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(54) Thick film heater

(57) An electrical resistance or heater of the type comprising a thick film resistive track provided on an insulating substrate has two predetermined sections of said track (8d,8e) with a predetermined current carrying capacity. These sections are bridged by a discrete bridge (22) of an insulating material, e.g. glass, which at a predetermined temperature becomes sufficiently conduc-

tive to cause a failure current to flow through one or both of said sections (8d,8e). The resistive track (8) is protected from oxidation by a separate overglaze layer. The heater track section (8d) passing the failure current is provided with means, such as an aperture (24) in the track, for concentrating locally the current flowing there-through.

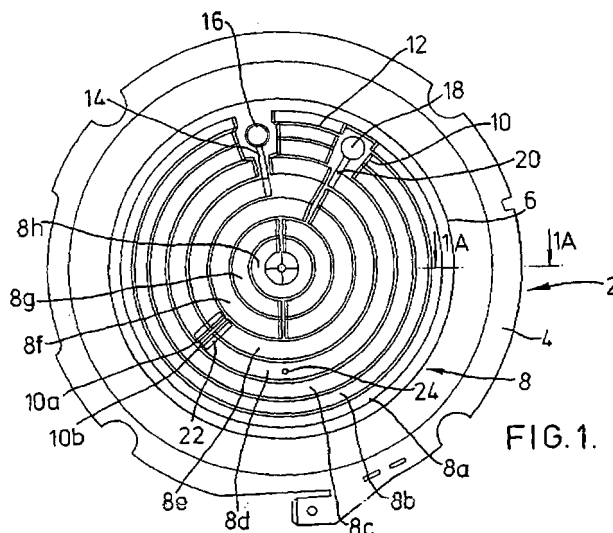


FIG. 1.

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Description

[0001] The present invention relates to electric heaters and in particular to electric heaters of the type comprising a resistive track provided on an insulating substrate.

[0002] Such heaters are used or have been proposed for use in a variety of applications, for example in domestic appliances such as water heating vessels, water heaters and irons. Typically an insulating layer eg of glass, ceramic, or glass ceramic (hereinafter collectively referred to as "glass") is provided on a metallic base such as a plate (which may for example form a part of the base of a liquid heating vessel) and the resistive track laid down on the insulating layer, usually by a printing technique. As an alternative to a coated metallic base, the base may be a solid ceramic body. A further electrical insulating layer may be applied over the track to protect it and prevent corrosion and oxidation. Such heaters are termed "thick film" heaters in the art.

[0003] It is clearly important that the heater should not be allowed to seriously overheat in a fault condition since this may cause substantial damage not only to the device or appliance in which it is being used, but also, potentially, to users thereof.

[0004] A number of proposals have been made to provide such severe overheat protection. In liquid heating vessels, it is common to provide a resettable overheat protector which operates in the event that the heater of the vessel overheats, for example if it is switched on without liquid in it or if it boils dry. Typically, this comprises a bimetallic actuator arranged in thermal contact with the heater and which operates at a given temperature, above the normal operating temperature of the vessel to open a set of contacts in the supply to the heater. However in the event that this protector should fail to operate it is also known to provide a back-up protector, for example a thermal fuse which will operate in the event that the temperature of the heater rises above a predetermined value. Such an arrangement is described in Applicant's WO-A-94/18807.

[0005] In the Applicant's U27 and U28 controls, two bimetallic actuators are provided which effectively back each other up, obviating the need to provide further severe overheat protection.

[0006] However, it is preferable to provide a heater or resistance with built-in protection. The Applicant has proposed such an arrangement in WO97/39603. According to this proposal, a bridge of a selected glass material is provided between adjacent heating tracks, the configuration of the track and the position and material of the track being chosen such that at a predetermined temperature the glass between the track sections becomes sufficiently conductive such that the track sections short circuit, thereby resulting in a controlled failure of the heater. The heater could therefore be said to "self protect", without the need for an external control.

[0007] This proposal for a "self protecting" heater was taken further in Applicant's WO99/02080 in which it was

specified that the location of the bridge between adjacent tracks was displaced from the end of the track so as to limit the current in the tracks when short circuiting occurred. This was intended to prevent the failure current blowing fuses in the domestic power supply.

[0008] The present invention in its various aspects builds further on the above proposals.

[0009] In WO97/39603, it was suggested that the self protecting glass bridge was by preference applied as a layer over the whole heater track. However, it is now found preferable to provide the bridge as a discrete bridge and, if the track needs protection against oxidation and corrosion, to provide a separate, overglaze layer.

[0010] From a first aspect, therefore, the invention provides an electrical resistance or heater of the type comprising a thick film resistive track provided on an insulating substrate, two predetermined sections of said track having a predetermined current carrying capacity being bridged by a discrete bridge of an insulating material which at a predetermined temperature becomes sufficiently conductive to cause a failure current to flow through one or both of said sections, the resistive track being protected from oxidation by a separate overglaze layer.

[0011] In this way conventional overglazes can be used to provide normal corrosion protection for the track and an appropriate insulating material, eg an appropriate glass material chosen for the severe overheat protection of the heater.

[0012] In a preferred embodiment, the severe overheat protection bridge is also applied as an overglaze bridging the appropriate track sections. Preferably also the bridge is positioned over abutting track section ends.

[0013] The time in which a "self protecting" heater will self protect in a severe overheat condition depends on the temperature of the heater in the region of the bridge of material. The hotter the heater becomes, the hotter the bridge becomes and the more quickly it will reach the temperature at which it will pass a failure current. In the context of say a water heating vessel such as a kettle, it is quite clearly important to prevent premature failure of the heater, particularly in a time before any primary overheat protection such as a bimetallic actuator has operated.

[0014] This problem is alleviated in accordance with a further aspect of the present invention by placing the bridge of material in a region of the heater which has a lower power density than an adjacent region. From a second aspect, therefore, the invention provides an electrical resistance or heater of the type comprising a thick film resistive track provided on an insulating substrate, two predetermined sections of said track having a predetermined current carrying capacity being bridged locally by a bridge of an electrically insulating material which at a predetermined temperature becomes sufficiently conductive to cause a failure current to flow through one or both of said sections, said resistive heating track having a variable power density, the said bridge of material being

provided in a region of the heater track having a relatively low power density.

[0015] By placing the eg glass bridge in a lower power density area of the heater, the temperature rise of that region in an overheat situation will lag behind the temperature rise in adjacent higher power density areas, thereby providing a longer time to failure. Of course, the position of the bridge should still be such that the heater will fail in that location rather than elsewhere. Accordingly, if a separate overglaze is provided over the heater track, it should be chosen such that breakdown does not occur elsewhere on the track first.

[0016] In the preferred embodiment, the lower power density region is flanked by higher power density areas. In a particularly preferred embodiment, the lower power density area is provided in a radially intermediate section of the heater track, with at least the radially outer regions of the track having a higher power density. This arrangement has the advantage of counteracting the tendency of the insulating substrate to form microcracks in an severe overheat situation, which could result in failure of the heater on testing. This effect is described more fully in Applicant's copending application filed on the same day as this application under agent's reference 74.46.70570 and also entitled Electric Heaters. The inventions described herein can be applied to the arrangements described in that application.

[0017] In "self protecting" heaters as described above and in Applicant's earlier referenced published International patent applications, the track fails due to a current in excess of the track's current carrying capability passing through a section of track when the bridge becomes sufficiently conductive at elevated temperatures. It has been found that in such a situation, the track section may fuse at any point along its length depending, for example on how accurately the track has been laid down and so on. Furthermore, when the track fails, an arc is generated. This arc is highly conductive and is mobile in a magnetic field and may, therefore, be drawn to other components such as control components. The arc may even damage the insulating layer on which the track is provided, leading potentially to the heater being live after failure. This is potentially dangerous and such a system would not meet present day safety standards.

[0018] It is therefore highly desirable to make the failure occur in a predetermined position on the track so that this could, for example be arranged in a position away from other components such as control components. The invention achieves this goal by providing means which concentrates locally the current flowing through the section of track which will fail.

[0019] From a further aspect, therefore, the invention provides an electrical resistance or heater of the type comprising a thick film resistive track provided on an insulating substrate, two predetermined sections of said track having a predetermined current carrying capacity being bridged by an electrically insulating material, eg a glass, which at a predetermined temperature becomes

sufficiently conductive to cause a failure current to flow through at least one of said sections, wherein the said track section is provided with means for concentrating locally the current flowing therethrough.

[0020] This aspect of the invention allows therefore allows a more controlled failure of the track. The current concentrator is preferably arranged away from any current carrying or earthed parts eg of a control associated with the heater.

[0021] The current concentration can be achieved in a number of ways. Preferably, however, it is achieved by reducing locally the width of the track. In one embodiment the track may be waisted in to achieved the desired concentration, but preferably the effect is achieved by providing a hole, for example a circular hole, through the track. This hole will then act as a focus for the failure of the track.

[0022] As in the embodiments described above, the bridge may be applied locally between adjacent track sections or over the whole track.

[0023] It should be noted that the various aspects of the invention are essentially independent of each other. Accordingly, the lower power density and current concentration features described can be applied to the arrangements described in WO97/39603, for example where the fusing glass bridge is applied as an overglaze to the whole track.

[0024] A preferred embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

Fig. 1 is a plan view of a heater in accordance with the invention;

Fig. 1A is a section along line A-A of Figure 1; and
Fig. 2 is a table giving relevant data for the heater shown in Figure 1.

[0025] Turning to Fig. 1, there is shown a thick film planar heater 2 embodying the present invention. The heater comprises a 0.5 mm thick stainless steel substrate 4 on which is deposited in a conventional manner an insulating layer 6 and heating track 8. In this particular embodiment, the insulating layer 6 is made from of Dupont 3500 ink and is about 85 microns thick (+/- 10 microns). The resistive heating track 8 laid down on the insulating layer 6 is made from a blend of Dupont F/612/F629 resistive inks and is about 13 microns (+/- 2 microns) thick.

[0026] As will be seen, the resistive heating track 8 is made up of a series of eight concentric arcuate track sections 8a, 8b....8h whose ends are joined by silver links 10. Such a track configuration is disclosed in general terms in Applicant's WO98/366182. Track sections 8a, 8b, 8c and 8h extend substantially completely around the heater while the other track portions are subdivided into generally semi-circular portions. One end of track 8e is connected by a silver track 14 to a silver pad 16 for receiving a silver contact (not shown), and one end of track

8d is connected to a further contact receiving pad 18 by a silver link 20. In use the contacts mounted on the pads, eg by soldering, receive a 230V (or other voltage) supply. The outer diameter of the outermost track 8a is about 60mm, the gap between adjacent tracks being about 0.5 mm.

[0027] The total power of this element is 1000W at 230V AC, the power contribution of each track portion being given in Figure 2.

[0028] It will be apparent from Figs. 1 and 2 that the width of the track portions 8a to 8h varies from the edge of the element to its centre. In particular the outermost track portion 8a is the narrowest, the track width increasing towards the track portions 8e and 8f in the radially central region, before decreasing again towards the innermost track portion 8h. Since power density is inversely proportional to the track width, the power density decreases from a maximum at track 8a to a minimum at tracks 8e - 8f and then increases to a second, local maximum in track 8h. The effect of this width distribution is to reduce the tendency of the insulating layer 6 to micro-crack in an severe overheat situation.

[0029] Returning to Fig. 1, it will be seen that opposed end portions of tracks 8d and 8e bridged by silver links 10 a and 10b are over printed with a "self protecting" glaze bridge 22 about 7mm wide and 4 mm long. This bridge 22 is printed from ESL 4771G material and is about 13 microns (+/- 2 microns) thick. It will be seen that the bridge 22 is arranged over the track portions connected to the respective ends of the track 8 so that a relatively large voltage drop occurs over the bridge 22. In fact, the bridge is arranged at about 61 mm from the end of track 8e and about 30mm from the end of track. This produces a voltage difference of about 208 V across the bridge.

[0030] It will be seen from Fig 1 that a hole 24 approximately 1mm in diameter is provided in the section of the track 8d between the bridge 22 and the end of the track 8d linked to the contact pad 18.

[0031] The whole element is overprinted with protective glaze eg of Dupont 3500 to a thickness of eg 13 microns +/- 2 microns.

[0032] In use, the heater shown is mounted for example in the base of a liquid heating vessel such as a kettle. Should the kettle boil dry or be switched on without any water in the kettle, then the temperature of the heater will rise very quickly due to the high power rating of the heater and its low thermal mass. Should any primary overheat protection such as a bimetallic actuator fail to operate then the temperature of the heater will continue to rise. However at a certain predetermined temperature, the conductivity of the self protecting overglaze bridge 22 will rise to the point where it effectively short circuits the majority of the track resulting in a very high current passing through the track sections 8d and 8e bridged by the track. In the particular embodiment, the resistance of these track sections is about 5Ω, leading to a current flowing through the sections of about 46 amps, which is well

above the normal operating current of about 4.35 amps and well in excess of the current carrying capability of the track sections. Accordingly, one or both of these track sections will fail. The current is, however, sufficiently low to prevent domestic fuses from blowing or earth leakage trips from operating. In general it has been found that a current at failure of between 10 and 15 A/mm produces a satisfactory failure.

[0033] In the described embodiment, the track section 3d will in fact fail due to the presence of the hole 24. This acts to concentrate locally the current flowing through the track so that the region around the hole 24 will be much greater than elsewhere in the section and causing failure to occur in that region.

[0034] It will also be noted that the bridge 22 is provided between relatively wide track sections. This acts to reduce the power density in the region of the bridge which means that the bridge will not get as hot as surrounding regions. This has the effect of increasing the time taken to reach the breakdown temperature of the bridge 22, thereby prolonging the time before the heater fails. This is advantageous in that it reduces the likelihood of the heater failing before a primary overheat protector operates.

[0035] In the described embodiment, it has been found that the time in which the heater self protects is about 8 seconds. This is well above the 4 seconds as would be expected for the operating time of a primary overheat protection bimetal so that the heater will not prematurely fail in the event of overheating say in a dry boil or dry switch on situation in a kettle or the like. It is, however below the time at which the insulating substrate of the heater will break down, leading to a safe failure mode.

[0036] It will be appreciated that various modifications may be made to the above embodiment without departing from the scope of the invention. For example, more than one current concentrator could be provided, for example one in each of the tracks 8d and 8e. Also, although preferred, it is not essential to provide the bridge 22 in a low power density area, so that the tracks 8a-8h may all be of the same width. Furthermore, the bridge 22 could be applied as an overglaze over the entire track 8 instead of being applied as a discrete bridge. The invention is not limited to the particular track sizes disclosed, and in some embodiments, depending on the size of heater and the required power of the heater the tracks may be wider or narrower than those widths disclosed.

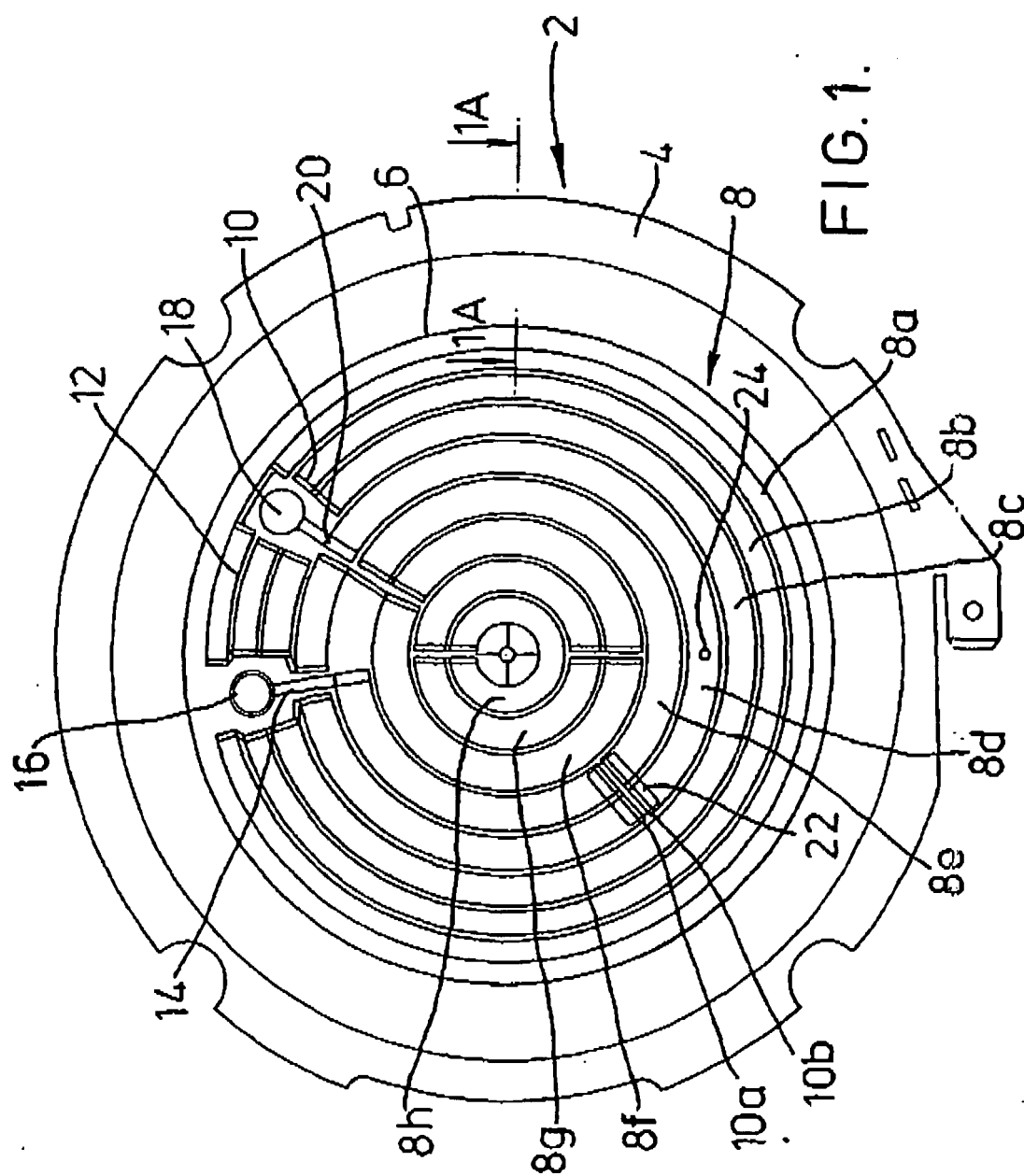
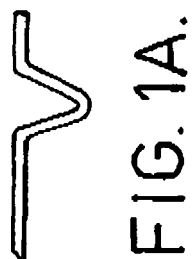
[0037] It will be seen from the above that the invention in its various aspects allows a controlled failure of the heater in a severe overheat situation in a manner which reduces the likelihood of the heater breaking down to neutral or earth.

[0038] It will be appreciated by those skilled in the art that the description relates merely to one example of how the invention may be implemented. In particular the various dimensions, parameters and tolerances are given by way of example only and should not be considered limiting.

Claims

1. An electrical resistance or heater of the type comprising a thick film resistive track provided on an insulating substrate, two predetermined sections of said track having a predetermined current carrying capacity being bridged locally by a bridge of a glass material which at a predetermined temperature becomes sufficiently conductive to cause a failure current to flow through at least one of said sections, wherein the said track section is provided with means for concentrating locally the current flowing there-through. 5
2. A resistance or heater as claimed in claim 1 wherein the current concentration is achieved by reducing locally the width of the track section. 10
3. A resistance or heater as claimed in claim 2 wherein a hole is provided through the track section. 15
4. An electrical resistance or heater as claimed in any preceding claim wherein said bridge is applied as a discrete bridge and the resistive track is protected from oxidation by a separate overlaze layer. 20
5. A resistance or heater as claimed in any preceding claim wherein the bridge is applied as an overlaze bridging the track sections. 25
6. A resistance or heater as claimed in any preceding claim wherein the bridge is positioned over abutting track section ends. ' 30
7. A resistance or heater as claimed in any preceding claim wherein the bridge of material is arranged in a region of the heater which has a relatively low power density. 35
8. A resistance or heater as claimed in claim 7 wherein region of relatively low power density is flanked by higher power density areas 40
9. A resistance or heater as claimed in claim 7 or 8 wherein the lower power density area is provided in a radially intermediate section of the heater 45
10. A resistance or heater as claimed in claim 9 wherein at least the radially outer regions of the heater track has a higher power density. 50

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	TOTAL	8a	8b	8c	8d	8e	8f	8g	8h	
Power	1000									W
Voltage	230									V
Resistance	52.90									Ω
Current	4.35									A
Width		1.9	2.2	2.7	3.1	3.3	3.3	2.8	2.4	mm
Length		158.23	139.03	122.44	107.43	78.81	64.04	41.91	23.94	mm
Nb. of Squares		82.23	63.20	45.35	34.65	23.88	19.41	14.97	9.98	
Area		2.97	3.06	3.31	3.33	2.60	2.11	1.17	0.57	cm ²
Resistivity K (hot)	0.180									Ω /sq
Resistance	52.9	14.81	11.38	8.17	6.24	4.30	3.50	2.70	1.80	Ω
Power	1000	280.0	216.2	154.4	118.0	81.3	68.1	61.0	34.0	W
Power Density		84.33	70.36	46.71	35.44	31.27	31.27	43.44	59.12	W/cm ²

FIG.2.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 9418807 A [0004]
- WO 9739603 A [0006] [0009] [0023]
- WO 9902080 A [0007]
- WO 98366182 A [0026]