

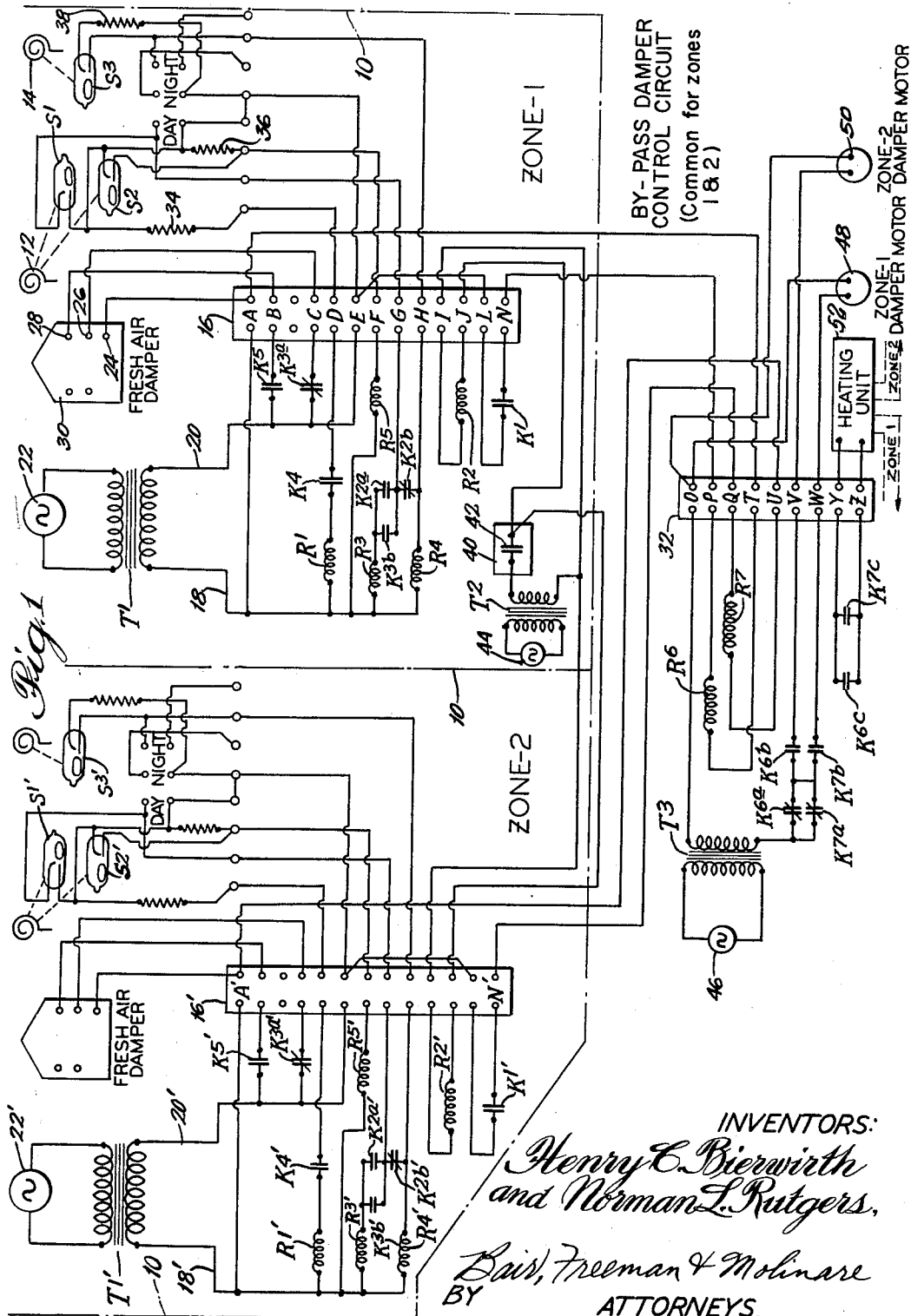
Aug. 28, 1962

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THERMOSTAT AND CONTROL CIRCUIT FOR HEATING, AIR
CONDITIONING AND VENTILATING SYSTEM

3,051,451

Filed Sept. 15, 1958

2 Sheets-Sheet 1



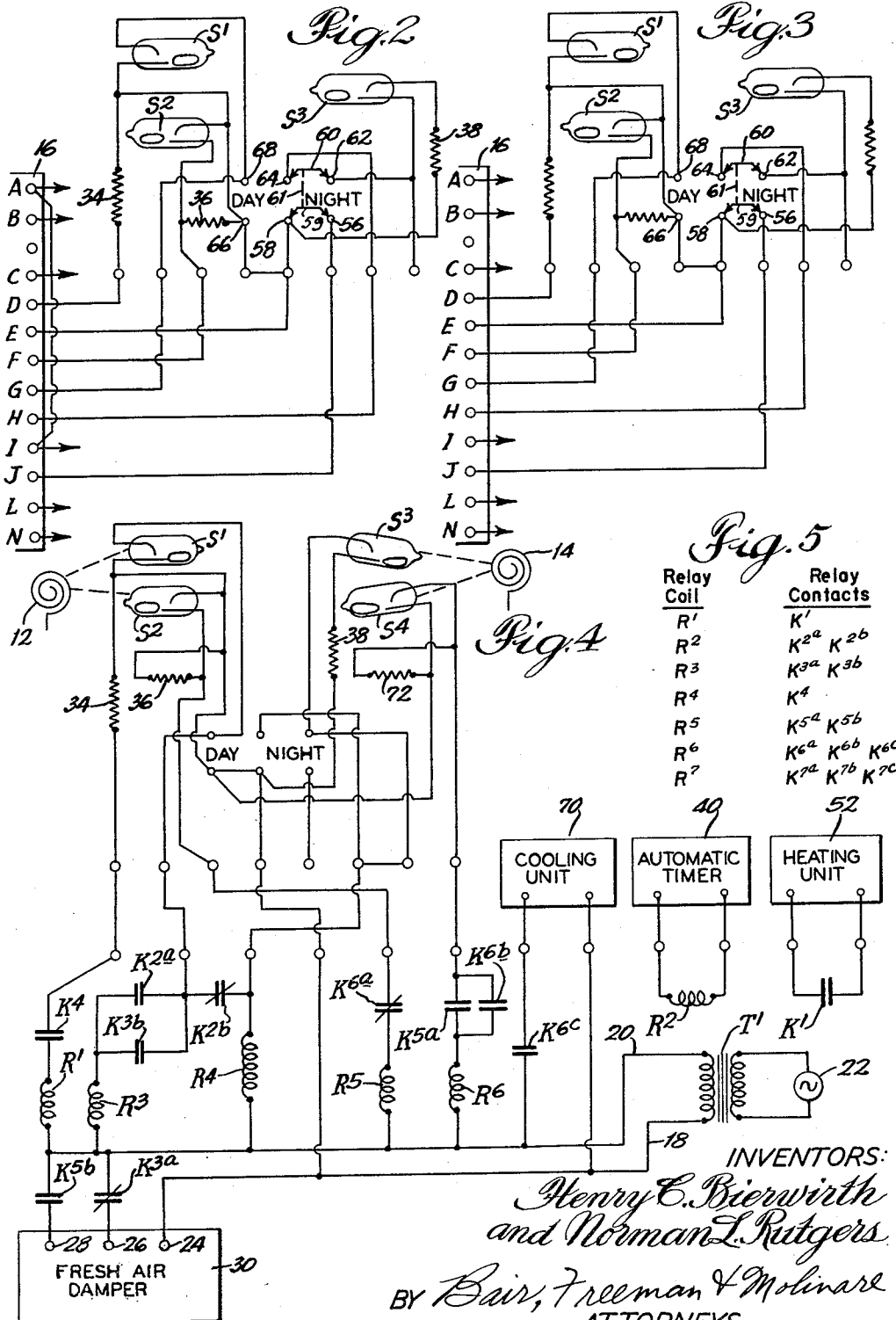
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THERMOSTAT AND CONTROL CIRCUIT FOR HEATING, AIR CONDITIONING AND VENTILATING SYSTEM

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8 Claims. (Cl. 257-274)

This invention relates generally to air distribution systems, and more particularly to new and improved temperature responsive control apparatus for regulating air distribution within enclosed areas.

The conditioning of the atmosphere within enclosed areas, such as school rooms and similar enclosures which present complex and highly variable requirements for heating, ventilating and cooling, represents a difficult problem for which presently known air systems fail to provide an adequate solution.

In our co-pending applications, Serial No. 742,393, filed June 16, 1958, now Patent No. 3,009,408 and Serial No. 729,872, filed April 21, 1958, now Patent No. 2,977,870, the particular difficulties encountered in schoolhouse heating, cooling and ventilating are discussed so as to present a full background for the typical requirements which are efficiently fulfilled for the first time by the inventions disclosed in these co-pending applications. These particular difficulties will be discussed hereinbelow to facilitate a full understanding of the present invention. However, it will be fully understood, as in the case of these co-pending applications, that the present invention is not limited in any way solely to schoolhouse structures, but is fully adapted for use in the air heating, ventilating and cooling of any enclosed zone which presents a variety of complex and changing conditions affecting the demands for conditioned air within that zone.

Architects, contractors and air treatment engineers recognize that classrooms frequently require cooling even when the outdoor weather is extremely cold. The cooling of such rooms often presents a far more challenging problem than does their heating. Body heat from the students and other persons present in the classroom, heat from lighting fixtures, and radiant heat from the sun as it strikes the walls, windows and roof, frequently produce "heat gains" within the room which exceed the normal transmission or "heat losses" from the room to the cold outdoor weather.

The number of occupants in classrooms, their physical size, their bodily activities, and their lighting requirements vary greatly from room to room within a schoolhouse and within each room during the course of a day. For example, small children of the lower class grades transmit relatively lower total quantities of heat to the room atmosphere than do the older and larger children of the upper class grades. There are also variations from class to class in the amount of lighting required, dependent upon the reading activities of the various grade levels. Such factors as recess and lengths of class periods also result in a variety of different and changing conditions of heat load within various classrooms.

Substantial heat is often needed in order to effect initial warming of a classroom during the early morning hours prior to the arrival of the students at the beginning of a school day. After the arrival of the students, the body heat load within the room is often supplemented by direct sunlight striking against the building as the day-light hours progress. In some instances, one or several of a large number of total classrooms may be subjected to use during the evening hours for adult community activities and the like, requiring the maintenance of proper temperature conditions within only one or a few of a large

number of classrooms within a given schoolhouse. It will be apparent, therefore, that conditions within any given classroom may change in a matter of minutes from no heat being required, to heat being required, to cooling being required, and such varying conditions within one room may be entirely different from the varying conditions and requirements of an immediately adjacent room. The maintenance of comfortable temperatures within every room is a matter of great importance, and it is necessary to effect the controlled distribution of conditioned air regardless of the outside weather conditions.

Outdoor air provides an economical source of relatively cool air for effecting room cooling during all weather conditions in which the outside air temperature is lower than a comfortable air temperature desired inside the room. The proper heating, cooling and ventilating system for a school house classroom is one which can very quickly bring in enough outdoor air, when needed, to offset the internal heat gains within the room and keep the room temperatures from overrunning a thermostat or other control setting. Such a proper distribution system, therefore, must be one that is capable of handling either heated air or cool air in a manner that will provide an absolutely even and uniform distribution of air velocity throughout the room.

Our Patent No. 2,977,870, discloses a distribution system for effecting the introduction of an upwardly moving "curtain" of air over the interior surfaces of the outside wall and windows of a room, so as to counteract any adverse drift of extreme temperature air along these surfaces and to thereby maintain a predetermined even circulation of conditioned air in a uniform pattern throughout the room.

Our Patent No. 3,009,408, discloses an air processing unit which is a component of critical importance to the over-all system for air heating, cooling and ventilating, in accordance with the above-described air "curtain" principle. The unit comprises a unitary cabinet structure containing the blower, air filter, dampers, and controls for regulating the temperature of the air to be introduced into the room through air distribution ducts. A system of motorized internal dampers directs either recirculated room air, heated room air, cool outside air, air conditioned air, or a balanced mixture of these, through filter means to the blower, and from the blower to the distribution duct system.

It is the primary object of this invention to provide an improved temperature responsive control system for air processing equipment to regulate air distribution within enclosed areas.

It is another object of this invention to provide an improved temperature control system for air processing equipment which permits completely automatic control of mechanical heating and cooling apparatus and which utilizes outside air as a cooling source when outside temperatures are lower than the thermostat control point.

More specifically, it is an object of this invention to provide a temperature control system, as described above, comprising improved thermostat automatic control means which eliminates the possibility of all outside air circulation during either a heat demand or a mechanical cooling demand, thereby resulting in greater efficiency of both the heating and cooling apparatus.

It is a further object of this invention to provide a temperature control system for the heating, ventilating and cooling of enclosed areas including means for manual switching from day to night, and night to day operation, means for automatically switching from day to night, and night to day operation, and means for providing automatic switching with manual over-ride.

It is a still further object of this invention to provide a temperature control system, as described above, com-

prising apparatus adapted to provide a morning warm-up period, i.e., when the control is first switched from night to day operating conditions and until the heater has been energized for a sufficient period of time to bring room temperature up to the day temperature control point, the outside air damper remains in the night position to block entry of any outside ventilation air.

It is still another object of this invention to provide a temperature control system having interlocking controls such that the cooling unit cannot be energized unless the full ventilation control is first energized, and when cooling is demanded, the full ventilation control becomes de-energized.

It is still another object of this invention to provide a new and improved temperature control system for use with air processing apparatus which is characterized by its optimum application flexibility and temperature sensitivity in controlling temperatures using heating, ventilating and/or cooling air in both occupancy and non-occupancy load conditions.

Further objects and advantages of this invention will become apparent as the following description proceeds, and the features of novelty which characterize this invention will be pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, reference is had to the accompanying drawing and descriptive material in which is shown and described several illustrative embodiments of the invention.

In the drawing:

FIGURE 1 is a schematic diagram of a two zone control system for heating and ventilating incorporating automatic switching of day and night control in accordance with one embodiment of the invention;

FIGURE 2 is a schematic diagram of the thermostat control apparatus incorporating manual operation of day and night switching in accordance with another embodiment of the invention;

FIGURE 3 is a schematic diagram of the thermostat control apparatus incorporating automatic operation with manual over-ride of day and night switching in accordance with a still further embodiment of the invention;

FIGURE 4 is a schematic diagram of heating, ventilating and cooling apparatus together with its control circuitry incorporating automatic switching of day and night control, in accordance with still another embodiment of the invention; and

FIGURE 5 is a chart illustrating the relationship of the relay windings and the associated contacts, as shown in FIGURES 1 to 4 of the drawing.

Circuit Description

Referring now to the drawing, and more particularly to FIGURE 1 thereof, there is shown an illustrative two-zone control system for providing heating and ventilating functions in accordance with principles of the invention. The control circuit is shown as divided into zone 1 and zone 2 by a broken line 10, and a by-pass damper control circuit is shown as common to the control circuitry of zones 1 and 2.

As the circuits of zones 1 and 2 are substantially identical, similar reference numerals have been applied to identify like components. The control circuitry for zone 1 comprises thermostat means including three single-pole, single-throw mercury switches mounted on two spiral-type bi-metals. Thus, a day heat control mercury tube switch S1 and a vent control mercury tube switch S2 are mounted in tandem on a single bi-metal 12 such that mercury tube switch S1 makes on a temperature fall and the mercury tube switch S2 makes on a temperature rise. The night heat control mercury tube switch S3 is mounted on the spiral bi-metal 14 so as to make on a temperature fall.

Each of the mercury tube switches comprises a pair of contacts and a mercury fill within a single envelope so that when the mercury tube switch is rotated by its

bi-metal in accordance with temperature changes, the mercury fill will serve to close the normally open contacts of the switch to thereby complete an energizing circuit.

In accordance with this embodiment of the invention, the three mercury tube switches S1, S2 and S3 are connected in a particular manner to a control panel through a terminal strip 16. Advantageously, the control panel comprises a pair of power leads 18 and 20 which are connected through a transformer T1 to a source of A.C. voltage 22. Power lead 18 is connected through terminals A of the terminal strip 16 to terminal 24 of a fresh air damper 30, and through terminals A of terminal strip 16 and terminals T of terminal strip 32 to the windings of relay R6 in the by-pass damper circuit. Relay R6, in turn, is connected through the terminals P of terminal strip 32 and through the terminals N of terminal strip 16 to the normally open contacts K1 of the heating relay R1. Contacts K1 are returned through terminals L and E of terminal strip 16 to the power lead 20.

Power lead 18 further is connected through the windings of the heating relay R1 and the normally open contacts K4 of the time delay relay R4 to the terminals D of terminal strip 16 which, in turn, are connected through the day heat anticipating resistance 34 to one contact of the day heat control mercury tube switch S1. The other contact of mercury tube switch S1 is connected through terminals G of terminal strip 16 to the normally closed contacts K2b of a timer relay R2 and the windings of time delay relay R4 to the power lead 18. The other contact of the day heat mercury tube switch S1 is also connected through the terminals G of terminal strip 16 to the normally open contacts K2a of the timer relay R2 and to the normally open contacts K3b of the vent relay R3, which in turn, are connected through the windings of the minimum vent relay R3 to the power lead 18.

Power lead 18 also is connected through the winding of the full vent relay R5 and the terminals F of the terminal strip 16 to one contact of the vent control mercury tube switch S2, the other contact of which is connected to a contact of switch S1 and through the terminals E of terminal strip 16 to the power lead 20. A vent anticipating resistance 36 is connected between the contacts of the vent control mercury tube switch S2.

The power lead 20 also is connected through the normally open contacts K5 of the full vent relay R5 to terminal 28 of the fresh air damper 30, and through the normally closed contacts K3a of the minimum vent relay R3 and terminals C of terminal strip 16 to terminal 26 of the fresh air damper 30.

One contact of the night heat mercury tube switch S3 is connected through terminals H of terminal strip 16 and the winding of the time delay relay R4 to power lead 18. The other contact of the night heat mercury tube switch S3 is connected through the night heat anticipating resistance 38 and terminals E of the terminal strip 16, to the power lead 20.

In accordance with one aspect of this invention, an automatic timer is provided to switch the heater control from the day heat control mercury tube switch S1 to the night heat control mercury tube switch S3, and back again, at predetermined times during each twenty-four hour period. Advantageously, this switching may be provided by means of an automatic clock or program relay timer 40 having a pair of contacts 42 which are opened and closed at said predetermined times. One terminal of the timer contacts 42 is connected to one side of a source of A.C. voltage, as represented by the transformer T2 and A.C. voltage source 44, and the other terminal of the timer contacts 42 is connected through the terminals J of terminal strip 16 to the windings of the timer relay R2, which, in turn, is connected through terminals I of terminal strip 16 to the other side of the transformer T2.

The control circuitry and thermostat means for zone 2 are similar to the control circuitry and thermostat

means described above for zone 1, and therefore similar components have been given similar reference numerals but have been differentiated therefrom by means of a "prime."

Zones 1 and 2 are connected to the control circuitry of a by-pass damper shown in the lower portion of FIGURE 1. The by-pass damper circuit comprises a source of A.C. voltage 46 which is connected to the windings of transformer T3. One terminal of the transformer T3 secondary winding is connected through the terminals O of terminal strip 32 to a terminal of the zone 1 damper motor 48 and to a terminal of the zone 2 damper motor 50. The other side of the transformer T3 secondary is connected to the normally closed contacts K6a and K7a of the zone 1 damper relay R6 and the zone 2 damper relay R7, respectively. Normally closed contacts K6a and K7a, in turn, are connected, in one path, through the normally open contacts K6b and terminals V of terminal strip 32 to the zone 2 damper motor 50, and in a second path through the normally open contacts K7b and terminals W to the zone 1 damper motor 48.

The zone 2 damper relay R7 is connected through terminals Q of terminal strip 32 and terminal N' of terminal strip 16' to the heating relay contact K1' in the zone 2 control circuit, and through the terminals U of terminal strip 32 and terminals A' of terminal strip 16' to the power lead 18' in the zone 2 control circuit. Similarly, the zone 1 relay R6 is connected through the terminals P of terminal strip 32 and terminals N of terminal strip 16 to the heating relay contacts K1 in the zone 1 control circuit, and through the terminals T of terminal strip 32 and the terminals A of terminal strip 16 to the power lead 18 in the zone 1 control circuit.

The normally open damper relay contacts K6c and K7c are connected in parallel and through the terminals Y and Z of terminal strip 32 to the heating unit 52.

Circuit Operation

In the operation of the circuit shown in FIGURE 1 each of the bi-metals advantageously may be adjusted by an associated dial graduated in 1° F. increments mounted in a thermostat case. The range of night temperature adjustment preferably may be from 50° F. to 85° F. and the range of day temperature adjustment preferably may be from 55° F. to 90° F. In one highly advantageous embodiment of the invention, the two dials for the bi-metals in each zone are internally interlocked so that the night temperature control must be 5° F. or more lower than the day temperature setting.

The operation of the circuit will be described with particular reference to the zone 1 circuit. The fresh air damper 30 may assume one of three operating positions, namely, a de-energized or night position, an intermediate or minimum outside air position, and a full or 100 percent outside air position. The outside air damper motor comprises an operating arm which sets the damper in one of its three operating positions as determined by the energizing potentials applied to terminals 24, 26 and 28 respectively. Thus, when the damper terminals 24 and 28 are energized, the damper motor operates the damper to its full outside air position; when the damper terminals 24 and 26 are energized, the damper motor operates the damper to its minimum outside air position; and when the damper motor is not energized, the damper is in its closed or night position wherein no outside air is vented.

The control circuitry for zone 1 is designed so that switching from day to night, and night to day operation may be done either manually at the thermostat by means of a manually operable switch or automatically by means of the automatic clock timer 40 and the contacts 42, or automatically with the ability to over-ride the automatic signal by the manual thermostat switch. These three possible control alternatives are accomplished through changes in the wiring diagram as illustrated by FIGURES

1, 2, and 3, FIGURE 1 being the wiring diagram for the fully automatic operation.

When the thermostat is switched to night operation by closing of the normally open timer contact 42, the timer relay R2 is energized, thereby closing contacts K2a and opening contact K2b. This results in the three position outside air damper 30 seeking the position which blocks the entry of outside air.

When there is a demand for heated air by the operation of the night heat control mercury tube switch S3, the time delay relay R4 becomes energized to close contacts K4, thereby energizing the heating relay R1. This results in the closing of the heating relay contact K1, which in turn energizes relay R6 in the by-pass damper circuit to close contact K6c in the energizing circuit for the heating unit 52. As the control point of the day heat control mercury tube switch S1 is a minimum of five degrees higher than the control point for the night heat control mercury tube switch S3, the contacts of switch S1 also will be closed at this time. However, the time delay relay R4 cannot be energized by the day heat control switch S1 during night operation due to the open contacts K2b, and this prevents control of the heating unit 52 by the day heat control of mercury tube switch S1 during this time.

When the thermostat is switched to day operation by the opening of the contacts 42 in the timer 40, the heat unit 52 will be energized since the night temperature control point and therefore the room temperature, is a minimum of five degrees lower than the day temperature. In accordance with a morning warm-up feature of this invention, the outside air damper 30 will remain in the night position to block entry of any ventilation air until the heating unit 52 has been energized for a sufficient interval of time to bring the room temperature to the day temperature control point. As soon as the day temperature control point is reached, the heating unit 52 is de-energized by the breaking of the day heat control mercury tube switch contacts, and the outside air damper 30 is simultaneously directed to seek its minimum air position by the energization of terminals 24 and 26. When further heat demands are made by the day heat control switch S1, the outside air damper 30 will remain in the minimum ventilation air position, during day operation.

Should the room thermostat sense a temperature rise in the room of approximately 1.5° F. above the heating control point, the vent control mercury tube switch S2 mounted on bi-metal 12 has its contacts closed to energize the full vent relay R5, and thereby direct the damper motor to admit all outside air and block the entry of any circulation air. This is brought about by the closing of the full vent contacts K5 which results in the energization of the damper terminals 24 and 28.

The time interval devoted to both the ventilation and heating demands is carefully controlled by the heat anticipating resistances 34 and 38, and by the vent anticipating resistance 36. Thus, only short heat demands are permitted during mild weather and only short ventilation demands are permitted during cold weather by the action of the anticipation resistances and the novel circuit described above.

By-pass damper controls are utilized in a plural zone system in which a common heating unit 52 satisfies the demands of two or more enclosed areas, such as classrooms. The by-pass controls serve to eliminate the possibility of admitting heated air to a room or zone not calling for heat. Each by-pass damper motor is a two-position device which either blocks the flow of heating air while admitting only by-pass or recirculated air, or in its alternative mode of operation, blocks the flow of by-pass air and admits only heating air should the thermostat in the room or zone be calling for heat.

Thus, when the thermostat in zone 1 calls for heat from the heating unit 52 at a time when the thermostat for zone 2 is not calling for heat, the damper relay R6 will

be energized by the closing of the heating contacts K1 in the zone 1 control panel. The damper relay R7 will not be energized since the heating contacts K1' in the zone 2 control panel will be open. The energization of relay R6 opens the normally closed contacts K6a and closes the normally open contacts K6b to cause an energizing circuit to be completed between the power transformer T3 and the zone 2 damper motor 50. This blocks the flow of heated air into zone 2, while at the same time, the zone 1 damper motor will be unoperated to permit heated air to flow into zone 1. In accordance with the feature of the invention, the by-pass damper motors 48 and 50 operate during both day and night control conditions.

The switching from day to night, and from night to day operation—which is accomplished automatically by the timer relay 40 in the circuit of FIGURE 1—may be done manually at the thermostat by manually actuable switching means if a control of this type is desired. The thermostat means and wiring diagram for such manual day-night switching are shown in FIGURE 2 of the drawing wherein elements corresponding to the similar elements of the FIGURE 1 drawing have been given similar reference numerals.

The manually controlled thermostat shown in FIGURE 2 differs from the automatically controlled thermostat shown in FIGURE 1 in that the terminal A of the terminal strip 16 is connected directly to the terminal I, and the terminal J of terminal strip 16 is connected directly to the night switch contact 56. The armature 59 of the manual switch 61 connects contact 56 to contact 58 which, in turn is connected to terminal E on terminal strip 16. In addition, the armature 60 of the manually operable switch 61 connects night contact 62 with contact 64 which, in turn, is connected to terminal H on terminal strip 16.

When it is desired to manually switch the thermostat from night to day operation, armatures 59 and 60 are actuated so that contact 58 is directly connected to day contact 66, and contact 64 is directly connected to day contact 68. Thus, it can be seen that when the manual switch 61 is in the night position, the night heat control mercury tube switch S3 has its contacts connected to the terminals E, H and J on the terminal strip 16 for controlling the operation of the venting and heating relays in the control panel. Similarly, when the manual switch 61 is placed in the day position, the contacts of the day heat control mercury tube switch S1 are connected to the terminals E, G and H on terminal strips 16 for controlling the venting and heating relays. The contacts of the vent control mercury switch 52 are connected to terminals E and F in both the night and day positions of manual switch 61.

It may be desirable to control the day-night switch of the thermostat by the automatic timer 42 while at the same time providing means for over-riding the automatic signal with the mechanical thermostat switch. This mode of operation may be achieved by the circuit shown in FIGURE 3, wherein elements corresponding to the elements of the thermostats of FIGURES 1 and 2 have been given like reference numerals. In the circuit of FIGURE 3, the jumper between terminals A and I of terminal strip 16b as shown in FIGURE 2, has been eliminated and with this single exception, the circuit of FIGURE 3 is similar to the circuit of FIGURE 2. Thus, the automatic timer 40 normally controls the day-night operation of the thermostat, and the open and closed condition of the timer contacts 42 determine whether the heating unit 52 is controlled by the day heat mercury tube switch S1 or the night heat mercury tube switch S3. However, the automatic control from the timer 40 may be over-ridden, as desired, by actuation of the manual day-night switch 61.

Thus, it will be appreciated that any desired mode of operation may be achieved in a simple yet effective manner merely by varying the installation wiring at the ter-

minal strip 16. It further will be appreciated that in the alternative embodiment shown in FIGURES 2 and 3, the wiring of the ventilation damper motors, the heating unit and the by-pass control circuitry remains the same as shown in FIGURE 1, although such wiring has not been shown to simplify the explanation of the FIGURES 2 and 3 circuits.

It is a feature of this invention that the novel control circuitry described hereinabove may be adapted for providing control of heating, ventilating, and cooling operations, and an illustrative circuit adapted to this desirable end is shown in FIGURE 4 of the drawing. The circuit of FIGURE 4 is similar in many respects to the circuit of FIGURE 1 and corresponding elements have been given corresponding reference numerals.

The circuit of FIGURE 4 differs primarily from the heating and ventilating control circuitry of FIGURE 1 in that a cooling control mercury tube switch S4 is mounted in tandem with the night heat control mercury tube switch S3 on the spiral bi-metal 14. In accordance with a preferred embodiment of the invention, the day heat and vent control mercury tube switches S1 and S2, respectively, are $\frac{1}{2}^{\circ}$ F. differential mercury tubes and are adjustable by means of a drum dial, calibrated at 1° F. increments, mounted on the thermostat case. These mercury switches are mounted so that the vent switch S2 makes contact at a temperature 1° F. above the temperature at which the day heat switch S1 breaks.

The night heating and cooling mercury switches S3 and S4, respectively, advantageously are of the 1° F. differential type and are mounted on the second bi-metal 14 so that the cooling switch S4 makes contact at a temperature 15° F. above the temperature at which the night heat switch S3 breaks. Advantageously, the adjusting drum dial may be calibrated in 1° F. increments to indicate the adjustment of the cooling switch.

In the heating, ventilating, and cooling control circuit of FIGURE 4, the day and night heat control mercury tube switches and the vent control mercury tube switch are connected to a control circuit similar to that described with respect to FIGURE 1. Thus, one contact of the day heat control switch S1, one contact of the vent control switch S2, and one contact of the cooling control switch S4 are connected to power lead 18 of the power transformer T1. One contact of the night heat control switch S3 also is connected thereto through the night heat anticipating resistance 38. In addition, power lead 18 of the power transformer T1 is connected to a terminal of the cooling unit 70 and to a terminal 24 of the fresh air damper 30.

The same contact of the day heat switch S1 is also connected through a day heat anticipating resistance 34, the normally open contacts K4 of the time delay relay R4, and the windings of the heat relay R1 to the power lead 20 of the power transformer T1. The other contact of the day heat switch S1 is connected to a parallel circuit of the normally open timer relay contacts K2a and the normally open minimum vent relay contacts K3b, which, in turn, are connected through the winding of the minimum vent relay R3 to the power lead 20.

The other contact of the vent switch S2 is connected to the normally closed contacts K6a of the cooling relay R6 and through the winding of the full vent relay R5 to the power lead 20. A vent anticipating resistance 36 is connected across the contacts of the vent switch S2.

The other contact of the night heat switch S3 is connected through the winding of the time delay relay R4 to the power lead 20, and through the normally closed contacts K2b of the timer relays R2 to the parallel circuit of the contacts K2a and K3b.

The other contact of the cooling switch S4 is connected to the parallel circuit comprising the normally open contacts K5a of the full vent relay R5 and the normally open contacts K6b of the cooling relay R6, which contacts

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are in turn connected through the windings of the cooling relay to the power lead 20.

Power lead 20 is also connected to the normally open contacts K5b of the full vent relay R5 and the normally closed contacts K3a of the minimum vent relay R3 to the fresh air damper terminals 28 and 26, respectively. Also, power lead 20 is connected through the normally close contacts K6a of the cooling relay R6 to the cooling unit 70.

In the operation of the heating, ventilating, and cooling circuit shown in FIGURE 4, the full ventilation (all outside air) and the cooling demands, as directed by the venting control switch S2 and the cooling control switch S4, are interlocked by the control circuitry so that the cooling unit 70 cannot be energized unless the full ventilation relay R5 is first energized. This desirable result is effected by placing the cooling relay R6 in series with the normally open contacts K5a of the full vent relay R5. Thus, contacts K5a must be closed in order to energize the cooling relay R6 for operating the cooling unit 70. Once cooling is demanded, however, by the making of the contacts in the cooling switch S4, the full ventilation relay R5 is de-energized. As shown in the drawing, the windings of relay R5 are connected in series with the normally closed contacts K6a of the cooling relay R6. Thus, when the cooling relay R6 is energized, its contacts K6b close to latch it in the energized condition, and, in addition, its contacts K6a open to de-energize the full vent relay R5.

The circuit of FIGURE 4 also incorporates the morning warm-up feature disclosed above with respect to the circuit of FIGURE 1. Thus, the outside air is prevented from entering the circulated air stream when the thermostat is first switched from night time to day time operating conditions by the day-night switch. As explained heretofore, the fresh air damper is in its de-energized condition and no outside air is vented when the day-night switch is in the night operating condition. Since the temperature control point of the day heat switch S1 is at least five degrees higher than the temperature control point of the night heat switch S3, when the day-night switch is actuated from the night to the day position, the contacts of day heat switch S1 will be made. The temperature of the area is below the day heat temperature control point, and heat will be demanded until such time as the temperature rises to the day heat temperature control point. After this period of time, the heat switch S1 breaks contact and, only at this time, is the outside air damper 30 allowed to assume the position admitting minimum quantities of outside air. Thus, it will be appreciated that in the circuit of FIGURE 4, as in the circuit of FIGURE 1, there is a morning warm-up period after the day-night switch is actuated to the day position during which no fresh air is vented until the room has been warmed to the day heat control temperature.

We have shown and described several embodiments of a novel temperature control circuit adapted to control either heating and venting functions, or heating, venting and cooling functions in one or more enclosed areas or zones.

It will be appreciated by those skilled in the art that various changes and modifications may be made in the illustrative embodiments shown and described herein without departing from the invention, and therefore, it is intended in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

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

1. A temperature responsive control system for air heating and venting apparatus comprising thermostat means for selectively operating the heating and venting apparatus in accordance with temperature changes, said thermostat means comprising a first spiral bimetal, a

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day heat control mercury tube switch and a vent control mercury tube switch supported on said first bimetal for rotation thereby as determined by said temperature changes, said day heat control mercury tube switch being mounted on said first bimetal so as to make on a temperature fall and said vent control mercury tube switch being mounted on said first bimetal so as to make on a temperature rise, a second spiral bimetal, a night heat control mercury tube switch supported on said second bimetal for rotation thereby as determined by said temperature changes, said night heat control mercury tube switch being mounted on said bimetal so as to make on a temperature fall, and circuit means connecting said thermostat means to said heating and venting apparatus for controlled operation of the latter in accordance with said temperature changes, said circuit means comprising relay means responsive to the rotation of said first bimetal for causing said heating apparatus to be energized upon the making of said day heat control mercury tube switch and for causing said venting apparatus to be energized upon the making of said vent control mercury tube switch, relay means responsive to the rotation of said second bimetal for causing said heating apparatus to be energized upon the making of said night heat control mercury tube switch, and selectively operable day-night control switching means in circuit with said relay means for rendering either the first or second bimetal mercury tube switches effective to control said air heating and venting apparatus, said switching means comprising an automatic clock timer for placing said heating and venting apparatus under control of said first or second bimetal mercury tube switches at predetermined intervals during each 24 hour period.

2. A temperature responsive control system for air heating and venting apparatus comprising thermostat means for selectively operating the heating and venting apparatus in accordance with temperature changes, said thermostat means comprising a first bimetal, a day heat control mercury tube switch and a vent control mercury tube switch supported in tandem on said first bimetal for operation thereby as determined by said temperature changes, a second bimetal, and a night heat control mercury tube switch supported on said second bimetal for operation thereby as determined by said temperature changes, and a control circuit connected to said thermostat means for controlling the energization of heating and venting apparatus during day and night operation in accordance with the operation of the tandem supported switches on the first bimetal and the single switch supported on the second bimetal, said control circuit including automatic clock timer for placing said air heating and venting apparatus under control of the first bimetal switches or the second bimetal switch at predetermined intervals during each 24 hour period.

3. A temperature responsive control system for selectively operating air heating and venting apparatus in accordance with temperature changes comprising a day heat control mercury tube switch, a vent control mercury tube switch, a first bimetal, means mounting said day heat and vent control mercury tube switches in tandem on said first bimetal for operation thereby as determined by said temperature changes, a night heat control mercury tube switch, a second bimetal, means mounting said night heat control mercury tube switch on said second bimetal for operation thereby as determined by said temperature changes, and a control circuit connected to said thermostat means for controlling the energization of heating and venting apparatus during day and night operation, said control circuit comprising a heating relay for causing the heating apparatus to be energized by said day heat control mercury tube switch during day operation and by said night heat control mercury tube switch during night operation, venting relay means for causing the venting apparatus to be energized by said vent control mercury tube switch to vary the degree of vent-

ing as determined by temperature changes during day operation and for preventing venting during night operation, and selectively operable day-night control switching means in circuit with said heating relay and said venting relay means for rendering different mercury tube switches effective only during different predetermined intervals of time, said switching means comprising an automatic clock timer operable to place said air heating and venting apparatus under control of different tube switches during said predetermined intervals of time for each 24 hour period.

4. A temperature responsive control system for selectively operating air heating and venting apparatus in accordance with claim 3 wherein said first bimetal is spirally wound and is adapted for rotation in either a clockwise or counterclockwise direction in response to temperature changes, said day heat control mercury tube switch and said vent control mercury tube switch being mounted on said first bimetal such that the contacts of one switch makes when the bimetal is rotated clockwise and the contacts of the other switch makes when the bimetal is rotated counterclockwise.

5. Temperature responsive control apparatus for an air processing and distribution system comprising a first spiral wound bimetal, a day heat control mercury tube switch and a vent control mercury tube switch supported on said first bimetal and adapted to be rotated thereby in response to temperature changes, a second spiral wound bimetal, a night heat control mercury tube switch and a cooling control mercury tube switch supported on said second bimetal and adapted to be rotated thereby in response to temperature changes, each of said mercury tube switches including a pair of contacts and a mercury fill for making and breaking said contacts, a heat control circuit for selectively operating a heating unit, said heat control circuit comprising a heating relay operable to close an energizing circuit for said heating unit, day-night switching means including an automatic clock timer operable in the day position to cause said heating relay to be responsive to the day heat control mercury tube switch and operable in the night position to cause said heating relay to be responsive to the night heat control mercury tube switch, a vent control circuit for selectively operating venting means to control the flow of air into the air processing and distribution system, said vent control circuit comprising venting relay means operable to adjust the flow of air as determined by the day heat control, cooling control and venting control mercury tube switches, a cooling unit, a cooling control circuit for selectively operating said cooling unit, said cooling control circuit comprising a cooling relay operable to close the energizing circuit for said cooling unit as determined by said cooling control mercury tube switch, and means electrically interconnecting said cooling relay and said venting relay means such that the venting relay means must first be energized to permit the cooling relay to be energized and the energization of said cooling relay serves to de-energize said venting relay means.

6. Temperature responsive control apparatus for an air processing and distribution system for a closed area comprising a first spiral wound bimetal, a day heat control mercury tube switch and a vent control mercury tube switch supported on said first bimetal and adapted to be rotated thereby in response to temperature changes, a second spiral wound bimetal, a night heat control mercury tube switch and a cooling control mercury tube switch supported on said second bimetal and adapted to be rotated thereby in response to temperature changes, each of said mercury tube switches including a pair of contacts and a mercury fill for making and breaking said contacts, the mercury tube switches on said first bimetal being oriented such that the day heat control switch contacts make when the bimetal rotates in one direction and the vent control switch contacts make when the

bimetal rotates in the opposite direction, the mercury tube switches on said second bimetal being oriented such that the night heat control switch contacts make when the bimetal rotates in one direction and the cooling control switch contacts make when the bimetal rotates in the opposite direction, and a heating, venting and cooling control circuit connected to said switches and responsive to the operation thereof for selectively controlling a heating unit, a cooling unit, and vent means to maintain a desired atmosphere within the closed area, said control circuit including heating relay means adapted to be energized by either said day or night heat control mercury tube switches, minimum and full vent relay means adapted to be energized by said vent control mercury tube switch, cooling relay means adapted to be energized by said cooling control mercury tube switch, and selectively operable timing relay means for enabling different ones of said relay means during different pre-selected time intervals.

7. A plural zone temperature responsive control system for air heating and venting apparatus comprising separate thermostat means for selectively operating the heating and venting apparatus in accordance with the temperature changes in each zone, each thermostat means comprising a first bimetal, a day heat control mercury tube switch and a vent control mercury tube switch supported on said first bimetal for operation thereby as determined by said temperature changes, a second bimetal, a night heat control mercury tube switch supported on said second bimetal for operation thereby as determined by said temperature changes, heating means common to said plural zones, separate venting means for each of said zones, and a control circuit for each zone connected to the thermostat means associated therewith for controlling the energization of the common heating means and its separate venting means during day and night operation, day-night switching means including an automatic clock timer common to the control circuits of said zones, each of said control circuits comprising a heating relay operable by its associated heat control switches, for causing the common heating means to be energized, and a venting relay operable by its associated vent control switch for causing its venting means to be energized, said day-night switching means being operable to prevent energization of said venting means when placed in the night position to prevent outside air from being vented, and by-pass damper means for each zone operable in response to the energization of the heating relay in its zone for permitting heated air to be admitted to the zone only when the zone heating relay is energized.

8. A plural zone temperature responsive control system for air heating and venting apparatus comprising separate thermostat means for selectively operating the heating and venting apparatus in accordance with the temperature changes in each zone, each thermostat means comprising a first spiral bimetal, a day heat control mercury tube switch and a vent control mercury tube switch supported on said first bimetal for rotation thereby as determined by said temperature changes, a second spiral bimetal, and a night heat control mercury tube switch supported on said second bimetal for rotation thereby as determined by said temperature changes, heating means common to said plural zones, separate venting means for each of said zones, and a control circuit for each zone including a heating relay and a venting relay connected to the thermostat means associated therewith for controlling the energization of the common heating means and its separate venting means during day and night operation, day-night switching means including an automatic clock timer common to the control circuits of said zones, said day-night switching means being operable to prevent energization of said venting means when placed in the night position to prevent outside air from being vented, and by-pass damper means for each zone

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operable to admit heated air to the zone only when the zone heating relay is energized.

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