Dec. 26, 1961 H. C. BIERWIRTH ETAL 3,014,704

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

Filed April 21, 1958

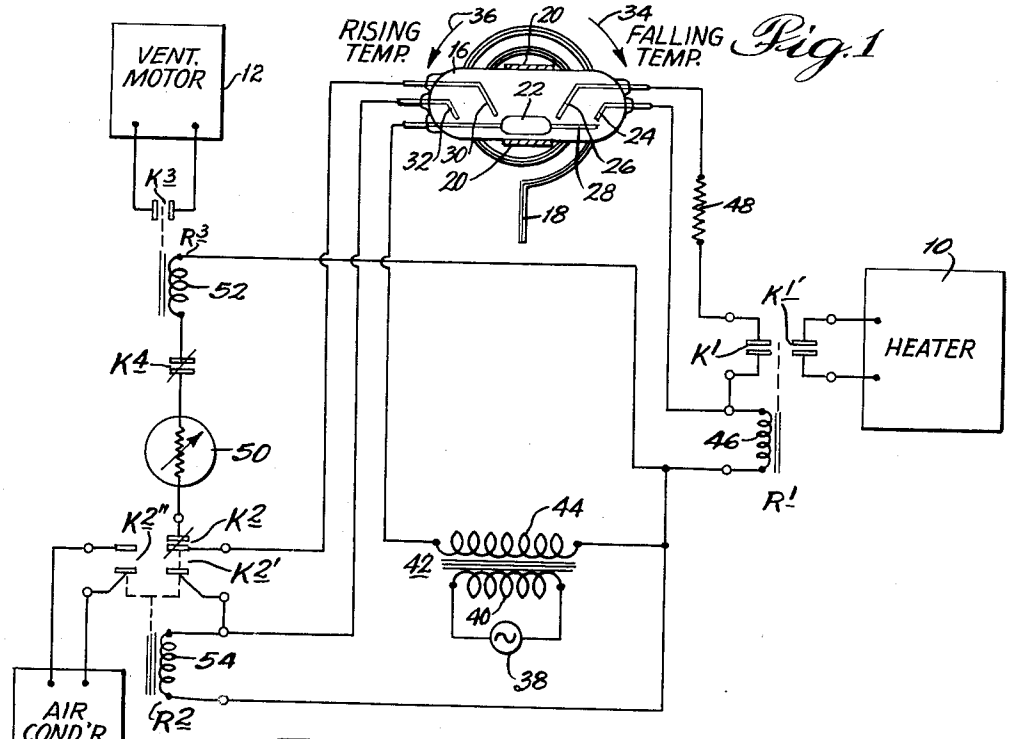


Fig. 1

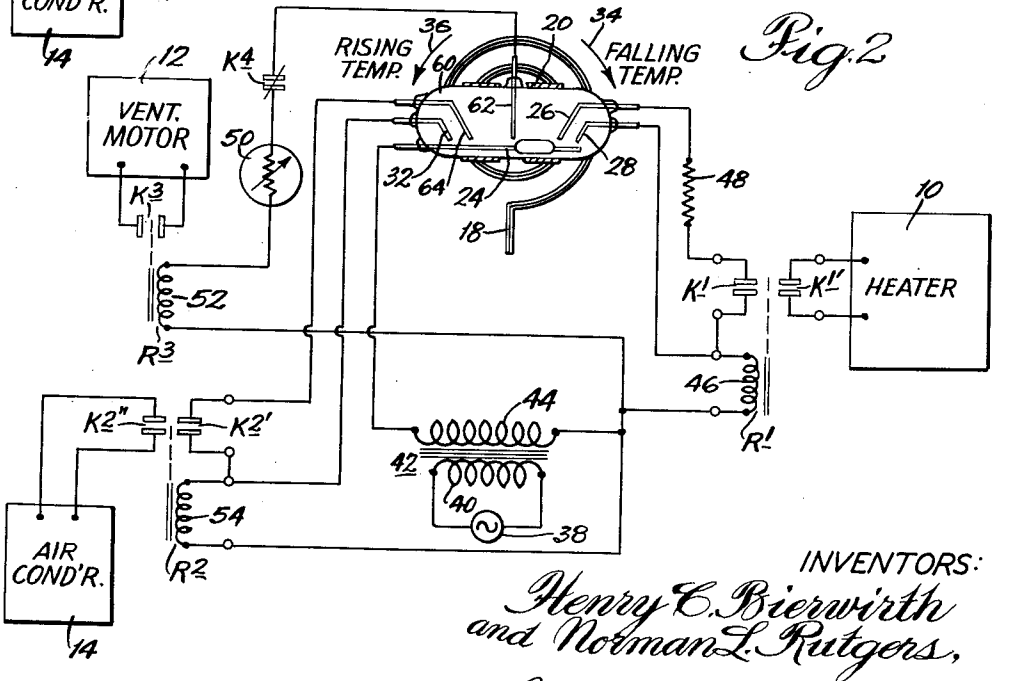


Fig. 2

INVENTORS:
Henry C. Bierwirth
and Norman L. Rutgers,
BY Bair, Freeman & Molinare
ATTORNEYS.

United States Patent Office 3,014,704
Patented Dec. 26, 1961

3,014,704

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

Henry C. Bierwirth and Norman L. Rutgers, Marshalltown, Iowa, assignors to Lennox Industries, Inc., a corporation of Iowa

Filed Apr. 21, 1958, Ser. No. 729,974
11 Claims. (Cl. 257—287)

This invention relates generally to improvements in electrical control apparatus, and more particularly to new and improved electrical control apparatus for an air distribution system of the type adapted for heating, cooling and ventilating.

Those skilled in the art know that the conditioning of the atmosphere within enclosed areas which have rapidly varying heat loads and occupancies represents a difficult problem. This problem exists because the requirements for heating, cooling and ventilating enclosed areas, such as classrooms in schoolhouse structures, offices in office buildings, and the like, are affected by the large variety of complex and changing conditions determining the demands for conditioned air within such areas.

For example, the 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. 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, and where still greater cooling is demanded, suitable air conditioning apparatus advantageously may be provided for a further lowering of the room temperature.

It is a general object of this invention to provide new and improved temperature control apparatus for effecting heating, cooling, and ventilating control functions in an air distribution system.

More particularly, it is an object of this invention to provide an air distribution system in which three stage control—heating, cooling and ventilating—is achieved with a single, unitized temperature control apparatus.

It is a further object of this invention to provide an improved temperature control circuit comprising the combination of air heating means, air cooling means, air venting means and unitized control means for selectively controlling the operation of the heating, cooling and venting means.

It is a still further object of this invention to provide an improved temperature control circuit, as described above, wherein said unitized control means comprises a single multi-contact mercury tube switch operatively mounted on a single bi-metal element.

It is another object of this invention to provide an improved temperature control circuit, as described above, which eliminates any overlapping of the heating and ventilating operations, or of the air conditioning and ventilating operations in the area being controlled.

It is still another object of this invention to provide improved temperature control apparatus, as described above, which is characterized by its compactness, its sensitivity, and its economy of construction and operation.

These and other objects are realized in accordance with the features of a specific illustrative embodiment of the invention, wherein a multi-contact switch positioned within a single mercury tube is mounted on a single bi-metal element, which advantageously may be in spiral form.

The mercury tube is constructed so that the mercury fill will make and break the enclosed contacts on nearly a zero-differential thermal change. This contact action has heretofore been known as a walking contact. Advantageously, the mercury tube is provided with an elongated

common contact which at all times is in electrical connection with the merucry fill.

In accordance with one feature of the invention, a heating contact and a latch contact are provided at one end of the mercury tube. As the bimetal on which the mercury tube is mounted cools, the tube is rotated in one direction to complete an electrical circuit to a heating relay which operates to cause the heater to be energized. The latch contact also is connected to the common contact to maintain the heater energized until heating of the bimetal causes it to rotate in the opposite direction and break the heating and latch contacts.

In accordance with a further feature of the invention, a vent contact and a cooling contact are provided in spaced relation at the other end of the mercury tube.

A continued rise in room temperature rotates the mercury tube in the opposite direction until the mercury fill electrically connects the vent contact to the common contact to operate a venting relay and energize the ventilation motor. If further cooling is demanded, as indicated by a continued rotation of the bi-metal, a circuit is completed between the cooling contact and the common contact to operate the cooling relay and thereby energize the air conditioner. Advantageously, the circuit to the ventilation motor is broken during the time the cooling relay is operated.

Accordingly, it will be appreciated by those skilled in the art that the novel construction of the invention permits a full range of temperature control by means of a single multi-contact mercury switch mounted on a single bi-metal, and operatively connected in circuit with heating relay means, venting relay means, and cooling relay means. The above and other features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects attained with its use, reference is had to the accompanying drawing and descriptive material in which is shown and described two illustrative embodiments of the invention.

In the drawing:

FIGURE 1 is a schematic diagram representation of one air distribution control circuit embodying the invention, and

FIGURE 2 is a schematic diagram representation of an alternative embodiment of air distribution control circuit in accordance with the invention.

Referring now to the drawing, and more particularly to FIGURE 1 thereof, there is shown a specific illustrative embodiment of an air distribution control circuit incorporating the principles of the invention. The illustrative circuit includes heating means in the form of a heater **10**, venting means in the form of a vent motor **12**, cooling means in the form of an air-conditioner **14**, and unitized control means for selectively controlling the operation of the heating, venting, and cooling means. In accordance with an aspect of this invention, the unitized control means comprises a single, elongated, multi-contact mercury tube switch **16** operatively mounted on a thermal motor such as the spirally wound bi-metal **18**. The mercury tube switch **16** advantageously may be mechanically supported by the bi-metal **18** in any suitable fashion, as by the clamp **20** positioned around the mercury tube.

In the embodiment shown in FIGURE 1, the multi-contact mercury tube switch **16** comprises a single envelope having therewithin five electrical contacts and a mercury fill **22**. An elongated common contact **28** extends substantially the length of the tube and is in constant electrical contact with the mercury fill **22**. At one end of the mercury tube, as shown in FIGURE 1, there is provided a pair of spaced contacts for controlling the heater **10**, said spaced contacts comprising a latch contact **26** and a

heating control contact 24. At the other end of the mercury tube, as shown in FIGURE 1, there is provided a pair of spaced contacts for controlling the vent motor 12 and air conditioner 14, the vent control contact being identified at 30 and the cooling control contact being identified at 32.

It will be appreciated by those skilled in the art that the contraction and expansion of the bi-metal 18 in response to temperature changes will rotate the mercury tube 16 in either a clockwise or counter-clockwise direction. As shown in FIGURE 1, mercury tube 16 will be rotated in a clockwise direction in response to falling temperatures, and conversely tube 16 will be rotated in a counter-clockwise direction in response to rising temperatures, as indicated by the arrows 34 and 36 respectively. Advantageously, the mercury tube 16 may be so constructed that the mercury fill 22 will make and break the enclosed contacts on nearly a zero-differential thermal change. This contact action has been described as a walking contact. Preferably, the bottom of the mercury tube may be gently radiused to eliminate the over-center or snap-acting switching conventionally associated with a mercury tube switch.

A source of electrical power 38 is connected to the primary winding 40 of a transformer 42. The secondary winding 44 has one terminal thereof connected to the common contact 28 within the mercury tube. The other terminal of the secondary winding 44 is connected to the winding 46 of a double-pole, single-throw relay R1 which, in turn, is connected to the heating control contact 24 within the mercury tube. The latch contact 26 within the mercury tube is connected through a heat anticipator resistance 48 and the normally open contacts K1 of relay R1 to the heating control contact 24. A further pair of normally open contacts K1′ of relay R1 are connected in the energizing circuit for the heater 10, such that closure of contacts K1′ causes the heater to be energized.

The vent control contact 30 within the mercury tube is connected through the normally closed contacts K2 of a double-pole, double-throw relay R2 to a negative coefficient thermal resistor 50, sometimes known as a thermistor, which in turn, is connected through the normally closed contacts K4 of a limit type ambient switch and the windings 52 of the vent relay R3 to the secondary winding 44 of the power transformer. The normally open contacts K3 of relay R3 are connected in the energizing circuit for the vent motor 12 such that closure of the contacts K3 causes the vent motor to be energized.

The cooling control contact 32 in the mercury tube is connected through the winding 54 of the double-pole, double-throw relay R2 to the secondary winding 44 of the power transformer. The normally open contacts K2′ of relay R2 are connected to the relay winding 54 such that energization of the winding 54 causes the normally closed contacts K2 to be opened and the normally open contacts K2′ to be closed. The normally open contacts K2″ of relay R2 are connected in the energizing circuit of the air conditioner 14 such that closure of the contacts K2′ causes the air conditioner 14 to be energized.

The operation of the circuit shown in FIGURE 1 will now be described. As the bi-metal 18, on which the mercury tube 16 is mounted, cools in response to falling temperatures, the mercury tube 16, as illustrated in FIGURE 1, rotates in a clockwise direction. The making of the latch contact 26 and the common contact 28 by the mercury fill 22 has no result at this time since the latch circuit is open at the contact K1 of the heating relay R1. However, continued cooling of the bi-metal 18 causes a further clockwise rotation of the mercury tube which results in the making of the heating control contact 24 and the common contact 28 by the mercury fill 22. This causes winding 46 of relay R1 to be energized and the relay R1 contacts K1 and K1′ close. Closing of contacts K1′ causes the heater 10 to be energized, and closing of the contacts K1 latches or holds the relay R1 in the energized condition until such time as the heating of the bi-metal 18 rotates the mercury tube in a counter-clockwise direction to break contact between the latch contact 26 and the common contact 28.

The rise in room temperature rotates the bi-metal driven mercury tube 16 in a counter-clockwise direction, as illustrated in FIGURE 1. Rotation in this direction first causes completion of a circuit through the vent control contact 30 and the common contact 28. After a determinable time delay required to reduce the resistance of the thermistor 50, the vent relay R3 will be energized to close its contacts K3 to energize the vent motor 12, thereby opening the outside air dampers. It should be noted that the limit type ambient switch contacts K4 are normally closed, but if the ambient switch indicates that the outside air temperature is too high to permit the outside air to be used for cooling purposes, the contacts K4 will be open and the vent motor 12 cannot be energized.

If still further cooling is demanded, as indicated by further counter-clockwise rotation of tube 16 by the bi-metal 18, a circuit will be completed between the cooling control contact 32 and the common contact 28 to cause winding 54 of the cooling relay R2 to be energized. Energization of relay R2 closes the normally open contacts K2″ to energize the air conditioner 14 and, at the same time, the normally open contacts K2′ are closed to hold the relay R2 energized until the vent control contact 30 and the common contact 28 break within the mercury tube as a result of the temperature falling below the desired level. The closing of the contacts K2′ causes the contacts K2 to be opened so that the circuit to the vent motor 12 will be broken as long as the cooling relay R2 is energized.

A modification of the circuit of FIGURE 1 is shown in FIGURE 2 of the drawing wherein like elements have been given like reference numerals. In the circuit of FIGURE 2, the mercury tube 60 differs from the tube 16 of FIGURE 1 in that it comprises at one end thereof a latch contact 26 and a heating control contact 28, at the center portion thereof a vent control contact 62 extending downwardly into the tube 60 as illustrated, and at the other end thereof a cooling control contact 32 and a holding contact 64.

Cooling control contact 32 is connected through the winding 54 of the cooling relay R2 to the secondary winding 44 of the power transformer. The holding contact 64 is connected through the normally open contacts K2′ of the cooling relays R2 to the winding 54 of the cooling relay R2 such that energization of relay R2 causes the contacts K2′ to be closed to maintain the relay energized until the contacts 64 and 24 within the mercury tube are broken. The vent control contact 62 within the mercury tube 60 is connected through the limit ambient switch contacts K4 and the thermistor 50 to the winding 52 of the vent relay R3.

As the bi-metal 18 on which the mercury tube 16 is mounted cools in response to falling temperatures, the mercury tube 60 rotates in a clockwise direction, as illustrated by the arrow 34. The making of contacts 26 and 24 results in no action at this time since the latch circuit is open at the contacts K1 of the heating relay R1. However, further cooling of the bi-metal 18 results in a further clockwise rotation of mercury tube 16 to make the contacts 28 and 24, thereby energizing the winding 46 of the relay R1. This causes the contacts K1′ to be closed to energize the heater 10 and also causes the contacts K1 to be closed to latch or hold the relay R1 energized until the contacts 26 and 24 break within the mercury tube.

Heating of the bi-metal 18 in response to rising temperatures results in a counter-clockwise rotation of mercury tube 60, as illustrated by the arrow 36, to first make the contacts 62 and 24 for completing the circuit through the relay R3, thereby causing the vent motor 12 of the ventilating air damper to be energized.

Further heating of the bi-metal 18 causes a further ro-

tation of mercury tube **16** which breaks the contacts **62** and **24**, resulting in the de-energization of the vent motor **12** and the closing of the ventilation air dampers. Further heating of the bi-metal, and consequently further counter-clockwise rotation of the mercury tube **60**, makes the contacts **64** and **24** with no result at this time since the holding circuit for the cooling relay R2 is opened at the cooling relay contacts K2'. However, further counter-cockwise rotation of mercury tube **60** makes the contacts **32** and **24** which results in the energization of the winding **54** of the cooling relay R2. This, in turn, causes the cooling relay K2'' to be closed to energize the air conditioner **14**, and also causes the hold contact K2' to be closed for holding the cooling relay R2 energized so that the air conditioner will continue to operate until the contacts **64** and **24** break within the mercury tube.

Thus, we have shown and described an improved temperature control circuit which utilizes unitized control means in the form of a single multi-contact mercury tube switch operatively mounted on a single bi-metal element for selectively controlling the operation of heating, cooling, and venting apparatus.

It will be appreciated by those skilled in the art that the use of the invention prevents the overlapping of the heating and ventilating functions, or of the air conditioning and ventilating functions in the area being controlled. The use of the invention is particularly helpful in heavily occupied areas in which outside air may be used for cooling much of the year so that mechanical air conditioning is not required.

While particular embodiments of the invention have been described in detail for the purpose of teaching the principles of the invention, it will be understood by those skilled in the art that these embodiments are illustrative only and are not to be taken as definition of the scope of the invention, reference being had for this purpose to the appended claims.

What is claimed as the invention is:

1. In an air processing and distribution system having air heating means, air venting means, and air cooling means, the improvement of heating, venting and cooling control relays, control means for selectively operating said heating, venting and cooling control relays in accordance with sensed temperature changes comprising a spirally wound bi-metal, an elongated, multi-contact mercury tube switch mounted on said bi-metal and adapted to be rotated thereby in response to temperature changes, said mercury tube switch including a mercury fill, a common contact in constant electrical contact with said mercury fill, a heating control contact at one end of said mercury tube, circuit means connecting said heating control contact to said heating control relay such that rotation of the tube by the bi-metal in one direction in response to a dropping temperature causes the mercury fill to complete an electrical circuit including said heating control contact, said common contact and said heating control relay to energize the latter, a venting control contact and a cooling control contact positioned in spaced relation at the opposite end of said mercury tube, circuit means connecting said venting control contact to said venting control relay such that rotation of the tube by the bi-metal in the other direction in response to a rising temperature causes the mercury fill to complete an electrical circuit including said venting control contact, said common contact, and said venting control relay to energize the latter, and circuit means connecting said cooling control contact to said cooling control relay such that the further rotation of the tube by the bi-metal in said other direction in response to further rising temperatures causes the mercury fill to complete an electrical circuit including said cooling control contact, said common contact and said cooling control relay to energize the latter.

2. An air processing and distribution system in accordance with claim 1 further comprising a latch contact in spaced relation with said heating control contact at said one end of said mercury tube, and circuit means connecting said latch contact to the heating control relay to maintain the latter energized until the tube is rotated in said other direction in response to rising temperatures a sufficient amount to break contact between said latch contact and said common contact.

3. An air processing and distribution system in accordance with claim 1 further comprising a negative temperature coefficient element connected in the circuit means connecting said venting control contact to the venting control relay for providing a determinable time delay period before the venting control relay is permitted to be energized.

4. An air processing and distribution system in accordance with claim 1 further comprising a pair of normally closed ambient switch contacts connected in the circuit means connecting said venting control contact to the venting control relay, said ambient switch contacts being responsive to the outside air temperature and being operable to open the venting circuit to prevent outside air from being vented wherever the temperature of the outside air exceeds the values desired for cooling purposes.

5. In an air processing and distribution system having air heating means, air venting means, and air cooling means, the improvement of heating, venting and cooling control relays, unitized control means for selectively operating said heating, venting and cooling control relays in accordance with sensed temperature changes comprising a thermal motor, an elongated multi-contact mercury tube switch mounted on said thermal motor and adapted to be rotated thereby in response to temperature changes, said mercury tube switch including a mercury fill, a common contact in constant electrical contact with said mercury fill, a plurality of spaced temperature control contacts disposed within said mercury tube and circuit means connecting said temperature control contacts to the heating control relay, venting control relay and cooling control relay such that rotation of the tube by the thermal motor in one direction in response to a dropping temperature completes an electrical circuit to energize the heating control relay, rotation of the tube by the thermal motor in the other direction in response to a rising temperature completes an electrical circuit to energize the venting control relay, and further rotation of the tube by the thermal motor in said other direction in response to further rising temperatures completes an electrical circuit to energize the cooling control relay.

6. An air processing and distribution system in accordance with claim 5 wherein said thermal motor includes a spirally wound bi-metal and clamping means for supporting said elongated, multi-contact mercury tube switch secured to said bi-metal.

7. An air processing and distribution system in accordance with claim 5 wherein said plurality of spaced temperature control contacts comprise a heating control contact positioned at one end of the mercury tube, and venting control and cooling control contacts positioned in spaced relation at the other end of said mercury tube.

8. An air processing and distribution system in accordance with claim 7 wherein said plurality of spaced temperature control contacts further comprise a latch contact for the heating control relay positioned in spaced relation to said heating control contact at said one end of said mercury tube.

9. An air processing and distribution system in accordance with claim 5 wherein said plurality of spaced temperature control contacts comprise a heating control contact and a latch contact for said heating means positioned in spaced relation at one end of said mercury tube, a cooling control contact and a latch contact for said cooling means positioned in spaced relation at the other end of said mercury tube, and a vent control contact positioned intermediate said heating control and said cooling control contacts.

10. In an air processing and distribution system having air venting means and air cooling means, the improvement of venting and cooling relays, a control circuit for selectively operating said venting and cooling relays in accordance with sensed temperature changes comprising a spirally wound bi-metal, an elongated multi-contact mercury tube switch mounted on said bi-metal and adapted to be rotated thereby in response to temperature changes, said mercury tube switch including a mercury fill, a common contact in constant electrical contact with said mercury fill, a venting control contact and a cooling control contact positioned in spaced relation at one end of said mercury tube, circuit means connecting said venting control contact to the venting relay such that rotation of the tube by the bi-metal in response to a rising temperature causes the mercury fill to complete an electrical circuit including said venting control contact, said common contact, and the venting relay to energize the latter, and circuit means connecting said cooling control contact to the cooling relay such that the further rotation of the tube by the bi-metal in the same direction in response to further rising temperatures causes the mercury fill to complete an electrical circuit including said cooling control contact, said common contact and the cooling relay to energize the latter.

11. In an air processing and distribution system having air heating means, air venting means, and air cooling means, the improvement of heating, venting and cooling control relays, control means for selectively operating said heating, venting and cooling control relays in accordance with sensed temperature changes comprising a spirally wound bi-metal, an elongated multi-contact mercury tube switch mounted on said bi-metal and adapted to be rotated thereby in response to temperature changes, said mercury tube switch including a mercury fill, a common contact in constant electrical contact with said mercury fill, a heating control contact at one end of said mercury

tube, circuit means connecting said heating control contact to the heating control relay such that rotation of the tube by the bi-metal in one direction in response to a dropping temperature causes the mercury fill to complete an electrical circuit including said heating control contacts, said common contact and the heating control relay to energize the latter, a cooling control contact at the opposite end of said mercury tube, circuit means connecting said cooling control contact to the cooling control relay such that rotation of the tube by the bi-metal in the other direction in response to rising temperatures causes the mercury fill to complete an electrical circuit including said cooling control contact, said common contact, and the cooling control relay to energize the latter, a venting control contact positioned intermediate said heating and cooling contacts within the mercury tube, and circuit means connecting said venting control contact to the venting control relay such that a lesser rotation than that required to energize the cooling control relay in response to rising temperatures causes the mercury fill to complete an electrical circuit including said venting control contact, said common contact and the venting control relay to energize the latter.

References Cited in the file of this patent

UNITED STATES PATENTS

2,162,571	Bock	June 13, 1939
2,182,449	Parks et al.	Dec. 5, 1939
2,191,967	Miller	Feb. 27, 1940
2,231,212	Miller	Feb. 11, 1941
2,299,580	Kronmiller	Oct. 20, 1942
2,344,555	McGrath	Mar. 21, 1944
2,561,067	Newton	July 17, 1951
2,802,059	Spack	Aug. 6, 1957
2,830,160	Engel et al.	Apr. 8, 1958