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(54) IMPROVEMENTS RELATING TO HEATING ELEMENTS, PARTICULARLY IN THE FIELD OF THICK FILM HEATIING ELEMENTS

VERBESSERUNGEN FÜR HEIZELEMENTE, INSBESONDERE FÜR DICKSCHICHTHEIZELEMENTE

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Description

Field of the Invention:

[0001] This invention concerns improvements relating to electric heating elements and, more particularly, concerns heating elements of the so-called thick film type comprising a substrate, commonly formed of stainless steel, carrying a resistance heating track or layer which, as appropriate having regard to the nature of the substrate, may be formed on an electrically-insulating layer, commonly of glass, provided on the substrate. An additional electrically-insulating layer may be provided over the resistance heating track or layer as a protective measure. Thick film heating elements are employed in a variety of applications and are currently becoming popular in the field of electrically-heated water boiling vessels, domestic kettles and hot water jugs for example, where their clean appearance as compared to the conventional immersion heating element of metal sheathed construction has aesthetic advantages. In addition it is possible with a thick film heating element to accommodate a greater power density than is readily accommodated with conventional sheathed heating elements, leading to more rapid boiling times.

Background of the Invention:

[0002] As mentioned above, thick film heating elements are commonly formed on a stainless steel substrate, for example by first providing an electrically-insulating layer of glass on one or both surfaces of a stainless steel plate or disc and then screen-printing a resistance heating track onto the glass surface using electrically conductive inks which are then fired. As abovementioned, a further layer of glass may then be provided over the resistive track. International PCT Patent Application No. WO 96/17496 discloses one such element that comprises, as aforementioned, a stainless steel substrate that is overlaid with an electrically insulating layer, a resistive heating track, and finally with a further insulating layer.

[0003] It is known that the manufacture of thick film heating elements by this process can give rise to problems of distortion of the heating element out of its normal planar configuration and that distortions can arise furthermore in use of the heating element on account of differential thermal expansion effects. In order to at least alleviate these problems, it has been proposed to select the materials deposited onto the stainless steel substrate to have compatible thermal expansion coefficients insofar as is possible and it has been proposed furthermore to provide layers on both sides of the stainless steel substrate so as to subject it to similar thermal expansion and contraction effects from both sides. All of these solutions give rise to cost implications which, when added to the basic cost of appropriate quality stainless steel substrates as are required for water boiling vessels, tend to render the product unattractive on considerations of cost irrespective of its other clear advantages.

[0004] To overcome or at least substantially reduce the distortion problem abovementioned, the invention of our British Patent Application No. 2349322 proposed to form the substrate of a thick film heating element with a slightly domed curvature, form the heating element track or layer on the convex surface of the domed substrate, and bond the thus formed thick film heating element to a planar surface to be heated by a process which flattens the domed thick film heating element onto the planar surface.

[0005] Whilst the invention of our British Patent Application No. 2349322 promises to overcome the distortion problem, there are a number of other problems in the manufacture and use of thick film heating elements which tend to limit their wider adoption, namely:

(i) The materials used are relatively expensive. Anything that can be done to reduce material content is desirable. This includes a reduction in thickness of the substrate, and a reduction in size of the substrate and printed area.

(ii) The usable power density is limited by the noise generated by such heaters during heating water. The noise principally arises from local formation of steam bubbles, which rapidly collapse, because the power density is too high to allow convection currents to become established close to the element surface, and especially directly opposite the location of the heater track.

(iii) The limiting power density leads to heaters that are of relatively large area, leading not only to increased costs but also to an inability to operate on more than a very small angle of slope. To overcome this problem it has been conventional to employ costly solutions of multiple protectors or electronics.

(iv) At present the only steel substrate which is successfully used is 400 series stainless steels. These materials have poor resistance to corrosion and give a low quality cosmetic surface. To overcome this various coatings have been proposed, which increases the cost and raises the running temperature of the heater tracks.

(v) In order to withstand thermal and mechanical shock arising from abuse of the appliance, it has normally been necessary to employ relatively thick steel substrates, which increases costs.

(vi) The screen printing techniques presently employed can only be applied to flat surfaces, with no rims or other projections above the printing surface. This limits the applications which can make use of such elements.

(vii) To overcome the limitations of the flat printing process it might be possible to fabricate the plate into a separate vessel. However the materials from which such vessels are commonly made (typically 300 series stainless steel) are not sufficiently compatible to allow straightforward and inexpensive direct assembly and joining.

Summary of the Invention

[0006] To overcome or at least substantially reduce these problems we propose to use a relatively small heater mounted to a larger vessel, with a layer of material of relatively high thermal conductivity between the steel substrate of the heater and the material of the vessel to act to spread the heat from the heater over a wider area of the liquid heating surface.

[0007] Any material may be used for the intermediate heat dispersion layer, provided it has a thermal conductivity significantly greater than the stainless steels used, i.e. about 20W/sqM/°C. Preferred materials are copper and aluminium, chosen for their thermal conductivity, relatively low cost and compatibility with the proposed assembly processes.

[0008] The joining process may be the same as or similar to any of the existing known methods of attaching aluminium mounting plates as for Blitzkocher type elements, i.e. impact pressure bonding, welding or brazing, with any of the known sources of heat. However the preferred method, because of its controllability, is induction brazing. This technique claims to give a good quality, repeatable, joint with few voids. The join of the heat dispersion layer to the vessel may be done first, for example by impact bonding, and the heating element may be induction brazed separately, giving the opportunity of inspecting the quality of the vessel/dispersion layer joint. Vents could be left in the part of the dispersion layer which extends beyond the heating element to allow the escape of flux and fumes generated during brazing. During the brazing process, the assembly is desirably pressed together with a clamping force, possibly as much as 4 tons, to ensure that the plates are flattened together without any gaps in the joint area. This clamping force enables the invention of our British Patent Application No. 2349322 be utilized in the practice of the present invention.

[0009] The above and further features of the present invention are set forth in the appended claims and will be explained in the following by reference to an exemplary embodiment which is illustrated in the accompanying drawings.

Description of the Drawings:

[0010]

Figure 1 is a schematic side elevation view of a thick film heating element embodying the present invention;

Figures 2A and 2B show alternative constructions of the peripheral edge of the thick film heating element of Figure 1; and

Figure 3 is a plan elevation view of the thick film heating element of Figure 1.

Detailed Description of the Embodiment:

[0011] The illustrated embodiment comprises a thick film heating element 1 of relatively small diameter which is bonded to a heat dispersion plate 2, formed of aluminium or copper for example and having a diameter greater than that of the thick film heating element 1, which in turn is bonded to a heating surface 3 shown in the example as a thin metal plate adapted to be fitted into the bottom of a water heating appliance, the alternative edge details shown in Figures 2A and 2B are, respectively, intended to provide a water-retaining well around the heating element periphery to facilitate sealing of the element into a vessel body by providing a cooler sealing environment and to facilitate interfacing with the vessel body; other edge configurations are of course possible.

[0012] It is conventionally considered that a thick film heating element having a power density of more than $30W/cm^2$ will give rise to unacceptable noise. This equates to an overall power output of about 3kW on an element formed on a 120mm diameter disc with a plain sealing area left all round. It is proposed according to the teachings of the present invention to use a significantly higher power density heating element formed on a disc of around 60mm, for example. It is proposed that the dispersion layer will spread the heat over an area extending about 10mm beyond the disc, thus giving a heating element of an effective diameter of 80mm. Bearing in mind that the material costs of a thick film heating element are proportion to its area (thickness being constant), a conventional 80mm diameter element would use 78% more material than one of 60mm diameter constructed according to the present invention, which represents a significant saving.

[0013] There are, of course, approximations in the above, since the power density of the embodiment will fall rapidly outside the disc region 1, and will tend to be concentrated towards the centre. However, examination of a conventional thick film heater on a stainless steel substrate shows that the heat is not spread evenly over the surface, but is closely concentrated directly above the tracks with little heating occurring between the tracks. The true power density is much greater than simply dividing the power by the disc area would suggest. It is believed that this is the cause of the excessive noise generation. This effect is caused by the low thermal conductivity of the stainless steel substrate, which forces the heat to flow perpendicularly to the plane of the heater, through the thickness, and significantly limits lateral heat flow. By the addition of the dispersion layer taught by the present invention, heat can flow laterally as well as transversely, so that a more uniform heat distribution is obtained on the liquid heating surface. Thus the power density on the liquid heating surface is close to the calculated value of the power divided by the surface area, rather than to the value of the power divided by the (much smaller) heater track area. The result is a lower effective power density and a significant reduction in noise generated.

[0014] As an example of the improvements that can be made, the following values are taken from present production elements. For a conventional element of around 110mm diameter, the heater track power density is 68W/cm^2. Thus, if the dispersion layer is fully effective, the area of the heater could be reduced to less than half, whilst maintaining the same power density on the liquid heating surface. By adding the further gain in surface area around the periphery of the heater disc, the heater can be reduced still further in size. The net result of this is a major reduction in the cost of the materials of the element. A disc of 77mm diameter has half the area of one of 110mm, and taking into account the dispersion layer, this gives an element diameter of approximately 60mm, the value used in the example above. Thus theoretically it should be possible, with an element of only 60mm diameter, to achieve approximately the same power density at the liquid heating surface as is presently achieved with a conventional 110mm diameter element. This is a reduction to just over one third of the area. The material cost of the element makes up over 80% of the total element cost, when fully automated. We believe that the track power density can be still further increased to in excess of 100W/cm^2, leading to still further cost reduction. In the end the limit is likely to be caused by the loss of area caused by the need to make electrical connections, with their associated creepage and clearances, and by the area needed to accommodate any necessary element protector controls as schematically shown in Figure 3.

[0015] This significant reduction in area may be accompanied by a similar reduction in substrate thickness. At present, substrates of between 1.2 and 1.5mm are used to achieve satisfactory mechanical rigidity and resistance to thermal and mechanical shock. We propose to reduce the substrate thickness, for example to 0.3mm, to allow the use of high power density without a penalty in increased track running temperatures. We anticipate that the improved heat transfer efficiency afforded by the dispersion layer will reduce the track running temperature to acceptable values, but this will only be possible by reducing the thermal resistance of the whole sandwich to values similar to those at present, taking into account the narrow thermal path of the present designs. The thin substrate becomes possible because of the support and cushioning of the dispersion layer, further supported by the water treating plate and/or vessel wall. Thus the complete assembly will be able to withstand mechanical impact and thermal shock better than an element with a unitary substrate of the present thickness. To further improve the heat transfer we propose that the vessel wall, which is preferably formed of a 300 series stainless steel commonly used in stainless steel cooking vessels like saucepans, is also reduced to around 0.3mm. This compares with 0.5mm normally found in stainless steel kettles. The arrangement of the sandwich is preferably such that the thermal resistance between the printed heater tracks and the heating surface is not more than that of a conventionally made thick film heating element on a 1.2mm substrate of 400 series (S430D or S444) stainless steel, with a dielectric thickness of no more than 100μ.

[0016] The complete heating element sandwich can be made as an "Easifix" (GB 2330064A) type element or as a Strix "Sure Seal" (WO 96/18331) for fitting to a moulded vessel, or it may be made directly onto the base of a stainless steel vessel. This latter option is a very cost effective method of fitting a thick film heater to a stainless steel appliance, something that, so far as we are aware, has only been done by Pifco - Russell Hobbs by using the same (costly) plastic securing ring as was developed for the Millennium kettle. Examples of such mountings are in Pifco's GB 2 291 324 and GB 2 319 154 which show the complexity of the method. It is possible to attach the small thick film element 1 into a depression, which would otherwise prevent screen printing, and this gives further advantages in that it allows a well to be formed around the periphery of the element to retain some water in the event of boiling dry, which will give protection to any adjacent seals or cosmetic mouldings. Such protection is given at present by providing an area free of heating element track around the element periphery, which increases the diameter and hence the cost of the heating element. An example of such a well is shown in Sunbeam, CA 1 202 659, applied to a mechanical embedded element. The ability to attach the element within a depression will allow a thick film printed element to be used where previously it was not possible. An example is a hotplate element which may have a raised heating surface surrounded by a mounting flange, so that the heating surface is above the general level of the top of the appliance.

[0017] A further advantage of the small element proposed by the present invention, which gives rise to savings in the manufacturing cost of the elements, is that they may be processed several at a time. The number of elements which can be printed simultaneously is limited by the area of the screen printer and by the width of the processing ovens. Clearly, by halving the diameter of the element, four times as many may be printed and processed together on the same equipment. Depending on the type of equipment used, this may be achieved by carrying the elements in a strip and separating them on completion, or by automated handling, placing individual discs into location jigs for printing and onto the oven belts for drying and firing. It is believed that retaining the discs in a strip for processing will lead to reduced distortion, as a result of the support of the strip. In any case, measures such as this may be desirable to reduce the effects of distortion.

[0018] The small diameter element has an additional operational advantage, in that it is less sensitive to being operated on a slope whilst heating liquids. The dispersion layer will ensure that, as liquid boils away, the exposed area of the heater is cooled to some extent by the remaining liquid until a protector can operate. In addition, any thermal protector will tend to cover a larger proportion of the heating element and give protection over a wider area.

[0019] The proposal of the invention may be considered to be similar in principle to the Blitzkocher type of heating element construction, where a sheathed heating element is secured to a heat transfer plate which in turn is secured to a steel plate which is part of a liquid heating vessel. However the power density available from a sheathed heating element is limited by the insulation of the mineral filling of the sheath and by the robustness of the joint between the sheath and the heat dispersion material. If the power density of a Blitzkocher heating element is too great, the thermal expansion of the sheath causes it to peel away from its support, leading to further overheating and subsequent premature failure. We are also aware of thick film ceramic heaters secured by conductive cement to the base of water heating vessels, such as the Hywel egg boiler. Such arrangements are limited by the relatively poor thermal conductivity of the ceramic substrate and are only suitable for low power density applications.

[0020] While the invention has been described in the foregoing with particular reference to water boiling vessels such as kettles and hot water jugs, the invention is not limited to such applications and, in particular, could be used in electric cooker hobs and hotplates for example.

Claims

1. A heating element assembly comprising a heating element (1), of thick film construction and comprising a substrate, secured to a surface to be heated (3) **characterised in that** a high thermal conductivity heat dispersion layer (2) is provided between the heating element (1) and the surface to be heated (3), the heat dispersion layer (2) extending laterally beyond the periphery of the heating element (1).

2. A heating element assembly as claimed in claim 1 wherein the substrate is of stainless steel.

3. A heating element assembly as claimed in claim 2 wherein said substrate has a thickness of less than 0.5mm.

4. A heating element assembly as claimed in any preceding claim wherein said heat dispersion layer (2) comprises copper or aluminium.

5. A heating element assembly as claimed in any of the preceding claims wherein the power density of the thick film heating element (1), measured over its total area, is substantially greater than 30W/cm^2.

6. A heating element assembly as claimed in claim 5 wherein the power density of the thick film heating element (1), measured over its total area, is at least 60W/cm^2.

7. A heating element assembly as claimed in any of the preceding claims wherein the area of the thick film heating element (1) is of the order of one third to one half of the area of the surface to be heated.

8. A heating element assembly as claimed in claim 7 wherein the surface to be heated (3) is a disc of diameter of around 100 or 110mm and the thick film heating element (1) is a disc of diameter around 60 to 80mm.

9. A heating element assembly as claimed in any of the preceding claims wherein the heat dispersion layer (2) extends at least 10mm beyond the periphery of the thick film heating element (1).

10. A heating element assembly as claimed in any of the preceding claims wherein the surface to be heated (3) comprises a heater plate adapted to be assembled into a plastic bodied liquid heating vessel.

11. A heating element assembly as claimed in claim 10 wherein the heater plate is formed around its periphery with a well.

12. A heating element assembly as claimed in any of claims 1 to 9 wherein the surface to be heated (3) comprises the bottom of a liquid heating vessel.

13. A heating element assembly as claimed in claim 12 wherein said liquid heating vessel bottom is formed of stainless steel.

14. A heating element assembly as claimed in claim 13, wherein the heating vessel bottom is formed of 300 series stainless steel.

15. A heating element assembly as claimed in claim 13 or 14 wherein said stainless steel has a thickness of less than 0.5mm, preferably 0.3mm.

16. A heating element assembly as claimed in any of claims 10 to 15 wherein the surface to be heated (3), viewed from the side to which the thick film heating element is affixed, has a depression into which the thick film heating element is affixed.

17. A heater assembly according to claim 1, wherein the

thick film heating element (1) provides an output having a predetermined power density and the effect of the heat dispersion layer (2) is to provide the overall assembly with a power density which is substantially less than that of the thick film heating element (1) itself.

18. A liquid heating vessel comprising a heating element assembly according to claim 1, wherein said thick film heating element (1) is significantly smaller than said surface to be heated (3), and said heat dispersion layer (2) is significantly larger than the thick film heating element (1).

19. A liquid heating vessel according to claim 18, wherein said thick film heating element is of a diameter which is less than half the diameter of said surface to be heated.

20. A liquid heating vessel according to claim 18 or 19, wherein said heat dispersion layer is of a diameter which is approaching twice the diameter of said thick film heating element.

21. A liquid heating vessel including a heating element assembly (1,2,3) as claimed in any of claims 1 to 17.

Patentansprüche

1. Heizelementaufbau, umfassend ein Heizelement (1) aus einem Dickschichtaufbau und umfassend einen Träger, der an einer zu erhitzenden Oberfläche (3) befestigt ist, **dadurch gekennzeichnet, dass** zwischen dem Heizelement (1) und der zu erhitzenden Oberfläche (3) eine Wärmezerstreuungsschicht (2) mit hoher Wärmeleitfähigkeit bereitgestellt ist, wobei sich die Wärmezerstreuungsschicht (2) über den Umfang des Heizelements (1) hinaus erstreckt.

2. Heizelementaufbau nach Anspruch 1, wobei der Träger aus Edelstahl ist.

3. Heizelementaufbau nach Anspruch 2, wobei der Träger eine Dicke von weniger als 0,5 mm aufweist.

4. Heizelementaufbau nach einem der vorhergehenden Ansprüche, wobei die Wärmezerstreuungsschicht (2) Kupfer oder Aluminium umfaßt.

5. Heizelementaufbau nach einem der vorhergehenden Ansprüche, wobei die über seine gesamte Fläche gemessene Leistungsdichte des Dickschichtheizelements (1) wesentlich größer als 30 W/cm^2 ist.

6. Heizelementaufbau nach Anspruch 5, wobei die über seine gesamte Fläche gemessene Leistungsdichte des Dickschichtheizelements (1) zumindest 60 W/cm^2 beträgt.

7. Heizelementaufbau nach einem der vorhergehenden Ansprüche, wobei die Fläche des Dickschichtheizelements (1) in der Größenordnung von einem Drittel bis zu einer Hälfte der Fläche der zu erhitzenden Oberfläche liegt.

8. Heizelementaufbau nach Anspruch 7, wobei die zu erhitzende Oberfläche (3) eine Scheibe mit einem Durchmesser von etwa 100 oder 110 mm ist, und das Dickschichtheizelement (1) eine Scheibe mit einem Durchmesser von etwa 60 bis 80 mm ist.

9. Heizelementaufbau nach einem der vorhergehenden Ansprüche, wobei sich die Wärmezerstreuungsschicht (2) zumindest 10 mm über den Umfang des Dickschichtheizelements (1) hinaus erstreckt.

10. Heizelementaufbau nach einem der vorhergehenden Ansprüche, wobei die zu erhitzende Oberfläche (3) eine Heizerplatte umfaßt, die dazu geeignet ist, in ein Flüssigkeitsheizgefäß mit Kunststoffkörper eingebaut zu werden.

11. Heizelementaufbau nach Anspruch 10, wobei die Heizerplatte um ihren Umfang herum mit einer Einsenkung ausgebildet ist.

12. Heizelementaufbau nach einem der Ansprüche 1 bis 9, wobei die zu erhitzende Oberfläche (3) den Boden eines Flüssigkeitsheizgefäßes umfaßt.

13. Heizelementaufbau nach Anspruch 12, wobei der Flüssigkeitsheizgefäßboden aus Edelstahl gebildet ist.

14. Heizelementaufbau nach Anspruch 13, wobei der Heizgefäßboden aus Edelstahl der 300er-Gruppe gebildet ist.

15. Heizelementaufbau nach Anspruch 13 oder 14, wobei der Edelstahl eine Dicke von weniger als 0,5 mm, und vorzugsweise 0,3 mm aufweist.

16. Heizelementaufbau nach einem der Ansprüche 10 bis 15, wobei die zu erhitzende Oberfläche (3) von der Seite, an der das Dickschichtheizelement angebracht ist, her gesehen eine Vertiefung aufweist, in der das Dickschichtheizelement angebracht ist.

17. Heizeraufbau nach Anspruch 1, wobei das Dickschichtheizelement (1) einen Ausgang bereitstellt, der eine vorbestimmte Leistungsdichte aufweist, und die Wirkung der Wärmezerstreuungsschicht (2) ist, den gesamten Aufbau mit einer Leistungsdichte zu versehen, die wesentlich geringer als jene des Dickschichtheizelements (1) selbst ist.

18. Flüssigkeitsheizgefäß, umfassend einen Heizelementaufbau nach Anspruch 1, wobei das Dickschichtheizelement (1) deutlich kleiner als die zu erhitzende Oberfläche (3) ist, und die Wärmezerstreuungsschicht (2) deutlich größer als das Dickschichtheizelement (1) ist.

19. Flüssigkeitsheizgefäß nach Anspruch 18, wobei das Dickschichtheizelement einen Durchmesser aufweist, der weniger als die Hälfte des Durchmessers der zu erhitzenden Oberfläche beträgt.

20. Flüssigkeitsheizgefäß nach Anspruch 18 oder 19, wobei die Wärmezerstreuungsschicht einen Durchmesser aufweist, der sich dem Doppelten des Durchmessers des Dickschichtheizelements nähert.

21. Flüssigkeitsheizgefäß, umfassend einen Heizelementaufbau (1, 2, 3) nach einem der Ansprüche 1 bis 17.

Revendications

1. Ensemble d'élément chauffant comprenant un élément chauffant (1), d'une structure à film épais et comprenant un substrat, fixé contre une surface à chauffer (3), **caractérisé en ce qu'**une couche de dispersion de la chaleur à haute conductivité thermique (2) est prévue entre l'élément chauffant (1) et la surface à chauffer (3), la couche de dispersion de la chaleur (2) s'étendant latéralement au-delà de la périphérie de l'élément chauffant (1).

2. Ensemble d'élément chauffant selon la revendication 1, dans lequel le substrat est en acier inoxydable.

3. Ensemble d'élément chauffant selon la revendication 2, dans lequel ledit substrat a une épaisseur de moins de 0,5 mm.

4. Ensemble d'élément chauffant selon l'une quelconque des revendications précédentes, dans lequel ladite couche de dispersion de la chaleur (2) comprend du cuivre ou de l'aluminium.

5. Ensemble d'élément chauffant selon l'une quelconque des revendications précédentes, dans lequel la densité de puissance de l'élément chauffant à film épais (1), mesurée sur sa superficie totale, est sensiblement supérieure à 30 W/cm^2.

6. Ensemble d'élément chauffant selon la revendication 5, dans lequel la densité de puissance de l'élément chauffant à film épais (1), mesurée sur sa superficie totale, est d'au moins 60 W/cm^2.

7. Ensemble d'élément chauffant selon l'une quelconque des revendications précédentes, dans lequel la superficie de l'élément chauffant à film épais (1) est de l'ordre d'un tiers à la moitié de la superficie de la surface à chauffer.

8. Ensemble d'élément chauffant selon la revendication 7, dans lequel la surface à chauffer (3) est un disque d'un diamètre d'environ 100 ou 110 mm et l'élément chauffant à film épais (1) est un disque d'un diamètre d'environ 60 à 80 mm.

9. Ensemble d'élément chauffant selon l'une quelconque des revendications précédentes, dans lequel la couche de dispersion de la chaleur (2) s'étend à au moins 10 mm au-delà de la périphérie de l'élément chauffant à film épais (1).

10. Ensemble d'élément chauffant selon l'une quelconque des revendications précédentes, dans lequel la surface à chauffer (3) comprend une plaque chauffante conçue pour être assemblée dans un récipient de chauffage pour liquides doté d'un corps en plastique.

11. Ensemble d'élément chauffant selon la revendication 10, dans lequel la plaque chauffante est conçue avec une cavité autour de sa périphérie.

12. Ensemble d'élément chauffant selon l'une quelconque des revendications 1 à 9, dans lequel la surface à chauffer (3) comprend le fond d'un récipient de chauffage pour liquides.

13. Ensemble d'élément chauffant selon la revendication 12, dans lequel ledit fond du récipient de chauffage pour liquides est conçu en acier inoxydable.

14. Ensemble d'élément chauffant selon la revendication 13, dans lequel le fond du récipient de chauffage est conçu en acier inoxydable série 300.

15. Ensemble d'élément chauffant selon la revendication 13 ou 14, dans lequel ledit acier inoxydable a une épaisseur de moins de 0,5 mm, de préférence 0,3 mm.

16. Ensemble d'élément chauffant selon l'une quelconque des revendications 10 à 15, dans lequel la surface à chauffer (3), vue du côté contre lequel est fixé l'élément chauffant à film épais, présente un creux dans lequel est fixé l'élément chauffant à film épais.

17. Ensemble chauffant selon la revendication 1, dans lequel l'élément chauffant à film épais (1) fournit une sortie ayant une densité de puissance prédéterminée et la couche de dispersion de la chaleur (2) doit avoir pour effet de conférer à l'ensemble global une densité de puissance qui est sensiblement inférieure à celle de l'élément chauffant à film épais (1) luimême.

18. Récipient de chauffage pour liquides comprenant un ensemble d'élément chauffant selon la revendication 1, dans lequel ledit élément chauffant à film épais (1) est nettement plus petit que ladite surface à chauffer (3), et ladite couche de dispersion de la chaleur (2) est nettement plus grande que ledit élément chauffant à film épais (1).

19. Récipient de chauffage pour liquides selon la revendication 18, dans lequel ledit élément chauffant à film épais a un diamètre qui est inférieur à la moitié du diamètre de ladite surface à chauffer.

20. Récipient de chauffage pour liquides selon la revendication 18 ou 19, dans lequel ladite couche de dispersion de la chaleur a un diamètre qui mesure près du double du diamètre dudit élément chauffant à film épais.

21. Récipient de chauffage pour liquides comprenant un ensemble d'élément chauffant (1, 2, 3) selon l'une quelconque des revendications 1 à 17.

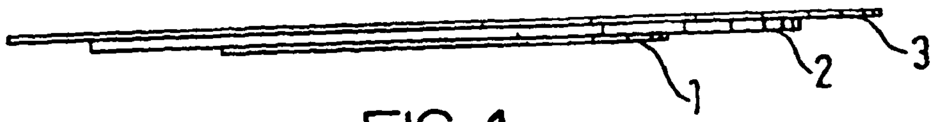

FIG. 1

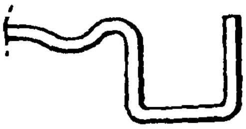

FIG. 2A

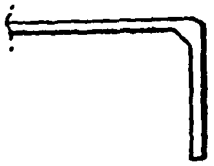

FIG. 2B

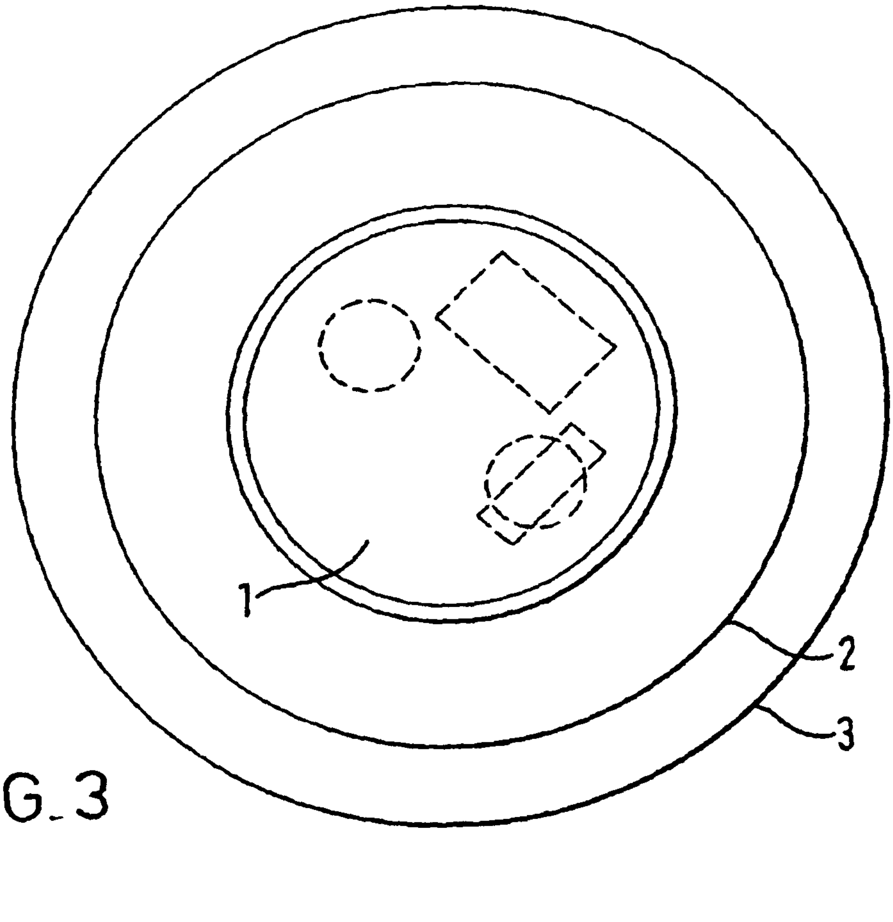

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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