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**H5H**

(54) **Electrical heaters**

(57) An electrical heater comprises a metal substrate having a ceramic coating deposited on one or both sides, preferably by plasma spraying  $Al_2O_3$ , and an electrically conductive heating element deposited on the face of one of the ceramic coatings remote from the metal substrate.

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## SPECIFICATION

**Electrical heaters**

5 This invention relates to electrical heaters, and is applicable particularly, but not exclusively, to domestic types of electrical heaters.

10 According to one aspect of the invention, there is provided an electrical heater including a metal substrate, a ceramic coating deposited on the metal substrate and an electrically conductive heating element deposited on the face of the ceramic coating remote from the metal substrate.

15 Conveniently the element is deposited by vapour deposition, metal spraying, sputtering, printing, electroplating or as a foil.

20 Preferably the ceramic coating is selected to have a high electrical resistance at high temperatures. For this purpose it may have a relatively low content of  $\text{Li}_2\text{O}$  or  $\text{Na}_2\text{O}$ .

25 According to another aspect of the invention such an electrical heater may be incorporated into a water heater, kettle, oil heater, deep fryer, space heater, radiator, building panel, electric iron, oven or hot plate.

30 The invention is described hereafter, by way of example only. A suitable metal substrate, which could be a casting but is preferably in wrought form such as in sheet form, and of an appropriate grade of steel, copper or aluminium and their alloys is prepared, in known manner, to receive a coating of a ceramic, such as a vitreous enamel.

35 The composition of the metal substrate may be chosen to be satisfactory for forming into the final product and also for adhesion of the required ceramic. The compatibility of the metal and the ceramic and the required surface treatment of the metal will be well known to those versed in the art of vitreous enamelling.

40 One or more coats of vitreous enamel are then applied to the metal substrate and fused using known enamelling techniques. For some applications both sides of the substrate will be enamelled and different grades of enamel may be used on opposite sides to satisfy the different functional needs of those sides. For example, on one side of the metal the enamel may serve only to protect the metal from corrosion, whereas on the other side the enamel may need the different or additional property of being an electrical insulator at high temperatures, for reasons explained below.

45 On selected areas of the enamel an electrical element is then deposited and fixed by an appropriate method. The materials of suitable electrical conductors for the element and the methods of their application may be already well known in themselves. For example, an ink of the type used for thick-film electronic circuits may be screen printed onto the enamel. A typical ink is a mixture of a metal powder such as silver and frit, which fuses when heated to bond to the enamel surface. Similar techniques are used for applying heating elements to vehicle windscreens. Alternative conductors may be carbon, metal foils, or semi-conductors and deposition may be by sputtering,

metal spraying or the like or by evaporation and condensation of the metal or other conductor material.

70 The conductor shape may be developed by additive or subtractive methods.

For some embodiments it may be advantageous to use a conductor material of higher resistivity than relatively pure metal, so that a thick and hence more robust element may be used.

75 Clearly, the element must be adequately insulated electrically from the metal substrate. Thus the enamel must be substantially free from pin holes which may reduce the dielectric strength of the insulating enamel. Furthermore it has been found that certain vitreous enamels have lower electrical resistivity at temperatures above ambient. Thus the enamel must be chosen to satisfy the requirements of porosity, resistivity and cost. Multiple coats of the same or different types of enamel may be needed to achieve those requirements.

80 For some low temperature applications conventional vitreous enamels will be satisfactory. However, such enamels have been found to conduct electricity unacceptably at temperatures above about  $130^\circ\text{C}$ . Such temperatures could be reached in the enamel in a water heater where one side of the heater is in intimate contact with the water, for example, where the metal forms part of the wall or base of a kettle. For such purposes an enamel having low content of alkali oxides and especially  $\text{Li}_2\text{O}$  and  $\text{Na}_2\text{O}$  has been found preferable.

85 Heaters using ceramic coatings suitable for operating temperatures up to  $500^\circ$  may be incorporated into a wide range of devices such as immersion heaters, kettles and water heaters, fryers, slow cookers, electric radiators, wall, ceiling or floor panels, ovens, toasters, grills, hot plates, hair curlers, irons, trouser presses, engine sump heaters, de-icers, fan heaters and so on.

90 Where the heater is used to heat water and the element is on the water side of the metal substrate, or in other applications where insulation or protection of the element is needed, a further coating of a suitable enamel or other protective material may be applied over the element.

95 The opposite side of the metal substrate from the element may be protected by a ceramic coating.

100 The enamels used are preferably of a devitrifying type which tend to be more stable at high temperatures.

105 In place of vitreous enamels it may be advantageous for some applications, especially for high temperature work, to use other appropriate ceramics, such as a plasma sprayed coating of  $\text{Al}_2\text{O}_3$  or  $\text{O}_3$ .

110 Furthermore, the process described above enables the use of materials for the element in which the electrical resistivity increases with increasing temperature, thereby providing a self-regulating form of heater. One such material is barium titanate which can be ground into a powder, mixed with a frit, applied in the required pattern and then fused by heat. Alternatively, the barium titanate may be applied by plasma spraying.

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## CLAIMS

1. An electrical heater including a metal substrate, a ceramic coating deposited on the metal substrate and an electrically conductive heating element deposited on the face of the ceramic coating remote from the metal substrate.
2. An electrical heater, according to Claim 1, in which the element is deposited by vapour deposition, metal spraying, sputtering, printing or as a foil.
3. An electrical heater, according to Claim 1 or 2, in which the ceramic coating is selected to have a high electrical resistance at high temperatures.
4. An electrical heater, according to any of Claims 1 to 3, in which the ceramic coating has a relatively low content of  $\text{Li}_2\text{O}$  or  $\text{Na}_2\text{O}$ .
5. An electrical heater according to any of Claims 1 to 4 in which the ceramic coating is a plasma sprayed ceramic coating.
6. An electrical heater, according to any of Claims 1 to 5 in which the ceramic coating is largely or entirely  $\text{Al}_2\text{O}_3$ .
7. An electrical heater, according to any of Claims 1 to 4, in which the ceramic coating is a devitrifying enamel.
8. An electrical heater, according to any of Claims 1 to 7, in which the metal is cast metal.
9. An electrical heater, according to any of Claims 1 to 8, in which the metal substrate is copper or copper alloy.
10. An electrical heater, according to any of Claims 1 to 8, in which the metal substrate is aluminium or aluminium alloy.
11. An electrical heater, according to any preceding Claim, in which the element includes or is composed of a material of which the electrical resistivity increases with increasing temperature.
12. An electrical heater, according to Claim 11 in which the material is barium titanate.
13. An electrical heater, according to any of Claims 1 to 10 in which the element includes or is composed of carbon.
14. An electrical heater, according to any preceding Claims, in which the face of the metal substrate remote from the heating element is also protected by a ceramic coating.
15. A liquid heater, according to any preceding Claim, in which the conductive element is on the liquid side of the metal substrate.
16. A water heater incorporating an electrical heater according to any of Claims 1 to 14.
17. An electric kettle incorporating an electric heater according to any of Claims 1 to 14.
18. An oil heater incorporating an electric heater according to any of Claims 1 to 14.
19. A space heater incorporating an electric heater according to any of Claims 1 to 14.
20. A radiator incorporating an electric heater according to any of Claims 1 to 14.
21. A building panel incorporating an electric heater according to any of Claims 1 to 14.
22. An electric iron incorporating an electric heater according to any of Claims 1 to 14.
23. An electric oven incorporating an electric heater according to any of Claims 1 to 14.
24. An electric hot plate incorporating an electric heater according to any of Claims 1 to 14.
25. A fryer incorporating an electric heater according to any of Claims 1 to 14.
26. A slow cooker incorporating an electric heater according to any of Claims 1 to 14.
27. A toaster incorporating an electric heater according to any of Claims 1 to 14.
28. A grill incorporating an electric heater according to any of Claims 1 to 14.
29. A hair curler incorporating an electric heater according to any of Claims 1 to 14.
30. A trouser press incorporating an electric heater according to any of Claims 1 to 14.
31. An engine sump heater incorporating an electric heater according to any of Claims 1 to 14.
32. A de-icer incorporating an electric heater according to any of Claims 1 to 14.
33. A fan heater incorporating an electric heater according to any of Claims 1 to 14.
34. An electrical heater constructed and arranged and adapted to operate substantially as described