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[54] **HEATING AND COOLING SYSTEM**

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[51] **Int. Cl.²** **F24F 3/00;** F25B 29/00

[58] **Field of Search** ..... 165/22, 50, 101, 27, 28, 165/100; 236/1 G, 13; 137/599.1

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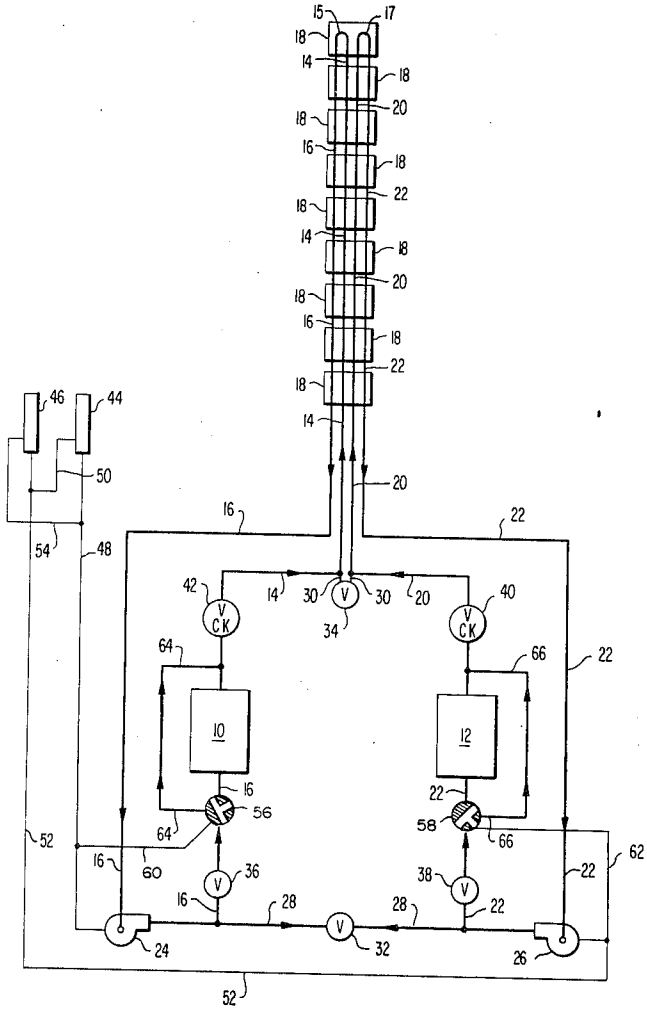
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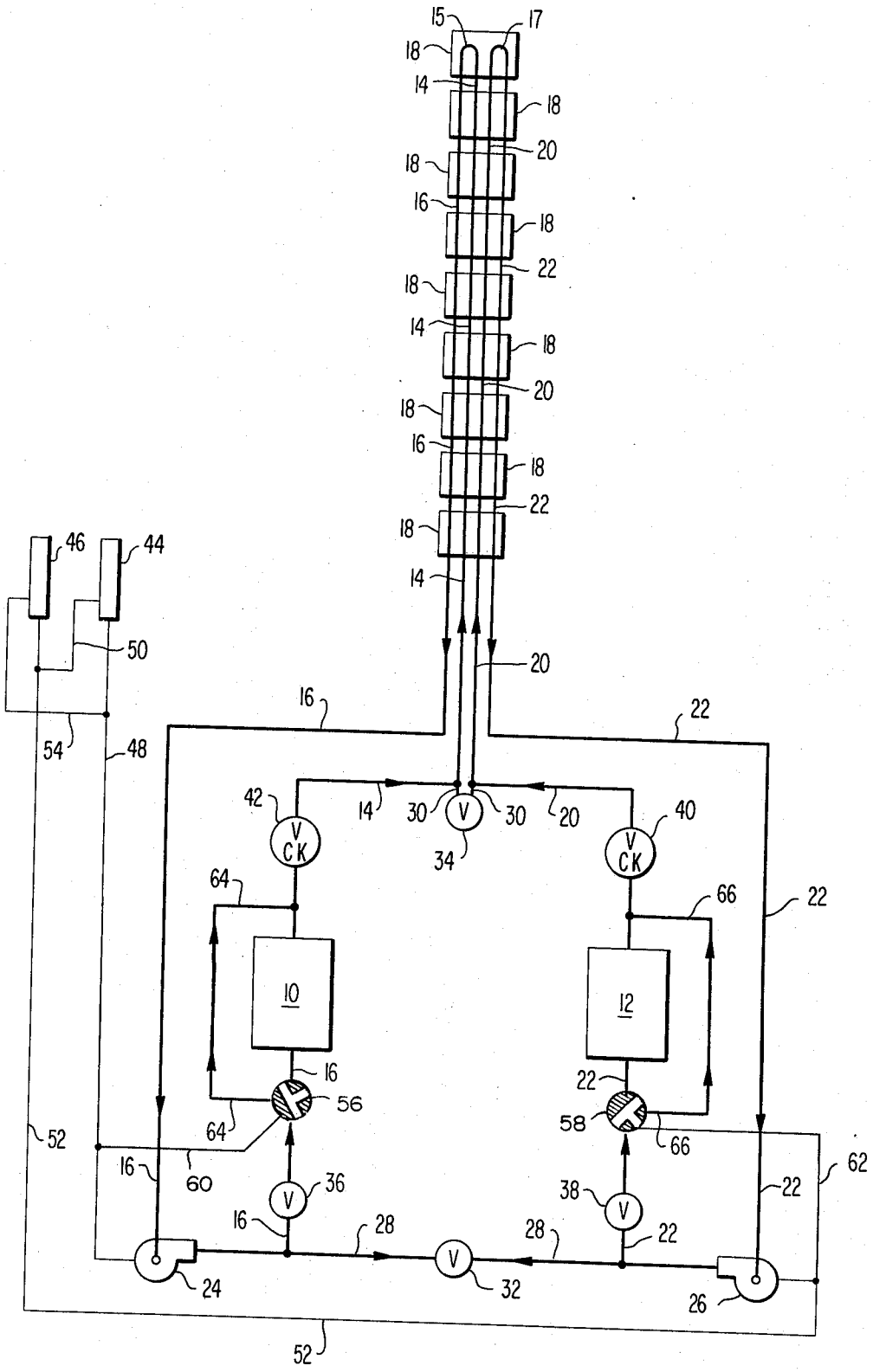
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[57] **ABSTRACT**

In a heating and cooling system having a plurality of zones to be heated and cooled, a heat exchange unit in each of the zones, a hot water piping circuit including a water heater and a first pump on the inlet side of the water heater for circulating hot water to and from each of the heat exchange units and a separate chilled water piping circuit including a water chiller and a second pump on the inlet side of the water chiller for circulating chilled water to and from each of the heat exchange units; further providing a valve and pipe system for selectively and mutually exclusively placing the water heater in fluid communication with the chilled water circuit, whereby the chilled water circuit may be utilized to circulate hot water during periods of high heat demand; and placing the water chiller in fluid communication with the hot water circuit, whereby the hot water circuit may be utilized to circulate chilled water during periods of high cooling demands.

11 Claims, 1 Drawing Figure




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HEATING AND COOLING SYSTEM

FIELD OF INVENTION

The present invention relates to a heating and cooling system used in multi-story buildings having a plurality of zones and, more particularly, to such a system having a heating circuit and cooling circuit both of which may be used for cooling or heating during time when more than 50% of the heating or cooling capacity is required.

BACKGROUND OF THE INVENTION

Two and four pipe hot and cold water systems are well known for heating and cooling buildings. In these systems, heat exchange or fan coil units are provided in the various rooms of the building and are connected to two or four risers which, in turn, are connected to water heating or water cooling apparatus to heat or cool the water circulating through the room heat exchange units. Thus, the heating or cooling apparatus raises or reduces the temperature of the heat conducting fluids, i.e., the water, and a suitable pump forces the water thus heated or cooled into the main flow circuit or circuits. From the main flow circuit or circuits, branch conduits conduct the water to the room heat transfer units, and return the water from these units back to the return line of the main flow circuit. A fan is mounted in each heat exchange unit to circulate room air through the unit to heat or cool the room.

The four pipe systems supply both hot and cold water to each heat exchange unit so that the rooms in the building can be heated or cooled in any season. However, the prior art four pipe systems are expensive because they require four pipes to be run on each floor of the building from the four risers to each of the heat exchange units. This involves not only the cost of the pipe runs but also the high labor cost of the pipe fitters for installing the pipe run outs and risers. Another disadvantage of such systems is the high cost resulting from furnishing separate return pipes for both the hot and chilled water.

To eliminate this difficulty, three pipe systems were developed which used a common return pipe for the hot and chilled water in combination with the hot water supply pipe and the chilled water supply pipe. However, when cold water from the heat exchanger in one zone is mixed with hot water from the heat exchanger in another zone, in a common return line, there is a loss of energy initially expended in heating and refrigerating the water.

Today, the energy and environmental crisis require new analysis of heating and cooling systems to reduce the amount of energy required to produce the maximum comfort conditions. Presently, the most popular heating and cooling system is the so-called "four pipe" system discussed above which is in reality two systems, one for heating and one for cooling. These systems are operated simultaneously during seasons between summer and winter to make available either heating or cooling. During the maximum heating season, the cooling system does not operate and during the maximum cooling season, the heating system does not operate. Thus, both the heating and cooling systems are sized to provide 100% of the required heating and cooling capacity, respectively. These systems suffer from the further disadvantages that 100% capacity is required less than 15% of the time and the 50% capacity is required approximately 75% of the time. Accordingly, added costs are incurred in the installation, including insulation, of such systems. Also, operational costs and energy requirements are increased by the necessary utilization of water circulating equipment which must be sized for 100% capacity.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to overcome the defects of the prior art, such as indicated above.

Another object of the present invention is to provide an improved heating and cooling system.

Another object is to provide a heating and cooling system which retains the non-mixing benefits achieved through the use of separate hot and chilled water return lines and at the same time greatly reduces the high piping and insulating costs normally associated with four pipe systems.

Yet another object of the present invention is to provide a heating and cooling system which substantially reduces the costs of circulating hot and chilled water.

Still another object is to provide a four pipe heating and cooling system having hot water supply and return pipes and chilled water supply and return pipes, all sized for less than 100% capacity and, thus, all being smaller than the standard size.

A yet further object is to provide means for connecting the heater of the hot water circuit to the chilled water circuit and for connecting the chiller of the chilled water circuit to the hot water circuit, whereby the chilled water piping is used to circulate hot water during winter operation, when the heating demand is high, and the hot water piping is used to circulate chilled water during summer operation, when the cooling demand is high.

In furtherance of these and other objects, a principal feature of the heating and cooling system of the present invention is the provision of two duplicate systems, sized for 50% of the maximum heating or cooling requirement, whichever is greater. Another feature is that both systems may be used for cooling or heating during the small percentage of the time when more than 50% of the heating or cooling capacity is required. Thus, the shortcomings of prior art heating and cooling systems are satisfactorily overcome by the present invention.

The heating and cooling system of the present invention which includes a plurality of zones to be heated and cooled, a heat exchange unit in each of the zones, a hot water piping circuit including a water heater and a first pump on the inlet side of the water heater for circulating hot water to and from each of the heat exchangers and a separate chilled water piping circuit including a water chiller and a second pump on the inlet side of the water chiller for circulating chilled water to and from each of the heat exchange units; is characterized by fluid transfer means including appropriate valves for selectively and mutually exclusively: permitting the water heater and the first pump to circulate hot water through only the hot water circuit when chilled water is not being circulated through the chilled water circuit, whereby only the hot water circuit is utilized to circulate hot water during periods of normal heating demands; permitting the water chiller and the second pump to circulate chilled water through only the chilled water circuit when hot water is not being circu-

lated through the hot water circuit, whereby only the chilled water circuit is utilized to circulate chilled water during periods of normal cooling demands; allowing the water chiller and the second pump to circulate chilled water through the chilled water circuit simultaneously with the circulation by the water heater and first pump of hot water through the hot water circuit, whereby simultaneous heating and cooling requirements may be satisfied; placing the water heater and the first pump in fluid communication with the chilled water circuit, whereby the chilled water circuit may be utilized to circulate hot water during periods of high heat demand; and placing the water chiller and the second pump in fluid communication with the hot water circuit, whereby the hot water circuit may be utilized to circulate chilled water during periods of high cooling demand.

For a better understanding of the invention a possible embodiment thereof will now be described with reference to the attached drawing, it being understood that this embodiment is intended to be merely exemplary and in no way limitative.

BRIEF DESCRIPTION OF THE DRAWING

The FIGURE is a schematic illustration of the four pipe heating and cooling system of the instant invention, including the controls.

DETAILED DESCRIPTION OF THE DRAWING

Referring to FIG. **1,** there is shown the heating and cooling system of the instant invention comprising a hot water circuit and a chilled water circuit, both of which run through a multiple-room building. The building may be constructed and adapted for any plurality of uses, such as offices, apartments, etc. Within the building are a plurality of rooms each having a heat exchange unit **18,** the heat exchange units **18** in the illustrative example being in a vertical array for use in a multi-story building.

The chilled water circuit includes chiller **10,** chilled water supply piping **14** and chilled water return piping **16.** The chilled water supply and return piping **14** and **16,** respectively, are in generally parallel adjacent relationship, and may be seen to extend successively through the various heat exchange units **18.** A pump **24** is positioned in the chilled water return line **16** for circulating chilled water throughout the chilled water circuit. The chilled water supply line **14** transports chilled water from the chiller **10** successively through the plurality of heat exchange units **18.** At their upper ends, the chilled water supply and return piping **14** and **16,** respectively, are in fluid communication, as by the U-shaped connector **15.** Thus, the upwardly pumped chilled water flowing through the chilled water supply piping **14** passes through the U-shaped connector **15** into the chilled water return piping **16** and thence passes successively downwardly through the heat exchange units **18** to the pump **24** and the chiller **10.** The chilled water circuit further includes check valve **42** located in the chilled water supply line **14** on the outlet side of the chiller tank and a stop valve **36** located in the chilled water return line **16** intermediate the pump **24** and the chiller **10.** A bypass **3**-way valve **56** in return line **16** controls flow through bypass piping **64,** which connects the chilled water return piping **16** to the chilled water supply piping **14** bypassing the chiller **10.** Valve **56** is employed so that certain quantities, determined by the outside temperature, of chilled water may bypass the chiller **10** and be mixed with the non-diverted chilled water exiting from the chiller **10.** The chiller **10** and the pump **24** may be either at the lower end of the system, as in the basement of the building, or at the upper end on the roof of the building.

The hot water circuit, which runs substantially parallel and adjacent to the chilled water circuit, includes heater **12,** hot water supply piping **20** and hot water return piping **22.** The hot water supply and return piping **20** and **22,** respectively, are in generally parallel adjacent relationship, and may be seen to extend successively through the various heat exchange units **18.** A pump **26** is positioned in the hot water return line **22** for circulating hot water throughout the hot water circuit. The hot water supply line **20** transports hot water from the heater **12** successively through the plurality of heat exchange units **18.** At their upper ends, the hot water supply and return piping, **20** and **22** respectively, are in fluid communication, as by the U-shaped connector **17.** Thus, the upwardly pumped hot water flowing through the hot water supply piping **20** passes through the U-shaped connector **17** into the hot water return piping **22** and thence passes successively downwardly through the heat exchange units **18** to the pump **26** and heater **12.** The hot water circuit further includes a check valve **40** located in the hot water supply line **20** on the outlet side of the heater **12** and stop valve **38** located in the hot water return line **22** intermediate the pump **26** and the heater **12.** A bypass **3**-way valve **58** in return line **22** controls flow through bypass piping **66.** This valve is employed so that certain quantities, determined by the outside temperature, of hot water may bypass the heater **12** and be mixed with the non-diverted hot water exiting from the heater **12.** Like the chilled water circuit, the heater **12** and pump **26** may be located either at the lower end of the system, or at the upper end thereof.

The heat exchanger units **18** may be of any suitable design. However, a preferred design is a cabinet having two compartments, each compartment housing a separate heat exchanger, one compartment housing the chilled water supply and return piping and the other housing the hot water supply and return piping. At the bottom of the cabinet there is provided a louvered air entrance which communicates with both compartments. At the top of the cabinet there is provided a louvered air exit which also communicates with both compartments. Separate motor and fan units may be provided in the chilled water compartment and the hot water compartment of the cabinet to force air over the chilled water supply piping and the hot water supply piping, respectively.

To improve heat transfer, the portions of the chilled and the hot water supply and return piping within their respective compartments may be provided with a plurality of spaced apart conducting fins. Moreover, selective heating and cooling of the rooms in the building may be effectively controlled by connecting the motor of the motor and fan units to a suitable room thermostat. If a single fan is employed, then selective heating and cooling may be achieved through the use of bypass dampers.

In the preferred embodiment, the hot water circuit and the cold water circuit are exactly identical in design, each circuit being sized for 50% of the maximum cooling or heating load. Thus, each circuit is sized to

handle 50% of the maximum heating or cooling load, which ever is greater. Although both systems are sized such that they may be used for cooling or heating during the large percentage of the time when less than 50% of their heating or cooling capacity is required, provision must be made as that they can be used for either heating or cooling during the small percentage of the time when more than 50% of the heating or cooling capacity is required.

To accomplish this result, the heating and cooling system described hereinabove further includes a first fluid conduit **28** connected between the chilled water return line **16,** intermediate the pump **24** and the stop valve **36**; and the hot water return line **22,** intermediate the pump **26** and the stop valve **38.** Similarly, a second fluid conduit **30** is connected between the chilled water supply line **14,** intermediate the check-valve **42** and the heat exchangers **18**; and the hot water supply line **20,** intermediate the check valve **40** and the heat exchangers **18.** Stop valves **32** and **34** are disposed in the fluid conduits **28** and **30,** respectively.

A first thermostat **44** is connected through line **48** to pump **24** and through line **60** to bypass valve **56** for controlling the operation of the chilled water circuit under normal cooling conditions. A second thermostat **46** is connected through line **52** to pump **26** and through line **62** to bypass valve **58** for controlling the heating circuit under normal heating conditions. The two thermostats are interlocked through lines **50** and **54** in such a manner that either one may simultaneously control both of the pumps **24** and **26,** as will be described hereinbelow.

In operation, at a first predetermined low temperature condition, which represents less than 50% of the heating capacity, sensed by thermostat **46** pump **26,** but not pump **24,** will be in operation. Also, during such heating periods stop valves **32** and **34** will be closed and stop valve **38** and check valve **40** will be opened; whereby hot water is being circulated only through the hot water circuit, while no water, chilled or hot, is being circulated through the chilled water circuit.

During the season when maximum heating capacity is needed and the cooling system is idle, pump **24** in addition to pump **26,** is operated by means of the thermostat **46** and the interlock line **54** as a heating pump. Therefore, during this season, when second predetermined low temperature conditions, lower than said first predetermined temperature conditions, are sensed by thermostat **46,** both of the pumps **24** and **26** will be in operation simultaneously for pumping hot water. Chiller **10** is isolated by closing the check valve **42** and the stop valve **36.** Since the check valve **40** and the stop valves **32, 34** and **38** are open and the bypass valve **66** is closed, the chilled water circuit may also be supplied with hot water from the heater **12** in unison with the supply of hot water to the hot water circuit. Thus, although it is necessary that the water heater **12** is sized for 100% capacity, the pumps **24** and **26,** like the hot water circuit piping, may be sized for only 50% of the heating capacity.

Contrariwise, when first predetermined high temperature conditions which represent less than 50% of the cooling capacity, are sensed by thermostat **44** pump **24** will be in operation, thereby circulating chilled water through the chilled water circuit. During such cooling periods, the stop valve **36** and the check valve **42** will be open. However, the stop valves **34** and **32** are closed and the pump **26** is not in operation so that neither hot nor cold water is being circulated throughout the hot water circuit.

When maximum cooling is needed and the heating system is idle, pump **26** is controlled by means of thermostat **44** and interlock line **50** and used as a cooling pump. Thus, when second predetermined high temperature conditions, which are higher than the first predetermined high temperature conditions, are sensed by thermostat **44** both of the pumps **24** and **26** will be in operation to circulate chilled water through both the hot water circuit and the chilled water circuit. The heater **12** is isolated by closing stop valve **38** and check valve **40.** Since the check valve **42** and the stop valves **32, 34** and **36** are open and the bypass valve **58** is closed, chilled water may be pumped through both the hot water circuit and the chilled water circuit so that 100% cooling capacity is achieved. Therefore, although chiller **10** must be sized for 100% cooling capacity, the pumps **24** and **26** and the cold water circuit piping may be designed for 50% of the cooling capacity.

More particularly, when the outside design minimum temperature is −10° F. and the temperature to be maintained inside is 70° F., 50% of the required heating system capacity will provide a temperature of 70° F. inside provided the outside temperature does not go below approximately 35° F. When the outside temperature drops below approximately 35° F., the cooling system which is idle, is converted to a heating system to provide the additional capacity required to heat the space.

Similarly, where the outside design temperature is 95° F. and the desired inside temperature is 75° F., 50% of the cooling capacity will maintain the desired inside temperature provided the outside temperature does not exceed approximately 85° F. When the outside temperature exceeds approximately 85° F., the heating system which is idle, converts to a cooling system to maintain the proper comfort conditions.

When simultaneous heating and cooling (i.e., four pipe capability) may be required pump **24,** normally the cooling pump, circulates chilled water through the water chiller **10** and heat exchangers **18,** thereby providing cooling on demand from a room thermostat (not shown). Pump **26,** normally the heating pump, circulates hot water through the heater **12** and the heat exchangers **18,** thereby providing heating on demand from the room thermostat (not show). Thus, for four pipe capability, both pumps **24** and **26** are operated simultaneously. Also, stop valves **36** and **38** are opened and stop valves **32** and **34** are closed. In this situation, chilled water is being circulated through the chilled water circuit while hot water is simultaneously being circulated through the hot water circuit. The system can be arranged so that when the outside temperature is near the desired room temperature neither pump **24** nor pump **26** will be in operation.

In order that the present system may economically and efficiently meet the variable heating and cooling requirements, the bypass valves **56** and **58** are employed in the chilled water circuit and the hot water circuit, respectively. More particularly, the chiller **10** and heater **12** supply chilled water and hot water, respectively, at constant temperatures. The temperature of the water flowing throughout the system regulates the amount of heat transfer available at the heat exchange

units **18.** Therefore, by regulating the temperature of the water circulating throughout the chilled water circuit and/or the hot water circuit, the amount of heat transfer may also be regulated. To accomplish this result, the bypass valves **56** and **58** are employed so that certain quantities of returning chilled water and returning hot water, which are at different temperatures than those produced in the chiller **10** and the heater **12,** may bypass the chiller **10** and heater **12,** respectively, and be mixed with the non-diverted chilled and hot water exiting at a constant temperature from the chiller **10** and heater **12,** respectively. Thus, the temperature of the water flowing through the hot and chilled water circuits may be varied by simply regulating the the amount of return hot and cold water bypassing the heater **12** and chiller **10,** respectively. The amount of bypassed water being dependent upon the outside temperature and, therefore, being conveniently controlled by the outdoor thermostats **44** and **46.**

Heating and cooling systems are designed and devised to provide comfort during the extreme summer and winter temperatures, which occur only a small percentage of the time. The efficiency of the heating and cooling system during this small percentage of the time that they are operated at maximum capacity is high, but as the heating and cooling demand is decreased, the efficiency of the system also decreases. Thus, by providing two systems of 50% capacity, one for heating during the mild portion of the winter and one for cooling during the mild portion of the summer and both for heating during extremely cold weather or both for cooling during extremely warm weather, greater overall efficiency is obtained.

It should be understood that the present invention may be used in any four pipe, or similar, heating and cooling system. Thus, the foregoing description of the specific embodiment will so fully reveal the nature of the invention that others can, by applying current knowledge, readily modify this embodiment and/or adapt it for various applications without departing from the generic concept, and, therefore such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiment. Further, it is to be understood that the phraseology or the terminology employed herein is for the purpose of description and not of limitation.

What is claimed is:

1. In a heating and cooling system having a plurality of zones to be heated and cooled, a hot water heat exchange unit and a cold water heat exchange unit in each of the zones, a hot water piping circuit including a water heater and a first pump for circulating hot water to and from each of the hot water heat exchange units and a separate chilled water piping circuit including a water chiller and a second pump for circulating chilled water to and from each of the cold water heat exchange units; the improvement comprising valve and conduit means for selectively and mutually exclusively:

placing the water heater and the first pump in fluid communication with the chilled water circuit, whereby the chilled water circuit may be utilized to circulate hot water during periods of high heat demands along with said hot water circuit thereby allowing smaller water pipes to be used in the hot water circuit; and

placing the water chiller and the second pump in fluid communication with the hot water circuit, whereby the hot water circuit may be utilized to circulate chilled water during periods of high cooling demand along with said cold water circuit thereby allowing smaller water pipes to be used in the chilled water circuit.

2. The heating and cooling system of claim **1,** wherein the hot water piping circuit and the chilled water piping circuit are both sized for approximately 50% of the maximum cooling load.

3. The heating and cooling system of claim **1,** wherein both the hot water piping and the chilled water piping circuits are sized for approximately 50% of the maximum heating load.

4. The heating and cooling system of claim **1,** wherein the hot water piping and the chilled water piping are sized for approximately 50% of the maximum heating load and cooling load, respectively.

5. The heating and cooling system of claim **1,** further comprising:

first thermostatic control means connected to the first pump for initiating the circulation of hot water through the hot water piping circuit when a first predetermined low outdoor temperature is sensed and for initiating circulation of hot water through the hot water piping circuit and the chilled water piping circuit when a second predetermined low outdoor temperature, lower than first said predetermined low outdoor temperature, is sensed; and

second thermostatic control means connected to the second pump for initiating the circulation of chilled water through the chilled water piping circuit when a first predetermined high outdoor temperature is sensed and for initiating the circulation of chilled water through the chilled water piping circuit and the hot water piping circuit when a second predetermined high outdoor temperature, higher than said first high predetermined outdoor temperature, is sensed.

6. The heating and cooling system of claim **5,** wherein said thermostatic control means is a thermostat.

7. The heating and cooling system of claim **5,** further comprising:

a first bypass conduit connected between the hot water return piping and the hot water supply piping, wherein returning hot water may bypass the heater;

a second bypass conduit connected between the chilled water return piping and the chilled water supply piping, wherein returning chilled water may bypass the chiller;

first bypass valve means in said first bypass conduit for variably regulating the amount of returning hot water bypassing the heater; and

second bypass valve means in said second bypass conduit for variably regulating the amount of returning chilled water bypassing the chiller.

8. The heating and cooling system of claim **7:**

wherein said first bypass valve means is controlled by said first thermostatic control means, and

wherein said second bypass valve means is controlled by said second thermostatic control means.

9. The heating and cooling system of claim **1,** wherein said valve and conduit means comprises:

a first fluid conduit connected between the chilled water return piping traveling from the heat exchangers, intermediate the water chiller and the second pump, and the hot water return piping traveling from the heat exchangers, intermediate the water heater and the first pump;

a second fluid conduit connected between the chilled water supply piping traveling to the heat exchangers intermediate the water chiller and the heat exchangers, and the hot water supply piping traveling to the heat exchangers, intermediate the water heater and the heat exchangers;

first valve means in said first fluid conduit for permitting fluid flow therethrough when said first valve means is in a first position and for prohibiting fluid flow through said first fluid conduit when said first valve means is in a second position;

second valve means in said second fluid conduit for permitting fluid flow therethrough when said second valve means is in a first position and for prohibiting fluid flow through said second fluid conduit when said second valve means is in a second position;

third valve means in the chilled water return piping traveling from the heat exchangers, between the intersection of said first fluid conduit with the chilled water return piping and the water chiller, for permitting fluid flow into the water chiller when said third valve means is in a first position and for prohibiting fluid flow into the water chiller when said third valve means is in a second position;

fourth valve means in the hot water return piping traveling from the heat exchangers, between the intersection of said first fluid conduit with the hot water return piping and the water heater, for permitting fluid flow into the water heater when said fourth valve is in a first position and for prohibiting fluid flow into the water heater when said fourth valve is in a second position;

fifth valve means in the chilled water supply piping traveling to the heat exchangers, between the intersection of said second fluid conduit with the chilled water supply piping and the water chiller, for permitting fluid flow from the water chiller when said fifth valve means is in a first position and for prohibiting fluid flow from the water chiller when said fifth valve means is in a second position; and

sixth valve means in the chilled water supply piping traveling to the heat exchangers, between the intersection of said second fluid conduit with the hot water supply piping and the water heater, for permitting fluid flow from the water heater when said sixth valve means is in a first position and for prohibiting fluid flow from the water heater when said sixth valve means is in a second position.

10. The heating and cooling system of claim **9**, wherein said first, second, third and fourth valve means are stop valves and said fifth and sixth valve means are check valves.

11. In a heating and cooling system having a plurality of zones to be heated and cooled, a hot water heat exchange unit and a cold water heat exchange unit in each of the zones, a hot water piping circuit including a water heater and a first pump for circulating hot water to and from each of the hot water heat exchange units and a separate chilled water piping circuit including a water chiller and a second pump for circulating chilled water to and from each of the cold water heat exchange units; the improvement comprising valve and conduit means for selectively and mutually exclusively:

permitting the water heater and the first pump to circulate hot water through only the hot water circuit when chilled water is not being circulated through the chilled water circuit, whereby only the hot water circuit is utilized to circulate hot water during periods of normal heating demands;

permitting the water chiller and the second pump to circulate chilled water through only the chilled water circuit when hot water is not being circulated through the hot water circuit, whereby only the chilled water circuit is utilized to circulate chilled water during periods of normal cooling demands;

allowing the water chiller and the second pump to circulate chilled water through the chilled water circuit simultaneously with circulation by the water heater and the first pump of hot water through the hot water circuit, whereby simultaneous heating and cooling requirements may be satisfied;

placing the water heater and the first pump in fluid communication with the chilled water circuit, whereby the chilled water circuit may be utilized to circulate hot water during periods of high heat demands; and

placing the water chiller and the second pump in fluid communication with the hot water circuit, whereby the hot water circuit may be utilized to circulate chilled water during periods of high cooling demands.

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