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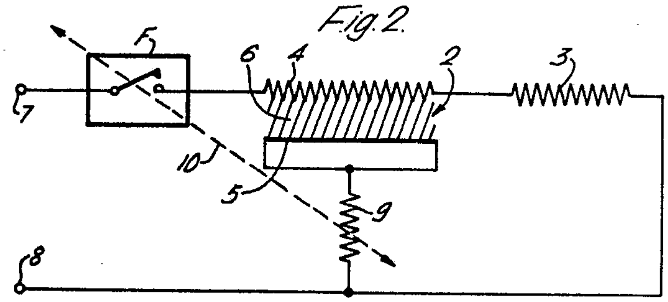
(71) Applicants
Dreamland Electrical Appliances Limited, Shipyard Estate, Hythe, Southampton, Hampshire, SO4 6YE
(72) Inventor
Graham Malcolm Cole
(74) Agents
D. Young & Co.

(54) Heating circuits

(57) A heating circuit, in particular for an electric blanket or pad (1), comprises a first tortuously disposed heating element (2) interlocated with a second tortuously disposed heating element (3). The first element (2) comprises heating and sensing conductors (4) and (5) separated by a material (6) which has a high impedance at normal temperatures, the impedance dropping to a low value upon overheating and/or the material (6) melding upon overheating to allow contact of the conductors (4) and (5) whereby the impedance drops to substantially zero. A resistor (9) is connected in series with said impedance between the input terminals (7, 8). The resistor (9) is thermally coupled (10) to a thermal fuse (9). If said impedance drops due to overheating, the current through the resistor (9) increases from a negligible to an appreciable value, the resultant dissipation in the resistor heating the thermal fuse to blow it. Switch means (not shown) can alter the heating circuit configuration to vary the heat output of the circuit.

Fig. 2



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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Fig. 1.

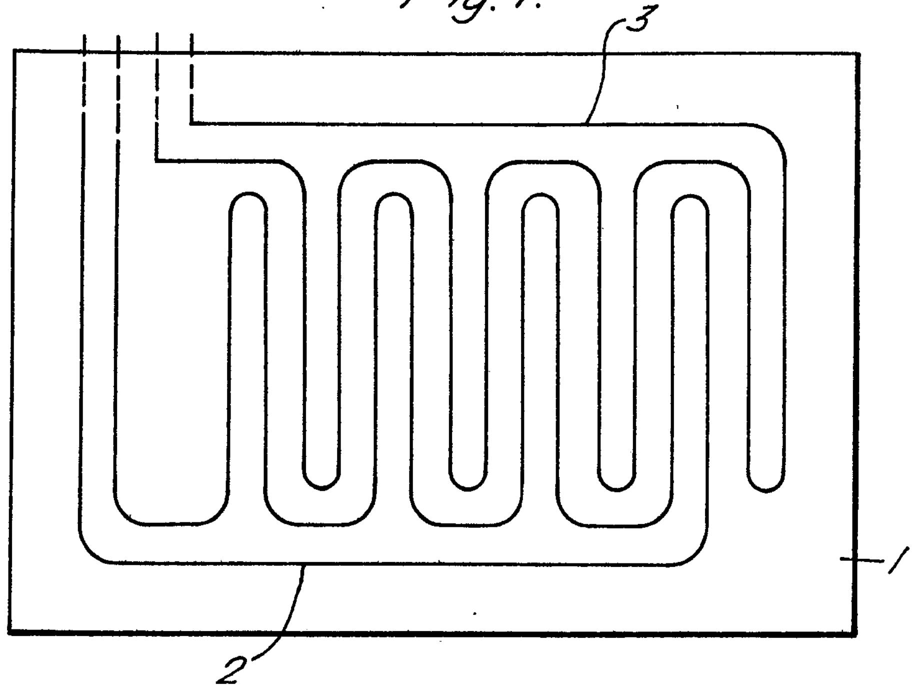


Fig. 2.

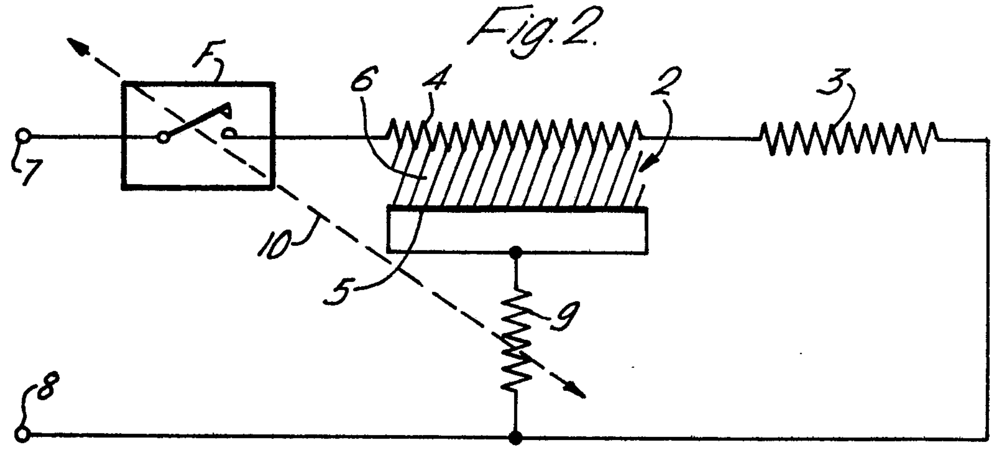


Fig. 3.

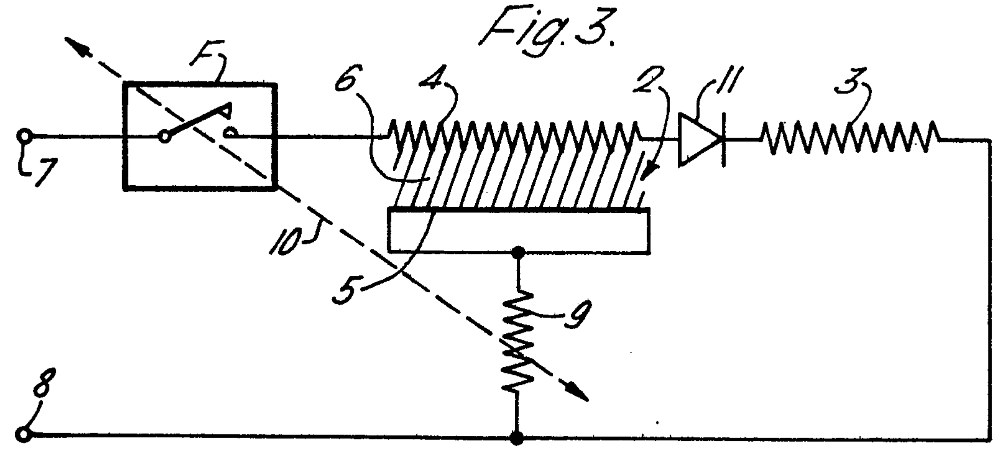


Fig. 4.

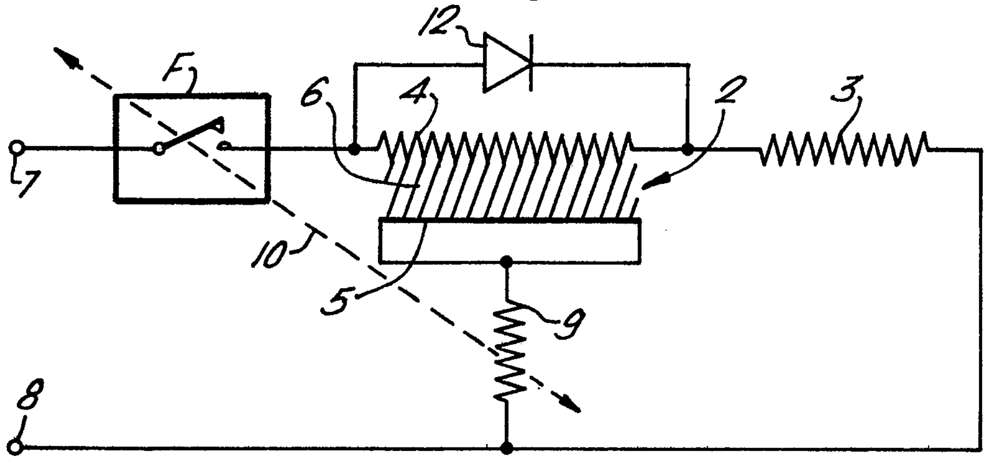
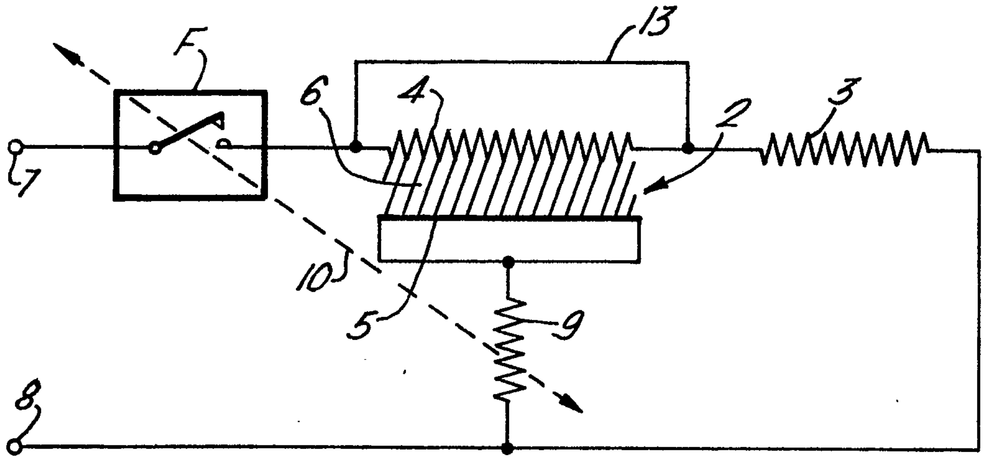


Fig. 5.



SPECIFICATION

Heating circuits

This invention relates to heating circuits.

UK Patent Specification No. 1 456 684 discloses a heating circuit for an electric blanket or the like in which a tortuously-disposed dual coil heating element is interlocated with a tortuously-disposed single coil heating element. The dual coil heating element comprises two coaxially-arranged coil conductors separated by a layer of polyvinyl chloride (PVC). More specifically, the PVC surrounds an inner one of the coil conductors and the other conductor is wound on the PVC. The single coil heating element comprises a single heating coil covered with insulating material. The arrangement is such that if the dual coil element is overheated the PVC will melt and allow the coaxial conductors to touch, the consequent short-circuit increasing the current flowing into the heating circuit. The heating current flows through a fuse, and the increase in the current in the event of overheating blows the fuse.

A disadvantage of the circuit disclosed in UK Patent Specification No. 1 456 684, as is acknowledged in the specification, is that selection of an appropriate fuse is critical. This leads to fuse selection problems, the cost and expense of mounting the fuse so that it is inaccessible to the amateur repair man, and the generally unsatisfactory technical feature of continuously running a highly sensitive fuse at very near its nominal current rating.

Further, since the operation of the circuit relies upon a short-circuit between the conductors of the dual element in the event of overheating, the circuit is very prone to function unsatisfactorily in the event of surface corrosion or oxidisation of either of these conductors. (The chlorine in the PVC separating the conductors can cause considerable surface corrosion of the conductors. Corrosion or oxidisation of the conductor surfaces can also occur if other separating materials than PVC are used.) Surface corrosion or oxidisation can lead to the contact resistance between the conductors in the event of a short-circuit between them caused by overheating being of generally the same order of magnitude as the resistance in the circuit. Thus, for at least some overheat positions, there will be no substantial decrease in the circuit resistance in the event of contact between the coaxial conductors, whereby there is no corresponding increase in current and the fuse is not in fact blown. In other cases, there can be such a very high power dissipation across the "lossy" short-circuit in the event of an overheat that the dual element quite literally explodes at the position of the overheat.

According to the present invention there is provided a heating circuit comprising input terminals for connection to an electrical power supply, a tortuously-disposed first heating element constituted by first and second conductors mutually separated by separating means which has a relatively high impedance at least at normal working temperatures, the separating means being of such a nature that in the event of overheating said impedance will drop to a relatively low value and/or it will melt to permit contact of the first and second conductors whereby said impedance will drop to substantially zero, the first conductor being connected to the input terminals whereby it can be supplied with heating current, a tortuously-disposed second heating element interlocated with the first heating element and comprising a third conductor connected to the input terminals whereby it can be supplied with heating current, a resistor connected between said second conductor and one of the input terminals such that the resistor and said impedance are connected in series between the input terminals, and circuit interruption means responsive to the current through the resistor rising as a result of said impedance dropping due to over-heating to stop heating current flowing from the power supply.

In a circuit in accordance with the invention, in the event of overheating the current through the resistor rises by a large amount on occurrence of an overheat, due to the impedance of the separating means either dropping from a high to a low value, or dropping from a high value to substantially zero on contact of the first and second conductors. Consequently, it is simple to detect when overheating has occurred and it is therefore not necessary to use a highly sensitive device relying on a relatively small increase in heating current. Aslo, any contact resistance between the first and second conductors in the event of their being short-circuited does not prevent current flowing through the resistor and therefore does not prevent an overheat being detected. Further, the resistor is in series with any such contact resistance and therefore eliminates or at least greatly reduces the risk of the first element exploding.

The circuit interruption means is preferably a termally-operative circuit interruption means (e.g. a thermal fuse) thermally coupled to the resistor to that heating of the resistor by the current flowing therethrough in the event of an overheat actuates the circuit interruption means.

The first and third conductors are preferably connected in series between the input terminals. The resistor is then connected to the input terminal remote from the first conductor. The heating circuit may comprise switch means to vary its heat output. The switch means may be operative to position a half-wave rectifier means in series with the first and third conductors; to position a half-wave rectifier means in parallel with either of the first and third conductors; or to short out either of the first and third conductors.

The resistor is preferably connected to both ends of the second conductor whereby the circuit will continue to operate satisfactorily in the event of a single break in the second conductor.

Heating circuits in accordance with the invention are applicable to the heating of a variety of objects or media. They may be used, for example, in pipe heating, soil warming, industrial process heating or in space heating, for instance in ceiling heating or under-floor heating. The invention is, however, espeically suited to the heating of an electric blanket, which term is to be deemed to encompass not only electrically heated overblankets but also electrically heated underblankets, and also an electrically heated pad.

The invention will now be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic plan view of an electric blanket or pad having arranged therein heating elements of a heating circuit embodying the invention;

Figure 2 is a circuit diagram of the heating circuit of which the heated elements thereof are arranged in the electric blanket or pad shown in Figure 1; and

Figures 3 to 5 are circuit diagrams of respective different modified configurations of the circuit as shown in Figure 2 that can be adopted by the operation of switch means (not shown).

Referring first to Figure 1, an electric blanket or pad 1 has tortuously-disposed thereon a dual coil heating element 2. The blanket or pad 1 also has tortuously-disposed thereon a single coil heating element 3, the elements 2 and 3 being interlocated.

Referring now to Figure 2, the heating circuit illustrated therein comprises the dual coil heating element 2 and the single coil heating element 3. The dual coil heating element 2 comprises a heating conductor 4 and a sensor conductor 5 separated by a material 6 shown by cross-hatching. The heating conductor 4 is of resistance wire and is therefore represented as a resistor. The sensor conductor 5 does not carry heating current and can therefore be a low resistance conductor, for example of copper.

The element 2 is preferably so constructed that the conductors 4 and 5 are coaxial: the heating conductor 4 is the inner one of the conductors and is wound on an electrically insulative core, the material 6 surrounds the conductor 4, and an outer sheath covers the sensor conductor 3. The material 6 may be of such a nature that its impedance falls with an increase in temperature, preferably logarithmically, whereby at normal operating temperatures the impedance Z of the material is high, the impedance Z dropping by a large amount in the event of over-heating. In this case the material 6 may be polyvinyl chloride (PVC) which may or may not be doped with a material enhancing its conductivity. Alternatively, the material 6 may be of a material (e.g. a plastics material) of which the impedance does not vary substantially with temperature, but which will melt in the event of overheating to allow contact between the conductors 4, 5. An example of a suitable material is polyethylene. The heating element 2 may in fact be constructed along the lines described in UK Patent Specifications Nos. 746 017 and 841 604.

The single coil heating element 3 comprises a single conductor constituted by a length of resistance wire sheathed with an insulating material (not shown).

The conductors 3 and 4 are connected in series with a thermal fuse F between a pair of input terminals 7, 8 for connection to the poles of an electrical power supply, which will generally be (but is not necessarily) an AC power supply. As is known to those skilled int he art, the termal fuse F is a non-resettable link and comprises an current-carrying device (generally incorporating a low melting point alloy) responsive to the application of external heat to non-resettably stop the passage of current therethrough.

The ends of the sensor conductor 5 are connected together and to one end of a resistor 9 (10 K). The other end of the resistor 9 is connected to the input terminal 8. The resistor 9 is thermally coupled to the termal fuse F, as represented by a dotted line 10, whereby the generation of a predetermined amount of heat by virtue of sufficient current flowing through the resistor 9 will cause the fuse to blow to disconnect the heating circuit from the power supply.

The above-described heating circuit operates in the following manner. When the terminals 7, 8 are connected to the electrical power supply, heating current flows through the heating conductors 4 and 3 in series and warms the blanket or pad. Current also flows from the supply via the series combination of the impedance Z of the material 6 and the resistor 9. However, since at normal operating temperatures the impedance Z is high, such current is negligible and produces a negligible amount of heating of the resistor 9.

Consider now the case when the material 6 is doped or undoped PVC or some other material of which the impedance falls, preferably logarithmically, with temperature. As the heating element 2 warms up, the impedance Z drops logarithmically so that the above-mentioned current flowing through the impedance Z and the resistor 9 increases. The circuit is so designed that at all normal operating temperatures the current flowing through the resistor 9 is of insufficient magnitude to cause enough heat to be generated in the resistor to actuate the thermal fuse F. Suppose, however, that general overheating of the element 2 occurs, that is to say that the material 6 is overheated along the length of the element 1. Suppose that the material 6 is PVC and it is heated to a temperature approaching its melting point, which is about 160°C. At temperatures of above about 140°C, the drop in the impedance Z caused by the impedance/temperature characteristic of the PVC is such that the material stops behaving as a good insulator. The current flowing through the impedance Z and the resistor 9 is therefore of an appreciable magnitude and the circuit is so designed that when the temperature of the material 6 reaches a predetermined value the current through the resistor 9 will be high enough to heat the resistor to cause the thermal fuse F to blow and therefore disconnect the heating circuit from the power supply.

Suppose now that instead of the element 2 being overheated along its whole length, it becomes overheated at a localised position along its length, for example due to a ruck in the blanket or pad, a twisting or looping of the element 2, or bunching of the conductors 3, 4 of the element 2. The impedance Z of the material 6 will then be locally rather than generally reduced. The voltage applied across the series combination of the locally reduced impedance Z and the resistor 9 will vary, in accordance with the position of the overheat, between a maximum value equal to the full supply voltage and a minimum value equal to a proportion of the supply voltage determined by the relative magnitudes of the resistances of the conductors 3 and 4. The minimum value will be equal to half the supply voltage if the resistances of the conductors 3 and 4 are, as is preferred, the same. The circuit is so designed that even if the overheat is at the extreme right-hand end of the element 2 as shown in Figure 3, whereby the voltage across the series combination of the impedance Z and resistor 9 is at a minimum, the current through the resistor 9 is nonetheless sufficient to generate enough heat to blow the thermal fuse F.

Consider now the case where the material 6 is polyethylene or some other material of which the impedance does not vary substantially with temperature. In this case, in the event of overheating, the material 6 will melt to allow the outer sensor conductor 5 to collapse onto and come into contact with the inner heating conductor 4. The resistor 9 is then applied across the input terminals 7,8 in series withthe contact resistance, if any, of the conductors 4, 5. Since the contact resistance, if any, will be substantially smaller than the resistance (10K) of the resistor 9, in all cases sufficient heat will be generated by the current flowing to the resistor 9 to blow the thermal fuse F. Further, since the resistor 9 is in series with any such contact resistance, there is no risk of the element 2 exploding at the location of the overheat due to the lossy short-circuit or contact resistance being connected directly across the electrical power supply.

As mentioned above, the conductors 3 and 4 are preferably of equal resistance. More specifically, the resistance of each of them is preferably such that if the conductor were individually connected across an electrical power supply of a predetermined voltage it would produce a heat output of 150 W. Consequently, in the arrangement of Figure 2, since two 150 W conductors 3, 4 are connected in series, the heat output of the circuit is 75 W.

To vary its heat output, the heating circuit shown in Figure 2 may be provided with switch means (not shown) enabling it to be switched from the configuration of Figure 2 to any one of the configurations of Figures 3 to 5.

In Figure 3, a diode 11 is connected in series with the conductors 3 and 4 whereby the heating current flowing through them is half-wave rectified to reduce the heat output from 75 W to 37.5 W. Naturally, in the case of the configuration of Figure 3, the electrical power supply must be AC.

In the configuration of Figure 4, in which case the power supply must again be AC, a diode 12 is switched-in in parallel with the conductor 4; through it could instead be switched-in in parallel with the conductor 3. In this case, during positive half-cycles of the AC supply, that is to say when the terminal 7 is positive with respect to the terminal 8, the diode 12 by-passes the conductor 4 whereby the supply voltage is applied across — and heating current flows through — the conductor 3 only, whereas in negative half-cycles of the AC supply voltage heating current flows through both the conductors 3 and 4 as in the configuration of Figure 2. This arrangement increases the power output of the circuit to 113 W.

In the configuration of Figure 5, the heating conductor 4 is shorted out by a link 13. Heating current therefore no longer flows through the conductor 4, which therefore acts only as a sensor conductor rather than a heating conductor. This arrangement increases the power output of the heating circuit to 150 W. The arrangement of Figure 5 could be modified by shorting out the conductor 3 rather than the conductor 4.

The circuit is so designed that in any of the configurations of Figures 2 to 5 there is always adequate current through the resistor 9 to cause the thermal fuse F to blow for any localised overheat position, even if the locally reduced impedance Z is several thousand ohms in value.

The invention can, of course, be performed in other ways than that described above by way of example. For instance, the resistor 9 could be connected to one end only of the sensor conductor 5. However, connection of the resistor 9 to both ends of the sensor conductor 5, or in other words connection together of the ends of the sensor conductor 5, has the advantage that the circuit will continue to function satisfactorily in the event of a single break in the conductor 5.

The amount of heat provided by the heating circuit could be controlled by disposing some form of switch means in series with the conductors 3, 4. The switch means could be electronic or mechanical and, in a manner known to those skilled in the art, could be employed to theremostatically control the heat output of the heating circuit in response to ambient temperature.

CLAIMS

1. A heating circuit comprising input terminals for connection to an electrical power supply, a tortuously-disposed first heating element constituted by first and second conductors mutually separated by separating means which has a relatively high impedance at least at normal working temperatures, the separating means being of such a nature that in the event of overheating said impedance will drop to a relatively low value and/or it will melt to permit

contact of the first and second conductors whereby said impedance will drop to substantially zero, the first conductor being connected to the input terminals whereby it can be supplied with heating current, a tortuously-disposed second heating element interlocated with the first heating element and comprising a third conductor connected to the input terminals whereby it can be supplied with heating current, a resistor connected between said second conductor and one of the input terminals such that the resistor and said impedance are connected in series between the input terminals, and circuit interruption means responsive to the current through the resistor rising as a result of said impedance dropping due to over-heating to stop heating current flowing from the power supply.

2. A heating circuit according to claim 1, wherein the circuit interruption means is a thermally-operative circuit interruption means thermally coupled to the resistor so that heating of the resistor by the current flowing therethrough in the event of an overheat actuates the circuit interruption means.

3. A heating circuit according to claim 2, wherein the circuit interruption means is a thermal fuse.

4. A heating circuit according to claim 1, claim 2 or claim 3, wherein the first and third conductors are connected in series between the input terminals, the resistor being connected to the input terminal remote from the first conductor.

5. A heating circuit according to any one of the preceding claims, including switch means to vary its heat output.

6. A heating circuit according to claim 5, wherein the switch means is operative to position a half-wave rectifier means in series with the first and third conductors.

7. A heating circuit according to cliam 5 or claim 6, wherein the switch means is operative to position a half-wave rectifier means in parallel with the first conductor or the third conductor.

8. A heating circuit according to claim 5, claim 6, or claim 7, wherein the switch means is operative to short out either the first conductor or the third conductor.

9. A heating circuit according to any one of the preceding claims, wherein the resistor is connected to both ends of the second conductor.

10. A heating circuit substantially as herein described with reference to Figures 1 and 2, or Figures 1 and 2 and any one or more of Figures 3 to 5, of the accompanying drawings.

11. An electric blanket incorporating a heating circuit according to any one of the preceding claims.

12. An electrically heated pad incorporating a heating circuit according to any one of the preceding claims.

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