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Henley et al.

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[54] **ELECTRODE BOILER**

[75] Inventors: **Eric D. Henley**, Derby; **Michael T. Hall; Godfrey Toole**, both of Swindon, all of England

[73] Assignee: **British Railways Board**, London, England

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[30] **Foreign Application Priority Data**

Dec. 23, 1970 Great Britain................ 61176/70

[52] **U.S. Cl.**................. **219/285,** 219/275, 219/286, 219/289, 219/291, 219/292, 219/324

[51] **Int. Cl.** **H05b 3/60**

[58] **Field of Search** 219/284–295, 219/271–276

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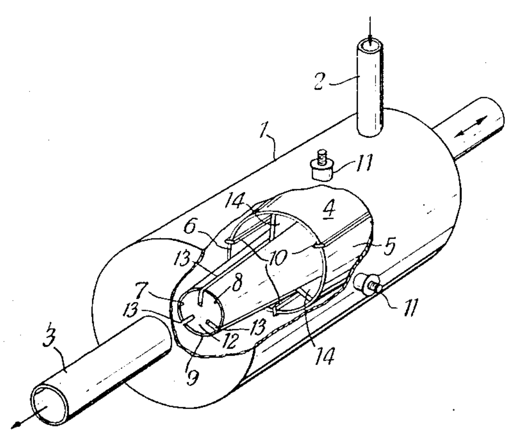
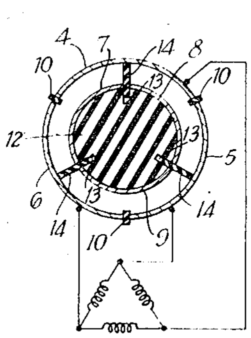
Primary Examiner—A. Bartis
Attorney, Agent, or Firm—George Vande Sande

[57] **ABSTRACT**

This invention relates to an electrode boiler in which the power electrodes are fixed and in which a separate transfer electrode, which is insulated from the power electrodes, is positioned in the current flow path between the power electrodes through the liquid to be heated. By altering the position of this transfer electrode, the power output of the boiler can be varied. The transfer electrodes are electrically insulated from each other and are electrically "floating" in the sense that they are not grounded nor connected to a terminal of the power source. The power electrodes are arranged in the form of a truncated cone as are also the transfer electrodes, the transfer electrodes being positioned concentrically of the power electrodes. Also, the transfer electrodes are rotatable relative to the power electrodes to permit varying the amount of effective overlap between the power electrodes.

3 Claims, 7 Drawing Figures





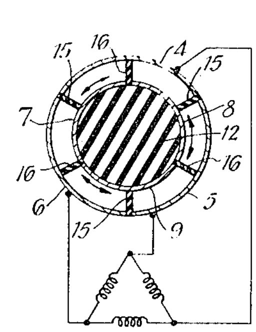


FIG. I

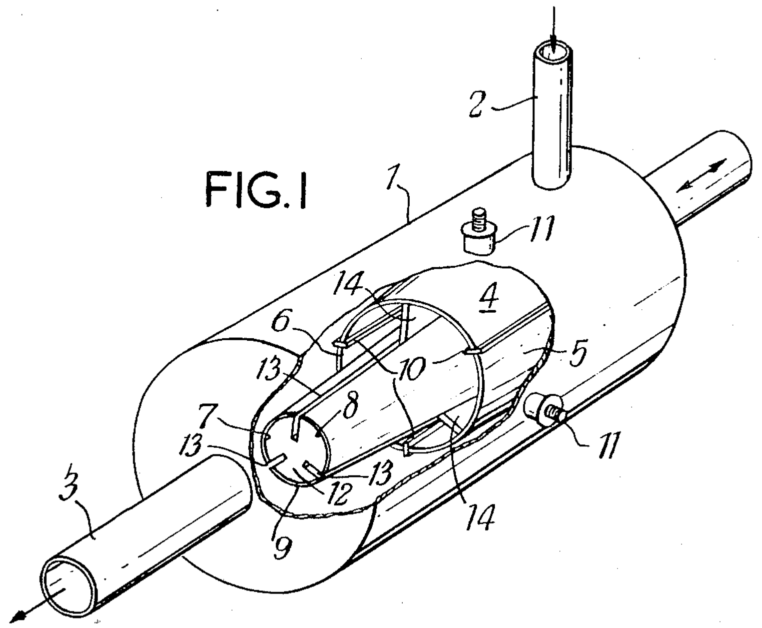


FIG. 2

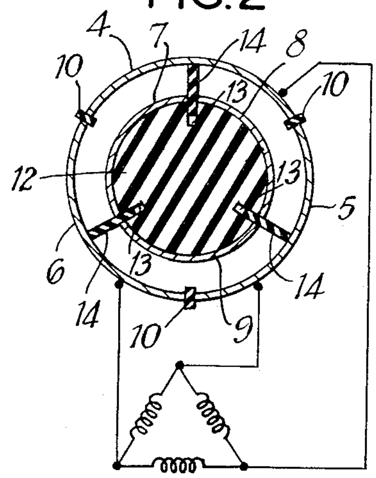
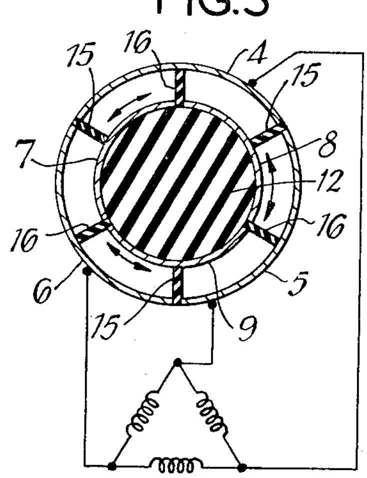


FIG. 3



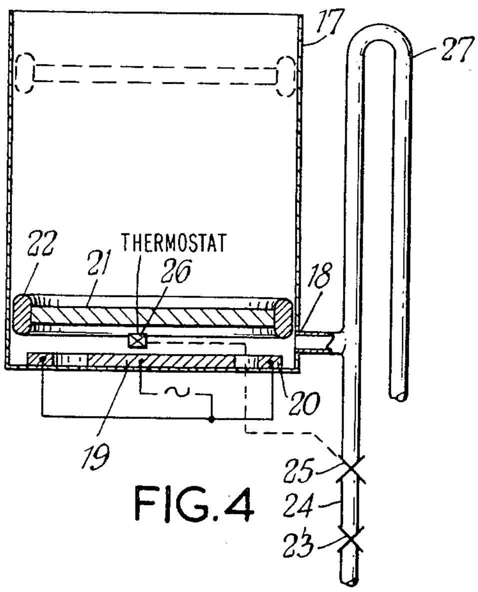


FIG.4

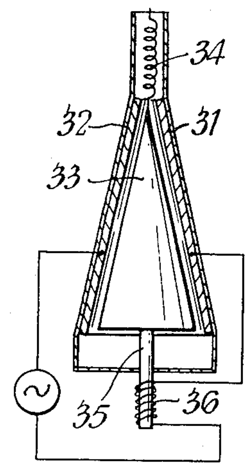
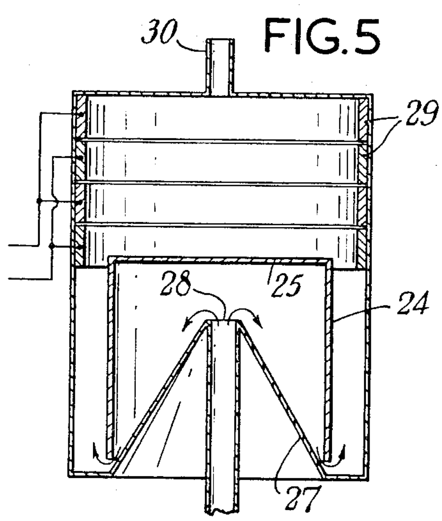


FIG.6

FIG.5



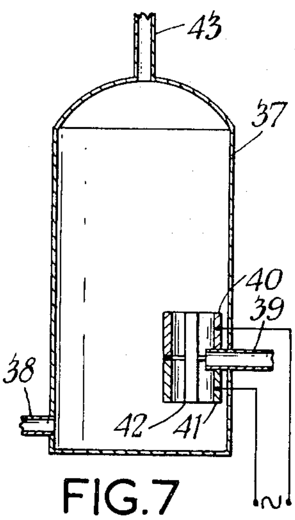


FIG.7

ELECTRODE BOILER

The present invention relates to an electrode boiler in which water, or other conductive liquid is heated by the passage of electric current between two electrodes immersed in the water.

In known electrode boilers, one of the methods of controlling the current passing between the electrodes is to alter the spacing between them, thus increasing the current path through the liquid. This arrangement necessarily requires that one or both of the electrodes be connected to the power supply by a flexible or sliding connection which is not satisfactory.

According to the present invention, there is provided an electrode boiler comprising two or more fixed power electrodes adapted to be connected to a source of electrical power, and one or more transfer electrodes insulated from each other and said power electrodes and each positioned in a current flow path between two of said power electrodes. The transfer electrodes are electrically "floating" in the sense that they are not grounded nor connected to a terminal of the power source.

Preferred embodiments of the invention will now be described with reference to the accompanying drawings in which:

FIG. **1** is a cut-away perspective view of an electrode boiler.

FIG. **2** is a cross section through part of an electrode boiler shown in FIG. **1** illustrating one arrangement of the electrodes.

FIG. **3** is a cross-section through part of an electrode boiler shown in FIG. **1** illustrating an alternative arrangement of the electrodes.

FIG. **4** is an axial cross section through a second embodiment of an electrode boiler.

FIG. **5** is an axial cross section through a third embodiment of an electrode boiler.

FIG. **6** is a diagrammatic representation of a fourth embodiment.

FIG. **7** is an axial cross section of a fifth embodiment.

The boiler shown in FIG. **1** consists of a casing **1** having an inlet **2** and an outlet **3.**

Water or other conductive liquid to be heated flows into the housing **1** through the inlet **2** and passes axially along the housing between three outer electrodes **4, 5** and **6** and three inner transfer electrodes **7, 8** and **9,** passing out of the housing through the outlet **3.**

The three outer electrodes **4, 5** and **6** are separated from each other by insulating strips **10** and each of the three electrodes is connected by way of a terminal **11,** which passes through the wall of the housing **1,** to one phase of a three phase power supply.

The three inner electrodes **7, 8** and **9** are held on an electrically insulating support member **12.** Slots **13** are formed in the support member **12** and extend between the electrodes **7, 8** and **9** which are thus insulated from one another. Strips **14** of insulating material are secured to the concave face of the electrodes **4, 5** and **6,** and extend across the annular gap between the inner and outer electrodes and engage in the slots **13.**

The inner and outer electrodes are both arranged in the form of a truncated cone, the cone formed by the inner electrodes being coaxial of the cone formed by the outer electrodes. The support member **12** for the inner electrodes is arranged to move axially of the housing **1** relative to the fixed outer electrodes thus varying the width of the gap between the inner and outer electrodes and hence the power output of the boiler.

Electric power from one phase of the three phase supply connected for example to the outer electrode **4,** can pass through the conductive liquid flowing between the electrodes to either of the two inner electrodes **7** and **8** and then back through the liquid to either of the two other outer electrodes **5** and **6.**

In the second embodiment shown in FIG. **3,** insulating strips **15** between the outer electrodes **4, 5** and **6** extend across the gap between the inner and outer electrodes and touch but do not penetrate the surface of the inner transfer electrodes **7, 8** and **9.** Similarly the three inner electrodes **7, 8** and **9** are separated by insulating strips **16** which extend across to the outer electrodes.

In the embodiment of FIG. **3,** the support member **12** for the inner transfer electrodes is rotatable about its longitudinal axis such that the area of each inner transfer electrode is not shared equally between two adjacent phases of the power supply applied to the outer electrodes. With the electrodes in the position shown in FIG. **3,** in which equal portions of the inner electrodes are opposite adjacent outer electrodes, maximum power is being consumed by the boiler. In the other extreme position, in which the member **12** is rotated until the strips **15** and **16** come into contact, each inner electrode is opposite only one outer electrode and consequently there can be no transfer of power via an inner transfer electrode between adjacent outer electrodes.

As the water passes along between the inner and outer electrodes, its temperature and hence its conductivity increases. To compensate for this in this embodiment, the inner and outer electrodes are preferably in the form of truncated cones so as to decrease the surface area of the electrodes in contact with the water as the water flows along in order to maintain the current density across the electrodes substantially constant.

FIG. **4** shows a third embodiment in which an insulated container **17** of preferably circular cross section is formed with a water inlet/outlet **18** adjacent its lower end. A circular electrode **19** is mounted at the centre of the floor of the container **17** and is surrounded by an annular second electrode **20.** These two electrodes **19** and **20** are connected to opposite poles of a single phase power supply.

A circular transfer electrode **21** is positioned above the power electrodes **19** and **20** and is provided with a peripheral float **22** of insulating material such as plastics material. Initially the transfer electrode **21** lies on top of the power electrodes **19** and **20,** the insulating material of the float **22** separating the electrodes and preventing a short circuit.

A water on/off tap **23** is provided in a water supply pipe **24** communicating with the inlet/outlet **18.** A water flow control valve **25** is also provided in the pipe **24** and is operatively connected to a thermostat **26** inside the container **17** as will be described.

To use the machine, the tap **23** is opened to admit cold water into the container **17,** and the power supply to the electrodes **19** and **20** is switched on. Only an initial small quantity of water is admitted into the container **17** before the thermostat **26** closes the flow valve **25.** This small volume of water is rapidly heated due to the current flow between the electrodes 19 and 20, both directly and via the transfer electrode 21, the initial volume of water being sufficient to just float the transfer electrode 21.

When the temperature of the water reaches the pre-set operating temperature of the thermostat 26, this operates to open the flow valve 25 to admit more water which mixes with the heated water in the container 17 until the temperature falls below the operating temperature of the thermostat 26 which then operates to close the valve 25 again. This increased volume of water is heated by the current flow between the power electrodes 19 and 20 until its temperature again rises to the operating temperature of the thermostat 26 when more water is admitted as before. The container 17 thus fills gradually with water at or near the desired high temperature, at which it is has a higher conductivity than when cold which is electrically desirable.

When the water reaches the top of the container 17, the current supply and the water are automatically switched off by way of a float switch (not shown). In this position, the level of water in the container 17 is above the top of a syphon 27 connected to the water inlet/outlet 18, which then operates to syphon off the hot water in the container 17. Actual discharge can be delayed by means of a valve (not shown) in the syphon which will only open when the final temperature of the water is at the pre-set level.

The advantages of this arrangement include:

i. Rapid heating since water always at or near maximum desired temperature, hence with maximum conductivity,

ii. Stable current conditions.

iii. Tolerant of different conductivities in water supplies.

If desired, this embodiment can be used in a coin-operated vending machine, the insertion of a coin initiating the switching on of the current supply and the water on/off tap 23.

As an alternative to using a circular disk electrode 19 and a concentric annular electrode 20, a pair of semi-circular disk electrodes laid side by side, their straight sides being separated by a uniform gap, may be used.

A fourth embodiment, is shown in FIG. 5. In this embodiment a movable, cylindrical, heavier-than-water, transfer electrode 24 having a closed top face 25 is positioned in a housing. The floor 27 of the housing is upwardly conical with a cold water inlet 28 at the apex.

A number of cylindrical power electrodes 29, alternately connected to opposite poles of a power supply are mounted in the upper portion of the housing 26. A water outlet 30 is positioned in the top of the housing 26.

A jet of water flowing into the housing through the inlet pipe 28, lifts the transfer electrode and brings it partially opposite the power electrodes 29. As the flow of water is increased, the transfer electrode 24 is lifted higher inside the housing 26 and hence more current flows between the electrodes 29 via the transfer electrode 24.

The conical floor 27 of the housing helps to stabilize the position of the transfer electrode 24. As the electrode 24 rises in the housing, so the size of the gap between the lower rim of the electrode 24 and the conical floor 27 increases. Provided that the area of the annulus between the electrode 24 and the wall of the housing is greater than the area of the annular gap between the lower rim of the electrode 24 and the conical floor 27, the piston effect of the electrode 24 will be eliminated and the transfer electrode 24 will assume a fixed position for a given water flow.

Insulating spacers or guides (not shown) will be necessary to centralize the floating transfer electrode 24 in the housing 26 and to prevent it from touching the power electrodes 29.

Adjustment for varying ranges of conductivity and flow rate of the water can be made by altering the weight of the transfer electrode 24.

A further embodiment is shown diagrammatically in FIG. 6. In this embodiment, a pair of semi-conical power electrodes 31 and 32 are arranged in the form of a cone being separated by suitable insulating strips. A conical transfer electrode 33 is positioned as shown, concentrically of the cone formed by the two electrodes 31 and 32. The apex of the electrode 33 is connected to the housing by a spring 34. A metal rod 35 extending from the base of the transfer electrode 33, is surrounded by a solenoid coil 36 is connected in series with the current supply leads to the power electrodes 31 and 32.

The current flowing in the boiler will depend upon the applied voltage and the conductivity of the water. If the applied voltage is fixed then the current flowing will be directly proportional to the conductivity. The current flow through the coil 36 determines the force applied to the electrode 33 against the spring 34.

As the temperature of the water increases, so its conductivity rises and hence the current flow between the electrodes 31 and 32, via the transfer electrode 33, increases. This increased current passes through the solenoid coil 36 which increases its downwards pull on the electrode 33 to increase the gap between the electrodes 31, 32 and the transfer electrode 33 with the result that the length of the current flow path through the water, and hence the resistance of this path, increases with a corresponding decrease in the current flow.

A corresponding solenoid arrangement can alternatively be employed in which the force of the solenoid is directed to turn the conical transfer electrode about its longitudinal axis, in order to vary the current flow, against the action of a spiral spring. The arrangement of the electrodes in this case would be somewhat as shown in FIG. 3.

The longitudinal or rotational mvoement of the transfer electrode 33 could alternatively be carried by remote magnetic action. This would avoid the use of the rod 35 with its attendant problems of sealing where it passes out of the housing, in this case the magnetic field produced by the solenoid 36 would act on the electrode 33 through the wall of the housing.

A last embodiment is shown in FIG. 7. One of the limitations of the direct electrical heating of water prior to actual use can be the load carrying capacity of the existing wiring at given sites. For this reason hot water storage is desirable, and this embodiment covers an arrangement of an electrode boiler to give hot water storage as well as some heating on draw-off.

FIG. 7 shows an electrode boiler consisting of a tank 37 having a cold water inlet 38 and a hot water outlet 39. A pair of cylindrical electrodes 40 and 41 are positioned adjacent the outlet 39 and are connected to opposite poles of a voltage supply. A cylindrical transfer electrode 42 is positioned centrally of the two power electrodes. The pipe forming the water outlet 39 passes into the annular space between the tubular electrodes **40** and **41** and the cylindrical transfer electrode **42.**

The tank **37** is initially filled with water up to the level of a vent pipe **43** formed in the top thereof and is maintained at this level by a suitable valve (not shown).

Water, which is heated by the passage of current between the electrodes **40** and **41** via the transfer electrode **42,** circulates in the tank **37** by convection. When hot water is drawn off from the outlet pipe **39** it is taken from directly inside the electrodes **40** and **41** where it is hottest. In this way water can be stored in the tank hot but below its using temperature but can be drawn off at the correct temperature.

The position of the transfer electrode **42** can either be varied to vary the temperature of the water or may be pre-set in the factory to the desired point and fixed at the point. The temperature may be also varied by using transfer electrodes of different diameters.

The electrode boilers described in the foregoing description can be used to heat any conductive fluid though their major application is in the heating of water for industrial or domestic use. Another application is in the rapid heating of milk in order to pasteurize it.

We claim:

1. An electrode boiler comprising,

a housing having a liquid inlet and a liquid outlet,

a plurality of power electrodes arranged in the form of a truncated cone and mounted in said housing and connected to respectively different terminals

of an electric power source,

a plurality of transfer arranged also arRanged about a common axis in the form of a truncated cone and positioned concentrically of said power electrode and spaced therefrom so as to leave a fluid flow path therebetween,

said transfer electrodes being electrically insulated from each other and electrically isolated from said power source so that each said transfer electrode is included in an electric circuit path only for the flow of current from one power electrode to another power electrode through the liquid disposed between said power electrodes and said transfer electrodes,

means for selectively rotating said transfer electrodes about their common axis relative to said power electrodes to thereby present a variable overlap between said power electrodes and hence a variation in the power output to the boiler.

2. An electrode boiler as claimed in claim **1** wherein said fluid flow path is from the larger diameter to the smaller diameter end of said conical electrode arrangement.

3. The heater of claim **1** which includes three said power electrodes and three said transfer electrodes, said power source being a three-phase delta power source whose three terminals are each connected to respective ones of said power electrodes.

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