

[54] **AIR CONDITIONING SYSTEM**

[72] Inventor: **Alwin B. Newton**, York, Pa.

[73] Assignee: **Borg-Warner Corporation**, Chicago, Ill.

[22] Filed: **Sept. 11, 1970**

[21] Appl. No.: **71,550**

[52] U.S. Cl. **165/21, 165/22**

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

[58] Field of Search.....165/14, 19, 20, 21, 22, 50

[56] **References Cited**

UNITED STATES PATENTS

1,827,099	10/1931	Otis	165/21
3,191,668	6/1965	Lorenz	165/22
3,378,062	4/1968	Rinquist et al.....	165/22

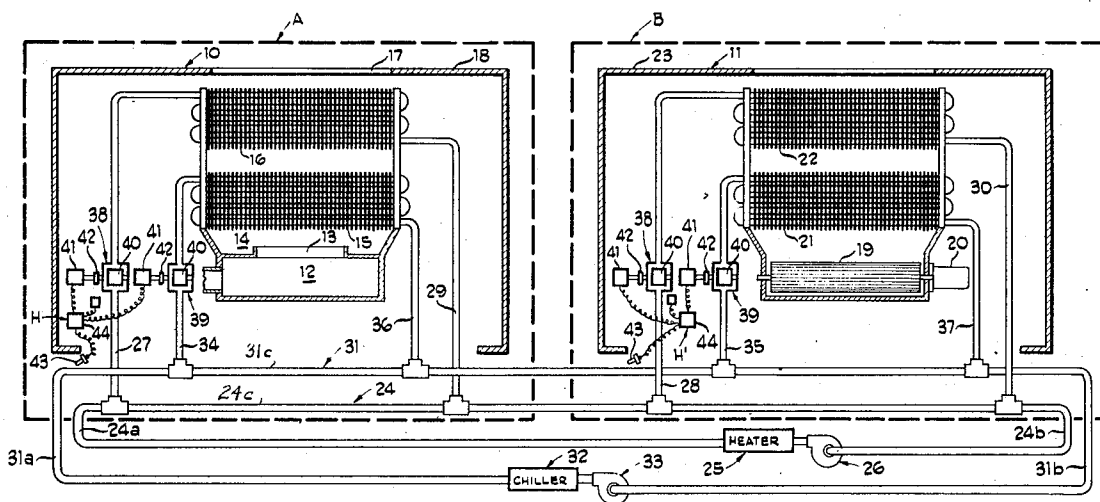
Primary Examiner—Charles Sukalo

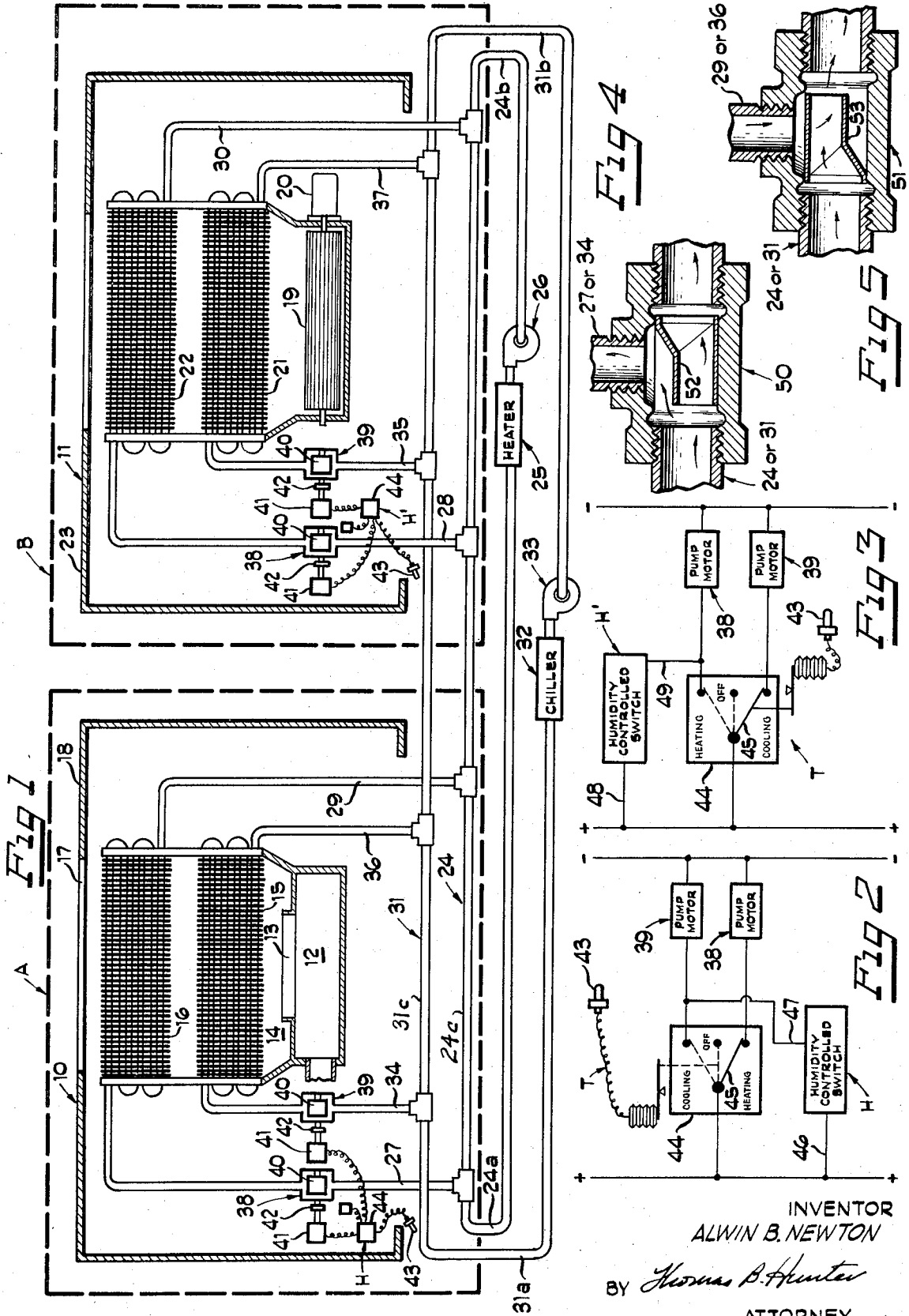
Attorney—Donald W. Banner, William S. McCurry and John W. Butcher

[57] **ABSTRACT**

An air conditioning system employing separate chilled water and heated water single pipe loops and designed for use with individual room air conditioning units (inductor or fan-coil) equipped with separate heating and cooling heat exchange coils. The system provides local control at each unit, for both heating and cooling at all times when the heated water and chilled water circuits are active, as each circuit in the unit includes a circulating pump and coil, the pumps being under thermostatic control responsive to room temperature requirement.

7 Claims, 5 Drawing Figures





INVENTOR
ALWIN B. NEWTON

By *Thomas B. Hunter*
ATTORNEY

AIR CONDITIONING SYSTEM

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates generally to air conditioning systems, and more particularly to a piping or water distribution system for a multi-room air conditioning installation.

The type of air conditioning system used in a multi-room building is often referred to in the trade by terms which relate to the piping or water distribution arrangement. In a "four-pipe" system, each room air conditioning unit is supplied with heated and chilled water through separate lines and is returned to the heater and chiller through separate lines, respectively. In a "three-pipe" system, each room air conditioning unit is supplied with heated and chilled water through separate lines, but the returning water is mixed together in a common line for return to the water chiller and heater. The "two-pipe" system comprises one supply line and one return line connected to each room unit. This system is thus limited to circulating hot and cold water to all units in the system at any given period so that, normally, hot water is circulated when most of the rooms require heating, and cold water when most of the rooms require cooling. When intermediate conditions exist, accurate control is impossible.

Despite the generally recognized fact that the four-pipe system provides the best and most flexible temperature control of the described hot and cold water distribution system for multi-room buildings, the three-pipe system has achieved significant commercial success over the four-pipe system because of its lower installation cost, attributed to its omission of the extra line for returning the water to the water chiller or heater. Unfortunately, the three-pipe system has been beset with problems, principally in the area of operating economy. The cost of chilling and heating water at a temperature which is approximately intermediate the desired operating temperature of the chilled water and hot water is obviously much higher than colling the returning water from the units receiving chilled water and heating the water returning from the units receiving hot water in a four-pipe system. However, the savings in piping cost by omitting costs one pipe are so substantial that the three-pipe system has been almost universally accepted for use in multi-room buildings. In this connection, the cost of piping for the water distribution system in the typical multi-room building may run as high as 50 percent of the cost of the entire installation including the heater, the chiller, the room units, and controls. In the past, most efforts have been directed toward decreasing the cost and improving the efficiency of the water chiller and other mechanical components, but it will be apparent that savings achieved in the piping and water distribution system represent a greater percentage of the total job cost than economies in the aforesaid areas.

The present invention can be characterized generally as an improved air conditioning system for a multi-room building and which may be termed a "twin-pipe" system, as each room is provided with a heat exchange unit having separate heating and cooling coils, the heating coils of the heat exchange units being connected to a single heated water supply pipe or loop and the

colling coils of the heat exchange units being connected to a single chilled water supply pipe or loop. The system provides local thermostatic control at each room unit, for both heating and cooling, at all times when the heated water and chilled water loops are both active. Each unit has two pumps, one pump for circulating chilled water through the cooling coil and the other pump circulating heated water through the heating coil, operation of the pumps being individually and selectively controlled by a thermostat in the unit location.

The present invention is also directed to providing improved humidity control arrangements. One arrangement for highly humid areas being provided by a humidistat in each room and which is effective to energize the chilled water pump when the humidity rises above some maximum value such as 60 percent. Sufficient operation from the humidity control will force the room thermostat into the heating position, thus providing re-heat. A second method of applying re-heat is disclosed in which the humidity controller is effective to energize the heated water pump, or a valve, to provide heated water in the unit upon a humidity rise to maximum value (60 percent). The resulting action will either lower the humidity by direct application of heat or, in addition, forces the thermostat into its cooling position to also energize the chilled water pump and provide dehumidification and offset surplus heat.

It is, therefore, a principal object of the invention to provide improved control arrangements for a multi-room air conditioning system of a "twin-pipe" type having two separate chilled water and heated water single pipe circuits connected respectively to cooling and heating coils in each heat exchange room unit.

Another object of the invention is to provide improved control systems for a multi-room air conditioning system of the "twin-pipe" type and in which each heat exchange room unit includes a pump controlling flow of chilled water through the cooling coil and a pump controlling heated water flow in the heating coil.

Another object of the invention is to provide improved control systems for a multi-room air conditioning system of the "twin-pipe" type and in which each unit is provided with a chilled water pump and a heated water pump with their operation thermostatically controlled.

Another object of the invention is to provide improved control systems for a multi-room air conditioning system of the "twin-pipe" type and in which the operation of a chilled water pump and heated water pump of each unit is supplied with and controlled by a thermostat and a humidistat for modifying thermostat operation.

Additional objects and advantages will become apparent from the following detailed description taken in conjunction with the drawing, wherein:

FIG. 1 is a cross-sectional view of an air conditioning system embodying the present invention;

FIG. 2 is a schematic illustration of a preferred temperature and humidity control arrangement;

FIG. 3 is a schematic illustration of a modified temperature and humidity control arrangement.

FIG. 4 is a cross-sectional view of a modified inlet connection for one of the room air conditioning units.

FIG. 5 is a cross-sectional view of a modified outlet connection for one of the room air conditioning units.

Referring now to FIG. 1, a plurality of room air conditioning units 10 and 11 are respectively located in rooms or zones A and B to be conditioned. The improvements of the present invention are adapted for use with a multiplicity of two or more units in series, the units being either induction or fan coil types of air handling or room air conditioning units or in combination, such as the units 10 and 11.

The unit 10 is an induction type air conditioner, the construction and operation of which are well understood in the art. Primary air from a suitable source is directed into a plenum chamber 12 and directed through a nozzle 13 into an induction chamber 14. In the disclosed example, room air is induced to pass over a heat exchange coil 15, supplied with chilled water, and then over a heat exchange coil 16, supplied with heated water, and the heated or cooled air, as the case may be, passes through an opening 17 in the top of a cabinet 18 into the room.

The unit 11 is a fan coil type air conditioner and having a fan 19 operated by a motor 20 for inducing room air to pass over a heat exchange coil 21, supplied with chilled water, and then over a heat exchange coil 22, supplied with heated water, the heated or cooled air exiting through a top opening in the cabinet 23.

Heated water is supplied to the heat exchange coils 16 and 22 by a closed circuit pipe or conduit system including a hot water supply and return conduit 24 constituting the major portion of the circuit. Each room air conditioner has its chilled water coil connected by conventional T-fittings to a supply riser 24a and a return riser 24b. A water heater 25 and pump 26 are provided in series in the conduit 24, the pump causing water to flow continuously through the heater 25 and riser 24a, the distribution loop 24a, and return riser 24b to pump 26. Coils 16 and 22 may be supplied with hot water through lines 27 and 28. Water is returned to loop 24a through lines 29 and 30.

Chilled water is provided to the heat exchange coils 15 and 21 by a single closed circuit pipe or conduit system including a chilled water supply and return conduit 31 which constitutes the major portion of the circuit. The coils 15 and 21 are connected by conventional T-fittings to a supply riser 31a and a return riser 31b. A water chiller 32 and pump 33 are positioned in series in the conduit 31, the pump being effective to circulate chilled water continuously through chiller 32, riser 31a, distribution loop 31c, and return riser 31b, to pump 33. Coils 15 and 21 may be supplied with cold water through lines 34 and 35. Water is returned to loop 24c through lines 36 and 37.

The inlet lines 27, 28, 34 and 35 are provided with small circulating pumps 38 and 39, each pump being preferably of the type known as a March model MDX-35 (March Mfg. Co., Skokie, Ill.), each pump including a completely enclosed, magnetic rotor 40 driven by motor 41 through an external rotating magnet 42. In the de-energized condition of each pump, it prevents flow of water from the associated conduits 24 or 31 to the heat exchange coil connected thereto.

Each air conditioner unit has the energization of the motors 40 of its pumps 38 controlled by the temperature of the air in the room to be conditioned as sensed by the temperature-responsive bulb 43 of a low differential heating-cooling thermostatic switch T. When the bulb 43 senses a room temperature below the

desired temperature level thereby calling for heating by the air conditioner unit, motor 41 of the pump 38 of the unit is energized to provide for the flow of heated water through the heat exchange heating coil 16; and, if bulb 43 senses a temperature above the desired temperature level, thereby calling for cooling by the air conditioner unit, motor 41 of the pump 39 of the unit is energized to provide for the flow of chilled water through the cooling coil 15.

More particularly, the pump motor control for each room unit may be constructed in the manner shown in FIGS. 2 and 3 in which the thermostatic control is a SPDT switch 44, with an intermediate neutral or "off" position, activated by the temperature-responsive bulb 43. Switch 44 has a contact 45 movable between a "cooling" identified contact (corresponding) to a corresponding for cooling and closed at approximately 74° F.) and a "heating" identified contact (corresponding to a demand for heating and closed at approximately 73° F.). It will be apparent that the system provides local control at each unit, for both heating and cooling, at all times when the heated water and chilled water circuits are both active.

In each of the air conditioning units 10 and 11, the heating coil is located downstream from the cooling coil, and re-heat may be provided in the individual units by the addition of a humidity controller.

Re-heat may be provided in either of two ways depending on geographical preference or designer's choice. For highly humid areas, it may be preferable to connect a humidistat to actuate a switch H, shown in FIGS. 1 (unit A) and 2 to the thermostatic switch T so that, when the humidity rises above some maximum value such as 60 percent, the humidity-actuated switch will close to provide an electrical circuit via conductors 46 and 47 to energize the motor of the chilled water circulating pump 39 of the air conditioner unit. As a consequence, the room temperature falls to a predetermined value causing the temperature-responsive bulb 43 to operate and move the contact 45 of switch 44 to the "heating" contact to provide an electrical circuit energizing the motor of the heated water circulating pump 38 to provide re-heat to lower the room humidity so that the humidistat will operate to open its switch to interrupt the motor-energizing electric circuit provided by conductor 46, switch H and conductor 47. A second method of applying re-heat is shown in FIGS. 1 (unit B) and 3 in which the humidity controller or humidistatically-operated switch H' operates connecting conductors 48 and 49 to the "heating" contact of thermostatic switch I to provide an electric circuit energizing the motor of the heated water circulating pump 38 when the room humidity rises to a maximum value such as 60 percent. The resulting action either lowers the humidity by direct application of heat to the room or, in addition, the temperature rise will cause the thermostat to operate its switch to move the contact 45 to engage the "cooling" contact to provide an electric circuit to energize the motor of the chilled water circulating pump 38 and provide dehumidification.

An alternate method of control for the water circuits is to provide scoop fittings 50 and 51 (FIGS. 4 and 5) in the supply and return lines 27 and 29 (and 34 and 36) from the circuit conduits 24 and 31 and, as shown in FIG. 3, to substitute electro-magnetically operated

valves (not shown), for the magnetically operated pumps 38 and 39, in the supply lines 27 and 34, the valve replacing the pumps in the electric circuits of FIGS. 2 and 3 including the thermostatically-operated switch 44 controlling energization of the pumps. The scoop fittings are the special type identified as Mono-Flow T-fittings (manufactured by Bell and Gossett Co.). The inlet fitting 50 (FIG. 4) and the outlet fitting 51 (FIG. 5) are constructed so that they divert a portion of the water flowing through lines 24 and 31 to the heat exchange coils by means of cone shaped baffles 52, 53, respectively. The outlet fittings 51 (FIG. 5) are arranged so that baffle 53 restricts the flow of water through line 31, thereby increasing its velocity and inducing flow through the outlet line 29 (or 36) and the water coils. The inlet fitting (FIG. 4) is arranged so that the baffle 52 scoops a portion of the water passing through lines 24 and 31, thereby facilitating flow into the inlet line 27 (or 34). This type of construction is further discussed U. S. Pat. No. 3,384,155 issued to A. B. Newton on May 21, 1968. It is understood that the Mono-flow fittings may also be used in the fan-coil unit 11.

It will be apparent that the "twin-pipe" system of the present invention provides operating results equal to a "four-pipe" system and at substantially lower installation costs and reduction in space required for the pipes. Another improvement resides in providing each room air conditioning unit with its own circulating pumps, thus completely eliminating the conventional control valves and thereby improving reliability, and permitting the main circulating pumps for the chilled water and heated water loops to be reduced in size since these pumps handle only the loop pressure and are not required to force water through the coils within the room units. Another advantageous feature is that a fan coil room unit of the "twin-pipe" system can be factory assembled complete with its own circulating pumps so that excessive field labor is reduced with the assurance that factory quality control is provided. Another highly advantageous feature is that the "twin-pipe" system eliminates all interchange of water between the chilled water and heated water loops thereby avoiding all hydraulic problems that could possibly be created by inter-connections; also avoiding storing of off cycle heated or chilled water; and eliminates any possibility of operating difficulties of the chiller which can sometimes be caused by inadvertent or accidental return from the heated water loop. Another advantageous feature of the invention is the improved control arrangements for the heated water and chilled water pumps of each room unit provided by the heating-cooling thermostat control of the pumps and the humidity control of the pumps modifying the operation of the thermostat control.

While this invention has been described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not by way of limitation; and the scope of the appended claims should be construed as broadly as the prior art will permit.

What is claimed is:

1. A multi-room air conditioning system comprising:
A. a plurality of room air conditioning units located in a plurality of zones subject to various thermal loads, each said conditioning unit including:

1. a liquid to air heat exchanger having a chilled liquid coil and a heated liquid coil, and
2. means for circulating room air in series flow over both said coils;

a heater adapted to heat a liquid heat exchange medium;

C. a chiller adapted to cool a liquid heat exchange medium;

D. a first closed circuit conduit system interconnecting said chilled liquid coils of said heat exchangers and said chiller, said system including:

1. a first main conduit,
2. individual inlet conduits connected between said first main conduit and the inlet side of said chilled liquid coils,
3. individual return conduits connected between said first main conduit and the outlet side of said chilled liquid coils; and
4. a first pump for circulating chilled liquid through said first main conduit and said chiller;

E. a second closed circuit conduit system interconnecting said heated liquid coils of said heat exchangers and said heater, said system including:

1. a second main conduit,
2. individual inlet conduits connected between said second main conduit and the inlet side of said heated liquid coils;
3. individual return conduits connected between said second main conduit and the outlet side of said heated liquid coils; and
4. a second pump for circulating heated liquid through said first main conduit and said heater; and

F. means for controlling the flow of chilled liquid from said first inlet conduits to said chilled liquid coils;

G. means for controlling the flow of heated liquid from said second inlet conduit to said heated liquid coils; one of said controlling means including pumps associated with the inlet conduits of one of said conduit systems and individually operable to control the flow of liquid from the main conduit of said one conduit system to the coils connected thereto.

2. A system as defined in claim 1 wherein:

A. both of said controlling means including pumps connected to said inlet conduits and individually operable to control the flow of heated and chilled liquid from the main conduits to the heated and chilled liquid coils of said heat exchangers.

3. A system as defined in claim 1 including:

A. temperature control means associated with each of said room units, said control means being operative to control said flow controlling means to effect selective operation thereof to effect heat transfer between the circulating heat exchange medium and the air in said zones only upon a demand for cooling and upon a demand for heating.

4. A system as defined in claim 2 including:

A. temperature control means associated with each of said room units, said control means being operative to control said pumps to effect selective operation thereof to effect heat transfer between the circulating heat exchange medium and the air in said zones only upon a demand for cooling and upon a demand for heating.

5. A system as defined in claim 4 wherein said temperature control means includes:

A. a thermostat in each zone and responsive to the temperature of the zone; and

B. electric circuits for selectively energizing said heated liquid and chilled liquid pumps of the air conditioning unit in the zone and including;

1. a switch controlled by said thermostat and operable thereby to alternately establish said circuits to energize either said heated liquid pump or said chilled liquid pump.

6. A system as defined in claim 2 including:

A. temperature control means associated with at least one of said room units, said control means being operative to control said pumps to effect selective operation thereof to effect heat transfer between the circulating heat exchange medium and the air in said zones only upon a demand for cooling and upon a demand for heating, said temperature control means including:

1. a thermostat in each zone and responsive to the temperature of the zone; and
2. first and second electric circuits for selectively energizing said heated liquid and chilled liquid pumps of the air conditioning unit in the zone and including:

- a. a switch controlled by and responsive to said thermostat, said switch having a first position establishing said first circuit for energizing said heated liquid pump, a second position establishing said second circuit for energizing said chilled liquid pump, and a third position in which said first and second circuits are open;

B. humidity controlling means including:

1. a humidistat in at least one zone and responsive to the humidity in said zone; and
2. a third electric circuit in parallel with said first circuit and including a switch operable by said hu-

midistat to establish said third electric circuit.

7. A system as defined in claim 4 wherein said temperature control means includes:

A. a thermostat in at least one zone and responsive to the temperature of said zone; and

B. electric circuits for selectively energizing said heated liquid and chilled liquid pumps of the air conditioning unit in the zone and including:

1. a switch controlled by said thermostat and operable thereby to establish said circuits to energize either said heated liquid pump or said chilled liquid pump, said temperature control means including:

a. a thermostat in each zone and responsive to the temperature of the zone; and

b. first and second electric circuits for selectively energizing said heated liquid and chilled liquid pumps of the air conditioning unit in the zone and including:

- c. a switch controlled by and responsive to said thermostat, said switch having a first position establishing said first circuit for energizing said heated liquid pump, a second position establishing said second circuit for energizing said chilled liquid pump, and a third position in which said first and second circuits are open;

B. humidity controlling means including:

1. a humidistat in each zone and responsive to the humidity in the zone; and

2. a third electric circuit in parallel with said second circuit and including a switch operable by said humidistat to establish said third electric circuit when said thermostatically controlled switch is in its first position establishing said first circuit.

* * * * *

40

45

50

55

60

65