

# PATENT SPECIFICATION

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## (54) DOMESTIC ELECTRIC APPLIANCE INCLUDING A HEATING DEVICE COMPRISING A RESISTANCE BODY OF P.T.C. MATERIAL

(71) We N.V. PHILIPS' GLOEILAMPENFABRIEKEN, a limited liability Company, organised and established under the laws of the Kingdom of the Netherlands, of Emmasingel 29, Eindhoven, the Netherlands do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a domestic electric appliance including a heating device comprising a resistance body of a material having a positive temperature coefficient of resistance provided with electrodes and means to connect these electrodes to an electric voltage source.

Heating devices of this kind are known *per se*. They have the advantage that the device stabilizes itself at a given temperature. Above this temperature the resistance of the resistance material strongly increases so that the current flowing through the resistance body decreases, and, consequently, the production of heat.

It is an object of the invention to provide, while using a resistance body of a material having a positive temperature coefficient of resistance and avoiding intricate circuits and avoiding the use of active or passive components such as diodes and resistors a step-wise controllable electric heating device.

According to the invention there is provided a domestic electric appliance including a heating device and an electric selector switch, wherein the heating device comprises a resistance body of a material having a positive temperature coefficient of resistance provided with at least three electrodes and means to connect these electrodes to an electric voltage source, at least one electrode of the heating device being arranged for connection to a first pole of a voltage source and the other electrodes being connected to the said switch such that

depending on the temperature level to be reached one of the other electrodes or a combination thereof can be connected to a second pole of the voltage source.

The invention is based on the recognition that it is possible to stabilize the heating device at different temperature levels by controlling the power output in a stepwise manner. It has appeared that when applying a given electric voltage the output power of the resistance body also depends on the ratio between the effective areas of the electrodes which are connected to one pole and to the other pole of the voltage source.

In a preferred embodiment of the combination according to the invention the resistance body comprises two opposite boundary surfaces, one of the boundary surfaces being provided with at least one electrode and the other boundary surface with at least two electrodes which are separated from one another.

The resistance body may, for example, consist of a rectangular, square or disc-shaped plate of a material having a positive temperature coefficient of resistance or also of a hollow cylinder of such a material. In the latter case the inner and the outer surface form the opposite boundary surfaces of the resistance body to which the electrodes are applied.

The resistance material having a positive temperature coefficient of resistance, also indicated by P.T.C material hereinafter, may, for example, consist of doped barium titanate, barium lead titanate, barium strontium titanate, whereas the doping may, for example, consist of a rare earth metal, antimony, yttrium or niobium. Such materials are commercially available and extensively described in the relevant literature. The electrodes which form an ohmic contact may, for example, consist of a coating of a metal or of an alloy such as silver, nickel, nickel chromium alloy. These coatings may be obtained, for example, by spraying or screen printing of a paste follow-

ed by a thermal treatment, by vapour deposition or by means of processing in an electroless metal bath.

It should be noted that bodies of a P.T.C. material having on an opposite boundary surface an electrode which covers the entire, or substantially the entire, boundary surface and two separate electrodes of mutually equal surfaces which cover the other boundary surface respectively are known for use in a degaussing circuit for cathode-ray tubes for colour television. Herein the resistance body is used as a switching element for a degaussing coil. In the relevant circuit the two electrodes situated in a boundary surface are connected *via* the resistance body in series between a pole of the voltage source and a pole of the degaussing coil. The single electrode situated on the other boundary surface is connected across an ohmic resistor in parallel with the other pole of the degaussing coil to the other pole of the voltage source. It is also known to use such bodies of P.T.C., a heating material, in an engine carburettor as disclosed and claimed in Patent No. 1 449 807.

In its simplest form a combination according to the invention comprises a plate-shaped resistance body which is provided on both opposite boundary surfaces with a single metal coating which covers the entire surface, this coating being divided on one such surface by means of a sawcut to give at least two separate electrodes with a mutually different surface. It is of course also possible to apply or etch electrodes according to given patterns by means of known photographic techniques.

By means of a switching device the mutually separated electrodes on one surface are connected to a pole of a voltage source. In its simplest form the switching device comprises three switching positions, by means of which the one or the other electrode or both electrodes can be connected in parallel with the voltage source. The electrode situated on the other boundary surface may be connected direct to the voltage source.

With this simple heating device heat can be dissipated at three different temperature levels. The lowest temperature level is obtained when the electrode having the smallest surface, the next higher when the electrode with the largest surface and the highest level when both electrodes are connected to one pole of the voltage source.

It is immediately clear that a boundary surface can also bear more than two electrodes and that the counter electrodes on the other boundary surface need not consist of a single electrode but also of two or more separate electrodes. In this manner the number of temperature levels can be

extended as required. Domestic electric appliances including heating devices according to the invention can be utilized everywhere where there is a need for controlling the temperature in a step-wise manner such as in haircurlers, irons, boiling plates, soldering irons, etc.

An embodiment of the invention will be further explained by way of example with reference to the accompanying drawing.

In the drawing:

Figure I shows diagrammatically a combination including a heating device having a resistance body with three electrodes and a counter electrode,

Figure II shows a cross-section of the resistance body incorporated in the curling tube of hair curling tongs and

Figure III is a graph in which the temperature variation versus the time is shown with different temperature levels measured at the outside of the curling tube.

On a resistance body 5 of doped barium lead titanate ( $\text{Ba}_{0.747}\text{Pb}_{0.25}\text{La}_{0.003}\text{TiO}_3$ ) having a Curie point of approximately  $200^\circ\text{C}$  and the dimensions  $3.5 \times 0.7 \times 0.5$  cm, electrodes 1, 2, 3 and 4 of nickel chromium are applied on the two opposite boundary surfaces with a layer thickness of 0.3 micrometers. The electrodes have an effective area of 1:0.4 cm<sup>2</sup>, 2:0.4 cm<sup>2</sup>, 3:1.1 cm<sup>2</sup> and 4:2.2 cm<sup>2</sup> respectively. By means of the switching device 6 (shown diagrammatically) the electrodes 1, 2, 3 can be connected in different combinations and separately to the voltage source 7.

Figure 2 shows a cross-section of the resistance body of Figure 1, provided with an envelope and accommodated in the curling tube of a pair of hair curling tongs (not shown in the drawing). The resistance body 5, provided with electrodes 1, 2, 3 and 4 and the current conductors 1A, 2A, 3A and 4A is disposed in a tube 9, consisting of a mixture of 30 weight % of silicone rubber and 70 weight % of magnesium powder, which, after pressing, is vulcanized. The resistance body 5 is embedded in a mass 8 consisting of 30 weight % of silicone rubber and 70 weight % of magnesium oxide which is vulcanized after application of the mass. The assembly is disclosed in an envelope 10 of aluminium having a wall thickness of 0.7 mm and is located in the so-called curling tube 11, also made of aluminium, of a pair of curling tongs. The wall of this curling tube is 0.8 mm thick, and there is an airgap of one millimetre between the two tubes.

In this embodiment, when the resistance was operated from a 220V mains, electricity supply after approximately ten minutes the outer wall of the curling tube reached a stable temperature level as shown in the table.

Curve	Switched on electrodes	Current in mA	Power output in W	reached temp. °C
A	(1+2) versus 4	50	11.0	106
B	3 versus 4	66	14.52	136
C	(2+3) versus 4	74	16.28	144
D	(1+2+3) versus 4	82	18.04	149

For these tests the heating device was built into commercially available curling tongs.

5 WHAT WE CLAIM IS:—

1. A domestic electric appliance, including a heating device and an electric selector switch, wherein the heating device comprises a resistance body of a material having a positive temperature coefficient of resistance provided with at least three electrodes and means to connect these electrodes to an electric voltage source, at least one electrode of the heating device being arranged for connection to a first pole of a voltage source and the other electrodes being connected to the said switch such that depending on the temperature level to be reached one of the other electrodes or a combination thereof can be connected to a second pole of the voltage source.

2. An appliance as claimed in Claim 1,

characterized in that the resistance body has two opposite boundary surfaces, one of the boundary surfaces being provided with at least one electrode and the other boundary surface with at least two electrodes.

3. An appliance as claimed in Claim 1, characterized in that the resistance body is provided with electrodes having different effective areas on at least one of the boundary surfaces.

4. A domestic electric appliance including a heating device substantially as hereinbefore described with reference to the accompanying drawing.

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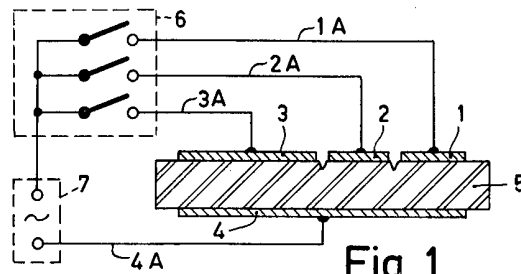


Fig. 1

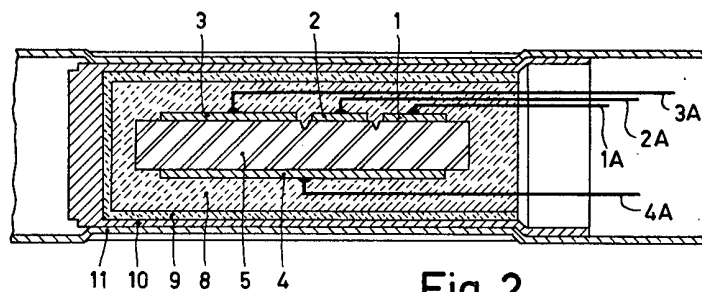


Fig. 2

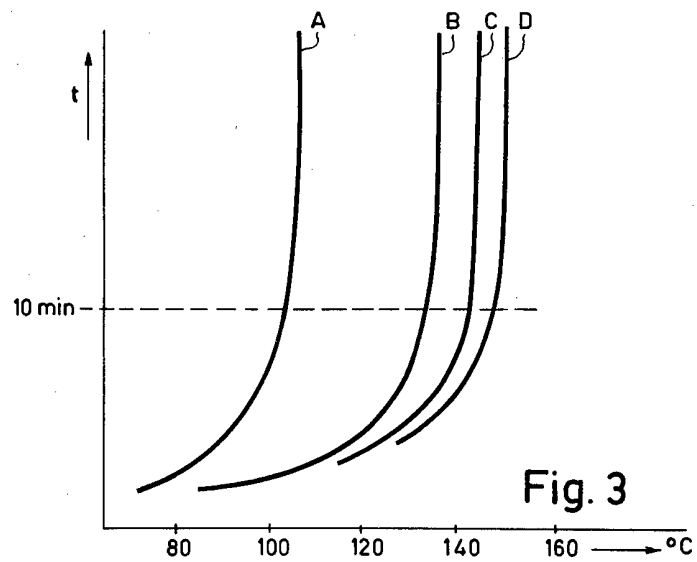


Fig. 3