Aug. 11, 1964 C. V. FOLEY ETAL 3,144,546

IMMERSED ELECTRODE HEATER FOR LIQUIDS

Filed March 5, 1963 2 Sheets-Sheet 1

Fig. 1

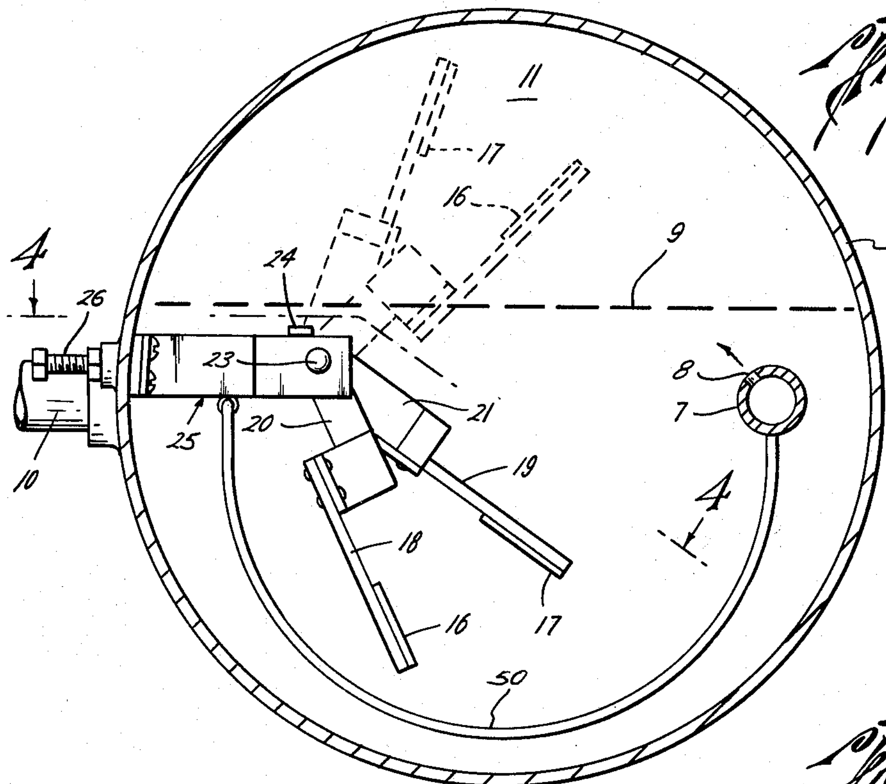
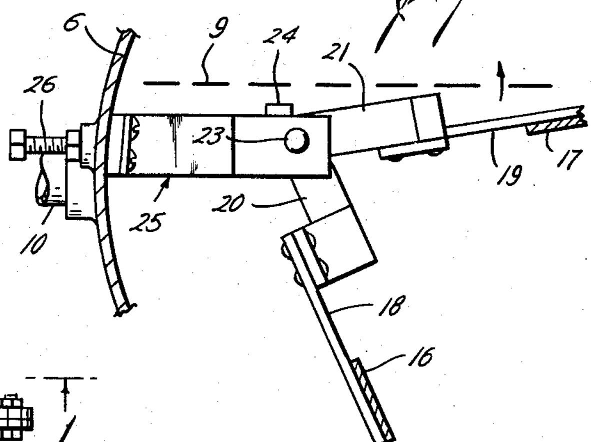


Fig. 3



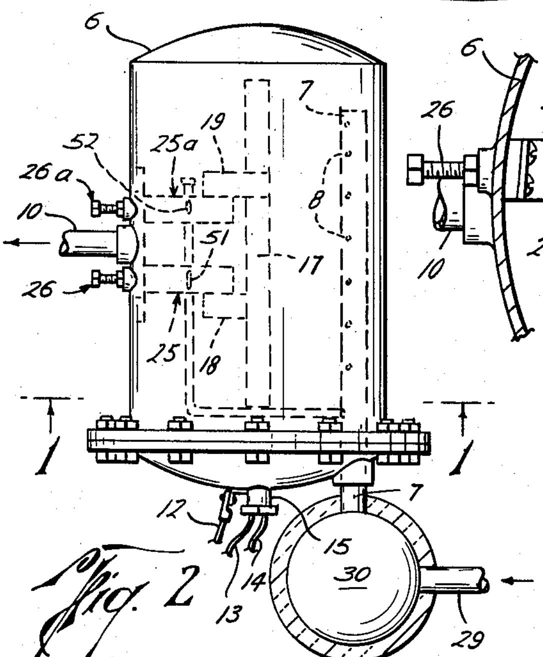


Fig. 2

Clyde V. Foley
Andrew H. Muhl
INVENTORS

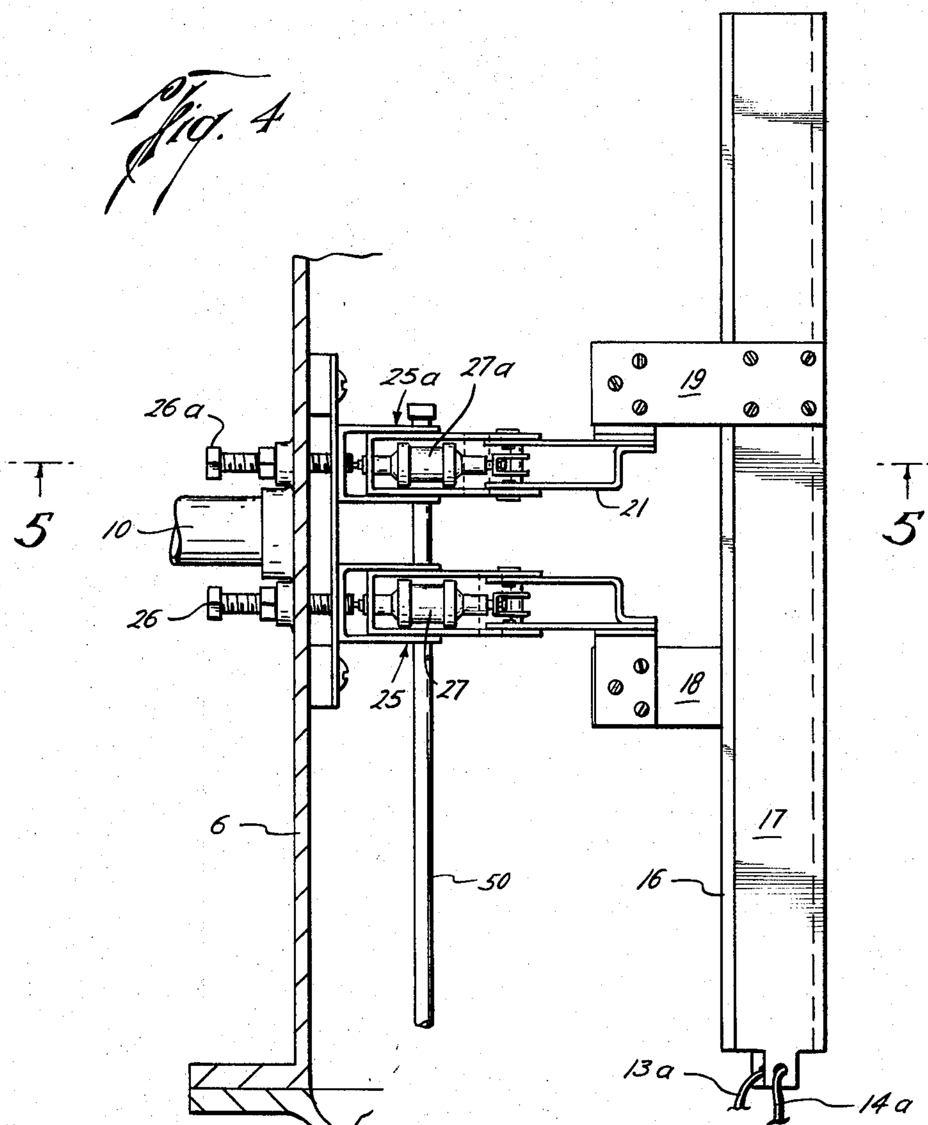
BY Browning, Simms, Hyer & Eisenmenger

ATTORNEYS

IMMERSED ELECTRODE HEATER FOR LIQUIDS

Filed March 5, 1963 2 Sheets-Sheet 2

Fig. 4



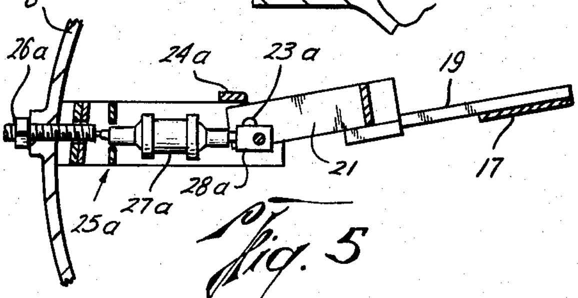


Fig. 5

Clyde V. Foley
Andrew H. Muhl
INVENTORS
BY Browning, Simms, Hyer & Eisenroht
ATTORNEYS

3,144,546

IMMERSED ELECTRODE HEATER FOR LIQUIDS

Clyde V. Foley and Andrew H. Muhl, both of P.O. Box 7753, Houston 7, Tex.

Filed Mar. 5, 1963, Ser. No. 262,968
8 Claims. (Cl. 219—289)

This invention is an improved immersed electrode type heater for liquids in which liquid to be heated is used as a resistance element in an electric circuit. This application is an improvement of the heater described in our U.S. Patent No. 3,053,964.

A great many heaters in which a conductive liquid is connected into an electrical circuit are known. In fact, an entire sub-class of patents is devoted to heaters of this type. A principal disadvantage of such heaters large enough to supply water for usual household uses results from the necessity of controlling flow of current both to prevent overheating of water in the heater and to prevent large surges of electricity on feed lines when the current is switched on and off.

When the temperature of water in an instantaneous household water heater of immersed electrode type is controlled by intermittent application of electric current, variations in demand on power supply lines have been so large as to require a rheostat for their control to prevent undesirable variations in voltage in the supply lines; but heaters equipped with rheostats are so expensive that they are not competitive in the household water-heating field.

In our prior Patent No. 3,053,964 we have shown a water heater in which the use of an outside rheostat is unnecessary. In that patent we used a means for making and breaking electrical contact which included a pair of contact points, one of which was movable through water from a position in a body of nonconductive gas in the heater above the surface of the water to a position making contact with a stationary second point at a position deep in the body of water. This movement permitted the use of varying resistance of water between the contact points to serve as an automatic rheostat. This means of control is an excellent one but requires that an electric circuit be completed by contact between two metallic members and occasionally may be subject to the disadvantage of sticking contact points.

All liquid heaters which contain gas in a closed heating zone are also subject to excessive backup of hot liquid into cold liquid feed lines due to variations in pressure on the cold liquid, such as are common in water supply systems, or to variations of pressure within the heater. Excessive backup may result in hot water being supplied to cold water faucets and result in loss of heat dissipated through the walls of the cold water feed line.

It is an object of the present invention to provide a small, compact electrical heater of immersed electrode type having sufficient capacity for ordinary household use in which the electrical circuit is made and broken without making and breaking contact between metallic members.

Another object is to provide a heater of the above type in which the large and instantaneous surges in power requirement are avoided by a varying resistance supplied by water to be heated, and in which all make and break of electric current is accomplished at an interface between water and a movable electrode.

Another object is to provide a heater of the above type in which adjustment to compensate for variations in electrolyte content of water are easily made from outside the housing of the heater.

Another object is to provide a highly efficient heater of the above type in which localized overheating of water with accompanying boiling and bumping are eliminated.

Another object is to provide a heater of the above type in which backup of hot water from the heater into cold water feed lines attached thereto in response to normal variations in water pressure on the feed lines and to variations in pressure of a gas confined above liquid level in the heater is substantially eliminated.

These objects are accomplished in the present invention by the provision of a heater of submerged electrode type in which the water or other conductive liquid to be heated supplies not only the heating resistance but a variable resistance for gradually increasing and decreasing the amount of electric current flowing through the liquid. As in our earlier heater, the liquid in the heater thus performs a function formerly requiring outside controls such as a rheostat, as well as the function of a heating element.

In the present invention a housing adapted to contain an electrically conductive liquid in a lower part thereof is provided. It is preferred that the housing be of electrically conductive material, be horizontally elongate and be connected to one lead of an electric current supply system, such as an ordinary house wiring circuit.

A body of nonconductive gas, such as air, is maintained in the housing above liquid level therein. The housing may have an opening to the atmosphere communicating with the body of gas but preferably is gas tight so that separate liquid level controls are not required. It is preferred that the housing have an inlet adapted to introduce a stream of cold electrically conductive liquid, such as water, and an outlet for heated liquid. When the housing is gas tight, the outlet is arranged at a side thereof so that, when cold liquid is introduced at fairly constant selected pressure, the outlet will be a short distance below liquid level in the housing when liquid and gas pressures are normal.

The gradual application and discontinuance of electric current flowing through the body of liquid is accomplished by providing at least one electrode in the housing which is arranged for lateral movement between a first position in which the electrode is entirely in the body of nonconductive gas in the housing above the liquid and a second position in which the electrode is entirely submerged in the body of liquid at a selected distance from the housing. The electrode is permanently connected to one lead of the electric current supply so that current begins to flow through the body of liquid to the housing at the time the electrode makes contact with the surface of the liquid; and as the electrode is moved further down into the liquid, the distance between the electrode and the housing decreases, thus lowering the resistance provided by the liquid in the space between the electrode and housing as the electrode moves to its second position.

Preferably two separate electrodes are used, each connected to a separate lead of a three-wire electric current supply system such as is commonly used with 220-volt house wiring circuits. When a three-wire 220-volt circuit is used, it is preferred that the housing be connected to a lead, usually called the "ground" wire, so that there is a potential of 110 volts between the housing and each of the electrodes and a potential of 220 volts between the electrodes.

A suitable temperature-responsive means is provided for moving the electrodes between positions entirely in the gas above the liquid and positions in which the electrodes are entirely submerged. When two electrodes are used in a three-wire system, the temperature-responsive means is preferably a pair of thermostats supported on a suitable support within the housing at a location near the outlet. The thermostats are set at such temperatures that the upper electrode is moved out of the liquid into its first position in the nonconductive gas in response to rising temperature before the lower electrode begins to move upward.

Means for selecting the distance between the electrodes in their second positions in the liquid and between the electrodes and housing is provided. This means preferably includes one or a pair of independently operable screws extending through the housing and connected to vary the positions of the thermostats controlling movement of the electrodes, thus providing a means for varying the distances between the electrodes in their respective second positions and between the electrodes and housing. It is necessary that these positions be adjustable in water heaters because water from different sources varies greatly in its electrolyte content. When the electrolyte content is low, the spacing between electrodes and between electrodes and housing should be relatively small as the resistance of the water is high, and a relatively short length of water supplies the required resistance for heating. On the other hand, when the electrolyte content is high, the distance between the electrodes and between the electrodes and housing should be greater so that the required amount of resistance for efficient operation is attained.

It is preferred that this heater be used with an alternating current supply, as alternating current prevents electrolytic deposition of scale-forming materials upon the surfaces of the electrodes.

Heaters which contain an enclosed body of gas are subject to the disadvantages that normal variations in water pressure result in a considerable expansion and contraction in the gas above the liquid. In water heaters, this frequenly results in backup of hot water into a cold water feed line connected to the heater and in our preferred type of heater this is prevented by connecting a small surge tank into the cold water line adjacent to the point at which the line connects with the heater inlet. This small tank may be merely a short section of insulated four-inch pipe having the inlet to the heater connected to an upper part thereof and a cold water feed line connected to the tank near the bottom. It will be seen that a section of four-inch pipe one foot in length will care for the same amount of backup that would require 64 feet of ½-inch pipe. Alternatively, a partition, preferably double walled and having an air space between the walls may be placed in the heater, the inlet line to the heating chamber being connected to the chamber formed between the partition and the bottom of the heater shell near an end of the chamber. An inlet line for cold liquid is arranged to introduce the cold liquid into the chamber near an opposite end of the heater. The heat put in by the electric current is thus easily conserved while the apparatus is still compact.

It is preferred that a small bypass line connected with the main inlet line be arranged to conduct cold water from the inlet directly to a position adjacent to the thermostats and that this line have openings discharging water substantially directly to the thermostats. The reason for this line is to be sure that the lower thermostat is moved downward to the full extent of its travel at the moment hot water is withdrawn from the heater. This withdrawal of hot water will cause flow of cold water through the inlet line and through the bypass line directly to the thermostats and thus cool the thermostats disproportionately with respect to the water in the heater. The bypass line should have two openings, a larger opening directing cold inlet water to the thermostat controlling the lower electrode and a smaller opening directing water from the same line to the upper electrode. The reason the larger opening is used to lead water to the thermostat controlling the lower electrode is to make sure the electrodes do not approach each other while in the body of liquid to a distance so small that the discharge between electrodes amounts substantially to arcing with resulting overheating of water between the electrodes and pumping and boiling in this local position.

In a less preferred form, our heater may contain a body of nonconductive gas open to the atmosphere above the water to be heated. The necessity for a surge tank is thus eliminated but the advantage gained is usually more than offset by the necessity for providing an inlet valve operated by a float or other water-level-sensitive means within the heater for maintaining the required water level therein and by the necessity for providing a pump or gravity flow system for withdrawing hot water from the heater. Heaters of this type are especially useful in cafeteria warming systems.

In the attached drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is a vertical cross section through one preferred type of heater of the present invention;

FIG. 2 is a plan view of the heater of FIG. 1, illustrating the location of inlet and outlet relative to each other and positions of the electrodes;

FIG. 3 illustrates one preferred method for mounting the electrodes for limited movement and an arrangement for means for adjusting distance between electrodes and housing;

FIG. 4 is an enlarged detail of the heater of FIG. 1 on the line 4—4; and

FIG. 5 is a detail of the preferred temperature-responsive device for moving electrodes taken on the line 5—5 of FIG. 4.

In the drawings the reference numeral **6** designates a housing having a cold water inlet line **7** disposed therein near to one side of the housing. The inlet line **7** is perforated with a plurality of openings **8** arranged to direct incoming water in a plurality of jets upward toward the surface **9** of the body of liquid contained in the housing **6** and across toward an outlet **10** attached to the housing on the side opposite to inlet **7**. We have found that location of the inlet and outlet near opposite sides of the housing, with the inlet near to and beneath the surface of the body of liquid, and construction of this inlet as a means for introducing a plurality of jets of liquid into the body of liquid upward toward the surface thereof and across toward the outlet greatly increases the smoothness of the heating obtained and eliminates all danger of uneven heating, bumping, boiling and such undesirable heating characteristics in a heater of this type. The outlet preferably is located near and between a pair of thermostats described below.

The location of the inlet and outlet in this manner has been found to be highly advantageous in maintaining the interface between liquid and gas at a desired level in a closed heater. If there is any localized overheating from any cause with resulting bumping, boiling or flashing liquid to vapor, the resulting vapor passes into the gas space and increases the quantity of gas therein. Then if the outlet be opened, non-conductive gas may be withdrawn and lost through the outlet so that the operation of electrodes described below becomes erratic and the desired effect cannot be obtained. The housing **6** illustrated is of closed type, and the position of the outlet is selected so that a body of air **11** is maintained in housing **6** above the liquid level **9** within the housing.

The heater shown is designed to be used with a three-wire 220-volt electric current supply system and has "ground" or neutral lead **12** of the system connected to the housing **6** which is made of electrically conductive material, preferably ordinary stainless steel. The other two leads of the three-wire electric current supply system, designated as **13** and **14**, enter the housing through a suitable fluid-tight connection **15** conveniently located and are connected through suitable flexible portions **13**a and **14**a shown in FIG. 4 to electrodes **16** and **17** within the housing so that there is equal potential (110 volt) between the housing and each electrode and twice said potential (220 volt) between the two electrodes.

The housing illustrated is horizontally elongate and the electrodes **16** and **17** are merely strips of an electrically conductive material, preferably stainless steel, carried on insulated arms **18** and **19**, respectively. Arms **18** and **19** have metallic sections **20** and **21** which are pivoted on shafts **23** for rotation in a vertical plane between positions in which the electrodes are entirely in the body of gas above the liquid as shown in dotted lines and second respective positions of the electrodes in which arms **18** and **19** and electrodes **16** and **17** occupy the positions shown in full lines.

It will be seen that electrodes **16** and **17** move laterally from a first position of each electrode in the gas above liquid in the housing to a second position for each electrode in which the electrode is entirely submerged in liquid. The broad surface presented by an electrode to the surface of the liquid as the electrode moves downward prevents localized overheating and results in smooth application of electric current to a large cross-section of the body of liquid.

The positions of the electrodes in the body of gas are limited by contact of the upper edge of metallic sections **20** and **21** with stops **24** and **24***a* attached to supports **25** and **25***a*. The stops **24** and **24***a* are arranged to prevent close approach of electrodes **16** and **17** to each other when in their respective first positions in the body of gas. This arrangement prevents arcing between wet electrodes when moved out of the liquid being heated.

The lower positions of electrodes **16** and **17** may be controlled by a pair of adjustment screws **26** and **26***a* which extend through the wall of the housing near the outlet **10** and make contact with outer ends of a pair of thermostats **27** and **27***a*, illustrated as of a common type which contains an expansible fluid. The thermostats **27** and **27***a* are mounted in supports **25** and **25***a* for longitudinal movement therein and at their inner ends are operably connected to metallic portions **20** and **21** by a connection illustrated as an eccentrically pivoted block **28**. Advance or retraction of the adjustment screws **26** and **26***a* in support members **25** and **25***a* thus determines the location of the lower end of an arc through which the electrodes travel from the first position limited by stops **24** and **24***a* to the second position determined by contraction of thermostats **27** and **27***a*.

In our preferred arrangement illustrated, a separate thermostat for each electrode is located within the body of liquid near the outlet from the heater. Preferably, these thermostats are of the type which expand with increasing heat and are connected in driving relationship to the pivoted arm carrying the respective electrode controlled by each thermostat. The thermostats are set so that a substantial temperature differential exists between their respective operating temperatures. For example, if it should be desired to maintain the body of liquid in the heater at a temperature of 200° F., the thermostate controlling the upper electrode may be set so that this electrode is moved from its second position in the body of liquid to its first position in the nonconductive gas above the liquid at a temperature of about 185° to 190° F. while the thermostat controlling the 110-volt electrode is set to move the 110-volt electrode from liquid into the gas at 200° F.

It will be observed that the sequence of movement of the electrodes is reversed as the electrodes enter the liquid to perform their heating function; that is, the lower volt electrode will enter at any time the tempertaure of the liquid falls below 200° F.; and if the current supplied by this electrode is insufficient to maintain the temperature of the liquid above the temperature required to operate the upper electrode, the second electrode will then enter the liquid and the greatly increased heating power of the upper electrode will become available.

While the double screw adjustment just described is the preferred structure, it is possible to omit one of these screws when the characteristics of the fluid to be heated are well known. In any case it will be seen that at temperatures in the range between that at which the upper electrode is removed from the liquid and that at which the lower electrode reaches its second position in the liquid the lower electrode will be stationary and the upper electrode will vary its position according to the temperature of the liquid, moving upward with increasing temperature until it ultimately occupies its first position in gas above the liquid.

A small bypass line **50** communicates with inlet line **7** and is disposed to carry cold inlet water from line **7** to points just beneath thermostats **27** and **27***a*. Line **50** has a larger opening **51** immediately below thermostat **27** and a smaller opening **52** below thermostat **27***a*. It will be seen that, at the beginning of flow of cold water through inlet line **7**, a small proportion of the cold water will be bypassed through line **50** directly to thermostats **27** and **27***a*. The thermostats then will be lowered immediately into the water and, when the water is heated sufficiently, thermostat **27***a* will lift the upper electrode **17** out of the liquid into the body of gas above the liquid. If the heat requirements are such that the lower electrode is sufficient to supply the required quantity of heat, the upper electrode remains in the body of gas above the liquid. Upon closing the outlet so that no more hot water is withdrawn, the flow of water through inlet **7** ceases and the temperature of the water in the body of the heater causes the second thermostat to move upward into the body of gas.

In the closed type heater illustrated in the drawings, the body of gas **11** necessarily increases and decreases in pressure as temperature fluctuates and as variations in inlet pressure occur. A small surge tank **30** preferably is connected between an inlet line for liquid flowing to the heater and the inlet line **7**. The liquid supply line **29** is of course connected to a lower part of surge tank **30**, and the inlet line **7** is connected to an upper part thereof. Thus, any backflow caused by variation of gas pressure within the heater and which would otherwise result in backup of hot water into the supply line **29** merely moves hot liquid into the surge tank **30** where it is trapped. Tank **30** may be insulated as illustrated so that there is little loss of heat due to backup of hot liquid.

In a heater of the type shown in the drawings in which the diameter of a horizontal cylindrical shell **6** was 10½ inches we found that location of a ½-inch inlet line **7** at a level 5½ inches below the top of the heater, approximately on a horizontal diameter of the shell, and location of the outlet **10** 4½ inches, i.e., about .43 of the shell diameter, below the top of the shell, gave best results in smoothness in operation and in maintaining the liquid level in the heater at the proper position.

It was found that, when the inlet and outlet were changed more than 10 percent of the shell diameter from these positions, water was the liquid heated and air was the gas in the shell above the heater, the heater performed erratically. The water-air interface could not be maintained at the proper level. Air was lost through the outlet; the liquid level rose until the electrodes in their respective first positions were in contact with liquid and heating could not be controlled.

It was found that location of the inlet and outlet as described above not only resulted in smooth operation of the heater but maintained the air-water interface at about 3½ inches (30 percent of the shell diameter) below the top of the shell with maximum variations of about ½ inch or so above and below this level.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. A heater for an electrically conductive liquid comprising in combination a housing adapted to contain a body of electrically conductive liquid in a lower part thereof; a body of nonconductive gas in the housing above liquid level; means for introducing liquid into the housing below liquid level therein in a series of jets spaced from each other longitudinally of the housing and directed upward and across the housing; an outlet for liquid communicating with a central part of a side of the housing opposite said means for introducing liquid; at least one horizontally elongate electrode in the housing; means, in the housing responsive to temperature of liquid therein, for moving the electrode laterally between a first position in which the electrode is entirely in the body of gas and a second position in which the electrode is entirely below liquid level in the housing; means, operable from outside the housing, for adjusting said second position of the electrode; and means for passing an electric current through the electrode and liquid in contact therewith.

2. The heater of claim 1 wherein the housing is horizontally elongate and has a closed top, the outlet is disposed at a point below liquid level in the housing, and the means for introducing liquid into the housing is a pipe having a series of lateral openings directing said jets.

3. The heater of claim 2 including a surge tank, a supply line for cold liquid communicating with the interior of the surge tank near the bottom thereof and in which the pipe having lateral drilled openings communicates with an upper part of the surge tank.

4. The heater of claim 1 wherein the temperature-responsive means for moving the electrode includes a thermostat located below liquid level in the housing near said outlet and the means for adjusting the second position of the electrode is arranged to vary the position of the thermostat.

5. The heater of claim 1 having two electrodes positioned one above the other and, independently movable between separate first positions in said gas and separate second positions below said liquid level, two separate temperature-responsive means for moving the electrodes between the first and second positions and exteriorly adjustable means for adjusting the second position of at least one of said electrodes.

6. The heated of claim 5 wherein the housing and each of the electrodes are connected to separate leads of a three-wire electric current supply system so that there is equal potential between the housing and, each, of the electrodes and twice said potential between the electrodes; and the temperature-responsive means move the electrodes between their respective first and second positions at different temperatures.

7. The heater of claim 1 wherein the means for introducing liquid into the housing includes a bypass line having an opening adjacent to the temperature responsive means.

8. The heater of claim 5 wherein the means for introducing liquid into the housing includes a bypass line arranged to conduct a smaller proportion of heated liquid to points adjacent the two temperature responsive means, and two openings in the bypass line of different cross section, namely, a larger opening arranged to discharge inlet liquid at a point adjacent to one temperature responsive means and a smaller opening adjacent to the second temperature responsive means.

References Cited in the file of this patent

UNITED STATES PATENTS

1,516,203	Oakley	Nov. 18, 1924
1,648,588	Nerew	Nov. 8, 1927
2,090,282	Bock	Aug. 17, 1937
2,387,103	Wicks	Oct. 16, 1945
2,428,445	Wicks	Oct. 7, 1947
3,053,964	Foley et al.	Sept. 11, 1962