United States Patent

Rice et al.

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[45] **Aug. 29, 1972**

[54] **ELECTRIC FLUID HEATER**

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[73] Assignee: **United Kingdom Atomic Energy Authority,** London, England

[22] Filed: **July 31, 1970**

[21] Appl. No.: **60,075**

Related U.S. Application Data

[63] Continuation of Ser. No. 777,342, Nov. 20, 1968, abandoned.

[52] **U.S. Cl.** **219/381,** 219/275, 219/307, 219/374, 219/382

[51] **Int. Cl.**............................**F24h 1/10,** H05b 3/12

[58] **Field of Search**.......219/381, 374, 307, 271–276

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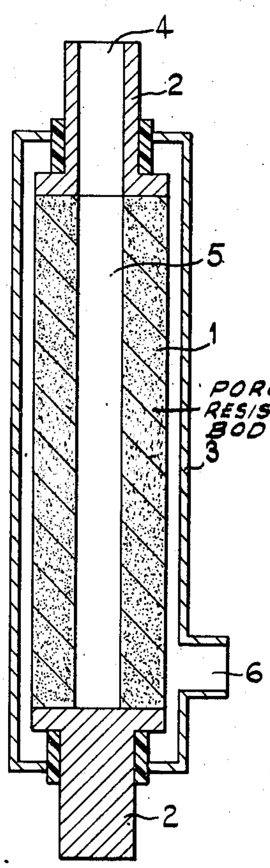
[57] **ABSTRACT**

An electrical resistor heater unit for the heating of liquids including a heater element of porous resistor material located within a casing serves to obstruct the flow path for constraining fluid therein to diffuse into the element through a first surface thereof. The fluid is heated by the element and leaves through a second surface thereof. A porous heat-conducting electrically insulating member having smaller pores than the heater element is disposed about the body first surface and serves as a flow distributor and a pre-heater for both directing fluid to flow through the element and for gradually raising the temperature of the incoming liquid to the temperature attained by the element, thereby minimizing boiling of the liquid externally of the liquid input surface of the member. The porosity of the insulating member may be varied along its axial length to control the liquid flow rate to obtain substantially uniform diffusion through the heater element. The heater element may be divided into concentrically arranged vaporizing and super heating zones separated by a thermally insulating gas gap.

7 Claims, 14 Drawing Figures



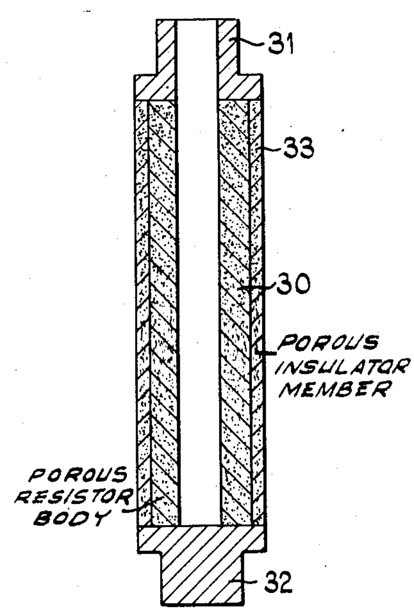


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FIG.1

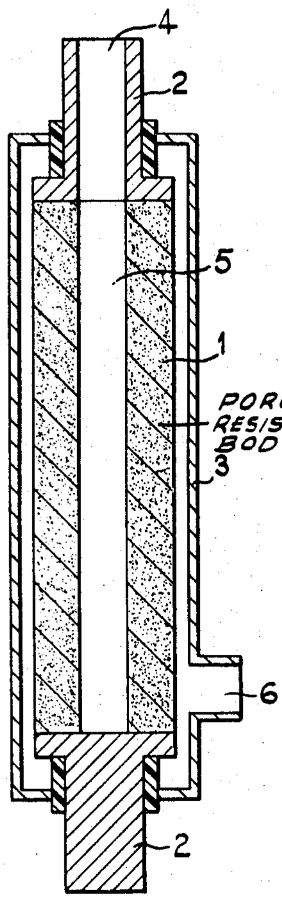


FIG.2

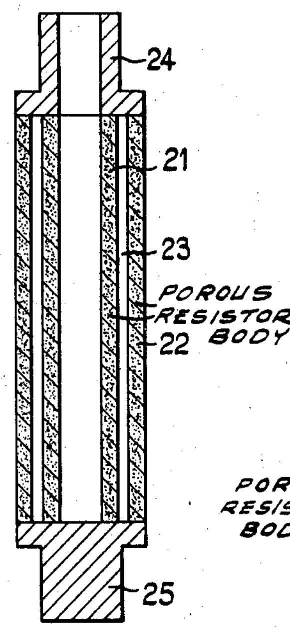


FIG.3

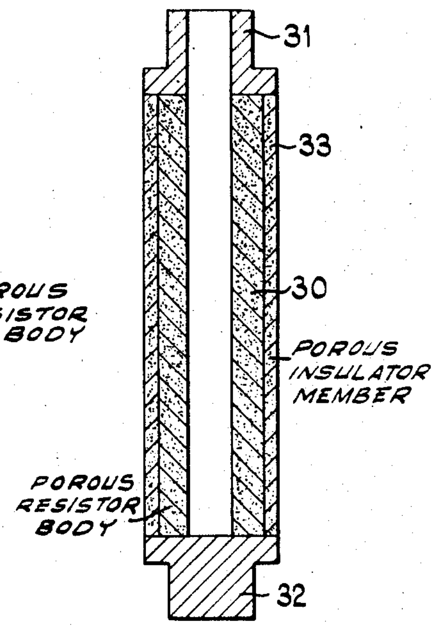


FIG.4

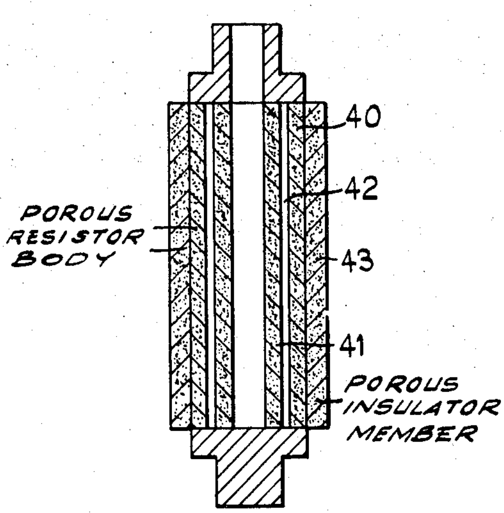
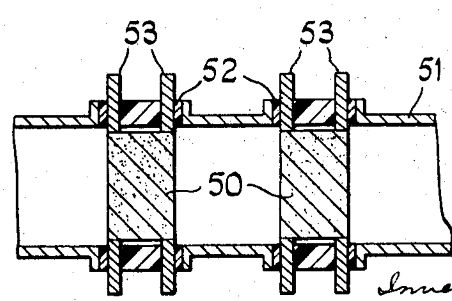


FIG.5



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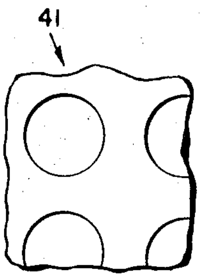


FIG. 4A

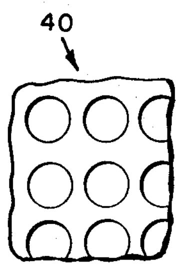


FIG. 4B

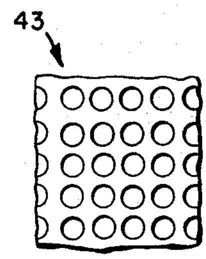


FIG. 4C

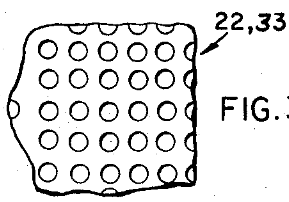


FIG. 3A

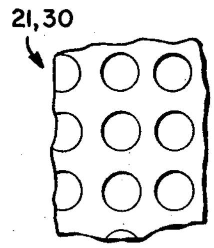


FIG. 3B

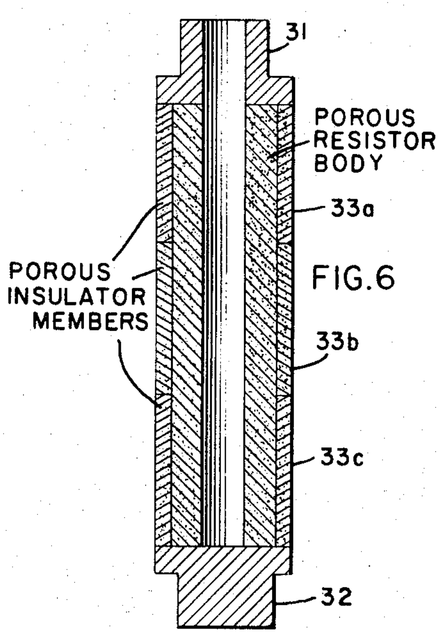


FIG. 6

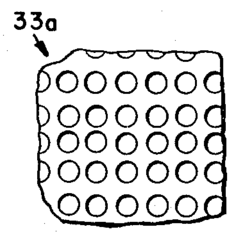


FIG. 6A

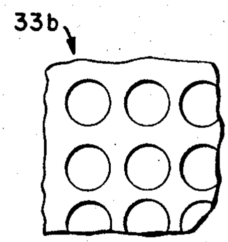
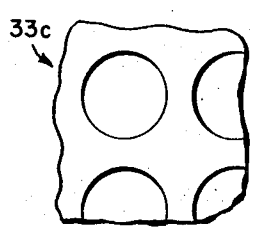


FIG. 6B

FIG. 6C



ELECTRIC FLUID HEATER

This application is a Streamlined Continuation of Application Ser. No. 777,342, filed Nov. 20, 1968, and now abandoned.

This invention relates to fluid heating equipment and in particular to electrical resistor heating elements for use in such equipment.

It is often necessary to heat, vaporize or superheat a liquid or gas in industrial processes and in many instances it is desirable to provide a quick acting easily controlled heat source for this purpose. It can also be advantageous if several stages of a process can be carried out simultaneously, for example, a heating stage and a catalytic reaction stage but such a combination has often proved impracticable. It is an object of the present invention to provide an improved form of heating equipment and in particular to provide a heater element well suited to such equipment.

It is known from British Pat. Specification No. 436676 (Roux) to heat gases by passing them through a porous resistive material which is heated by carrying an electric current and to use the heated gas in a heater coil in a steam generator.

Also, British Pat. Specification No. 592325 (Froges) shows a porous electrical resistor having gas flowing through it to protect the resistor from oxidation.

The present invention is for vaporizing a liquid for example water, preferably to produce dry or super heated steam, for example for sterilizing food stuffs or for cleaning.

Preferably the liquid passes first through a region with fine pores for controlling and distributing the flow to a second region with more open pores. Both may be heated and change of state from liquid to gas may start in either region.

Preferably the heater element comprises an elongated hollow cylindrical body arranged such that the fluid to be heated diffuses through the wall of the body. The heater element may be annular such that the fluid diffuses radially through the element wall.

In an alternative form the heater element may comprise a porous disc or plug located in a fluid carrying duct.

Each element may be divided into a plurality of heating regions, for example, when heating a liquid the element may be divided into a vaporizing zone and a super-heating zone. The said zones may be separated by a thermally insulating layer, said layer preferably having the form of a gas gap or alternatively the layer may comprise a thermal insulating material.

To enable the nature of the invention to be more readily understood various embodiments of the invention will now be described by way of example with reference to the accompanying drawings. In the drawings:

FIG. 1 is a mid-sectional elevation of an electrical resistor element;

FIGS. 2, 3, 4 and 5 are mid-sectional elevations showing alternative forms of the element, the casing not being shown in FIGS. 2, 3 and 4.

FIGS. 3A and 3B are schematic representations, greatly exaggerated for clarity of the relative pore sizes between the porous resistor body and the porous insulator member shown in FIG. 3 and of the relative pore sizes between the porous resistor body members of FIG. 2;

FIGS. 4A, 4B and 4C are schematic representations, greatly exaggerated for clarity, of the relative pore sizes between the porous body 41, the porous body 40 and the porous member 43;

FIG. 6 is a longitudinal sectional view showing another alternate form of the electrical resistor elements; and

FIGS. 6A, 6B and 6C are schematic representations, greatly exaggerated for clarity of the relative pore sizes between regions of the porous insulator member.

Referring to FIG. 1, a heater element comprises an elongated hollow body 1 formed from a porous electrical resistor material for example, carbon or a sintered metal. The element is clamped endwise between two electrical contact members 2. The element is enclosed within a fluid tight casing 3 and a duct 4 is connected to the interior space 5 within the element. A second duct 6 penetrates the casing 3 and may be used as an inlet or outlet to said casing.

In operation, a fluid, i.e. a liquid or gas is supplied to one side of the porous resistor element via one of the ducts, the fluid diffuses through the element wall, being heated in the process due to the electrical power dissipated in the resistor and the heated fluid is subsequently extracted through the other duct.

Using an annular element 10 cms long, 2.54 cms external diameter, 0.65 cms internal diameter, formed from a resistor material having a pore size of 40–80 microns and providing a heat rating of 1 kw per centimeter of length it is possible to generate steam at a temperature in the range 100°–300°C by supplying water at atmospheric pressure to the outer casing and extracting the steam from the central space in the element. A flow rate of up to 10 cc/second has proved satisfactory and preferably the electrical supply is maintained at approximately 12 volts.

When it is desired to vaporize and superheat a liquid it has proved advantageous in some instances to separate the element into a plurality of zones, i.e. a vaporizing or boiling zone and a superheating zone. For example, should the element be of low power rating and required to generate superheated steam the element may be formed from two porous bodies having a thermal barrier interposed between them. FIG. 2 illustrates an example of this form of element and shows an element comprising two concentric porous annular bodies 21 and 22 spaced apart to provide an annular gap 23. Both bodies are clamped endwise between electrical contact members 24 and 25. The radial gap may be of the order of 1 mm for elements of up to 3 cms external diameter. The body 22 may have lower porosity than the body 21 to help to distribute the fluid over the element.

The provision of a gap is also useful where the resistor bodies are formed from a good thermal conducting material since the gap permits the superheat region to operate at a higher temperature than the boiling region. It will be appreciated that the relative position of the boiling and super-heating regions are dependent upon the direction of flow of the fluid being heated, i.e. radially inwards or outwards flow.

It has also been found advantageous to permit preheating of a fluid in a region other than that electrically heated in the resistor material and FIG. 3 shows one example of a suitable element. Referring to FIG. 3 the element comprises a hollow porous resistor body 30 clamped between two electrical contact members 31, 32. The outer surface of body 30 has an external layer 33 of a porous heat conducting electrically insulating material for example, alumina. In operation the alumina becomes heated by conduction from the resistor body and the fluid is preheated during its passage through the alumina layer. When heating a liquid the amount of conducted heat received by the alumina may be arranged to boil or vaporize the liquid such that the resistor body acts as a superheater for the liquid flowing radially inwards through the element. The alumina layer may comprise a close fitting alumina tube or the alumina may be applied as a coating to the resistor material.

FIG. 4 shows a further alternative form of element in which the element comprises two concentric porous annular bodies 40,41 of resistor material, similar to the respective porous resistor bodies 22,21, spaced apart to provide an annular gas gap 42 (which functions in a manner similar to gap 23) between the bodies and a layer 43 of alumina adjacent the outer surface of the outer tube. The layer 43 is designed for operation similar to layer 33 described with reference to FIG. 3. The inner and outer annular resistor bodies 40, 41 act as a superheater and vaporizing zone respectively and the alumina layer provides a useful pre-heating zone. As pointed out with respect to FIG. 2, the outer porous resistor body 40 may have smaller pores as compared to the inner porous resistor body 41 to help distribute the fluid over the element. Such different pore sizes are shown schematically in FIGS. 4A and 4B. FIG. 4C schematically represents porous insulator member 43 in FIG. 4 having smaller pores as compared to either body 40 or body 41.

The alumina layer 33 on the element 30 of the FIG. 3 embodiment, and the alumina layer 43 on the element 40 of the FIG. 4 embodiment, inhibits external boiling, i.e. boiling in the space enclosing the element and has the additional advantage in the case of long elements of providing a convenient method of regulating the fluid flow rate to obtain substantially uniform diffusion through the element since the porosity of the alumina sleeve 33 or 43 may be varied according to the height of the element, i.e. by using a number of short sleeves 33*a*, 33*b*, 33*c* of varying porosity (see FIG. 6) to encase the resistor element 30 and thus compensate for the pressure head caused by the element height. FIGS. 6A, 6B and 6C schematically show the relative pore sizes between such sleeves, it being understood that the figures are only representative of various porosities of the porous insulator member 33 sleeves, without the invention being restricted thereto. Also, FIGS. 6A, 6B and 6C are exemplary of various porosity regions along the length of porous member 33.

An alternative method of obtaining uniform flow rates through the element is to introduce a powder into the fluid being heated such that the powder is carried along by the fluid and up on the element and tends to equalize flow over the element surface.

FIG. 5 shows a modified arrangement in which one or more heating elements 50 may be arranged in a duct 51 such that a fluid flowing through the duct is heated as it diffuses through an element.

The heater elements may be formed as a porous disc or plug located in the duct bore and electrically insulated from the duct walls in a conventional manner by suitable spacers 52, and connected with the electrical power supply via contact members 53.

It will be appreciated that the resistor elements may be constructed in various manners, for example the resistor bodies may be machined from a porous carbon, formed by aggregating and sintering metallic particles into the desired shape or the element can comprise a plurality of concentric tubes of porous construction.

It will be apparent that a compact heating equipment incorporating electrically heated porous resistor elements has many advantages over conventional equipment and may be used as generator for hot gases for many industrial processes, i.e. welding of plastic materials, electronic components, as a sterilizing unit for liquid and gases or a vaporizer for many fungicides, insecticides and solvents. The equipment has also many applications in the petro-chemical industry.

In most applications the liquid will be passed first through a region such as 22 or 33 (FIG. 3A) or 43 (FIG. 4C) of low porosity, for example with pores less than 10 microns in maximum dimension, and then through a more porous region such as 21 or 30 (FIG. 3B) or 41 (FIG. 4A), perhaps with pores of at least 50 microns in size. The region may be spaced or in contact as in FIGS. 2 and 3. Also, it should be noted that FIGS. 3A and 3B are exemplary only of the different pore sizes between the porous insulator member 33 and the porous resistor body 30 and between the porous resistor bodies 22, 21.

The first region acts to control the flow of liquid and to disperse it fairly evenly to the more porous region. Vapor may be formed in the first region for example and it may be completely dried and possibly superheated in the second region.

The invention is particularly concerned with the generation of saturated or superheated steam, for example for sterilization or for steam cleaning processes. If the heater element is of a material which does not react with water or steam, the dry steam can be used for sterilizing food. It represents a very cheap way of raising superheated steam.

What we claim as our invention and desire to secure by Letters Patent is:

1. An electrical resistor heater unit for heating liquids comprising a casing having an inlet and an outlet and defining a path for fluid, a heater element in the form of a self-supporting porous body of resistor material having electrical terminals thereon and disposed in said casing, said body obstructing the path for constraining fluid in the path to diffuse into said body through a first surface thereof, to be heated by said body, and to leave said body through a second surface thereof, said first and second surfaces together constituting the major part of the total external surface area of said body, and a porous heat-conducting electrically insulating member disposed about and substantially co-extensive with said first surface of said body, said member serving as a flow distributor and preheater for both directing fluid to flow through said heater element and for gradually raising the temperature of the incoming liquid to the temperature attained by said heater element in operation of the unit, thereby minimizing boiling of the liquid externally of the liquid input surface of said member, the pores of said member being smaller than those of said heater element.

2. An electrical resistor heater unit as claimed in claim 1 in which one of said terminals is hollow to define a passage for the fluid.

3. An electrical resistor heater unit for heating liquids comprising a casing having an inlet and an outlet and defining a path for fluid, a heater element in the form of a self-supporting elongated, hollow, cylindrical, porous body of resistor material having electrical terminals thereon and disposed in said casing, said body obstructing the path for constraining fluid in the path to diffuse into said body through a first surface thereof, to be heated by said body, and to leave said body through a second surface thereof, said first and second surfaces together constituting the major part of the total external surface area of said body, and a porous heat-conducting electrically insulating member disposed about and substantially co-extensive with said first surface of said body, said member serving as a flow distributor and preheater for both directing fluid to flow through said heater element and for gradually raising the temperature of the incoming liquid to the temperature attained by said heater element in operation of the unit, thereby minimizing boiling of the liquid externally of the liquid input surface of said member, the pores of said member being smaller than those of said heater element.

4. An electrical resistor heater unit as claimed in claim 3, wherein the porosity of said member is varied along its axial length so as to effect control of liquid flow rate through said element to counterect any hydrostatic variation in liquid pressure caused by the height of said element.

5. An electrical resistor heater unit as claimed in claim 3, wherein a hollow self-supporting elongated cylindrical porous inner body of resistor material having electrical terminals thereon is located concentrically inside said heater element to form effectively a heater unit having a plurality of heating regions.

6. An electrical resistor heater unit as claimed in claim 5 in which said regions are separated by a thermally insulated region.

7. An electrical resistor heater unit as claimed in claim 5, wherein said hollow cylindrical porous inner body comprises a material having a larger pore size than that of said heater element.

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