water line **75**, and for pump **96** to handle return water from lines **90** and **92** and direct it through return water line **84** and line **70**. However, the header lines pemit free transverse flow through the header lines so as to maintain balanced pressure conditions. A tank **102** is connected through a line **104** to header line **94**, and additional water is supplied through a valve **106**.

As indicated above, the operation of the entire system is regulated by controller **2** in accordance with the temperature of the air discharged from unit **4**. The air from unit **4** is directed to the periphrey of the building to handle the heat losses and gains by conduction through the external building walls. Accordingly, an outside air temperature thermostat **108** modifies the control functions of controller **2** to take into account variations in the outside temperature. During operation, controller **2** operates cooling tower **30** to discharge heat from the system only when there is an excess of heat and it operates auxillary heater **72** to add heat to the system only when there is a deficiency of heat in the system. In controlling the discharging of heat from the system it is desirable to provide maximum heating of the water by double condenser **28**, valve **38** is operated to bypass the entire cooling water stream through line **40** without any flow through condenser **26**. At that time, only heat from condenser **24** is discharged from the system and, of course, auxillary heater **72** is not operating. As indicated above, unit **8** is controlled by thermostat **68** in the return air stream entering the unit and this unit supplies air to interior zones and handles a cooling load at all times.

Unit **6** supplies conditioned air to the major interior zones or spaces and receives controlled portions of return air and outside air. Under peak heating load conditions, return air only is supplied to unit **6**, but during the major portion of the operating range a predetermined "minimum" quantity of outside air is supplied. However, the proportion of outside air is increased to a "maximum" during the range of operation when there is an excess amount of heat in the system and the outside air temperature is below the exhaust air temperature, with consideration being given to possible excessive high outside humidity conditions. At high outside temperatures the "minimum" quantity of outside air is supplied. The air treating coils of units **4**, **6** and **8** are of the "wide range" type so as to permit the temperature of the return water to approach closely to the room air temperature.

The system of the illustrative embodiment described above includes features and inventions covered by U.S. Pat. Nos. 3,354,943 and 3,628,600 of A. I. McFarlan. The present invention provides for improved efficiency and control, as explained below, by utilizing humidification of the air handled by unit **6** as a factor in maintaining acceptable conditions. In accordance with the present invention, sprayer **52** is operated to utilize internal heat of the sytem to raise the humidity of the air. For example, assume that the system has been operating at the "break even temperature," and neither the cooling tower **30** nor the auxillary heater **72** is operating. Also, that sprayer **52** is not operating, and the minimum quantity of air is being supplied to the system.

If there is an increase in the outside temperature or in the amount of heat being produced within the system, controller **2** will determine a need to lower the heat level within the system. This can readily be accomplished by starting the cooling tower or by increasing the amount of fresh air to the maximum value. However, alternative to either of those and in accordance with the present invention, sprayer **52** is turned on so as to thoroughly wet coil **50** and cause evaporation of the water into the air stream. The evaporation of the water produces adiabatic cooling of the air and spray, and heat of vaporization is taken from the air and from the water in coil **50**. The stream of water flowing through coil **50** returns through line **100** to pump **98** at a temperature lower than before. The stream of air is cooled below its prior level, but controller **58** adjusts valve **86** to maintain the same temperature of the discharge air. That adjustment causes coil **50** and **48** to receive a smaller portion of the low temperature chilled water from line **80** and a larger portion of the return water from line **84**. Pump **98** directs the lower temperature water from line **100** through line **75** to the evaporator-chillers.

As indicated above, pump **96** tends to direct water through the return water line **84** and the heated water lines **70** and **74**, and unit **8** always handles a cooling load. Hence, heat is picked up from the return air by the stream of water flowing through coil **64**, and that heat is carried through line **92** and pump **96** to the return water line **84** and line **70**. Valve **88** delivers to coil **64** the low temperature chilled water from line **80** and/or return water from line **84** in accordance with the temperature of the return air. Hence, when the return air is at high temperature, coil **64** receives chilled water from line **80** which picks up a substantial amount of heat so that the return water is at substantially room temperature. With sprayer **52** operating, controller **58** has positioned valve **86** so that coil **50** receives from line **84** a substantial amount of return water which is warmer than water from line **80**. Hence, the heat is picked up in unit **8** and is delivered to unit **6** and provides heat of evaporation for the water being sprayed. Heat picked up at coil **42** of unit **4** is also available to provide the heat of evaporation at coil **50**.

As has been indicated above, humidistat **55** can close valve **53** when the humidity of the return air becomes excessive but controller **2** can override the humidistat. Comfort conditions can be maintained with a fairly wide range of relative humidity, and the system operates so that controller **2** will override the humidistat or modify its operation so as to permit the operation of sprayer **52** to absorb heat as discussed above. For example, during a 24 hour period when there is a wide swing in the outside temperature, the sprayer can be turned on so as to increase the humidity to the top of the acceptable level during the middle of the day when there is an excess of heat in the system, and the humidity can be dropped at night when there is a net heating load on the system. The high humidity conditions then acts to avoid the necessity for discharging heat during the day and to reduce the net heating load during the night.

It is thus seen that the humidification of the air provides cooling which reduces the requirements for discharging heat from the system. If at that time outside air is the sole means for discharging excess heat, turning on sprayer **52** reduces the requirement for such excess air. However, in any case turning on sprayer **52** produces a net reduction in the amount of heat which must be discharged from the system to maintain stable operating conditions.

In the illustrative embodiment, return water is supplied through line **84** and valve **88** to coil **64** of unit **8.** The invention contemplates that heated water may be supplied through an extension of line **74** to a valve **88** of a unit **8** or a similar unit. It is understood that various other modifications and embodiments may be provided within the scope of the claims.

What is claimed is:

1. In an air conditioning system of the character described, the combination of, a plurality of air treating units one of which treats the air which is a cooling load and another of which treats air which may be either a heating load or a cooling load or neither, and which also includes a heat-transfer-liquid circulating system which passes a stream of liquid through the first-named of said units to carry heat therefrom and which is adapted to circulate the heated liquid to the second-named of said units in heat transfer relationship with a stream of air, spray means to spray water in said stream of air to thereby produce evaporation to cool and humidify the stream of air and extract heat from the heated liquid, means to discharge heat from the system when there is an excess of heat in the system, auxiliary heating means to add heat to the system when there is a deficiency of heat in the system, means to utilize heat in the system to evaporate said spray water, and control means to exert overall control upon the entire system to add heat to the system when desirable and to discharge heat from the system when desirable, said control means being operative to utilize said spray means when there is an excess of heat in the system as an alternative to discharging that excess heat from the system by utilizing that excess heat to evaporate said spray water to increase the relative humidity of the air in the system and thereby increase the relative amount of heat in the air in the system while maintaining acceptable temperature conditions.

2. A system as described in claim **1** wherein said circulating system provides each of said units with two streams of said liquid at different temperatures, and control means to provide liquid from one or the other of the streams or a mixture of the two.

3. A system as described in claim **2** which includes refrigeration means to provide a stream of chilled liquid for said units.

4. A system as described in claim **3** which includes a third unit and wherein said refrigeration means provides heated liquid for said third unit.

5. In the art of maintaining acceptable ambient conditions within an air conditioned space having a plurality of zones in which one zone may require cooling while other zones may require heating or cooling, and wherein heat is transferred from a zone requiring cooling to a zone requiring heating and wherein heat is discharged from the system only when there is an excess of heat for the entire system and auxiliary heat is added to the system only when there is a deficiency of heat for the entire system, that improvement which comprises as an alternative to discharging excess heat from the system the step of utilizing that excess heat to vaporize water into air passing to a zone or zones to thereby provide cooling for the zone or zones and increase the relative amount of heat in the air while maintaining acceptable temperature conditions, and the step of reducing the relative humidity of the air in the system when changes in the operating conditions create a net heating load for the system thereby to maintain comfort conditions throughout the system while making it unnecessary to add the amount of auxiliary heat equal to said excess heat utilized to evaporated the water as an alternative to discharging that excess heat.

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