

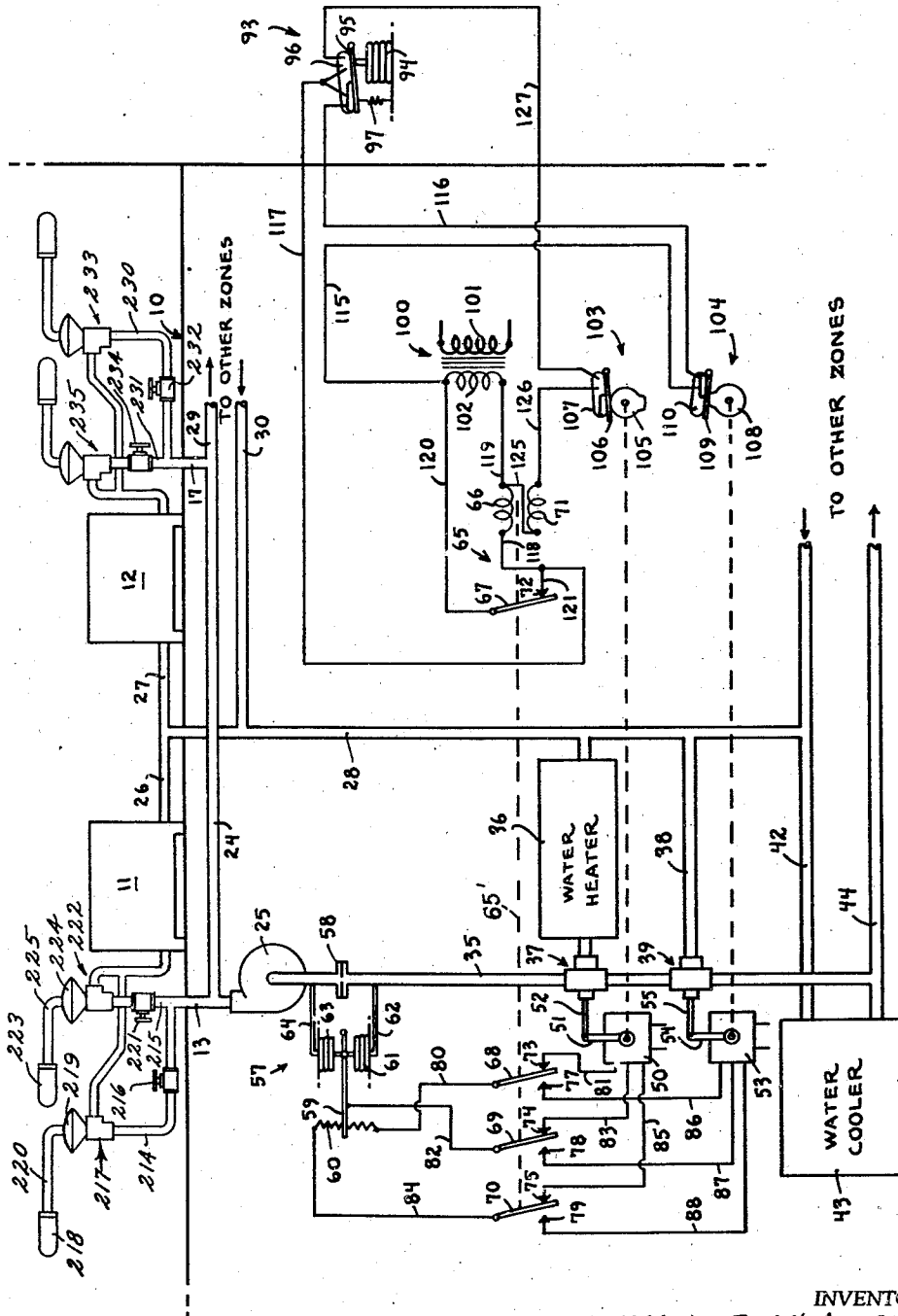
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W. L. McGRATH

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HEATING AND COOLING SYSTEM

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INVENTOR.

William L. McGrath.

BY

George H. Fisher
Attorney

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HEATING AND COOLING SYSTEM

William L. McGrath, Philadelphia, Pa., assignor
to Minneapolis-Honeywell Regulator Company,
Minneapolis, Minn., a corporation of Delaware

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This invention relates to air conditioning systems and controls therefor, particularly systems wherein a heated or cooled medium is circulated to a space for controlling the temperature therein.

The primary object of the invention is to provide an improved arrangement for measuring the load in such a heating or cooling system and for adjusting the heating or cooling effect of the medium accordingly.

More specifically, an object of my invention is to provide a control arrangement for an air conditioning system using hot or cold water for conditioning purposes wherein the demand on the system is measured in terms of the amount of water being circulated to maintain a given temperature and the heat content of the water is adjusted accordingly. The volume of water being circulated may depend upon the demands of individual zones or individual radiators or heat exchange devices in the same zone.

Another object is to provide a heating and cooling system having separate valves controlling heating and cooling with an automatic changeover arrangement for shifting from heating to cooling in response to outdoor conditions, the changeover requiring either valve to be in a minimum position in order to shift to the other.

Numerous other objects and advantages of my invention will become apparent from the following detailed description and annexed drawing.

Referring to the drawing, a portion of a building is represented, having apparatus therein constituting that necessary for one zone of a zone type of arrangement embodying my invention. Numeral 10 represents diagrammatically the floor of the building or other structure in which the air is to be conditioned. Within the space to be conditioned are heat exchange devices 11 and 12 which, as disclosed, take the form of radiators. The radiator 11 is supplied with water through a pipe 13 and one or the other of the two parallel pipes 214 and 215. The pipe 214 is provided with a hand valve 216 and an automatic valve 217 which comprises a temperature sensitive bulb 218 connected to a pressure motor 219 by means of the capillary tubing 220. This valve is of the direct acting type, that is, the valve is closed on an increase in temperature for controlling hot water for heating purposes during the heating season. The pipe 215 is provided with a hand valve 221 and an automatic valve 222 which comprises a thermal bulb 223 connected to a pressure motor 224 by means of capillary tubing 225. The valve 222 is of the reverse acting type, that is,

the valve is opened on an increase in temperature for the purpose of controlling the flow of cooled water to the radiator during the cooling season.

During the heating season the hand valve 216 will be open and the hand valve 221 will be closed, and during the cooling season the hand valve 216 will be closed and the hand valve 221 will be open. It will be obvious that the two valves 217 and 222 could be replaced by a single automatic valve whose connections could be reversed for getting direct and reverse action. Such an arrangement is shown in the patent of Frederick D. Joesting, No. 2,310,293.

Water is supplied to the radiator 12 through pipe 17 and either one or the other of the two parallel pipes 230 and 231. The pipe 230 is provided with a hand valve 232 and a direct acting thermostatically controlled valve 233 similar to the valve 217. The pipe 231 is provided with a hand valve 234 and a reverse acting thermostatically operated control valve 235 which is a duplicate of the valve 222. It is obvious that these two valves could be replaced by the reversible valve of the aforementioned Joesting patent.

The supply pipes 13 and 17 are connected to a distributing header 24 and water is forced to the header by a motor driven circulating pump 25. The radiator 11 has an outlet pipe 26 and the radiator 12 has an outlet pipe 27 and these pipes are connected to a return main 28.

As pointed out, the apparatus as disclosed on the drawing may represent the apparatus necessary for one zone of a zone type system and the distributing header 24 and the return main 28 may have branches 29 and 30 respectively for serving other similar zones. The radiators 11 and 12 are intended as exemplary disclosures of any type of heat exchange devices suitable for heating or cooling air in the space. That is, unit air conditioners might be used instead, these conditioners being of a type adapted to have either hot or cold water circulated therethrough with the supply of water to each either being modulated or controlled in an on and off manner, the supply water being heated or cooled depending on whether or not it is winter or summer. The invention of course comprehends reversing the controls of the heat exchangers in the space to provide for winter and summer operation, the valves opening on low temperature in winter and opening on high temperature in summer.

Connected to the inlet of the circulator 25 is a pipe 35 and connected between this pipe and

the return main 28 is a water heater 36. At the juncture of the outlet pipe from the heater 36 and the pipe 35 is disposed a three-way valve 37 of a type known in the art. Also connected between the pipe 35 and the return main 28 is a by-pass pipe 38 and at the juncture of this pipe with the pipe 35 is another three-way valve 39. The three-way valve 37 controls the proportions of water passing through the water heater 36 and through the by-pass 38, that is, the three-way valve 37 takes a position permitting a certain proportion of the water to pass through the water heater 36 and the remainder passing through the by-pass 38, the three-way valve 39 being in a position at the time to permit water to pass freely from pipe 38 to pipe 35.

The water heater 36 may be any suitable type heat exchanger. For instance, it may be a tank and tube type with an arrangement for supplying steam to the tubes for heating the water.

The return main 28 is connected to a branch return pipe 42 and the pipe 42 is connected to a water cooler 43. The lower end of the pipe 35 is connected to another distributing pipe 44 which is also connected to the water cooler 43. The branch pipes 42 and 44 may be connected with other zones so that the water cooler 43 can serve all of the zones. As will now be apparent, water being returned through the return main 28 can either pass through the by-pass pipe 38 or through the pipe 42, the water cooler 43 and pipe 44 back to pipe 35. The three-way valve 39 controls the proportions of water which can pass through the by-pass 38 and to the water cooler.

The water cooler 43 may be any suitable type of heat exchanger with the coil of a direct expansion refrigerating system, for example, supplying the necessary cooling.

As will presently be explained, either one or the other of the three-way valves 37 and 39 is in control at any given time. When the valve 37 is in control, the valve 39 is in a minimum position, ordinarily an extreme position, wherein water can freely pass from by-pass pipe 38 to pipe 35. In this position of valve 39, water is prevented from going through the water cooler and then upwardly through the pipe 35. However, water from other zones may freely circulate through the water cooler. When the three-way valve 39 is in control, valve 37 is in a minimum position, ordinarily an extreme position, wherein water can freely pass upwardly through pipe 35, but it is prevented from passing from return main 28 through the water heater and into pipe 35.

From the foregoing it is apparent that each of the plurality of zones may have apparatus including a water heater, circulator, radiators and so on, as disclosed on the drawing, but with a single water cooler for supplying the necessary cooled water for all zones.

The three-way valve 37 is actuated by a proportioning type motor 50 of the type disclosed in the patent of D. G. Taylor, No. 2,028,110, this patent also disclosing a proportioning control system in detail. The motor 50 drives a shaft on which is mounted a crank arm 51 which is connected to the valve member of the three-way valve 37 by a stem 52. The three-way valve 39 is driven by a similar motor 53 having a crank arm 54 connected to the stem 55 of the valve.

A single proportioning controller is provided which may be connected so as to control either

the valve 37 or the valve 39. This controller is of a differential pressure type and it is designated by the numeral 57. The pressure differential is established by means of an orifice member 58 connected in the pipe 35 ahead of the circulator 25. The orifice is, of course, of fixed cross-sectional area and of course, there will be a pressure drop through the orifice depending upon the rate at which water is being circulated, that is, upon the volume of water being circulated. The differential controller comprises a pivoted slider member 59 adapted to slide over a slide wire resistance 60 so as to form a potentiometer. The slider 59 is actuated by two bellows devices, one of which designated by the numeral 61 is connected to the pipe 35 on the up-stream side of the orifice 58 by a tube 62. The other bellows device designated 63, is connected to the pipe 35 on the down-stream side of the orifice 58 by a tube 64. The bellows devices are arranged to act on the slider 59 in direct opposition to each other so that the slider will take a position depending on the difference in pressures on opposite sides of the orifice 58, that is, the controller 57 will respond to the rate of flow of water being circulated. In other words, for example, when more radiators have their valves closed, the resistance to flow between the supply header 24 and the return main 28 will be increased and as a result there will be an increase in pressure beyond the orifice 58 relative to the pressure on the up-stream side of the orifice. Under these circumstances the force exerted by the bellows 63 will preponderate over that of bellows 61 and slider 59 will be adjusted downwardly along resistance 60. On the other hand, when more radiator valves are opened, the pressure differential will change in the opposite direction and slider 59 will move upwardly along resistance 60.

The controller 57 may be connected so as to control either the motor 50 or the motor 53, the connections being automatically changed by means of a relay designated by the numeral 65. The relay 65 comprises a first winding 66 and an armature 65' associated therewith connected to movable switch blades 67, 68, 69 and 70. The relay includes a second winding 71 which when energized produces a magnetic-motive force completely neutralizing that of winding 66. When only winding 66 is energized the armature is attracted and the blades 67, 68, 69 and 70 are moved to the right into engagement with fixed electrical contacts 72, 73, 74 and 75 respectively. When the winding 71 is energized, it neutralizes the effect of winding 66 and the armature moves in the opposite direction, either under the influence of gravity or a spring, and blade 67 moves out of engagement with contact 72 and the blades 68, 69 and 70 move to the left into engagement with fixed electrical contacts 77, 78 and 79.

With the parts in the position shown, winding 66 alone of relay 65 is energized and with the relay in this position, the controller 57 is connected to the motor 50 so as to control the three-way valve 37. Under these circumstances the lower end of slide wire resistance 60 is connected to motor 50 by wire 80, blade 68, contact 73, and wire 81. The slider 59 is connected to motor 50 by wire 82, blade 69, contact 74 and the wire 83. The upper end of slide wire resistance 60 is connected to motor 50 by wire 84, blade 70, contact 75, and wire 85.

When the relay 65 is in its other position, the controller 57 is connected to motor 53 for con-

trolling the three-way valve 39. Under these circumstances, the lower end of slide wire resistance 60 is connected to motor 53 by wire 80, blade 68, contact 77, and wire 86. The slider 59 is connected to motor 53 by wire 82, blade 69, contact 78 and wire 87. The upper end of slide wire resistance 60 is connected to motor 53 by wire 84, blade 70, contact 79, and wire 88.

The relay 65 is controlled by a temperature responsive controller 93 responsive to outdoor temperature. The controller 93 comprises an expansible and contractible bellows 94 filled with a vaporizable liquid which causes the bellows to expand and contract in accordance with outdoor temperature. The movable end of the bellows carries a stem which engages a pivoted switch carrying lever 95 carrying a double ended mercury switch 96. The lever 95 is normally biased in a counter-clockwise direction by a coil spring 97. The mercury switch 96 has electrodes at its left end which are bridged by the mercury when the outdoor temperature is below a predetermined value. The mercury switch 96 also has electrodes at its right end which are bridged when the outdoor temperature rises to a predetermined value causing the bellows to expand rotating the lever 95 in a clockwise direction.

Power for operation of the relay 65 is supplied by a step-down transformer 100 having primary winding 101 and a secondary winding 102, the primary winding having the greater number of turns.

As will presently become more clear, the controller 93 shifts control from one to the other of the three-way valves 37 and 39 by energizing and deenergizing the relay 65. The control arrangement is such that in order to shift from one valve to the other, the one being shifted from must be in a minimum position; this may be of course, an extreme position and for instance, if the three-way valve which controls heating is being shifted from, it must be in a position wherein little or no water is being passed through the water heater before the shift can be accomplished. To provide for this feature, the system includes auxiliary switches 103 and 104. The auxiliary switch 103 comprises a cam 105 mounted on the shaft of the motor 50. The cam 105 has a single dwell and this cam actuates a pivoted switch carrying lever 106 carrying a mercury switch 107. The mercury switch 107 is normally open and is closed by the cam 105 when motor 50 has positioned valve 37 to a minimum or extreme position wherein little or no water is allowed to pass through the water heater 35. The auxiliary switch 104 comprises a cam 108 mounted on the shaft of motor 53. The cam 108 has a single dwell and this cam operates a pivoted switch carrying lever 109 carrying a mercury switch 110 which is closed by the cam when motor 53 has positioned valve 39 to a minimum or extreme position wherein little or no water can pass from return main 28 through the water cooler 43 to pipe 35, this position of three-way valve 39 permitting water to pass freely through by-pass 38 into pipe 35.

The outdoor temperature controller 93 may be adjusted so as to cause the electrodes at the right end of mercury switch 96 to be bridged at an outdoor temperature of 70°, for example. With the parts in the position shown on the drawing, the outdoor temperature is below 70° and the system is operating on the heating part of the cycle. Valve 39 is in its minimum position and mercury switch 110 is closed. Winding 66 of

relay 65 is energized through the following circuit: from secondary 102 of transformer 100 through wire 115, mercury switch 110, wire 116, the left end of mercury switch 96, wire 117, wire 118, winding 66, and wire 119 back to secondary 102. Engagement of blade 67 with contact 72 produces a maintaining circuit for winding 66 as follows: from secondary 102 through wire 120, blade 67, contact 72, wire 121, wire 118, winding 66 and wire 119 back to secondary 102.

The system is now operating to produce heat in the spaces being served with the three-way valve 37 under control of controller 57. If the temperature adjacent the thermal bulb 218 tends to rise, valve 217 throttles down, thereby reducing the demands for heated water. Radiator 12 may be controlled by valve 233 in a similar manner. The throttling action of one or more valves as pointed out above will tend to increase the resistance between the supply header 24 and the return main 28 and this will result in an increased pressure effecting bellows 63 relative to that effecting bellows 61. The result of this is that the force exerted by bellows 63 preponderates moving slider 59 downwardly along slide wire resistance 60. This tends to produce a shunt between wires 81 and 83 connected to motor 50 and the motor will now operate in a direction to position the three-way valve 37 to cause less water to pass through the water heater and more through the by-pass 38. (The operation of a motor of this type is described in detail in the above referred to Taylor patent.) The effect of this operation of the three-way valve is therefore to reduce the temperature of the water being supplied to the radiation without changing the volume, that is, the rate of flow. On the other hand, when valves 217 and 233 are moved toward open position by their thermal bulbs, the resistance between the supply header 24 and return main 28 is reduced and consequently, the pressure affecting bellows 63 will be reduced relative to that affecting bellows 61. In other words, the differential will vary in the opposite direction and slider 59 will be moved upwardly along resistance 60. This tends to produce a shunt between wires 83 and 85 of motor 50 and the motor will now operate in a direction to move the three-way valve 37 to a position causing more water to pass through the water heater 35 and less through the by-pass 38. In other words, the temperature of the water will be raised without change in volume.

From the foregoing it can be seen that the controller 57 measures the load demands on the system as determined by the number of radiators demanding heated water and the amount demanded by each radiator. The controller 57 thus measures the load on the system as a whole and adjusts the heat content of the water being supplied accordingly. Thus, as the load decreases, water will be supplied at a lower temperature and as respects the controller 57 this will have a rebalancing effect. In other words, as the load decreases and less heat is demanded, the controller will cause water at a lower temperature to be supplied and thus the demands of the radiators will tend to be less easily met so that the movement of the controller 57 towards a position demanding water at a lower temperature will be dampened.

When the outdoor temperature rises to 70°, for example, the mercury switch 96 will be positioned to have the electrodes at its right hand bridge and this, of course, is an indication that cooling

rather than heating will be required in the spaces. However, the mercury switch 96 may be thus shifted before the temperature in the spaces reaches a value such that cooling is actually required. That is, the electrodes at the right end of mercury switch 96 may become bridged while some heating is still required in the spaces. Thus, the system does not shift over to cooling until the three-way valve 37 has been positioned to a minimum or extreme position wherein little or no water is being heated. This indicates of course, that there is no further demand for heat in the spaces. When valve 37 has been so positioned mercury switch 107 will be closed and winding 71 of relay 65 will be energized through the following circuit: from secondary 102 of transformer 100 through wire 119, wire 125, winding 71, wire 126, mercury switch 107, wire 127, the right end of mercury switch 96, wire 117, wire 121, contact 72, switch blade 67, and wire 120 back to secondary 102. When winding 71 is thus energized it neutralizes the effect of winding 66 and the armature moves to the left as above described, thus moving blade 67 away from contact 72 and interrupting the circuits of both windings. Blades 68, 69 and 70 are also moved to the left connecting controller 57 to motor 53 in the manner above described. The three-way valve 39 will now be controlled in a manner similar to that described above so as to cause water to be supplied to the spaces in accordance with the load demands. As pointed out above, the valves 222 and 235 may have their control mechanisms reversed so as to throttle towards closed position as the temperature falls. Or as also pointed out, unit air conditioners may be used in lieu of radiators which are turned on and off individually in accordance with cooling demands. As the demand for cold water decreases, the differential affecting controller 57 will vary in the same manner as described above to cause slider 59 to move downwardly along resistance 60. This will tend to produce a shunt between wires 86 and 87 connected to motor 53 and the motor will operate in a direction to move valve 39 toward a position permitting more water to flow through the by-pass 38 and less through the water cooler 43. On the other hand, upon increased demands for cooling water slider 59 will move upwardly tending to produce a shunt between wires 87 and 88 and valve 39 will be moved toward a position causing less water to pass through by-pass 38 and more to pass through water cooler 43. Thus, the temperature of the water will be varied in accordance with the load demands for cooling water.

When the control shifts from cooling to heating, valve 39 must be in its minimum position indicating that there is no further need for cooling before the shift is brought about. That is, mercury switch 110 must be closed as already described.

Various other arrangements may be used for varying the temperature of the water delivered to the radiators although I prefer the three-way valve and by-pass arrangement as described above.

From the foregoing, those skilled in the art will appreciate that I have provided a very efficient means whereby the heating or cooling load on a system as a whole may be measured. This measurement may be utilized in any convenient manner to adjust the capacity of the system in accordance with the load demands. When there are many zones in a zone system or a large num-

ber of radiators in an individual zone, the load demands, that is, the demands for heating or cooling water may vary considerably. My arrangement provides an accurate measurement of the demands and adjusts the heating or cooling accordingly.

The single embodiment of my invention is exemplary of one of its preferred forms. There are many modifications and variations which fall within the realm and scope of the invention and therefore the invention is to be limited only in accordance with the terms of the claims appended hereto.

I claim as my invention:

1. In apparatus of the character described, in combination, a water circulating system, heating means and cooling means for the water, a valve controlling the temperature of the water when heating is required of the system, a valve controlling the temperature of the water when cooling is required, condition responsive means for automatically controlling the valves, means for automatically shifting control from one valve to the other depending upon outdoor temperature, and control means operated as a result of valve movement for preventing a shift to one valve until the other valve is in its minimum position.

2. In apparatus of the character described, in combination, heating means including a control device therefor, cooling means including a control device therefor, control apparatus including means responsive to a condition representative of temperature changing load requirements, said control apparatus including means whereby each device can assume a position dependent on the said load, changeover means for shifting between the heating means and cooling means to render one or the other effective depending upon outdoor temperature, and means operated as a result of the movement of one control device to prevent said shift until said one control device is in a position representative of a minimum temperature changing load with reference to that device.

3. In apparatus of the character described, in combination, a fluid circulating system including supply and return pipes, means providing communication between said pipes including heating means for the fluid, cooling means for the fluid, and by-pass means, flow control apparatus including three-way valve means for selectively adjusting the proportions of fluid passed through the heating means and by-pass means or the proportion of fluid passed through the cooling means and by-pass means, means responsive to a condition representative of temperature changing load requirements in a space being served by the system for adjusting the three-way valve means, and means responsive to outdoor conditions for rendering either the heating means or cooling means effective.

4. In apparatus of the character described, means for circulating a temperature changing medium to a space, means for selectively heating or cooling the medium, means responsive to temperature in the space, means varying the rate of flow of medium to said space in accordance with the demand as measured by said temperature responsive means, and means for adjusting the temperature of the medium in accordance with said rate of flow.

5. In apparatus of the character described, in combination, a fluid circulating system including supply and return pipes, means providing communication between said pipes including heating

means for the fluid, cooling means for the fluid, and by-pass means, flow control apparatus including a three-way valve for controlling the proportions of fluid heated and passed through the by-pass means, a three-way valve for controlling the proportions of fluid cooled and passed through the by-pass means, means responsive to a condition representative of temperature changing load demands for fluid in a space served by the system, and means whereby said condition responsive means may control each of the three-way valves depending upon the outdoor temperature.

6. In apparatus of the character described, in combination, a fluid circulating system including supply and return pipes, means providing communication between said pipes including heating means for the fluid, cooling means for the fluid, and by-pass means, flow control apparatus including a three-way valve for controlling the proportions of fluid heated and passed through the by-pass means, a three-way valve for controlling the proportions of fluid cooled and passed through the by-pass means, means responsive to a condition representative of temperature changing load demands for fluid in a space served by the system, and control means whereby the condition responsive means is rendered effective to control one or the other of the three-way valves depending upon the outdoor temperature, the said control means embodying mechanism whereby in order for control to be shifted from one valve to another the valve being shifted from must be in a position representative of minimum temperature changing load requirements with reference to that particular valve.

7. In apparatus of the character described, in combination, a fluid circulating system including supply and return pipes, means providing communication between said pipes including heating means for the fluid, cooling means for the fluid, and by-pass means, flow control apparatus including a three-way valve for controlling the proportions of fluid heated and passed through the by-pass means, a three-way valve for controlling the proportions of fluid cooled and passed through the by-pass means, means responsive to a condition representative of temperature changing load demands for fluid in a space served by the system, and means responsive to outdoor temperature for causing said condition responsive means to control either of the three-way valves.

WILLIAM L. McGRATH.