Dec. 24, 1968 W. D. RYCKMAN, JR 3,418,454

ELECTRIC BEDCOVER OVERTEMPERATURE CONTROL SYSTEM

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Fig. 1.

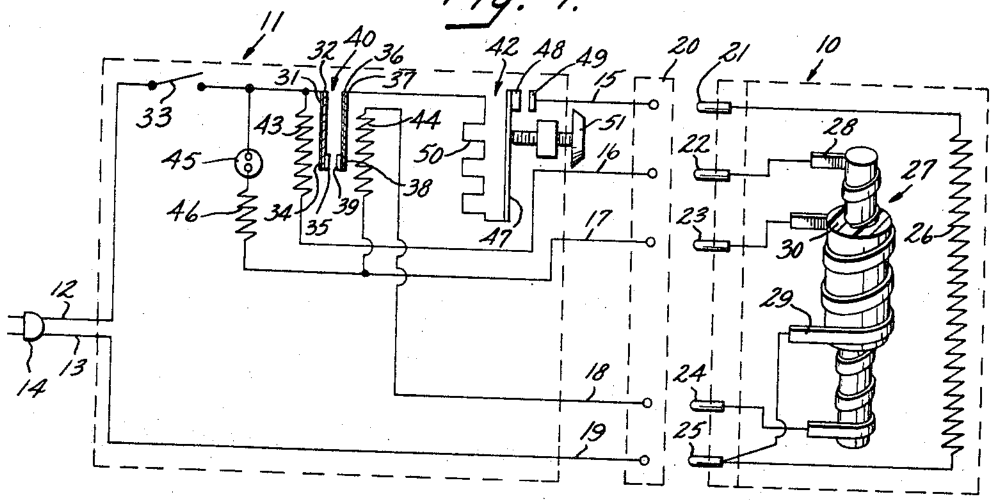


Fig. 2.

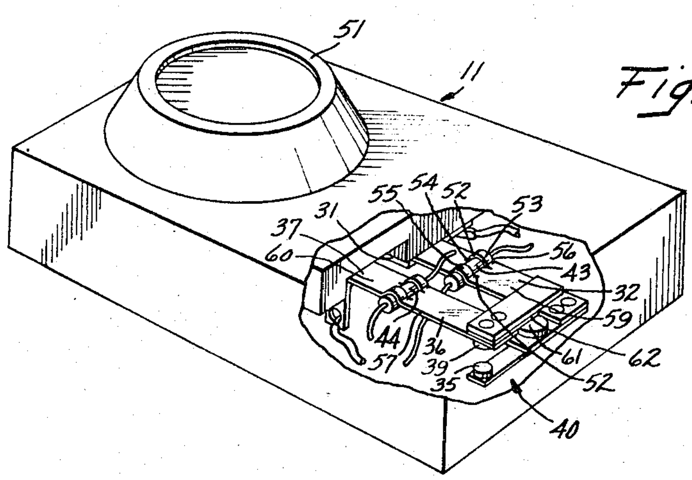
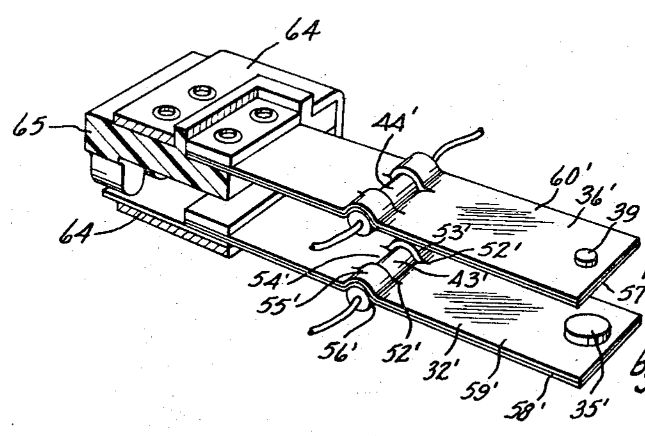


Fig. 3.



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ELECTRIC BEDCOVER OVERTEMPERATURE CONTROL SYSTEM

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The present invention relates to control systems for electrically heated bedcovers or the like and, more particularly, to control systems which utilize a temperature sensor including a layer of sensor material having a negative temperature coefficient of electrical impedance.

A typical electrically heated bedcover includes heating wire distributed between two plies of fabric; and, in addition, there is usually provided means for the user to regulate the heat output of the bedcover. In use, heat is dissipated through the bottom surface of the bedcover to the body of the user, and through the top surface to the air in the room. At times, the normal dissipation of heat may be inadvertently obstructed such as if an insulating object is placed over a localized area of the surface, or if the blanket is folded or bunched. In the event of an obstruction, an overtemperature condition may occur in the sense that the amount of heat in this localized area obtains such a degree as to cause scorching of the fabric. It therefore becomes necessary to provide a control system which will open the power circuit to the heating wire before the overtemperature reaches dangerous proportions.

In the design of an effective control system several factors must be taken into consideration. As one consideration, it is desirable that the control system be fail-safe in that should one of the elements in the control system become inoperative for one reason or another, the power circuit to the heating wire of the blanket is opened. While fluctuations in line voltage in the power supply to the control system may occur upon the starting of motors and other devices also operated from this same power supply, these fluctuations are not as a result of overtemperature in the blanket; therefore, it is desirable that the control system not be affected by these fluctuations. Furthermore, there may be slight variation in the normal line voltage to the homes of different users; consequently, the control system should be effectively operable throughout normal variation in line voltages. It is also advantageous for the control system to have an automatic recycling feature so that in the event the cause of the overtemperature condition is corrected, such as by the user in his sleep, heat will once again be supplied in a normal manner from the blanket to the user. As an additional consideration, often the control system includes a relay which is actuated as a result of overtemperature condition in the bedcover. The relay may be located in a control housing remote from the blanket and the relay should not be affected by normal change in room ambient temperature.

It is therefore an object of the present invention to provide an improved control system of the type utilizing a sensor material having a negative temperature coefficient of electrical impedance positioned throughout the heating area of an electric bedcover to control a line switch wherein the control system has relative insensitivity to line voltage fluctuations, is adapted to automatically recycle and is fail-safe in operation.

A further object is to provide a control system of the character indicated which utilizes a line switch in a control case remote from the blanket, and operation of the line switch is not affected by normal changes in room ambient temperature.

Another object is to provide a control system of the character indicated which combines the features of safety with comfort to the user and utilizes a relay which is inexpensive to manufacture.

In carrying out my invention in one form, I provide a control system for an electrically heated bedcover which includes a temperature sensor distributed over the heated area of the bedcover. The sensor comprises a pair of electrical conductors separated by a temperature sensor layer which is essentially an insulator at normal operating temperatures and conducts current of control magnitude at an elevated temperature. The electrical heater for the blanket is controlled by a line switch having cooperating contacts, each of which includes an actuator. Movement of each contact by its actuator depends upon the energy supplied to it. The electrical element of one actuator is in a parallel circuit with the sensor layer, while the other actuator element is in electrical series with this parallel circuit. In normal operation of the blanket when there is no appreciable conduction through the temperature sensitive layer, the energy ratio supplied to the actuators is selected to cause the contacts to close. Upon an overtemperature condition, conduction through the temperature sensitive layer changes the energy ratio supplied to the actuators so that the contacts open.

The subject matter which I regard as my invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. My invention, however, both as to organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which:

FIG. 1 is an electrical schematic diagram of a preferred embodiment of the invention;

FIG. 2 is a partial perspective view of a control box broken away to illustrate a line switch used in the circuit of FIG. 1; and

FIG. 3 is a partial perspective view of another embodiment of a line switch.

With reference to FIG. 1, numeral **10** indicates a blanket, and numeral **11** indicates a control box. Power leads **12** and **13** extend from the control box to a conventional power plug **14** to be inserted into an ordinary alternating current household outlet. In order to connect the control box to the blanket, conductor leads **15** through **19** extend from the control box to appropriate receptacles in a female connector plug **20**. The blanket carries male plug portions **21** through **25** which are received in respective ones of the receptacles in the female connector plug.

To supply heat to the blanket, a heater wire **26** is connected between plugs **21** and **25**. The heater wire may be distributed through the blanket in a conventional serpentine pattern. A temperature sensor **27** is also distributed through the blanket in a pattern which may be similar to the pattern followed by the heater wire so that the temperature sensor is in heat transfer relation with the heater wire. The temperature sensor includes a pair of conductors **28** and **29** separated by a layer **30** of material which is essentially an insulator at normal operating temperatures of the blanket and a conductor of significant current at an elevated temperature corresponding to an overtemperature condition of the blanket. The conductor **28** is connected between plugs **22** and **24**, and the conductor **29** is connected between plugs **23** and **25**.

In the control box **11**, power lead **12** is connected to a fixed end **31** of a first bimetallic blade **32** via a manual switch **33**. The blade **32** has a deflectable end **34** which carries a contact **35**. A second bimetallic blade **36** has one end **37** secured to the control box, and the other end **38** is deflectable and carries a contact **39**. The bimetallic blades thereby function as a line switch **40** in that the contacts **35** and **39** are adapted to be engaged or disengaged with each other depending on certain operating conditions of the entire system as will be hereinafter pointed out in more detail. The fixed end of the bimetallic blade 36 is connected to conductor lead 15 through an ambient responsive control 42. The bimetallic blades 32 and 36 are so arranged as to have the contacts normally open or disengaged, and they deflect in the same direction under the influence of heat.

In order to supply heat to the bimetallic blade 32, a first heater 43 in the form of a resistance element is positioned in intimate heat transfer relation with the blade. The heater is connected between the power line 12 via switch 33 and the conductor 16. To supply heat to the bimetallic blade 36, a second heater 44 is positioned in intimate heat transfer relation with this latter blade, and is connected between conductors 17 and 18. The heaters 43 and 44 thereby function as actuators respectively for the bimetallic blades 32 and 36. The resistance of heater 44 is preferably greater than the resistance of heater 43. The heaters are thereby in electrical series with each other, and the conductors 28 and 29 are also in the series circuit. The temperature sensor layer 30 is in circuit parallel with the second heater 44.

A pilot lamp 45 is connected between line 12 and plug 23 and is energized at all times when the switch 33 is "on." A current limiting resistor 46 is in electric series with the pilot lamp.

The ambient responsive control 42 includes a bimetallic blade 47 which carries a contact 48 adapted to engage a fixed contact 49. The bimetallic blade is of such a character as to move the contact 48 away from the contact 49 under the influence of heat. A heating resistor 50 is connected in electrical series in the line with the bimetallic blade, and the resistor is in thermal transfer relationship with the blade. The blade is thereby influenced both by the resistor 50 and by changes in the ambient temperature. Assuming that the blanket is cold, the contacts 48 and 49 will be engaging each other. Now, if the other line switches are closed, current will flow through the contacts and also through the resistor 50. The resistor will warm the blade until it deflects moving the contacts out of engagement. The length of time that it takes to warm the blade sufficiently to deflect will depend on the ambient temperature surrounding the blade. Once the contacts 48 and 49 are open, the heater and blade will cool thereby causing the contacts to once again close, and the cycle repeats itself. An adjustment knob 51 is operatively associated with the bimetal to permit the user to exercise control over the temperature at which the contacts open, and thereby regulate the heat output of the blanket.

Assuming the male plugs 21 through 25 are plugged into their respective female receptacles in the connector plug 20, and assuming the power plug 14 is plugged into a household outlet, the control system of FIG. 1 operates as follows: When the switch 33 is closed, current flows in a path through the heater 43 to the male plug 22. Assuming there is no overtemperature condition, the layer 30 is essentially an insulator; therefore, current flows from the plug 22 through the conductor 28 to the plug 24. From the plug 24 the current continues through heater 44, thence to the other power lead 13 via conductors 17, 29 and 19. The heater 44 supplies more heat to bimetal 36 than the heater 43 supplies to bimetal 32; therefore, the blade 36 will be deflected a greater distance than the blade 32. The gap between the blades is so calibrated with respect to the deflection properties of the blades that this greater deflection causes the contact 39 to engage contact 35. All of the above takes place in a relatively short period of time on the order of about one-half minute. When the contacts are engaged, current flows through the blanket heating wire 36 via ambient responsive control 42.

Now, assume that an overtemperature condition exists so that the layer 30 becomes a conductor of significant

current. The current will flow through heater 43 to the conductor 28; however, because the layer 30 is a conductor, there will be a significant flow of current through the layer between conductors 28 and 29. In other words, the second heater 44 is shunted by layer 30 upon an overtemperature condition. In this situation, current flow through heater 43 increases; but the current flowing through heater 43 then divides, with part flowing through heater 44 and the other part flowing through layer 30. The result is increased heat to bimetal 32 and reduced heat to bimetal 36, causing bimetal 36 to move away from bimetal 32, and thereby the switch 40 is opened so as to interrupt the current to the blanket heater wire 26. Now, as the blanket cools, the electrical impedance of the layer 30 increases to a point where the contacts 35 and 39 will be engaged. If, however, the reason for the overtemperature condition still exists, there will soon be an overtemperature condition again so that the layer will once again become conducting causing the contacts 35 and 39 to open. The system will thereby continue to recycle until the cause of the overtemperature condition is corrected. The user, in his sleep, may remove the cause (such as a bunching of the blanket) of the overtemperature condition and then the blanket will continue to supply heat in a normal manner to the comfort of the user.

It will be appreciated that the above control system is fail-safe in the sense that should an open circuit occur in any of the elements including the heaters 43 and 44, or the conductors 28 and 29, there will be no power to either of the heaters and the contacts 35 and 39 will open. Furthermore, should a short circuit occur between the conductors 28 and 29, the effect on the system will be the same as if an overtemperature condition exists, and the contacts of the switch will open.

Now referring to FIG. 2, a preferred embodiment of a relay or line switch 40 used in the control system is illustrated in more detail. The manner of mounting the heating resistors 43 and 44 on their respective bimetallic blades 32 and 36 assures that the resistors are in intimate heat transfer relation with the blades. Because of the good thermal transfer relationship between the heaters and the blades, the resistance value of the heaters can be so chosen that, while they provide sufficient heat individually to their respective blades to cause deflection of the blades in a desired manner, the heat supplied from these heaters to other components in the control box is kept at a minimum. The mounting in blade 32 is accomplished by providing parallel slits 52 through the blade. Integrally formed arcuate portions 53, 54, and 55 extend alternately in opposite directions from the plane of the blade thereby forming a channel 56 having an axis extending through the slits. The heater is positioned in the channel and, if desired, a thermally conducting adhesive may be applied to the outer surface of the heater to aid in holding the heater in place in the channel. The heater 44 is mounted on blade 36 in the same manner.

I mount the blades in the control box so that they will deflect in the same direction under the influence of heat. Thus, the surfaces 57 and 58 are of a metal having a relatively low coefficient of thermal expansion, while the surfaces 59 and 60 are of a metal having a relatively high coefficient of thermal expansion. I prefer to make the bimetallic blades substantially identical to each other so that any normal changes in room ambient temperature surrounding the blades in the control box will affect the deflection of each of the blades in substantially the same manner and the position of one blade relative to the other blade will not be changed.

Instantaneous fluctuations in line voltage, such as may occur on starting of a motor, across power leads 12 and 13 will not affect the operation of the line switch because the heaters do not lose heat instantaneously, and normal voltage will most probably be returned before the heaters are influenced to any great degree. Furthermore, the operation of this line switch tends to accommodate itself to voltage fluctuations that remain on the line over an indefinite period of time. The reason for this accommodation is that if the voltage across the heater **43** is reduced, the current will be less through the heater and the blade **32** will tend to return to normal position. This reduction in voltage, however, also reduces the current through the heater **44** and the blade **36** will thereby tend to follow the blade **32**. In this manner, the line switch automatically accommodates itself to reduction or increase in line voltage up to a certain degree.

The heaters **43** and **44** are preferably in the form of molded composition resistors and are coated with a material that is electrically insulating and thermally conducting. As a specific example, I have found that by using a resistance value of 2,400 ohms for the heater **43** and a value of 10,000 ohms for the heater **44**, the control system operates very well.

The temperature sensor layer **30** which I have used is a plasticized polyvinyl chloride having approximately .825% of tetrabutylammonium picrate compounded therewith. By utilizing a uniform average wall thickness on the order of .010 inch between the conductors this material has an impedance between the conductors **28** and **29** on the order of 200,000 ohms at room temperature. When the blanket achieves warmest normal operating temperatures of approximately 135° F. at the heater wire, the resistance of the sensor material is still at a value of from 35,000 to 54,000 ohms so it is still considered, for present purposes, to be an insulator. If an overtemperature condition exists in any portion of the bedcover, however, the impedance of the layer **30** drops to a value of say 9,000 ohms before the overtemperature reaches dangerous proportions. At this latter value the layer **30** is considered to be a conductor of substantial current because at this value (and also at higher temperatures of the heating wire) the layer conducts enough current to operate the line switch **40** in the manner set forth above.

It may be desirable to mount a permanent magnet **61** near the deflectable end of the blade **32**. The magnet cooperates with a metal surface **62** to assure a snap action in opening and closing the contacts.

It will be understood from the above description that operation of the line switch is predicated on the basis of a difference in the amount of heat supplied to the respective bimetallic blades **32** and **36**. Say, for example, that the switch is calibrated so that the contacts will be open when the ratio is unity; that is approximately the same amount of heat is supplied to each blade. Then if more heat is supplied to the second blade than to the first blade, this ratio will increase to a calibrated value (for example, .1 watt difference) where the contacts are closed, and the contacts will remain closed as long as the ratio is above this value. On the other hand, as the heater **43** receives more and the heater **44** receives less heat in an overtemperature condition, the ratio will decrease to a value where the contacts will open. In order to supply more heat to the blade **36** than the blade **32** in normal operation of the bedcover and thereby hold the contacts closed, I have chosen to use a greater resistance value for heater **44** than heater **43**. It is to be understood, however, that means other than a larger resistance may be used to increase this ratio in normal operation of the blanket. In this latter regard, the ratio may be increased by utilizing a better thermally conductive coating between the heater **44** and the blade **36** than might be used between the heater **43** and the blade **32**.

In certain instances, it may be desirable to increase the sensitivity of the line switch in the sense of maximizing the heat differential supplied by the two heaters and experienced by the bimetallic blades. This increase in sensitivity may be beneficial when a material is used for the layer **30** having higher initial and overtemperature impedance values than the material mentioned above. One

such material having higher impedance values is plasticized polyvinyl chloride having, as an additive, approximately 0.75% stearyldimethylbenzyl ammonium chloride. Other materials which may be used are disclosed in United States Patent 2,846,560 to J. F. Jacoby, Aug. 5, 1958, and assigned to General Electric Company, assignee of the present application.

FIG. 3 illustrates a line switch which may be utilized to maximize the heat differential, and I have used like numerals to indicate like parts correspondng to the line switch **40** of FIG. 2. In the relay of FIG. 3, the fixed ends of the bimetallic blades **32'** and **36'** are mounted in a metal, such as steel, mounting bracket **64** having good heat dissipating properties. The blade **32'** is in good heat transfer relation with this bracket. It is significant to note, however, that the blade **36'** is thermally insulated from the bracket **64** through the medium of a plastic insulating block **65**. As the two blades become heated by the heaters **43'** and **44'**, the blade **36'** will tend to retain heat because of the insulating block **65**. On the other hand, the blade **32'** will tend to give up heat through the heat dissipating bracket **64**; and, in this manner, the heat differential between the blades is maximized so as to speed up the time it takes for the contact **39'** to engage contact **35'**.

While preferred embodiments of the invention have been shown and described, various other embodiments and modifications thereof will be apparent to those skilled in the art, but will fall within the spirit and scope of the invention as defined in the following claims.

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

1. An overtemperature control system for an electrically heated bedcover or the like adapted to be connected to a source of power comprising:

(a) a temperature sensor having a pair of electrical conductors separated by a layer of material which is essentially an insulator at normal operating temperatures and a conductor of significant current at an elevated temperature;

(b) first and second actuators;

(c) a parallel circuit including said second actuator in electrical parallel with said sensor layer;

(d) a series electrical circuit connected to the power source including said first actuator in electrical series with said parallel circuit;

(e) a pair of switch contacts arranged to open and close a circuit from the electrical power source, said contacts being actuated by respective ones of said actuators to close said contacts from the energy ratio supplied to said actuators when there is no appreciable conduction through said layer at normal operating temperatures and to open said contacts when there is appreciable conduction through said layer.

2. A control system for an electrically heated bedcover or the like comprising:

(a) a temperature sensor in heat transfer relation with the bedcover and having a pair of electrical conductors separated by a temperature sensor layer of material which is essentially an insulator at normal operating temperatures and a conductor of significant current at an elevated temperature;

(b) an electrical line switch including first and second thermally responsive elements with cooperating contacts, said contacts being separated when said elements are at the same temperatures and engaged only when said second element is heated to a predetermined higher temperature than said first element;

(c) first and second heaters in intimate heat transfer association with said elements for supplying more heat to said second element than said first element when current is flowing through said conductors at normal operating temperatures of said bedcover;

(d) a series electrical circuit including said heaters and said pair of temperature sensor conductors connected to a source of power; and

(e) a parallel electrical circuit including said second heater and said temperature sensor layer whereby said second heater is shunted upon an overtemperature condition in the bedcover to reduce heat supplied to said second thermally responsive element and thereby open the line switch operated by said thermally responsive elements.

3. The control system as set forth in claim **2** wherein said second heater has a resistance value higher than the resistance value of said first heater.

4. The control system as set forth in claim **2** wherein said first and second thermally responsive elements respectively comprise first and second bimetallic blades.

5. The control system as set forth in claim **4** wherein said first and second heaters are mounted respectively in surface to surface contact with said first and second bimetallic blades.

6. The control system as set forth in claim **4** wherein said bimetallic blades are substantially identical in construction and are mounted to deflect in the same direction under the influence of heat.

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