Jan. 13, 1959 G. T. GADDIS 2,868,461

STEAM HEATING CONTROL SYSTEM

Filed Jan. 16, 1956 2 Sheets-Sheet 1

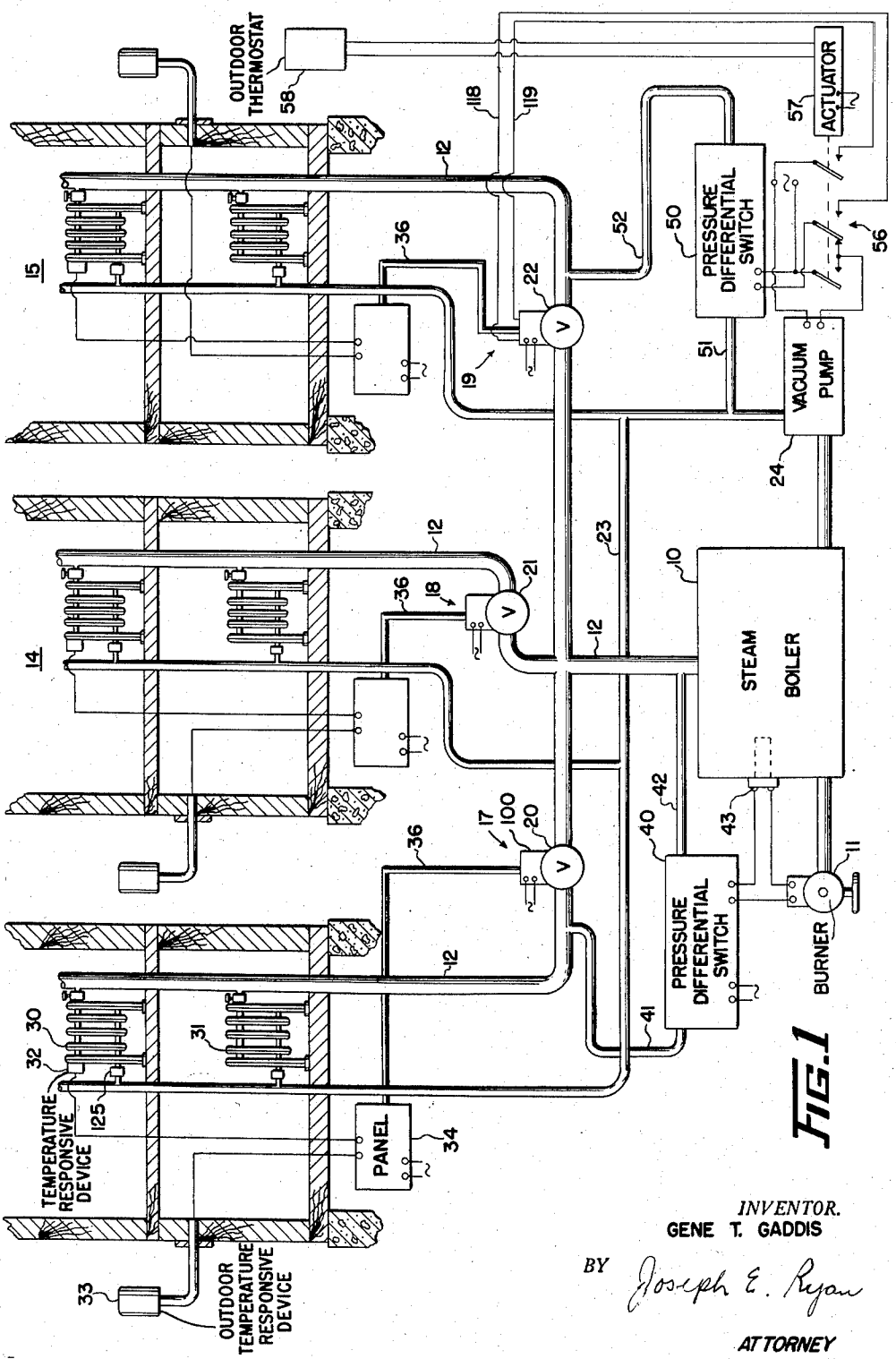


FIG. 1

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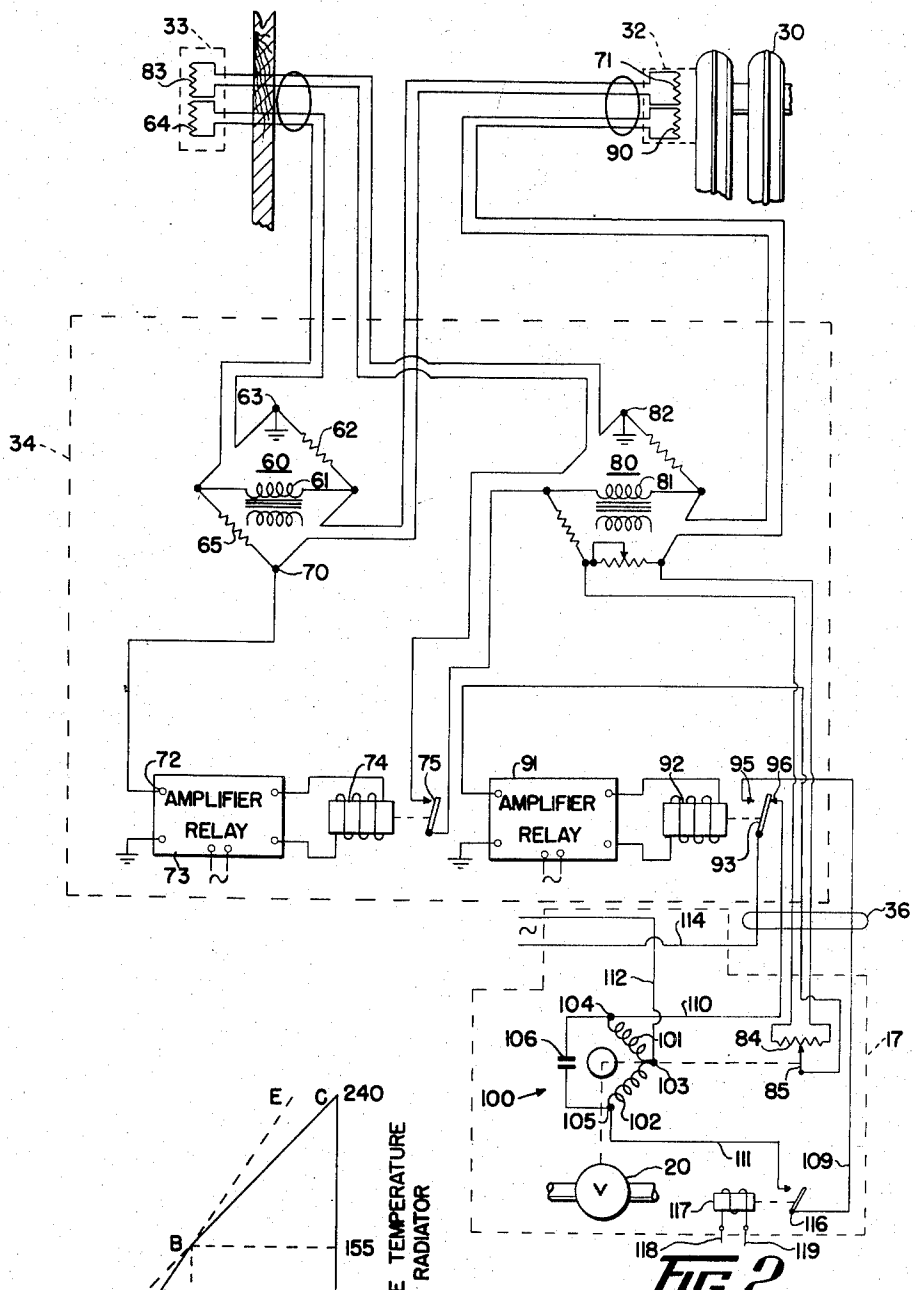


FIG. 2

FIG. 3

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STEAM HEATING CONTROL SYSTEM

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10 Claims. (Cl. 237—9)

The present invention is concerned with an improved temperature control apparatus for use in particular with a steam heating installation supplying steam to heat exchangers in a plurality of zones.

In zone controlled heating installations in which heat is furnished from a common furnace or boiler to a plurality of buildings whether hot water or steam is used for the medium for supplying heat from the boiler to the zones or buildings depends on a number of factors. Steam provides for large amounts of heat readily available and it can be supplied to heat exchangers in extremely high buildings with very little head pressure being developed in the boiler. It has been quite difficult to control with steam. This is especially true during mild weather as control equipment normally adapted for heavy load seasons is not readily adapted for throttling the flow of steam more gradually during mild weather conditions.

There has been a trend to the use of hot water as a medium for supplying heat from the furnace to heat exchangers. With hot water it is possible to not only vary the flow to the heat exchangers but vary the temperature of the medium itself thus during mild weather conditions the water temperature is reduced to increase control preventing the normal temperature overshooting in the area in which the temperature is being controlled. While hot water installations have many advantages for single level dwellings and even dwellings with a relatively low head pressure they pose many problems when used in high buildings as an extreme head pressure is placed on the boiler which in some cases makes the use of hot water quite impractical.

In the present invention apparatus is provided for controlling the flow of steam to a multizone installation. While the quantity of steam flow to the various zones of the installation is controlled by temperature responsive means sensing a need for heat in the zones, the temperature of the steam is also modified. This provides for a steam heating installation having the advantages of circulating hot water and yet the head pressure is quite low when used for heating high buildings.

In controlling the valve in the steam line to the individual zones the invention provides for normal modulation of the valve opening during a portion of the range of temperature control in which throttling of the steam line is practical and during the remaining portion the valve is operated in an on-off manner to maintain an average heat exchanger temperature adequate to meet the need.

It is therefore an object of the present invention to provide an improved apparatus for controlling the boiler in a steam heating installation.

A further object of the present invention is to provide an improved apparatus for controlling a steam boiler in a multizone heating installation in which the pressure differential across a valve controlling the supply of steam to a first zone is maintained by controlling the burner and the vacuum pump pumping a vacuum on the return line is controlled to maintain a predetermined pressure differential across the heat exchanger in a second of the zones.

Another object of the present invention is to provide a steam heating installation in which steam is furnished to a plurality of zones through a supply main having a valve therein for controlling the supply of steam to each zone, the valve being operated in response to an outdoor temperature sensor to maintain a predetermined schedule of average heat exchanger temperature for every different outdoor temperature by modulating the valve position through a portion of the range of the outdoor temperature and controlling the valve in an off or on manner during the remaining portion of the outdoor temperature range.

And still another object of the present invention is to provide in valve control apparatus the control of the valve in a modulating manner through a first portion of a range of conditions and in an off-on manner for the remaining range of conditions.

These and other objects will become apparent upon a study of the specification and drawings of which:

Figure 1 is a schematic drawing of a typical steam heating installation in which steam is supplied from a boiler to a plurality of zones each having a control valve in the supply line;

Figure 2 is a valve control apparatus for controlling a valve of the sort used in the installation shown in Figure 1 to maintain a predetermined schedule of heat exchanger temperature over a range of outdoor temperatures; and

Figure 3 is a graphical representation of the operation of the valve control apparatus shown in Figure 2.

Referring to Figure 1, a steam boiler **10** is shown having a burner **11** for supplying heat thereto. As the burner is operated steam is developed and is supplied through a supply main **12** connected to heat exchangers in a plurality of zones **13**, **14**, and **15**. Interposed in supply main **12** between boiler **10** and each of the aforementioned zones is a control valve **20**, **21**, and **22**, respectively, for controlling the flow of steam to each of the zones. The valves have respective actuators **17**, **18**, and **19**. A return main **23** for returning condensate, that is condensed steam, from the heat exchangers is connected to the boiler return through a vacuum pump **24**.

As each of zones **13**, **14**, and **15** are somewhat identical in the disclosure, only the apparatus in zone **13** will be explained in detail. Referring to zone **13** supply main **12** is connected to two heat exchangers or radiators **30** and **31** of a possible plurality of heat exchangers of which heat exchanger **30** is considered a typical heat exchanger not the farthest nor the nearest from the valve **20** in that particular zone. Return main **23** is also connected to the radiators **30** and **31** through conventional traps which close before steam can pass from the radiator to the return main.

Valve **20** controlling the flow of steam to zone **13** is controlled to maintain a predetermined average temperature at radiator **30** for various outdoor temperatures. A radiator temperature responsive device **32** and an outdoor temperature responsive device **33** are connected to a panel **34** containing control apparatus for controlling valve **20**. Actuator **17** is connected to panel **34** through conduit **36**. The details of the apparatus for controlling valve **20** are disclosed in Figure 2 and will be considered subsequently. Each of the valves **20**, **21**, and **22** is controlled by a similar apparatus to maintain a predetermined average radiator temperature at the typical radiator in its zone for various outdoor temperatures in accordance with a selected schedule. By means of an adjustable orifice radiator valve serving typical radiator **30**, the

steam flow rate to it can be adjusted to insure proper steam flow to all other radiators.

Burner 11 is controlled by a conventional pressure responsive switch 40 to close the burner power circuit whenever the pressure difference across valve 20 as sensed by conduits 41 and 42 drops below a selected value. The power circuit of the burner contains a conventional limit control 43 which is normally closed but upon the boiler temperature becoming excessive it opens to turn off the burner. As connected switch 40 senses the pressure differential across valve 20 and operates burner 12 to maintain a steam pressure in the boiler so that at all times there is a selected pressure drop across valve 20. A second pressure responsive switch 50 is connected to either vacuum pump 24 or valve 22 depending upon the position of a gang switch 56. Switch 50 closes when the pressure difference between conduits 51 and 52 drops below a predetermined value. As connected it is responsive to the pressure across the heat exchangers of zone 15. Switch 56 is controlled by an actuator 57 responsive to outdoor temperature. When the outdoor temperature is below 37 degrees as sensed by thermostat 58, a figure used for the particular example of this case, switch 56 is de-energized as shown. The vacuum pump is then controlled by switch 50 during cold weather. During warm weather with switch 56 closed by actuator 57 the vacuum pump is continuously energized and switch 50 controls actuator 117 of Figure 2. Whenever pressure switch 50 opens during warm weather motor 100 of valve 22 cannot further open the valve.

In selecting the zones associated with the pressure differential switches 40 and 50 the heating requirements of the zones must be considered as best operation is provided when the pressure switch 40 senses the pressure across the valve controlling the supply of steam to the coldest zone that is the zone requiring the greatest amount of heat. Pressure switch 50 is associated with the warmest zone, that is the zone which under normal conditions is more apt to be satisfied first. As previously stated zone 13 is the last to be satisfied.

Referring to Figure 2 the apparatus for controlling valve 20 includes the outdoor temperature responsive device 33 and radiator temperature responsive device 32. Panel 34 contains a network circuit for controlling the operation of valve 20 in a novel manner. A bridge circuit 60 of a conventional type comprises two parallel circuits connected to a secondary 61 of a transformer. A first of said parallel circuits comprises a temperature responsive resistance element 64 which is a part of device 33, a grounded terminal 63, and a resistor 62, the element being responsive to outdoor temperature. A second branch comprises a resistor 65, a tap 70 and a temperature responsive resistance element 71 which is a part of device 32, it being responsive to the average radiator temperature of the typical radiator 30 in the heating system. The output of bridge circuit 60 obtained at tap 70 is connected to one input terminal 72 of an amplifier 73. A second input terminal is grounded in a conventional manner. Amplifier relay 73 is of a conventional type and might be of the sort as disclosed in the A. P. Upton Patent No. 2,423,534 in which the output thereof varies in magnitude proportionally to the input signal. A relay 74 has its windings connected to the output terminals of amplifier 73 and upon the magnitude of the signal as obtained from bridge 60 increases to a predetermined amount relay 74 is energized to close switch 75.

A second bridge circuit 80 is of a type similar to bridge circuit 60 having two parallel branches connected to the secondary of a transformer 81. A first branch has a grounded terminal 82 and a temperature responsive resistance element 83 which is a part of device 33, it being responsive to outdoor temperature. A second branch contains a resistor 84 having a movable wiper 85 positioned thereon and a temperature responsive resistance element 90 which is a part of device 32, it being responsive to the average temperature of radiator 30. The output of bridge 80 as obtained at wiper 85 is connected to one input terminal of amplifier 91, it having a second input terminal grounded. Amplifier relay 91 is similar to amplifier relay 73 and has a relay 92 connected to its output terminals. As the output of bridge 80 varies switch blade 93 associated with relay 92 moves to one of three positions a first engaging contact 95, a center position, and a third position engaging contact 96. As the output bridge 80 increases switch blade 93 moves from the position shown engaging contact 96 to the center position between contacts 95 and 96. Upon a further increase in the output of the bridge, member 93 engages contact 95.

A conventional reversible type A. C. motor 100 has two windings 101 and 102 connected at terminal 103 and their opposite extremities 104 and 105, respectively being connected by a condenser 106. When A. C. voltage is applied to terminals 103 and 105 the motor will run in one direction and when applied to terminals 103 and 104 in the opposite direction. Terminal 104 is connected to contact 96 by a conductor 110. For the system of control valves 20 and 21, terminal 105 is connected directly to contact 95 through interconnected conductors 109 and 111; however, for control 22 switch 116 is interposed between conductors 109 and 111. Terminal 103 is connected by a conductor 112 to one terminal of a source of A. C. power. Switch member 93 is connected by a conductor 114 to the other side of the source of power.

Motor 100 is connected to valve 20 as well as wiper 85 so that as the motor opens and closes valve 20 it simultaneously positions wiper 85 on resistor 84 to rebalance the bridge circuit. Bridge circuit 80 by means of relay 92 modulatingly controls the position of valve 20 depending upon the demand as required by the temperature responsive elements 90 and 83. When relay 92 moves switch member 93 against contact 95 the motor will run in one direction to open valve 20 and should the output of bridge 80 be such to call for less heat member 93 will engage contact 96 to energize motor 100 to close valve 20. Whenever the bridge 80 is balanced member 93 is intermediate contacts 95 and 96 and the valve remains in the position it has until a further need for more or less heat is demanded by the output of bridge 80.

Switch 75 is connected in one leg of bridge 80 to open the bridge when bridge 60 is balanced effecting the motor 100 to close the valve 20.

As previously mentioned, the valve control circuit of Figure 2 is substantially the same for each valve 20, 21, and 22 of Figure 1, with the exception of a modification for valve 22. Switch 116, shown in Figure 2, is placed in the motor control circuit between conductors 109 and 111 so that when its associated actuator 117 is de-energized the opening energization circuit of motor 100 is broken. Actuator 17 is energized whenever switch 56 is energized by actuator 57 through conductors 118 and 119.

Referring to Figure 3 a graphical representation of the average temperature at radiator 30 for various outdoor temperatures is shown. A curve ABC is obtained by calibrating bridge 80 with its temperature responsive elements 83 and 90 so that the correct valve position is maintained at various outdoor temperatures to provide for steam flow from the boiler to the radiators at a rate that the average temperature of the typical radiator 30 follows the schedule ABC. As the radiator temperature exceeds the selected temperature for any outdoor temperature and rises above the line ABC the output of the bridge would cause member 93 to engage contact 96 and begin closing the valve. Similarly if the outdoor temperature drops and the average radiator temperature is below the line ABC for that particular outdoor temperature the output of bridge 80 will energize motor 100 to drive the valve in a valve opening direction to increase the steam flow to the radiators.

Bridge circuit 60 with its associated temperature re-

sponsive element 64 and 71 is so calibrated that its output in controlling switch 75 tends to control motor 100 in an on-off manner so that valve 20 provides intermittent steam flow to maintain the average radiator temperature along a schedule shown as line DBE. Should the average radiator temperature for a particular outdoor temperature rise above line DBE the output of bridge 60 changes to open switch 75 to unbalance bridge 80 so that valve 20 closes.

It is thus seen that by proper calibration of the bridges 60 and 80 a cross-over point as shown in Figure 3 for the two lines ABC and DBE at B is selected for a particular average radiator temperature. Above the average radiator temperature at the cross-over point B (shown as 155°) the valve 20 is controlled along the schedule BC required in cold weather in a modulating manner, that is, its position is selected for maintaining a sufficient steam flow therethrough to maintain the average radiator temperature selected for the particular outdoor temperature. Below the point B, valve 20 is either open or closed depending upon the average radiator temperature selected by the schedule DB required in mild weather. By the proper selection of a differential in the amplifier 73 pulses of steam flow of sufficient length are provided to result in proper steam distribution to all heat exchangers in the zones.

A schedule of radiator temperature versus outdoor temperature such as DBC is selected to match an emission characteristic of the radiators. The heating capacity of the boiler is then more closely matched to the heating load as the outdoor temperature changes.

Operation

In a steam heating installation of the sort shown in Figure 1 it is desired that the steam pressure of boiler 10 thus the steam temperature be maintained at a sufficient level to take care of the needs of the coldest zone. This is zone 13 in this case, usually a north zone having no sun effect but exposed to prevailing winds. As the other zones in the system require less heat a regulation of the steam pressure as a function of the load of the coldest zone provides that adequate steam pressure is available to meet the needs of the remaining zones in the heating system at all times. Pressure differential switch 40 maintains a selected pressure difference across valve 20 which controls the supply of steam to the coldest zone. This is an advantage as the flow control characteristics of a valve are more readily controlled when the pressure differential across it is maintained at some constant value. As the pressure differential across the valve increases switch 40 de-energizes burner 11 to reduce the steam pressure of boiler 10 until the pressure difference across the valve 20 is as selected. Pressure switch 40 also provides another function in that it limits the steam pressure of the boiler to the highest steam pressure needed to heat the coldest zone of the heating installation. As zone 13 becomes satisfied valve 20 closes slightly to reduce steam flow to the radiators. The pressure drop across valve 20 will thus increase. Switch 40 will then de-energize burner 11 to reduce the steam pressure to its desired value. As the outdoor air temperature rises a similar sequence of events will take place and the boiler pressure will gradually be reduced but at all times the position of valve 20 will remain substantially wide open and the resulting reduction of steam pressure to zone 13 reduces the steam and radiation temperature for reduced heat output.

It is commonly known that vacuum pumps such as shown at 24 are used in steam heating installations to reduce the temperature of the steam by pumping the vacuum on the return conduit 23 of the system. As shown each of the radiators has a restricting device similar to that shown at 125 on radiator 30. The restricting device is of a sort having a temperature responsive actuator for closing the return line from the radiator to conduit 23 when the temperature of the operator reaches some selected value. This prevents steam from passing from the radiator into the return conduit and only allows the cooler condensate, air, or water to pass therethrough. Device 125 is commonly known as a trap. Vacuum pump 24 will maintain a vacuum in return conduit 23 and a pressure drop will be developed across the traps of the various radiators as long as they are closed. The amount of vacuum is determined by switch 50. Assume here that the heating load to zone 15 decreases and the controller associated with valve 22 energizes it in a closing direction to reduce the flow of steam from the boiler to the radiators. The resulting drop in the steam supply pressure reduces the steam temperature for reduced heat emission from the radiators in zone 15. The pressure between conduit 12, downstream valve 22, and return conduit 23 would drop slightly and switch would energize vacuum pump 24 to increase the vacuum in conduit 23. The pressure difference previously mentioned is thus maintained at a selected value. Upon an increase in the vacuum in conduit 23 the steam temperature available to all of the zones is reduced. Upon a subsequent reduction in the load of zone 15 an even lower vacuum is developed in conduit 23 to further reduce the steam temperature. Upon a reduction in the steam temperature as a function of the load requirement of the warmest zone 15 even better control is then provided for the other zones as for that minimum steam temperature they are less likely to be overheated. Should any zone require hotter steam it is available as the heating load of zone 13 determines the maximum steam temperature by its control of burner 11 through switch 40.

Such a system is thus seen to have the advantage of a hot water heating installation where the temperature of the hot water is varied by outdoor temperature. During mild weather conditions the temperature of the steam can be maintained quite low and thus prevent any overheating brought about by the commonly known overshooting of the control temperature. Here the steam temperature is reduced first by a reduction in the steam pressure and then by pumping a vacuum on the return line. During a given weather condition a steam pressure is maintained at a value sufficient to take care of the needs of the coldest zone. Simultaneously, the minimum steam temperature available is maintained at a value to prevent overheating any of the other zones. Upon the pumping of the vacuum in return conduit 23 it is possible to keep the radiators full of steam at a reduced temperature so that the average temperature of the radiators can be modulatingly controlled for various outdoor temperatures. As the heat load of the coldest zone determines the maximum steam temperature there is always a sufficient capacity for the other zones. As the heat load of the warmest zone determines the minimum steam temperature needed all zone valves are able to properly control in mild weather.

It has been found that upon a control of the zone valves in a modulating manner to vary the flow therethrough to select an average radiator temperature at the typical radiator in accordance to the outdoor temperature along a line such as ABC as shown in Figure 3, there is a point at which the steam temperature can no longer be reduced. Partially filled radiators and uneven distribution become prevalent on a further reduction. In this particular installation the maximum vacuum obtainable provides for a reduction in the steam temperature to 155° F. It is seen that for an outdoor temperature of 37° which required an average radiator temperature of 155° the radiator could be maintained full steam as the steam temperature would be 155° assuming a maximum vacuum being pumped on the system. Upon

restricting the valve more to drop the average radiator temperature below 155° as the outdoor temperature increased above 37 results in a partially filled radiator. For a system such as a non-orificed steam heating system proper distribution of steam to the various radiators in the zone is not obtained when the flow of steam is further restricted.

In order to provide for the control of the average temperature at the radiator in the range below 155° which is needed when the outdoor temperature rises above 37°, a schedule following DBE as shown in Figure 3 is used to match the radiator emission curve. Throughout this schedule the steam valve to the zone is controlled in an on-off manner and by the proper selection of a differential in the controlled apparatus pulses of steam are sent to the radiators to maintain an average radiator temperature as scheduled. A sufficient pressure is allowed to develop in the system so that distribution to all the radiators is obtained. When the last radiator in the system increases in temperature to such an extent to satisfy bridge circuit **60** of Figure 2 switch **75** will deenergize the motor and allow the valve to close off. Thus it is seen for each of the zone valves a modulating control of the valve to maintain an average radiator temperature is provided throughout the range BC, as shown in Figure 3, and through the range DB an on-off control of the valve is maintained. During the range of operation BD while the average radiator temperature is reduced below 155° F. the boiler steam pressure is always high enough to produce 155° F. steam which contributes to a uniform distribution of the steam to all radiators of the zones. While values such as 155° for the selected cross-over point B in Figure 3 are chosen, it, as well as other figures, has been only for illustrative purposes and would vary for certain applications.

During mild weather when pressure switch **50** controls the opening circuit of valve **22** the vacuum pump is continuously energized. When there is a call for heat in zone **15**, valve **22** starts to open and immediately the pressure in main **12** increases. To limit the pressure, switch **50** is effective to open the energization circuit of valve **22** by switch **116** to limit its open position. As the vacuum pump draws air from the radiators in zone **15** the steam under this limited pressure will flow into the zone radiators. At all times the steam pressure is held low and an overshooting of the desired temperature in zone **15** is thus prevented.

It is intended that the scope of the invention be limited only by the appended claims in which I claim:

1. In a steam heating installation having a boiler for delivering steam to a plurality of zones, the boiler having a burner for supplying heat thereto; conduit means for each zone for connecting the boiler to a heat exchanger in the respective zones; valve means associated with each of said conduit means for controlling the flow of steam to the heat exchanger and thus the average temperature thereof; a vacuum pump; return conduit means for each zone for connecting the heat exchanger of each zone to the return of the boiler through said vacuum pump; first pressure responsive controller responsive to the pressure across said valve means of one zone for controlling the burner to maintain sufficient steam pressure in the boiler to maintain a predetermined pressure drop across said valve means; second pressure responsive controller responsive to the pressure across the heat exchanger associated with said valve means of another zone controlling the flow to the last mentioned heat exchanger, said second control being connected to control the operation of the vacuum pump to maintain a selected pressure drop across the heat exchanger of said second mentioned zone; control means for each of said valve means, said control means comprising; temperature responsive means responsive to outdoor temperature; temperature responsive means responsive to the average temperature of the heat exchanger in its particular zone; motor means for controlling said valve means; means connecting said outdoor temperature responsive means and said heat exchanger temperature responsive means in controlling relation to said motor means, said last mentioned means including means controlling said valve means to modulate the flow of steam to its zone in a first portion of the total range of outdoor temperature to maintain a scheduled average heat exchanger temperature and further means to selectively open and close said valve means to control the flow of steam in a second portion of the total range of outdoor temperature to maintain a scheduled average heat exchanger temperature.

2. In a multizone steam heating installation each of the zones having heat exchangers receiving steam from a boiler to which heat is supplied by a burner, the installation having a vacuum pump for pumping condensate from the zones back to the boiler, valve means in each of the supply lines to the zones, temperature responsive means for each zone responsive to a need for heat in its particular zones, connection means connecting the respective temperature responsive means for each zone in controlling relation to the particular valve means of that zone so that the flow of steam to the zone is controlled by the need for heating therein, first pressure responsive means responsive to the pressure drop across said valve means controlling the flow of steam to one zone having the greater heating load, connection means connecting said first pressure responsive means in controlling relation to the burner, second pressure responsive means responsive to the pressure drop across another zone having the smallest heat load, and connection means connecting said second pressure responsive means to control the vacuum pump.

3. In a steam heating installation, a boiler having a burner for supplying heat thereto to generate steam, a plurality of supply mains connected to the boiler to furnish steam to various zones having radiators, a plurality of return mains connected to each of said zones for returning condensate from the radiators, said return mains being connected through a vacuum pump to the boiler, valve means in the supply mains to each of the zones for controlling the flow of steam thereto, pressure responsive switch means for controlling the operation of the burner, said pressure responsive means being connected to be responsive to the pressure drop across a first of said valve means so that upon a drop in the pressure across said first valve means below a predetermined value the burner is energized to increase the steam pressure, and second pressure responsive switch means for controlling the operation of the vacuum pump, a second of said valve means, controlling the flow of steam to another zone, said pressure responsive means being connected to be responsive to the pressure drop between the supply main down stream said second valve means and the return main so that as the heating load to said another zone decreases said vacuum pump will be energized to decrease the steam temperature.

4. In a heating installation, heat furnishing means for generating a supply of heated medium, means associated with said heat furnishing means for controlling the temperature of said heated medium, a plurality of zones to be heated, conduit means for delivering heated medium to heat exchangers in each of said zones, a return conduit connected to the heat exchangers in each zone for returning the medium to the heat furnishing means, plurality of valve means for controlling the flow of heated medium, one of said valve means being connected in the supply conduit of each one, first pressure responsive controller, said controller being responsive to the pressure differential between the downstream and upstream pressure of a first of said valve means controlling the flow of heated medium to a first zone, means con-

necting said controller in a manner to control the operation of the heat furnishing means to maintain a sufficient supply of heated medium so that a predetermined pressure drop exists across said first valve means, second pressure responsive controller, said controller being responsive to the pressure between the supply and return conduits of a second zone, and connection means connecting said controller in a manner to control said means associated with said heat furnishing means for controlling the temperature of the heated medium so that as the supply of heated medium to said second zone is reduced the temperature of the heated medium generated is reduced.

5. In a heating installation, valve means for controlling the flow of heated medium from a supply to a plurality of heat exchangers, control means for controlling said valve means, said control means comprising first circuit means having outdoor temperature responsive means, heat exchanger temperature responsive means, and relay means, means connecting both of said temperature responsive means in controlling relation to said relay means, said relay means modulatingly controlling said valve means so that the flow of heated medium is scheduled therethrough to maintain a predetermined temperature at the heat exchanger through a first range of outdoor temperatures, second network circuit means having outdoor temperature responsive means, heat exchanger temperature responsive means and relay means and means connecting both of said last mentioned temperature responsive means in controlling relation to said relay means, said relay means controlling said valve means through a second range of outdoor temperature in an either on or off position to maintain a lower predetermined temperature at the heat exchanger through said second range.

6. In a heating installation, valve means for controlling the flow of heated medium from a supply to a plurality of heat exchangers, motor means for controlling one of said valve means, first control means comprising, outdoor temperature responsive means, heat exchanger temperature responsive means, relay means, and connection means connecting said temperature responsive means in controlling relation to said relay means, motor means for controlling said valve means, means connecting said relay means to said motor means to modulatingly control said valve means to maintain a predetermined schedule of heat exchanger temperature throughout a first portion of a range of outdoor temperatures, second control means comprising, outdoor temperature responsive means, heat-exchanger temperature responsive means, second relay means and connection means connecting said second mentioned temperature responsive means in controlling relation to said second relay means, and means connecting said second control means in controlling relation to said motor means to either open or close said valve means throughout a remaining portion of said range of outdoor temperatures to maintain the average temperature of the heat exchanger along a predetermined schedule.

7. In control apparatus, means for furnishing a quantity of medium to a plurality of zones, valve means associated with each of said zones for controlling the amount of medium delivered to the respective zone, condition changing means associated with said first mentioned means for changing the conditioned level of said medium, means responsive to the pressure drop across one of said valve means for controlling the operation of said condition changing means, further condition changing means connected in a return line connecting said zones to said first mentioned means, and means responsive to the pressure drop across another of said zones for controlling said further condition changing means.

8. In a steam heating installation having a boiler for delivering steam to a plurality of zones, the boiler having a burner for supplying heat thereto; conduit means for each zone for connecting the boiler to the heat exchangers in the respective zone; valve means associated with each of said conduit means for controlling the flow of steam to the heat exchangers; a vacuum pump; return conduit means for each zone for connecting the heat exchangers in each zone to said vacuum pump; means connecting said vacuum pump to the boiler; first pressure responsive controller; means connecting said first pressure responsive controller to respond to the pressure across said valve means of one of said zones; further means connecting said controller to control the operation of the burner; second pressure responsive controller; means connecting said second pressure responsive controller to respond to the pressure drop across the heat exchangers of another of said zones; another means connecting said second controller to control the operation of said vacuum pump; control means for each of said valve means comprising, first and second temperature responsive means responsive to outdoor temperature; first and second temperature responsive means responsive to the average temperature of one of the heat exchangers of the zone associated with its respective valve means; motor means; means connecting said motor means to control said valve means; means connecting said first outdoor temperature responsive means and said first heat exchanger temperature responsive means to said motor means, said motor means modulatingly controlling said valve means to maintain a predetermined schedule of heat exchanger temperature for various outdoor temperatures; and means also including said second outdoor temperature responsive means and said second heat exchanger temperature responsive means connected in a controlling relation to said motor means, said last mentioned means controlling said motor so that said valve means is either on or off through a portion of the range of outdoor temperatures.

9. In a heating installation, heat furnishing means for generating a supply of heated medium, means associated with said heat furnishing means for controlling the temperature of said heated medium, a plurality of zones to be heated, conduit means for each zone for delivering heated medium to heat exchangers in said zones from said heat furnishing means, valve means in each of said conduit means for controlling the flow of heated medium therethrough, return conduit means connected to the heat exchangers in each of said zones for returning the medium to said heat furnishing means, first pressure responsive controller, said controller being responsive to the pressure differential across said valve means in one of said zones, said controller controlling the operation of said second mentioned means, second pressure responsive controller, said controller being responsive to the pressure across the heat exchangers of another of said zones, further means for varying the temperature of said medium, said second mentioned controller controlling the operation of said further means, and control means for each of said valve means for controlling said valve means in response to a condition indicative of the need of operation of said valve means comprising, first means for modulatingly controlling said valve means through a first portion of a range of said condition, and second means for controlling said valve means in an on or off manner through a second portion of a range of said condition.

10. In a multizone steam heating installation each of the zones having heat exchangers receiving steam from a boiler to which heat is supplied by a burner, the installation having a vacuum pump for pumping condensate from the zones back to the boiler, valve means in each of the supply lines to the zones, temperature responsive means for each zone responsive to a need for heat in its particular zones, connection means connecting the respective temperature responsive means for each zone in controlling relation to the particular valve means of that zone so that the flow of steam to the zone is controlled by the need for heating therein, first pressure responsive means responsive to the pressure drop across said valve means controlling the flow of steam to the zone having the greater heating load, connection means

connecting said first pressure responsive means in controlling relation to the burner, second pressure responsive means responsive to the pressure drop across the zone having the smallest heat load, condition responsive means responsive to a condition and means including said last mentioned means connecting said second responsive means to said vacuum pump when said condition is in a first range and to said value of said warmest zone when said condition is in a second range.

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