

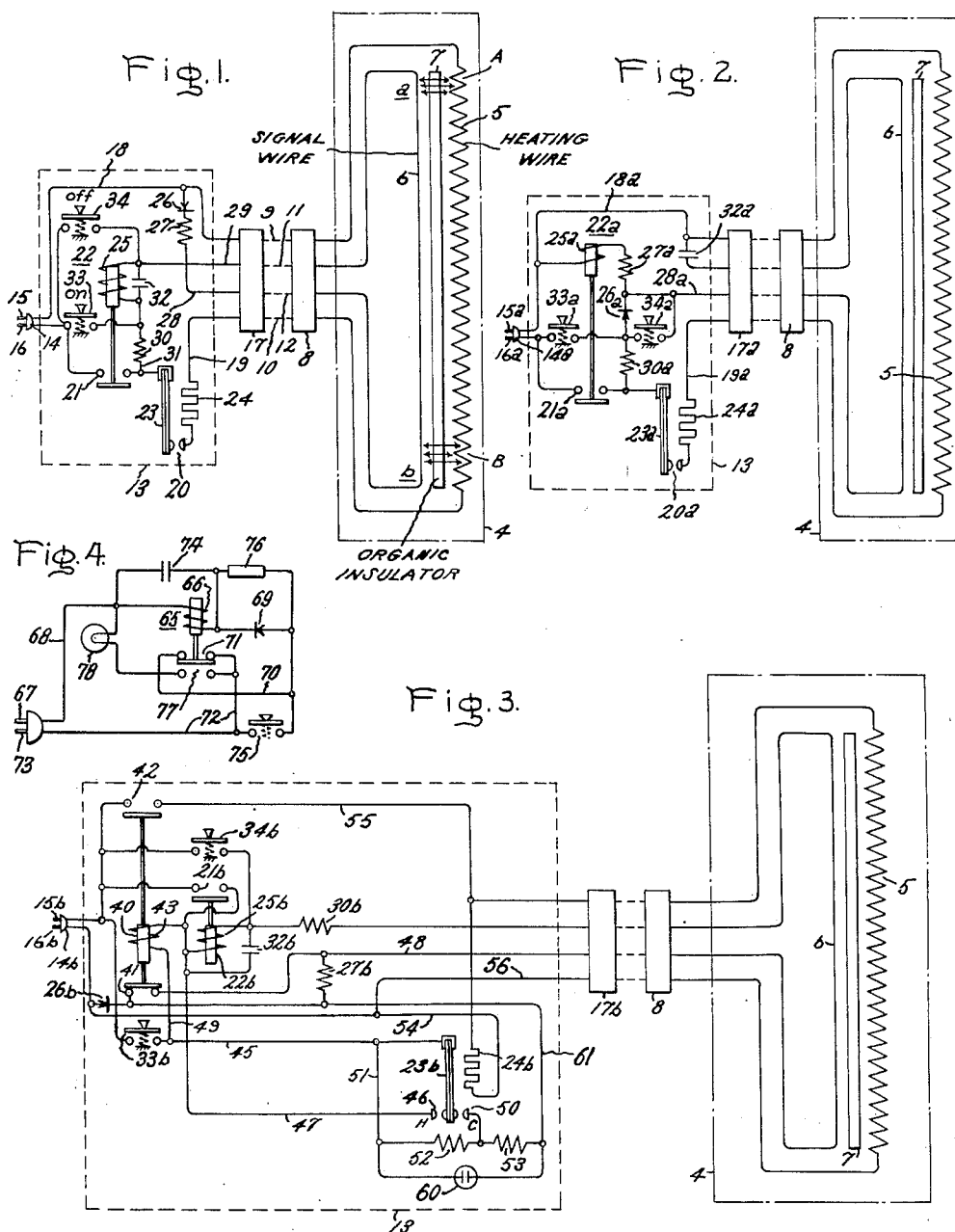
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P. H. ESTES

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VARIABLE RESISTOR CONTROL SYSTEM

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Inventor:
Phillip H. Estes,
by *Frank L. Neelander*
His Attorney.

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VARIABLE RESISTOR CONTROL SYSTEM

Phillip H. Estes, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

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The present invention relates to control systems for use with or which embody a variable resistor, it being understood that by a variable resistor I mean an electrical resistor which under a given set of operating conditions, which may be termed normal operating conditions, has a high resistance, for example a resistance so high as to be essentially an insulator, and which under another set of operating conditions, which may be termed abnormal operating conditions, has a lower resistance whereby an increase in flow of current through it is permitted, the increase in flow of current functioning to effect operation of a relay in the control system. The system may be utilized in connection with any operating condition which upon change will effect a change in the resistance of the resistor. As examples, a system embodying the invention may be responsive to a change in temperature, a change in pressure, or a change in light intensity; and the relay when operated may cause the operation of a signal, the opening or closing of an operating circuit, or both.

One application of my invention is to temperature responsive control systems for use with heating cable of the type comprising two wires, for example a resistor wire and a signal wire, separated from each other by a thin layer of a material which at a lower temperature is essentially an insulator and a higher temperature becomes an electrical conductor which will permit of the flow of significant current, for connecting the cable to a source of alternating current such as the 115 volt source in ordinary use. Such cable and its structure is now known. One form wherein the thin separating layer is an organic material such as nylon is disclosed in the patent to Spooner et al. 2,581,212, issued January 1, 1952, and assigned to the same assignee as is the instant application. The invention has especial utility in such control systems wherein the heating cable is embodied in electrically heated bed coverings such as blankets and sheets heated by such cable, and this is one application of the invention which I have elected to specifically illustrate and describe. It is to be understood, however, that this is only by way of example and that the invention may be used wherever found applicable.

An object of the invention is to provide an improved control system for use, for example, in connecting cable of the type referred to in the preceding paragraph to an alternating current source, which is simpler in structure than systems used heretofore, quieter in operation, and which at the same time is equally reliable in operation.

Other objects and advantages of the invention will be pointed out in and will appear from the following detailed description of the invention; and for a consideration of what I believe to be novel and my invention attention is directed to the following specification and to the claims appended thereto.

According to one form of the invention when used in a bed covering, the resistor wire which is utilized to heat the covering and the signal wire of a cable of the above referred to type are connected to a source of alternating current by a control system comprising a heating circuit

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connected to the resistor wire and a signal circuit connected to the signal wire, there being in the signal circuit the winding of a direct current signal relay to which current is supplied through a rectifier, the direct current relay functioning to control the heating circuit and also its own circuit.

In the drawing,

Fig. 1 is a diagrammatic view of a bed covering heated by cable of the type above referred to, the cable being connected to a control system embodying the invention;

Fig. 2 is a view similar to Fig. 1 showing a modified form of control system embodying the invention;

Fig. 3 is a similar view showing still another form of control system embodying the invention.

Fig. 4 is a diagrammatic view showing a different application of the invention.

Referring first to Figs. 1 to 3, the dotted rectangle 4 indicates the outline of a bed covering having distributed over it in the now well-known manner a heating cable of the type referred to above, 5 indicating the heating resistor wire of the cable, 6 the signal wire and 7 the organic separating layer. The ends of the resistor wire and the signal wire are indicated as being connected to a plug connector 8, the connector having terminals 9 to 10 to which the resistor wire is connected and terminals 11 and 12 to which the signal wire is connected. Also, in Figs. 1 to 3, the dotted rectangle 13 indicates a control box in which the elements which make up the control system are housed.

Referring now to Fig. 1, 14 indicates a plug having terminal prongs 15 and 16 for connecting the control system to a source of power, for example a conventional 115 volt, 60 cycle alternating current domestic circuit. Heating resistor wire 5 is connected to terminal prongs 15 and 16 by way of plug connector terminals 9 and 10, a pair of terminals of a plug connector 17 having terminals for detachable connection with terminals 9, 10, 11 and 12, and conductors 18 and 19. In conductor 19 are the contacts 20 of a cycling switch and the contacts 21 of a direct current signal relay 22. The cycling switch is shown diagrammatically as comprising a bimetallic thermostat 23 which carries at its free end one of the contacts 20, and a heating coil 24 for heating thermostat 23. Heating coil 24 is in circuit conductor 19 and on one side is connected to the other contact 20. The construction and operation of cycling switches of this type is now well-known. Thermostat 23 operates alternately to open and close a circuit through heating coil 24 in response to heat supplied to it by coil 24 and by the surrounding atmosphere. At a lower temperature when the control is calling for heat, contacts 20 are closed by the flexing of thermostat 23 toward the right. When heated to a certain extent by heating coil 24 thermostat 23 flexes toward the left to separate contacts 20 to open the heating circuit on both the heating resistor wire 5 and the heating coil 24. A cycling switch of this type is disclosed in the patent to Kearsley, No. 2,195,958, issued April 2, 1940.

Relay 22 of which contacts 21 are a part, has its winding 25 connected in a signal circuit with signal wire 6 which circuit includes a half-wave rectifier 26 for supplying direct current to the relay winding, and the contacts 21 of the relay. This signal circuit may be traced as follows: plug terminal 15, conductor 18, rectifier 26, a current limiting resistance 27, conductor 28, connector terminal 12, signal wire 6, connector terminal 11, conductor 29, direct current relay winding 25, a current limiting resistance 30, conductor 31, and relay contacts 21 to plug terminal 16. Connected across the terminals of relay winding 25 is a capacitor 32 for supplying power to the winding during the non-conducting half cycles of the rectifier.

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It will be noted that both the heating circuit and the signal circuit include relay contacts 21, the signal circuit serving also as a holding circuit for the relay.

At 33 is an "on" switch connected in shunt to relay contacts 21 and current limiting resistance 30 for initially closing a circuit on relay winding 25 to "turn on" the control circuit; and at 34 is an "off" switch connected in shunt to relay winding 25 for "turning off" the control circuit. Switches 33 and 34 are suitable manually operated switches biased to open positions.

In operation, assuming plug 14 has been connected to a source of alternating current, the user closes "on" switch 33 to close the signal circuit through signal relay winding 25 but in shunt to relay contacts 21 and current limiting resistance 30. This causes the relay to operate to close the signal circuit through relay contacts 21. The user then releases "on" switch 33 permitting it to open. The relay remains energized to hold contacts 21 closed since its winding is in the signal circuit which includes the relay contacts. When "on" switch 33 is opened, current limiting resistance 30 is put back into the circuit through direct current relay winding 25. This reduces the current flow through the relay to a value near the drop out point so that a relatively small reduction of current flow through the relay will cause it to open or drop out. With relay contacts 21 closed, the heating circuit for heating wire 5 may be closed and opened by the cycling switch comprising thermostat 23 to effect closing and opening of the heating circuit thus effecting normal operation of the bed covering.

If, when the blanket is "on," it should become overheated for any reason at a point in the vicinity of one end of the cable, for instance at the point indicated at A, then due to decrease in the resistance of layer 7, a path for flow of current between the heating resistor wire 5 and the signal wire 6 will be formed as indicated by the arrows *a*. This would form a path for flow of current around rectifier 26 and resistance 27 by way of conductor 18, leakage path *a*, conductor 29, direct current relay winding 25, resistance 30, conductor 31, and relay contacts 21, thereby putting alternating current directly on direct current relay winding 25 which would cause it to drop out, thus opening at relay contacts 21 both the signal circuit and the heating circuit. On the other hand, should the blanket become overheated in the vicinity of the other end of the cable, for instance at the point indicated at B, then a path for flow of current between heating resistor wire 5 and signal wire 6 will be formed as indicated by the arrows *b*. This would form a path for flow of current in shunt to relay winding 25 by way of cycling switch contacts 20 thereby reducing the current flow through winding 25 to cause the relay to drop out, thus opening at relay contacts 21 both the signal circuit and the heating circuit. Since the normal current flow through the relay winding is just sufficient to hold it closed, the relay will open upon a relatively small reduction in such current flow. Should the blanket become overheated at any point between the vicinity of its ends, then the disturbances in the circuit will cause the relay to open due to a combination of the shunting of and the impression of alternating current on the winding of the direct current relay.

Fig. 2 shows a modified form of control system similar to that of Fig. 1 and to which reference numerals corresponding to those used in Fig. 1 with the letter *a* added have been applied to corresponding parts. The Fig. 2 system differs from that of Fig. 1 in that relay winding 25*a* and resistance 27*a* are connected in parallel with signal wire 6 instead of being in series therewith, the capacitor 32*a* is placed in series with signal wire 6, and "off" switch 34*a* is connected to shunt into the rectifier 26*a*. The normal operation of the control system of Fig. 2 and its operation when overheating occurs at a point in the covering is the same as that described already in connection with Fig. 1. If overheating occurs in the

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vicinity of the upper end of the cable, a path for flow of current in shunt to the relay winding is established by way of conductor 18*a*, the flow path between wire 5 and 6, and signal wire 6, thus shunting or short circuiting the relay and causing it to drop out; and if overheating occurs in the vicinity of the lower end of the cable a path for flow of current through the relay winding in shunt to the rectifier 26*a* is established by way of relay winding 25*a*, resistance 27*a*, conductor 28*a*, the flow path between wires 5 and 6, cycling switch contacts 20*a* and relay contacts 21*a* thus putting alternating current directly on the direct current relay winding to cause it to drop out.

In Fig. 3 is shown another control system embodying my invention. In the Fig. 3 construction the signal circuit is similar to that in Fig. 1 but the bimetallic cycling thermostat instead of closing and opening the heating circuit directly operates through the intermediary of a direct current heater relay 40 capable of quiet operation on half wave current and having a set of back contacts 41 and a set of front contacts 42. The winding of relay 40 is designated 43. In Fig. 3 parts corresponding to those of Fig. 1 have been designated by the same reference numerals with the exponent *b* added. The Fig. 3 modification will be understood readily by a description of its operation.

Assuming plug 14*b* has been connected to a source of alternating current, then when "on" switch 33*b* is closed a circuit is established through winding 25*b* of direct current signal relay 22*b* as follows: plug prong 15*b*, "on" switch 33*b*, conductor 45, bimetal 23*b*, contact 46 (if at this time the ambient temperature is of a value high enough so that the bimetal is in engagement with contact 46), conductor 47, signal relay winding 25*b*, resistance 30*b*, signal wire 6, conductor 43, relay contacts 41, and rectifier 26*b* to plug prong 16*b*. If at this time bimetal 23*b* is not in engagement with contact 46 then the circuit through signal winding 25*b* will be by way of conductor 49 and relay winding 43. However, relays 22*b* and 40 are so related to each other that while the current flowing in the circuit will be sufficient to operate relay 22*b* it will not operate relay 40. In other words, relay 22*b* is designed to operate on a current of a small value not sufficient to operate relay 40. Signal relay 22*b* closes contacts 21*b* and establishes the signal circuit as follows: plug prong 15*b*, signal relay contacts 21*b*, signal relay winding 25*b*, resistance 30*b*, signal wire 6, conductor 43, heater relay contacts 41, and rectifier 26*b* to plug prong 16*b*. This establishes the holding circuit on signal relay 22*b* to maintain its contacts 21*b* closed, thus holding the signal circuit closed. There is established also a circuit through heater relay 40 as follows, assuming bimetal 23*b* stands out of engagement with contact 46 and also co-operating contact 50: plug prong 15*b*, signal relay contacts 21*b*, heater relay winding 43, conductors 49 and 45, conductor 51, resistances 52 and 53, conductor 61 and rectifier 26*b* to plug prong 16*b*. However, resistances 52 and 53 have values such that when in series the current flowing through heater relay winding 43 is not sufficient to operate it. When bimetal 23*b* cools down it engages contact 50 thus short circuiting resistance 52, i. e., cutting it out of the circuit through winding 43. The current then flowing in the circuit is sufficient to cause relay 40 to operate, opening contacts 41 and closing contacts 42. The opening of contacts 41 puts current limiting resistance 27*b*, which is connected in shunt to contacts 41, in the signal circuit thus reducing the current flow through direct current signal relay winding 25*b* to near the drop out point. The closing of relay contacts 42 closes the heating circuit through resistor wire 5 as follows: plug prong 15*b*, contacts 42, conductor 55, resistor wire 5, and conductors 56 and 54 to plug prong 16*b*. It closes also a circuit through thermostat heating coil 24*b* as follows: plug prong 15*b*, contacts 42, conductor 55, heating coil 24*b*, and conductor 54 to plug prong 16*b*. Current is thus supplied to heating resistor wire 5 and to

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thermostat heating coil 24b. Thermostat heating coil 24b imparts heat to bimetal 23b and after a period of time bimetal 23b will move from engagement with contact 50 thus putting resistance 52 back into the circuit through heater relay winding 43. This reduces the current through the winding, but such current is still sufficient to hold the relay "in." Eventually, bimetal 23b will be heated until it engages its contact 46. This short circuits relay winding 43 by way of conductor 47, contact 46 and bimetal 23b whereupon the relay drops out opening contacts 42 and closing contacts 41. This opens the circuits through resistor wire 5 and thermostat heating coil 24b. The parts are now positioned to repeat the heating cycle.

The signal circuit, as stated, is similar to that of Fig. 1. It functions in the same way to effect operation of signal relay 22b to open contacts 21b in case of overheating in the cable.

At 60 is a suitable lamp connected across the source to indicate when the system is operating.

In connection with the Fig. 3 construction it will be noted that "on" switch 33b is connected in shunt to direct current signal relay contacts 21b and direct current heater relay winding 43 so that after the "on" switch is closed to cause relay 22b to operate to close its contacts 21b, a circuit will not be closed on relay winding 43 to effect closing of the heating circuit at relay contacts 42 until switch 33b opens again. This means that a holding closed or a jamming in "on" position of "on" switch 33b cannot cause overheating of the bed covering and insures that before the heating circuit is put in operating condition, relay 40 has operated to open contacts 41 to place resistance 27b in the signal circuit so as to reduce the current in the signal circuit to the normal low level current value so as to provide full protection against overheating.

In Fig. 4 is illustrated a modification of my invention utilizing a form of variable resistor other than that illustrated in Figs. 1 to 3, the control system being shown as operating an indicating signal.

Referring to Fig. 4, wherein the elements of the system are shown as being in their operating positions, direct current relay 65 has its winding 66 connected in a circuit as follows: plug terminal 67 which represents one side of an alternating source, conductor 68, relay winding 66, rectifier 69, conductor 70, relay holding circuit contacts 71, and conductor 72 to the other side 73 of the alternating current source. Connected across the terminals of relay winding 66 is a capacitor 74 for supplying power to the winding during the non-conducting half cycles of the rectifier. A normally open starting switch 75 is connected in shunt to relay holding contacts 71 for use in effecting initially the energization of relay winding 66 to cause the relay to pick up.

Connected across the terminals of a rectifier 69 is a variable resistor 76 which has the property that under a given normal set of operating conditions it has high resistance, being essentially an insulator; but which under an abnormal set of operating conditions has a lower resistance thus permitting the flow of current of significant value through it. For example, it may be in the nature of a thermistor, the resistance of which changes with changes in its temperature or it may be in the nature of a piezoelectric crystal, the resistance of which varies with changes in pressure applied to it. The variable resistor is located where it is subjected to the operating condition to be controlled. As an example, in the case of a thermistor, it would be located where it would be subjected to the temperature of the apparatus or device in connection with which the control system was used.

As shown in Fig. 4, the circuit through direct current relay winding 66 is closed, the relay being kept energized by rectified alternating current; and as long as variable resistor 76 is subjected to normal operating conditions of that in connection with which it is used no significant electric current will flow through the variable resistor. How-

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ever, in case the variable resistor is subjected to abnormal operating conditions whereby its resistance is reduced permitting of the flow through it of electric current of significant value, then the winding 66 will have applied to it alternating electric current to cause the relay to drop out.

The relay when it drops out may effect the opening or the closing of an electric circuit to perform any desired operation. For example, it may effect the opening or the closing of a power or work circuit. In the present instance the relay is shown as being provided with a pair of contacts 77 which are bridged when the relay drops out to close a circuit through a signal lamp 78. This circuit is to be taken as representing a power or work circuit.

An important advantage of my control system resides in its quietness in operation. Heretofore, as far as I am aware, signal systems of the general type to which my invention relates have utilized alternating current relays and while such relays are satisfactory from a functioning standpoint they have the disadvantage, especially objectionable in the case of bed coverings, of being noisy in operation due to inherent alternating current hum. My improved system wherein I utilize a direct current relay completely overcomes such disadvantage. At the same time my system is relatively simple in structure, reliable in operation and capable of being manufactured at low cost.

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

1. In combination, a length of cable comprising a heating resistor wire and a signal wire separated from each other by a layer of material which at a lower temperature is essentially an electrical insulator and at a higher temperature becomes an electrical conductor which will permit flow of significant current, and a control system for connecting the cable to an alternating current source comprising a heating circuit connected to the resistor wire, a direct current relay having contacts controlling the heating circuit, a signal circuit including a half wave rectifier connecting the winding of the direct current relay to the signal wire, a capacitor connected in shunt to the relay winding, a starting switch for initially closing a circuit through the winding of the relay to energize it to effect the closing of its contacts, and means controlled by the starting switch which maintains the heating circuit open as long as the starting switch is in closed position.

2. In combination, a length of cable comprising a heating resistor wire and a signal wire separated from each other by a layer of material which at a lower temperature is essentially an electrical insulator and at a higher temperature becomes an electrical conductor which will permit flow of significant current, and a control system for connecting the cable to an alternating current source comprising a heating circuit connected to the resistor wire, a direct current relay having contacts controlling the heating circuit, a signal circuit including a half wave rectifier connecting the winding of the direct current relay to the signal wire, a capacitor connected in shunt to the relay winding a starting switch for initially closing a circuit through the winding of the relay to energize it to effect the closing of its contacts, and circuit closing means for the heating circuit including a connection with said starting switch to maintain the heating circuit open as long as the starting switch is closed.

3. A control system for connecting to an alternating current source a heating cable of the type adapted for use with an electric bed covering or the like and including a signal wire and a heating resistor wire separated from each other by a layer of material which at a lower temperature is essentially an electrical insulator and at a higher temperature becomes an electrical conductor permitting flow of significant current, comprising a heating circuit including a heating circuit relay for opening and

closing the connection to the resistor wire, a cycling switch controlling operation of said relay, a direct current relay having contacts for controlling the heating circuit, and a signal circuit for connection to the signal wire comprising the winding of the direct current relay, a half wave rectifier in series with the direct current relay winding and a capacitor in shunt to the relay winding.

4. A control system for connecting to an alternating current source a heating cable of a type adapted for use with an electric bed covering or the like and including a signal wire and a heating resistor wire separated from each other by a layer of material which at a lower temperature is essentially an electrical insulator and at a higher temperature becomes an electrical conductor permitting flow of significant current, comprising a heating circuit including a heating circuit relay for opening and closing the connection to the resistor wire, a cycling switch having two sets of contacts to operate said heating circuit relay and thereby open and close said heating circuit, a direct current relay having contacts for controlling the heating circuit, and a signal circuit for connection to the signal wire comprising the winding of the direct current relay, a half wave rectifier in series with the direct current relay winding and a capacitor in shunt to the direct current relay winding.

5. In combination, a length of cable comprising a heating resistor wire and a signal wire separated from each other by a layer of material which at a lower temperature is essentially an electrical insulator and at a higher temperature becomes an electrical conductor which will permit the flow of significant current, and a control system for connecting the cable to an alternating current source comprising a heating circuit connected to the resistor wire, a direct current relay having contacts controlling the heating circuit, a signal circuit connecting the winding of the direct current relay to the signal wire comprising a rectifier, the relay contacts, a current limiting resistance in series with the winding, a starting switch, circuit means for connecting the starting switch to the relay winding for closing a circuit through the relay winding in shunt to the relay contacts and through the current limiting resistance for initially energizing the relay to effect closing of its contacts, and means controlled by said starting switch for maintaining the heating circuit open while the starting switch is in closed position.

6. The combination with an electric bed covering or the like having distributed thereover a cable comprising a heating resistor wire and a signal wire separated from each other by a layer of material which at a lower temperature is essentially an electrical insulator and at a higher temperature becomes an electrical conductor which will permit the flow of significant current, of a control system for connecting the cable to an alternating source comprising a heating circuit connected to the heating resistor wire, a heating relay having contacts in the heating circuit, a cycling switch, a cycling circuit connecting the cycling switch to the winding of said heating relay whereby the cycling switch effects operation of said relay to control the heating circuit, a direct current signal relay having contacts which control the cycling circuit, a signal circuit connected to the signal wire comprising the winding of said signal relay, contacts of the signal relay, and a rectifier in series with the signal relay winding, whereby said cycling switch can effect operation of said heating relay to close the heating circuit only when said signal circuit is closed to hold the contacts of the signal relay closed.

7. The combination defined by claim 6 wherein there is provided an "on" switch and a starting circuit for the "on" switch connected to the signal relay winding in shunt to the heater relay winding whereby the heater re-

lay winding cannot be energized to close the heating circuit while the "on" switch is in closed position.

8. In combination, a length of cable comprising a heating resistor wire and a signal wire separated from each other by a layer of material which at a lower temperature is essentially an electrical insulator and at a higher temperature becomes an electrical conductor which will permit of the flow of significant current and a control system for connecting the cable to an alternating current source comprising a heating circuit connected to the resistor wire, a relay having contacts controlling the heating circuit, a signal circuit responsive to flow of current between the resistor wire and the signal wire connecting the winding of the relay to the signal wire, a starting switch connected to the relay winding for closing a circuit through the winding for initially energizing it, and means controlled by the starting switch which maintains the heating circuit open as long as the starting switch is in closed position.

9. An over-temperature protection system for an electrically heated device having a heating resistor comprising a direct current relay and a rectifier defining first and second circuit elements connected in series across a source of alternating current power, a capacitor connected in shunt to said direct current relay, power being supplied continuously to said circuit elements when the system is in operation, said heating resistor being in electrical parallel with said circuit elements, a variable impedance continuously associated with said heating resistor to be sensitive to the temperature thereof and having a negative temperature coefficient of impedance, said variable impedance being connected in electrical parallel with one of said circuit elements and in series with the other of said circuit elements, and a work circuit including said heating resistor controlled by said relay.

10. An over-temperature protection system for an electrically-heated device having a heating resistor comprising a direct current relay and a rectifier defining first and second circuit elements connected in series across a source of alternating current supply, power being supplied continuously to said circuit elements when the system is in operation, said heating resistor being in electrical parallel with said circuit elements, a variable impedance continuously associated with said heating resistor to be sensitive to the temperature thereof and having a negative temperature coefficient of impedance, said variable impedance being connected in electrical parallel with one of said circuit elements and in series with the other of said circuit elements, and a work circuit including said heating resistor and said circuit elements controlled by said relay.

11. An over-temperature protection system for an electrically-heated device having a heating resistor comprising a direct current relay and a rectifier defining first and second circuit elements connected in series across a source of alternating current supply, power being supplied continuously to said circuit elements when the system is in operation, said heating resistor being in electrical parallel with said circuit elements, a variable resistor sensing the operating temperature of the device and which when subjected to normal operating conditions is essentially an insulator and when subjected to an abnormal operating condition becomes a conductor to permit flow of significant current, said variable resistor being connected in electrical parallel with one of said circuit elements and in series with the other of said circuit elements, and a work circuit including said heating resistor controlled by said relay.

12. An over-temperature protection system for an electrically-heated device having a heating resistor comprising a direct current relay winding and a rectifier defining first and second circuit elements connected in series across a source of alternating current, power being supplied continuously to said circuit elements when the sys-

tem is in operation, said heating resistor being in electrical parallel with said circuit elements, a variable resistor sensing the operating temperature of the device and which when subjected to normal operating conditions is essentially an insulator and when subjected to an abnormal operating condition becomes a conductor to permit flow of significant current, said variable resistor being connected in electrical parallel with one of said circuit elements and in series with the other of said circuit elements, and a work circuit including said heating resistor and said relay winding controlled by said relay winding.

13. The combination defined by claim 12 wherein said

work circuit includes contacts operating when closed as a holding circuit for said relay winding.

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