

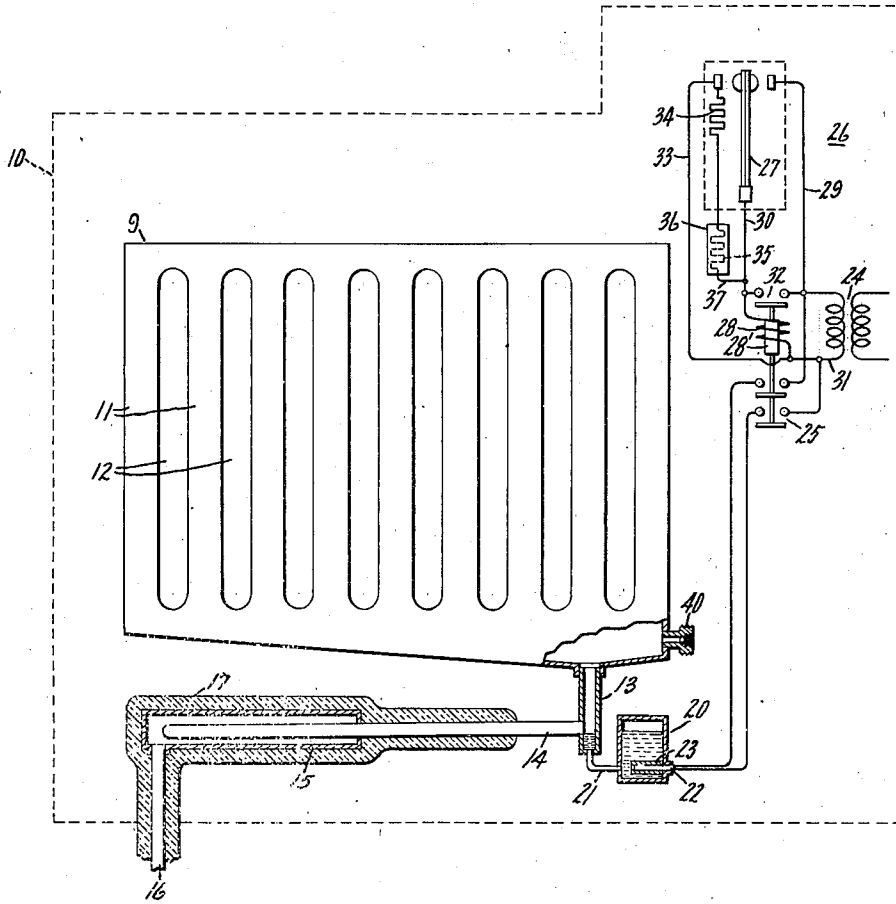
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COMPENSATED PREHEAT COIL

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COMPENSATED PRE-HEAT COIL

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My invention relates to temperature control and provides an improved preheat thermostatic modulating control that is peculiarly suited for use with modulating heat transfer systems but which may be used with other types as well.

The present invention is advantageously used in heating service where a thermostatically graduated or modulated variation in the rate of heat transfer is desired, but is applicable equally well to all systems controlled by thermostatic systems using a local pre-heat at the thermostat to obtain a more even temperature in the space to be heated.

In the copending application of Marcus E. Fiene, Serial No. 25,691, filed June 8, 1935, and assigned to the assignee of the present application, there is disclosed a modulating vapor heat transfer system in which the rate of heat transfer to a radiator for heating air or liquid may be varied smoothly and quickly between wide limits to meet widely varying heating requirements. In that system a fluid vaporizing and condensing surface is connected to receive heat from a suitable source such as a steam supply main or the like and is provided with a liquid control chamber which is preferably out of heat transfer relation with the vapor system and has a separate pilot heater therefor. The vaporizing surface receives heat from the source and the condensing surface releases heat to the air, water or other medium which is to be heated. The liquid control chamber is so arranged and connected that when the separate pilot heater is inactive, substantially all of the vapor in the heat transfer system condenses and accumulates as liquid in the liquid control chamber. Under these conditions substantially no transfer of heat from the supply source can occur.

Upon operation of the pilot heater the temperature within the liquid evaporating chamber is raised and the liquid is expelled therefrom into the heat transfer system. The expelled liquid effects transfer of heat from the heat source through the vaporizing surface to the condensing surface. Due to the establishment of thermal and hydrodynamic equilibrium in the system the liquid expelled from the control chamber is always automatically properly proportioned in amount to maintain the area of wetted surface of the vaporizing surface just sufficient to effect the transfer of heat from the source at the rate required to equalize the temperature of the condenser surface with that of the control chamber, the limit of course being the temperature of the heat source. This condition obtains irrespective

of the widely varying dissipating conditions to which the condenser surface may be subjected.

Should the temperature of the condenser surface tend to fall upon increased dissipation of heat therefrom, the vapor pressure in the control chamber is effective to expel additional liquid into the vapor heat exchange system and thereby effect transfer of heat at a greater rate from the source through the vaporizing surface to the control surface. This will result in a higher rate of heat transfer from the heat source to the condenser surface because of increased wetted surface in the vaporizer. Conversely, should the temperature of the condenser surface rise upon decreased dissipation of heat therefrom, the increased pressure in the vapor system becomes effective to force the return of fluid to the control chamber until the wetted surface of the vaporizer is decreased to the value providing the required rate of heat transfer to maintain the condenser surface temperature the same as the control chamber temperature.

Selective variation of control chamber temperature will result, therefore, in corresponding changes in the temperature of the condenser surface. By selectively varying the heat input of a small capacity pilot heater the temperature of the control chamber readily may be varied between limits as wide as desired to effect a corresponding variation in the temperature of the condenser surface as well as a corresponding variation in the rate of heat transfer from the heat source to the condenser.

In the application mentioned the pilot heater is illustrated as an electrical heating unit of relatively small capacity, selectively energized by a thermal responsive means, such as a thermostat, positioned in the space the temperature of which is to be controlled. The capacity of the heater is such as to expel all the liquid in 15 or 20 minutes. Immediately upon energization a portion of the fluid is expelled, and the longer the heater is energized the more fluid will be expelled with the result that a greater area of vaporizing surface is wetted and the temperatures of the control chamber and condenser surface equalize. After the temperature of the space reaches the desired value the thermostat deenergizes the heater allowing the temperature of the control chamber and the condenser surface to fall. The control chamber is so constructed that its rate of heat dissipation under normal conditions will reduce its temperature to approximately room temperature in 15 or 20 minutes.

Modulated control is obtained by providing the

control thermostat with means for locally heating it, as by a pre-heat coil. Application of pre-heat to the thermostat causes the latter to operate at relatively frequent intervals, dependent upon the amount of pre-heat, intermittently energizing the heater. Due to this intermittent heating and the heat storage capacity of the pilot heater the temperature of the liquid is maintained at an average value varying but slightly from that predetermined value at which heat is transferred to the heated space continuously and at a rate just sufficient to overcome losses due to dissipation.

This type of modulated control resulted in certain disadvantages due to subcalibration of the thermostat when the pilot heater was energized for greater lengths of the time in response to increased demands for heat. In other words, when temperature conditions are such as to require the thermostat to energize the heater for greater lengths of time, the preheat coil is energized over a longer period to apply more pre-heat. Furthermore, to increase the frequency of operation of the thermostat to achieve better results through a more critical modulation, the pre-heat coil must have a greater capacity. Thus, in cold weather, with a relatively large capacity pre-heat coil, the locally applied heat actuates the thermostat to its off position at a temperature lower than that which it is calibrated at, with the result that lower temperatures are maintained within the space during cold weather.

The above described subcalibration occurs not only in the arrangement described but in all heating systems wherein a preheat coil is associated with the control thermostat. It is obvious that when the thermostat is in a position wherein it calls for heat and the pre-heat coil is energized for a greater percentage of time the result will be that the temperature of the preheat coil and the thermostat will be raised locally and thus a lower temperature will be maintained within the space where they are located.

It is the principal object of my invention to provide an improved temperature control system in which such subcalibration is avoided and heat is transferred at variable rates to maintain a predetermined temperature condition more nearly constant under all operating conditions.

It is a further object of my invention to provide improved means for automatically varying the effect of local heating means associated with a thermostat in response to increased demands upon the heat exchanger controlled thereby.

A still further object of my invention is to provide means for decreasing the effect of the local heating means on the thermal responsive means during periods when the latter is in a position calling for heat during a relatively greater percentage of the time.

Briefly, this is accomplished by connecting in series with the pre-heat coil of the thermostat an auxiliary resistor having a high temperature coefficient of resistance, preferably surrounded by some material as a metal to give it a high thermal capacity and suitably located at some point remote from the thermal responsive element or thermally insulated from the latter. During mild weather when the control thermostat calls for heat only a relatively small percentage of time the resistor remains at a comparatively low temperature, at which it does not materially affect the flow of current through the pre-heat coil. However during cold weather, with comparatively longer and more frequent calls for heat by the

thermostat the resistor is heated to a high temperature. Its resistance increases and consequently the flow of current through the pre-heat coil and the average heating effect of the latter on the thermostat is decreased.

In this manner subcalibration of the thermostat is avoided and more nearly constant conditions are maintained within the room.

While I have described my invention in connection with a heat transfer system of a particular type, it will be obvious to those skilled in the art that it can be applied equally readily to any heating system wherein modulated control is required. For instance, it could be applied to the control of a valve regulating the flow of a gaseous or liquid fuel to a burner, or the position of the damper of a furnace as well as to all types of thermostatic control where a source of local heat is used to modify the action of a thermostat. My invention in its broader aspects is thus not limited to any particular type of heat transfer system.

A more detailed understanding of the present invention may be secured from the following description taken in connection with the accompanying drawing in which is illustrated a preferred embodiment of the invention.

The single figure of the accompanying drawing diagrammatically shows, partly in section, an air heating radiator unit with a fluid vaporizing and condensing heat transfer system therefor deriving heat from a steam chamber and the liquid control chamber electrically heated under the control of a thermostatic switch provided with the usual pre-heat coil and a preferred form of auxiliary resistor.

In the illustrated embodiment there is provided a radiator 9 for heating the air in the room indicated by the dotted lines 10. This radiator is preferably formed of suitably pressed metal plates welded together to form a series of interconnected vapor condensing columns 11 with open air circulation passages 12 therebetween to facilitate dissipation of heat from the radiator to the air. The bottom wall of the radiator 9 is preferably sloped so as to readily drain the condensed vapor into the condensate receiving tube 13. Tube 13 is joined with the vaporizing tube 14 having one end thereof bent downward and extending into the steam chest 15 in which live steam is maintained at all times. The steam is supplied from any suitable boiler or other source (not shown) by the steam supply pipe 16 which also serves to return the condensed steam to the source. A suitable heat insulating cover 17 effectively prevents any dissipation of heat from the steam chest 15, the steam pipe 16, as well as from the vaporizing tube 14 except through the operation of the heat transfer system in a manner to be described hereinafter.

A closed liquid control chamber 20 is located remotely from both the vaporizing surfaces of the tube 14 and the condensing of radiator 9 and has a relatively small size tube 21 communicating between the bottom thereof and the bottom of the condensate receiving tube 13. This serves to minimize the transfer of any heat between the control chamber 20 and the main heat transfer system consisting of tube 14 and radiator 9.

An electrical heating unit 22 of the cartridge type is mounted inside the tube 23 which is sealed into the liquid control chamber 20. The electrical heating unit 22 is of relatively small capacity and is energized at low voltage derived from the secondary of the transformer 24 to which it is connected by means of a switch 25 under the

control of thermal responsive means 26. The thermal responsive means consists of a thermal responsive element 27 illustrated as being of the bimetallic type and adapted to close an energizing circuit for a relay 28 which controls the position of switch 25 when the temperature within the space 10 falls to a predetermined low limit. The energizing circuit extends from the secondary winding of transformer 24 to the right hand contact of the thermal responsive means through a conductor 29, the bimetallic element in engagement with its right hand contact, connection 30 leading to the relay 28 which in turn is connected to the other terminal of the secondary winding through connection 31. The resulting energization of relay 28 effects upward movement of its associated armature 28' and closure of the energizing circuit to the heater 22 by closure of switch 25. Simultaneously with the closure of switch 25 a holding circuit for relay 28 is established by closure switch 32 which cuts out a portion of the circuit including the thermal element. The energization of relay 28 also results in the flow of current through a circuit including connection 33, pre-heat coil 34, and an auxiliary resistor 35 of material possessing a high temperature coefficient, such as nickel or tungsten, suitably mounted within a metallic body 36 and connected by means of electrical connection 37 to electrical connection 30. It may be noted that the pre-heat coil and auxiliary resistor are energized immediately upon the engagement by thermal responsive element 27 with its associated right hand contact and that they remain energized upon the return of the holding circuit for relay 28 by closure of switch 32.

The metallic body 36 is preferably made of some material which has a high thermal capacity such as brass or copper and the whole, including the auxiliary resistor 35 and the metallic body 36, may be placed at some point remote from the thermal responsive element 27. The reason for this is that it is not desirable that the auxiliary resistor 35 thermally affect the operation of bimetallic element 27.

Inasmuch as it has been assumed that thermal responsive element 27 moves to the right in response to a decrease in temperature, it is obvious that upon an increase in temperature it will move in the opposite direction. If the increase in temperature exceeds a desired predetermined limit the thermal responsive element will engage its left contact to short circuit the pre-heat coil and the auxiliary resistor as well as the relay 28 and thus effectively deenergize the latter.

Before describing in detail the operation of my system I shall briefly describe the construction of the heat transfer system and liquid control chamber which form the basis of the above entitled Fiene application, Serial No. 25,691.

The vapor condensing radiator 9, vaporizing tube 14, and the liquid control chamber 20 as well as the interconnecting tube 13 and 21 therebetween are preferably all joined together and hermetically sealed by welding or brazing so that a closed vapor tight heat transfer system is obtained. This entire system is then evacuated of substantially all non-condensable gases through a suitable evacuating connection 40. Thereafter a predetermined charge of suitable vaporizable liquid such as water, alcohol or the like is introduced into the closed system. The amount of this liquid charge is such as to insure that the entire effective heat transfer system of the vaporizing tube within the steam chest 15 may be effectively

wetted under maximum heat transfer conditions. Ordinarily this condition may be obtained when the volume of the liquid charge is sufficient to fill the effective portion of the vaporizing tube 14 within the steam chest 15 substantially one-third full. Preferably the volume of the control chamber 20 is made somewhat larger than necessary to contain the total amount of liquid with which the system is charged. This insures that substantially all of the liquid in the system can be withdrawn into the control chamber 20 and thereby practically stop the transfer of heat from the steam chest 15 through the vaporizer 14 to the radiator 9 whenever required. Since the system is evacuated and charged with a vaporizable liquid, some extremely small portion of the liquid will of course remain as vapor with the saturated vapor pressure in the system corresponding to the temperature of the remaining liquid. However, since the vapor remaining does not condense, practically no heat transfer can occur but conditions are such that additional amounts of liquid will immediately vaporize whenever the temperature of the liquid in control chamber 20 is raised.

After the vapor system is exhausted and charged with the proper amount of fluid, any small amount of non-condensable gas which may happen to remain in the system will be forced by the movement of the vapor into the upper portion of the radiator 9 without any serious interference with the operation of the vapor system. In order to reduce the non-condensable gases in the system to a minimum, preferably the apparatus is baked or heated to a relatively high temperature during the exhausting process. After exhaustion and charging of the system through the charging connection 40 is completed, this connection is pinched and sealed.

The wattage input of the electrical heating unit or pilot heater 22 is made such that under ordinary ambient air conditions, heat will be imparted to the control chamber 20 at the proper rate to effect the vaporization of a small portion of the liquid therein required to generate a vapor pressure sufficient to expel substantially all of the liquid from the chamber 20 in a predetermined time interval such for example, as 15 or 20 minutes.

The control chamber 20 is so constructed that its cooling time corresponds with its heating time in order to provide the best conditions for modulated heat control operation by the thermostatic switch 26. In other words, the chamber is so prepared and designed that its rate of heat dissipation to its environment under normal conditions will reduce the temperature thereof to substantially room temperature in approximately a period of 15 to 20 minutes.

In operation when the temperature of the air in the enclosure or room 10 falls below the predetermined value at which the thermostatic element 27 engages its right hand contact, relay 28 is energized by connection across the secondary of the transformer through electrical connection 30, element 27, and electrical connection 29. The result is the establishment of a holding circuit for the relay by closure of switch 32 and energization of the electric heating unit 22 by closure of switch 25. In addition, the thermostatic element 27 is locally heated by preheat coil 34 as this coil and its associated auxiliary resistance 35 is connected in parallel with the relay across the transformer by electrical connections 30, 37 and 33.

As soon as the temperature of the liquid in chamber 20 is raised due to the heat input of the pilot heater 22 a small portion of the liquid is at once vaporized. The resultant vapor pressure in chamber 20 forces some liquid from the bottom of that chamber through tube 21 into the condensate return tube 13. As soon as the level of the liquid in tube 13 rises above the entrance of the vaporizing tube 14, the expelled liquid flows toward the end of the tube extending within the steam chest 15 thereby wetting the vaporizing surface of tube 14. The liquid is vaporized by the steam and subsequently condensed in radiator 9. The resulting increase of vapor pressure in tube 14 and radiator 9 retards or even stops momentarily the further supply to control chamber 20 but as the temperature of the liquid in control chamber 20 continues to increase due to continued energization of pilot heater 22, an additional amount of liquid is vaporized therein and more and more of the liquid is expelled into the vaporizing system.

As the rate of transfer of heat from the steam chest through the vaporizing system varies with the amount of liquid effective to wet the vaporizing surface, the heating action of the radiator 9 upon the ambient air of the enclosure 10 is increased as more and more of the liquid becomes effective to wet the vaporizing surface. Consequently, the temperature of the ambient air to which the thermostat 26 is responsive increases.

The effect of preheat coil 34 is to provide a modulated control by varying the time of response of the thermostatic switch 26 to make it less than the heating and cooling time of control chamber 20. Thus when the thermostatic switch 26 is made quickly responsive to an increase or decrease in the temperature of the ambient air in the enclosure 10, the heat input of the pilot heater is started and stopped at relatively frequent intervals. Because of this intermittent heating action as well as temporary heat storage in chamber 20 the temperature of the liquid in chamber 20 is practically maintained at an average value which varies only slightly from the desired predetermined temperature value. This will result in maintaining the temperature of the radiator 9 at a corresponding average value such as is required to maintain the ambient air in the enclosure 10 substantially at the predetermined temperature value determined by the setting of the thermostat 24.

It is apparent that in colder weather the thermostat will maintain the heater 22 energized for a greater percentage of time and, therefore, the pre-heat coil 34 and auxiliary resistor 35 will be energized for a greater percentage of time since they are energized and de-energized conjointly with the relay.

In order to obtain a more critical control, it has been found desirable to increase the frequency of operation of the thermostat 27. This has been accomplished by increasing the heating effect of pre-heat coil 34. By placing the auxiliary resistance 35 in series with pre-heat coil, subcalibration of the thermostat has been avoided to a large extent because of the fact that when the pre-heat coil is energized for a greater percentage of time the effective resistance of the auxiliary resistance is increased and consequently, the flow of current through the pre-heat coil 34 is decreased. The resulting decrease in current flow lessens the effect of the pre-heat coil on the thermostat when conditions are such as to require more heating. In this manner, by varying

the time of response of the indoor thermostat in accordance with the length of time that it calls for heat, or, as expressed in another way, in accordance with the demands upon the heating system, subcalibration of the thermostat is greatly avoided and a substantially constant indoor temperature obtained.

It is obvious that by the use of my invention the frequency of operation of the thermostat 27 may be varied within wide limits depending upon the choice of value of resistance 34 and 35, and that the temperature within space 10 may be maintained at a substantially constant value over wide ranges of operation.

It will furthermore be obvious to those skilled in the art that my invention is not restricted to the embodiment disclosed in the drawing but that it is applicable to all heating systems whether they be of the type in which the position of a damper or valve is regulated constantly, as by a "floating" control, or operated from one extreme to the other, as by the "on-off" type of control.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, means for heating a space, an auxiliary electric heater and a space temperature responsive thermostat for placing both of said heaters in operation upon a call for heat, the auxiliary heater being arranged to heat the thermostat locally, and a high temperature coefficient resistance in series with said auxiliary heater for varying the effect of the auxiliary heater on said thermostat.

2. In combination, a thermostat, a heat exchanger influencing said thermostat and controlled thereby, a secondary source of heat comprising an electric heater influencing said thermostat, and means affected by current flow through the secondary source of heat for varying the effect of said secondary source of heat on said thermostat.

3. In combination, means for heating a space, an auxiliary electric heater and a space temperature responsive thermostat for placing both of said heaters in operation upon a call for heat, the auxiliary heater being arranged to heat the thermostat locally, and means including a high temperature coefficient resistance surrounded by material having a high thermal capacity and positioned so as not to affect said thermostat thermally in series with said auxiliary heater for varying the effect of the auxiliary heater on said thermostat.

4. In combination, means for heating a space, an auxiliary electric heater, a space responsive thermostat for placing both of said heaters in operation on a call for heat, the auxiliary heater being arranged to heat the thermostat locally, and a high temperature coefficient resistance in series with said auxiliary heater for decreasing the effect of the auxiliary heater on said thermostat in response to increased demands on said heating means.

5. In a temperature control system, the combination including a main temperature changer for changing the temperature of a space to be controlled, a space temperature responsive thermostat in control of the temperature changer, an auxiliary electrical temperature changer also controlled by the space temperature responsive thermostat and adapted to affect the temperature of the space temperature responsive thermostat locally, and means affected by current flow through the auxiliary temperature changer for

additionally controlling the effect of the auxiliary temperature changer on said thermostat.

6. In a temperature control system, the combination including a main temperature changer for changing the temperature of a space to be controlled, a space temperature responsive thermostat, thermo-calibrated to operate to a plurality of control positions at predetermined temperatures in control of the temperature changer, an auxiliary temperature changer also controlled by the space temperature responsive thermostat adapted to affect said thermostat locally, said auxiliary temperature changer having a heating capacity sufficient to operate said thermostat to one of its control positions in a brief interval for intermittently placing said main temperature changer into operation, and means affected by current flow through the auxiliary temperature changer for decreasing the effect of said auxiliary heater on said thermostat in response to increased demands on said main temperature changer for preventing subcalibration of said space temperature responsive thermostat.

7. In combination, an enclosure, a thermostat, temperature changing means influencing said thermostat and controlled thereby, an auxiliary

temperature changing means having a predetermined time constant influencing said thermostat and having the time of operation thereof controlled by said thermostat, and thermal timing means within said enclosure connected with said auxiliary temperature changing means and having a greater time constant than the auxiliary temperature changing means for varying the effect of the latter in proportion to the percentage of time said auxiliary temperature changing means is in operation.

8. In combination, temperature control means including a thermostat responsive to variations in the temperature to be controlled and having a preheater controlled by said thermostat for locally heating said thermostat only during predetermined temperature variations, and separate timing means operable with a time delay under the control of said thermostat for varying the heating effect of said preheater toward a predetermined minimum limit during the time said predetermined temperature variations occur and toward a predetermined maximum limit during other times.

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