

with such a planar element.

Summary of the Invention:

According to the present invention in one of its aspects there is provided a generally planar electrical heating element which is designed for use with an element protector control having a primary thermally-responsive actuator and a secondary thermally-responsive actuator operable in response to the element temperature rising significantly above the temperature at which the primary actuator is designed to operate, said electrical heating element comprising a substrate defining an electrically-insulating surface, an electrical conductor formed on said electrically-insulating surface, said electrical conductor being formed of a material having such an electrical resistance as to constitute an electrical resistance heating element proper, and an electrically-insulating layer formed over said electrical conductor, said electrically-insulating layer having an opening therethrough whereat, in use of the electrical heating element with the element protector control aforesaid, the primary thermally-responsive actuator may access the said electrical conductor so as to be responsive directly to the

temperature thereof, the secondary thermally-responsive actuator being prevented from accessing the said electrical conductor directly and being responsive to the temperature thereof by conduction of heat through the electrically-insulating layer.

In an exemplary embodiment of the above aspect of the present invention which is adapted for use with a modified form of the aforementioned X1 element protector control, the bimetallic primary thermally-responsive actuator of the control is arranged to be responsive directly to the temperature of the heating element by virtue of being located so as to register with the opening in the insulating layer, and the feet of a plastics material carrier which constitutes the secondary thermally-responsive actuator of the control and serves as a mounting for the bimetallic primary thermally-responsive actuator are arranged to contact the insulating layer outside of the said opening therein. As described in detail hereinafter, the said embodiment has a stainless steel substrate, two electrically-insulating layers formed of a glass material, one on the substrate and a further one on top of the electrical resistance heating element proper, and the resistance heating element proper comprises a heater track formed of a conductive ink. The heater track has end terminations which are

accessible through respective openings formed in the second electrically-insulating (eg., glass) layer and the element protector control has spring metal conductors adapted to make contact with the said end terminations when the control is put into operative positional relationship with the heating element. The use of a stainless steel substrate is advantageous for heating elements which are to be used in plastics bodied vessels since the relatively poor thermal conductivity of stainless steel can be employed to thermally isolate the plastics vessel body from the resistance heating element proper. However the use of a stainless steel substrate is exemplary only and other materials could be used. The substrate could even be formed of electrically-insulating material, in which case the electrical resistance heating element proper might be formed directly on the substrate.

The invention also extends to the combination of a heating element as aforesaid with an element protector control as aforesaid, and to a liquid heating vessel incorporating such a combination. A preferred form of element protector control for use with the heating element of the present invention comprises a body part formed of electrically insulating material, a primary thermally-responsive switch actuator provided on one side of said body part

to be juxtaposed with the generally planar heating element, a secondary thermally-responsive switch actuator provided on said one side of said body part to be juxtaposed with said generally planar heating element at one or more locations spaced apart from the location whereat said primary thermally-responsive switch actuator is arranged to be juxtaposed with the generally planar heating element, switch means in said body part responsive to said primary and secondary thermally-responsive switch actuator for determining the supply of electrical energy through the control to the generally planar heating element, and terminal means electrically connected to said switch means and extending on said one side of said body part for electrically contacting electrical terminals of said generally planar heating element.

In another aspect of the present invention, there is provided a generally planar electrical heating element which is designed for use with an element protector control having a primary thermally-responsive actuator and a secondary thermally-responsive actuator operable in response to the element temperature rising significantly above the temperature at which the primary actuator is designed to operate, said electrical heating element comprising a substrate defining an electrically-insulating surface, an electrical conductor formed on said electrically-insulating surface, said electrical conductor being

formed of a material having such an electrical resistance as to constitute an electrical resistance heating element proper, and an electrically-insulating layer formed over said electrical conductor, said electrically-insulating layer having an opening therethrough whereat, in use of the electrical heating element with the element protector control aforesaid, the primary thermally-responsive actuator may access the said electrical conductor so as to be responsive directly to the temperature thereof, the secondary thermally-responsive actuator being prevented from accessing the said electrical conductor directly and being responsive to the temperature thereof by conduction of heat through the electrically-insulating layer.

A further aspect of the present invention provides an element protector control for use with the heating element of the present invention, said control comprising a body part formed of electrically insulating material, a primary thermally-responsive switch actuator provided on one side of said body part to be juxtaposed with a generally planar heating element, a secondary thermally-responsive switch actuator provided on said one side of said body part to be juxtaposed with said generally planar heating element at one or more locations spaced apart from the location whereat said primary thermally-responsive switch actuator is arranged to be juxtaposed with the generally planar heating element, switch means in said

body part responsive to said primary and secondary thermally-responsive switch actuators for determining the supply of electrical energy through the control to the generally planar heating element, and terminal means electrically connected to said switch means and extending on said one side of said body part for electrically contacting electrical terminals of said generally planar heating element.

In an exemplary embodiment of the present invention which is described in detail hereinafter a bimetallic primary thermally-responsive actuator of the control is arranged so as in use to be responsive directly to the temperature of a heating element according to the present invention by virtue of being located so as to register with the opening in the insulating layer of the heating element, and the feet of a plastics material carrier which constitutes the secondary thermally-responsive actuator of the control and serves as a mounting for the bimetallic primary thermally-responsive actuator are arranged to contact the insulating layer of the heating element outside of the said opening therein. As described in detail hereinafter, the heating element has a stainless steel substrate, two electrically-insulating layers formed of a glass material, one on the substrate and a further one on top of the electrical resistance heating element proper, and the resistance heating element proper comprises a heater track formed of a conductive ink. The heater track has end terminations

which are accessible through respective openings formed in the second electrically-insulating (eg., glass) layer and the element protector control has spring metal conductors adapted to make contact with the said end terminations when the control is put into operative positional relationship with the heating element. The use of a stainless steel substrate is advantageous for heating elements which are to be used in plastics bodied vessels since the relatively poor thermal conductivity of stainless steel can be employed to thermally isolate the plastics vessel body from the resistance heating element proper. However the use of a stainless steel substrate is exemplary only and other materials could be used. The substrate could even be formed of electrically-insulating material, in which case the electrical resistance heating element proper might be formed directly on the substrate.

The foregoing and other aspects and features of the present invention are set forth with particularity in the appended claims and, together with the advantages thereof, will best be understood from consideration of the following detailed description, given with reference to the accompanying drawings, of an exemplary embodiment of the invention.

CLAIMS:

1. A generally planar electrical heating element which is designed for use with an element protector control having a primary thermally-responsive actuator and a secondary thermally-responsive actuator operable in response to the element temperature rising significantly above the temperature at which the primary actuator is designed to operate, said electrical heating element comprising a substrate defining an electrically-insulating surface, an electrical conductor formed on said electrically-insulating surface, said electrical conductor being formed of a material having such an electrical resistance as to constitute an electrical resistance heating element proper, and an electrically-insulating layer formed over said electrical conductor, said electrically-insulating layer having an opening therethrough whereat, in use of the electrical heating element with the element protector control aforesaid, the primary thermally-responsive actuator may access the said electrical conductor so as to be responsive directly to the temperature thereof, the secondary thermally-responsive actuator being prevented from accessing the said electrical conductor directly and being responsive to the temperature thereof by

conduction of heat through the electrically-insulating layer.

2. A heating element as claimed in claim 1 wherein said substrate has an electrically-insulating layer formed on a portion of at least one surface thereof, said electrical conductor is formed on said electrically-insulating layer so as to be isolated thereby from said substrate, and said opening is formed in a further electrically-insulating layer.

3. A heating element as claimed in claim 1 or 2 wherein said substrate is formed of a metallic material.

4. A heating element as claimed in claim 3 wherein said metallic material comprises stainless steel.

5. A heating element as claimed in claim 1 or 2 wherein said substrate is formed of a non-metallic electrically-insulating material.

6. A heating element as claimed in claim 5 as dependent upon claim 2 wherein the substrate is formed of the same material as the first-mentioned electrically-insulating layer formed thereon.

7. A heating element as claimed in claim 2 or in any of claims 3 to 6 as dependent upon claim 2 wherein the first-mentioned electrically-insulating layer and/or the said further electrically-insulating layer is/are formed of a glass material.

8. A heating element as claimed in any of the preceding claims wherein said electrical conductor comprises an electrically-resistive heater track deposited onto the electrically-insulating surface.

9. A heating element as claimed in claim 8 wherein said heater track comprises electrically conductive ink printed onto the electrically insulating surface.

10. A heating element as claimed in claim 8 or 9 wherein said heater track includes end terminations underlying respective apertures provided in the overlying electrically-insulating layer for enabling said end terminations to be accessed for supplying electrical energy to the heater track.

11. A heating element substantially as herein described with reference to Figures 3A and 3B of the accompanying drawings.

12. A heating element as claimed in any of the preceding claims in combination with an element protector control as aforesaid.

5 13. A combination as claimed in claim 12 wherein the primary thermally-responsive actuator comprises a bimetallic element and the secondary thermally-responsive actuator comprises a member formed of a material selected to be deformable under spring pressure at temperatures above a predetermined level.

10 14. A combination as claimed in claim 13 wherein the secondary thermally-responsive actuator comprises a member formed of a thermoplastics material.

15 15. A combination as claimed in claim 13 or 14 wherein the secondary thermally-responsive actuator comprises a carrier for said bimetallic element.

16. A combination as claimed in any of claims 12 to 15 wherein said element protector control comprises a body part formed of electrically-insulating material, said primary thermally-responsive switch actuator is provided on one side of said body part to be juxtaposed with said opening of the heating element, said secondary thermally-responsive actuator is

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provided on said one side of said body part to be juxtaposed with said heating element at one or more locations spaced from said opening, switch means are provided in said body part responsive to said primary and secondary thermally-responsive actuators for determining the supply of electrical energy through the control to the heating element, and terminal means are provided electrically connected to said switch means and extending on said one side of said body part for electrically contacting electrical terminals of said heating element.

17. A combination as claimed in any of claims 12 to 16 wherein said element protector control is substantially as herein described with reference to Figure 1 of the accompanying drawings.

18. A planar heating element comprising a heater track formed on a substrate and provided with an overlying electrically-insulating layer having an aperture therein in registry with a portion of the heater track whereby access may be obtained to the heater track for directly monitoring the temperature thereof.

19. A planar heating element as claimed in claim 18

in combination with an element protector, control including a primary thermally-responsive actuator arranged to be responsive directly to the temperature of that portion of the heater track which is accessible through said aperture and a second thermally-responsive actuator arranged to be responsive to the temperature of the heater at one or more locations outside of said aperture.

20. A liquid heating vessel incorporating a planar heating element and element protector control combination as claimed in any of claims 12 to 17 and 19.

21. An element protector control for use with a generally planar heating element, the said control comprising a body part formed of electrically insulating material, a primary thermally-responsive switch actuator provided on one side of said body part to be juxtaposed with a generally planar heating element, a secondary thermally-responsive switch actuator provided on said one side of said body part to be juxtaposed with said generally planar heating element at one or more locations spaced apart from the location whereat said primary thermally-responsive switch actuator is arranged to be juxtaposed with the generally planar heating element, switch means in said

body part responsive to said primary and secondary thermally-responsive switch actuators for determining the supply of electrical energy through the control to the generally planar heating element, and terminal means electrically connected to said switch means and extending on said one side of said body part for electrically contacting electrical terminals of said generally planar heating element.

22. An element protector control as claimed in claim 21 wherein the primary thermally-responsive switch actuator comprises a bimetallic element and the secondary thermally-responsive switch actuator comprises a member formed of a material selected to be deformable under spring pressure at temperatures above a predetermined level.

23. An element protector control as claimed in claim 22 wherein the secondary thermally-responsive actuator comprises a member formed of a thermoplastics material.

24. An element protector control as claimed in claim 22 or 23 wherein the secondary thermally-responsive actuator comprises a carrier for said bimetallic element.