

Jan. 2, 1934.

G. N. SEXTON

1,941,584

ELECTRICAL HEATER

Filed Feb. 20, 1931

2 Sheets-Sheet 1

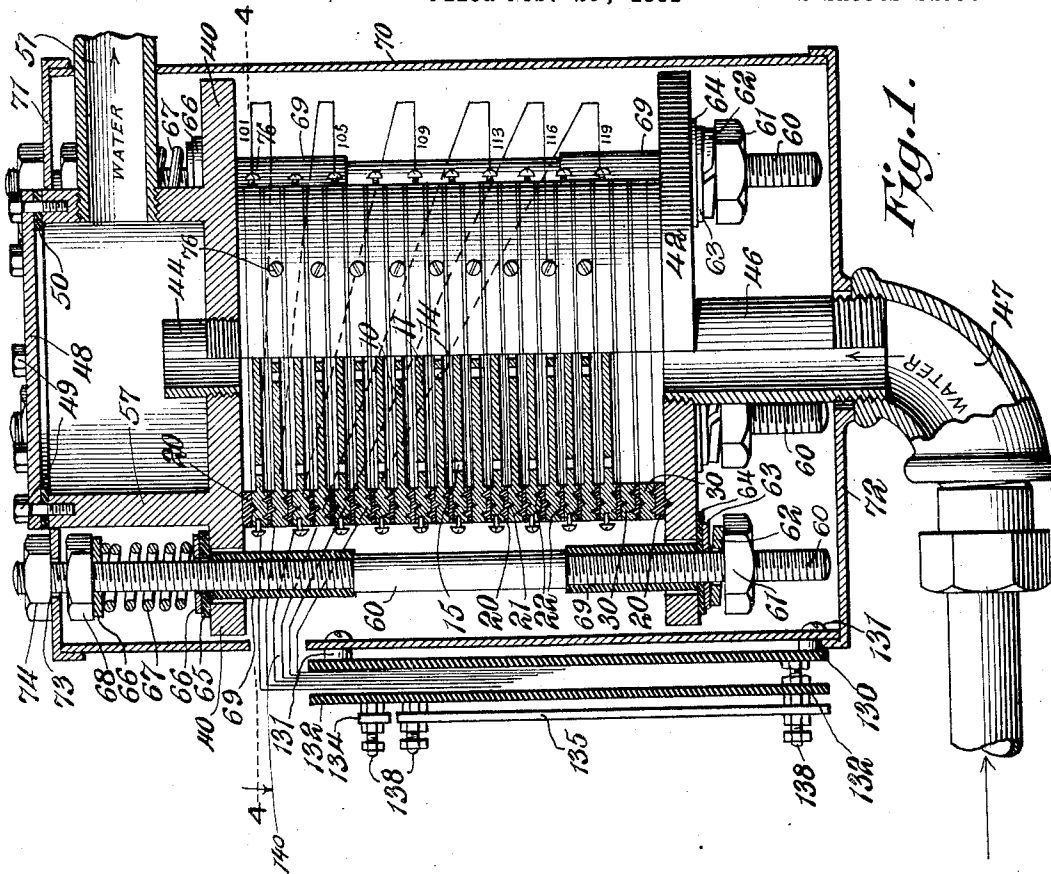
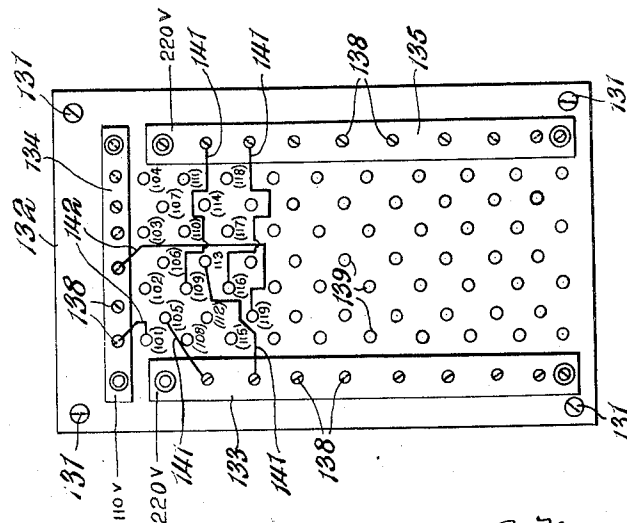


Fig. 2.



Inventor

J. Norvell Sexton
Mauo & Lewis
Attorneys

Mauo + Lewis

Attorneys

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2 Sheets-Sheet 2

Fig. 4.

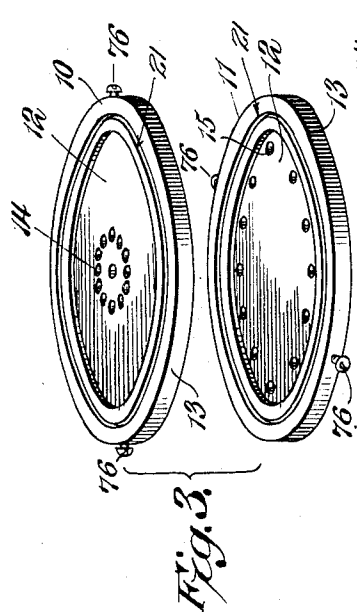
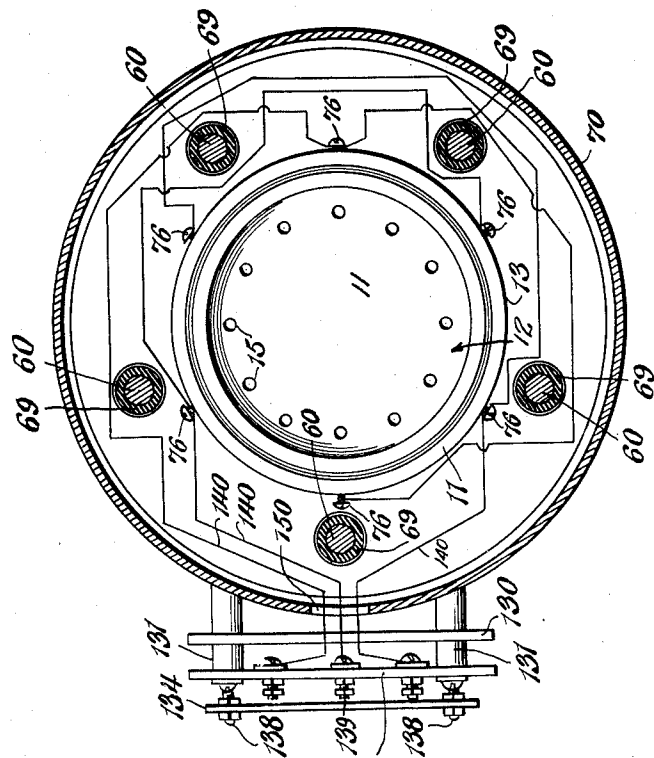
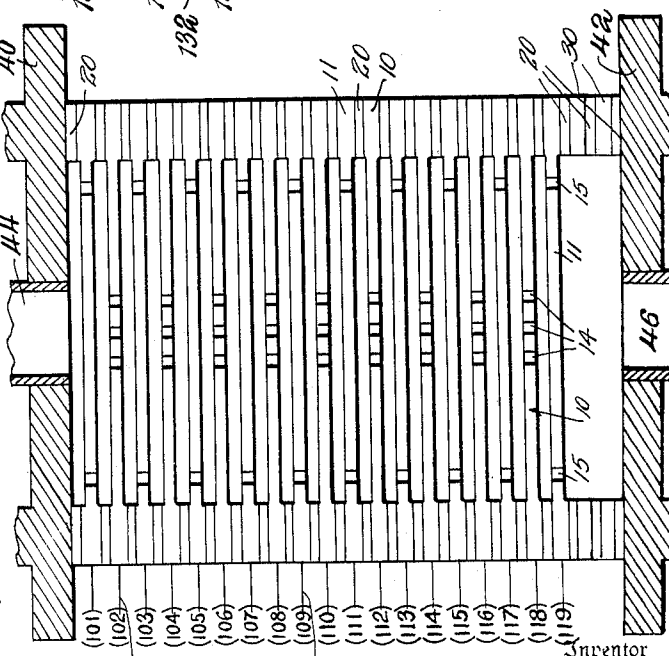


Fig. 5.



Inventor
G. Norvell Sexton
Mauro + Lewis

Attorney

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ELECTRICAL HEATER

George Norrell Sexton, Richmond, Va.

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26 Claims. (Cl. 219—40)

The invention relates to electric heaters, and to systems for connecting such heaters in circuit.

While the heater here shown may be used for many purposes, it is intended, more particularly, for the heating of water for household supply. As here shown, the heater is connected directly in the pipe line, but its use is not limited to this type of connection.

The heater belongs to that type in which the heat is generated by the passage of current directly through the fluid while the fluid is flowing through the heater, as distinguished from those heaters in which the current passes through some special resistance material from which the heat is transmitted to the fluid by conduction or radiation to the fluid.

While chemically pure water has a very high resistance, too high to be heated by current at commercial voltages, the water that is ordinarily used for household supply always contains more or less mineral matter in the form of dissolved salts and other foreign matter; and the presence of these salts or other substances, even in small quantities, so lowers the resistance of the water that current of commercial voltages may be readily used to secure the necessary heat.

Moreover the water from any one locality is substantially constant in its dissolved salts and other foreign matter, so that it is practical to so adjust the heaters for any given locality that they will consume only the current necessary to produce the required heat; and when once adjusted do not ordinarily require to be changed. Therefore while the resistance of water of different localities may vary considerably, the fact that it does not vary substantially for any given location makes it possible to so adjust the heaters that they may be adapted to any particular locality when used as water heaters; and when they have been once adjusted they may continue in use without substantial change for an indefinite period of time.

Heaters in which the heat is developed by current flowing through the fluid itself are best adapted for use with alternating currents. While direct current may be used, a certain amount of fluid is then always decomposed, with the formation of gas and the destruction of the electrodes; whereas with alternating current these objectionable results are not produced in a substantial amount. However, when direct current is used, the amount of fluid decomposed is small, and if the electrodes are made of materials which are not affected by the resulting conditions, the use of direct current is practical.

One of the objections to heaters of this type, as heretofore constructed, has been the formation of short circuits and the passage of leakage currents through the water and through the walls of the heater to the water pipes themselves. This not only results in a loss of current but injuriously affects the pipes as the result of electrolysis, which occurs where the current flows between the pipe and the ground. One of the objects of my invention is to so connect the heater in the electric circuit as to reduce this leakage current to a negligible amount.

This object is accomplished by means herein-after described, the principal advantage secured thereby being the increased safety to life and property, which are endangered by leakage of currents from the high power supply circuits now commonly used. A further advantage is the incidental saving in the quantity of current used.

Another major object of the present invention is to attain substantially increased efficiency in operation relative to the size and cost of the heater unit and the quantity of electrical energy consumed. This object is attained mainly by the manner in which several groups of conducting plates or electrodes are arranged relatively to each other and connected into the power circuit, and other disconnected electrodes are interposed between members of said groups of connected electrodes as will be hereinafter explained.

Referring to the accompanying drawings which illustrate one form of my invention:

Fig. 1 is a view of the heater itself partly in section to illustrate the internal construction;

Fig. 2 is a front view of the connecting panel which is attached to and forms a part of the heater shown in Fig. 1;

Fig. 3 is a view of two plates of the heater separated to show the relative arrangement thereof;

Fig. 4 is a horizontal section on the line 4—4, Fig. 1, showing how the heating elements are connected in the circuit.

Fig. 5 is a diagrammatic view of the heating elements and of the electrical connections therefor.

Heating element

The heater proper is built up of a plurality of plates of cast iron or other suitable material, said plates being all of the same or substantially the same construction and form. These plates, represented by the numerals 10 and 11 (Fig. 3), have relatively thin body portions 12 and thickened rims 13; and the body portions of plates 10 are

Clamping devices

provided in the central portion thereof with perforations 14, while the plates 11 have perforations 15 located in the outer portion of the thinner section. The heater is built up of these plates 5 alternately arranged, so that, when the thickened edges rest one upon the other the water is compelled to follow a sinuous path through the heater between the thin body portions of the plates and through the perforations 14 in plates 10 and 10 perforations 15 in plates 11 (see Fig. 5) thereof.

The plates 10 and 11 are separated each from the other by insulating rings or gaskets 20 which lie between the thickened rims thereof. The rims of the plates are provided on one side with 15 annular groove or recess 21, and on the other side with annular recesses 22 (Figs. 1 and 3). The gaskets may be made of any suitable insulating material, such as bakelite, rubberized asbestos, or other suitable insulating material; and as the 20 plates are forced tightly together as hereafter described, the material of these gaskets will be forced into the grooves 21 and 22, thereby aiding in sealing the joints between the plates so that water tight electrically insulated joints may be 25 provided.

The plates 10 and 11 with the gaskets 20 constitute the body of the heater; and the spaces between the plates, in conjunction with the perforations 14 and 15, constitute the sinuous path 30 through which the water flows. This flow of water may be in either direction, but as here shown, it will pass in at the bottom and out at the top.

Preferably, a chamber is formed in the bottom 35 of the heater by the use of rings 30, which are separated from each other and from the heating elements by means of insulating gaskets 20 like those used to separate the heating elements, or by forming an annular rim or header 42.

The heater is completed by headers or plates 40, 42; header 40 being mounted on the top of the plates and insulated therefrom by a gasket 20, and header 42 being secured to the bottom 45 of the heater, and being likewise insulated therefrom by a gasket 20.

The header 40 is provided with an opening into which is secured a discharge pipe 44, while the other header 42 is provided with a pipe inlet 46. And to the latter is secured the main supply 50 pipe 47.

As stated above, the water may flow in either direction through the heater, but as here illustrated it enters through the pipe 47, passes 55 through the pipe 46 into the bottom chamber of the heater formed by the rings 30, thence through the perforations 15 of the lowermost plate 11, through the annular space between this and the next higher plate 10, thence through the perforations 14 of the last mentioned plate, thence alternately through the outer perforations of the one 60 plate and the inner perforations of the other until the upper end of the heater is reached, whereupon it is discharged from the body of the heater, and passes out through discharge pipe 51.

The water might discharge from the heater directly into the distributing system, but as here shown it discharges into a top chamber made up 65 of the annular extension 57 of the header 40, which chamber is closed by a removable cover 48 secured in position by bolts 49, a suitable gasket 50 being arranged between the extension 57 and the cover plate 48. By removing the 70 bolts 49 and the cover 48, access may be had to the chamber for any purpose desired.

The plates 10 and 11, and the headers 40 and 42, are held together by any suitable clamping devices. Those here employed are a series of 80 bolts 60 which extend through openings in the headers 40 and 42. There may be any suitable number of bolts, but in the form here shown five are provided. Both ends of these bolts are threaded for the reception of suitable securing devices. Nuts 61 carried by one end of the bolts lie against lock washers 62, which in turn rest against ordinary metallic washers 63, and these 85 latter rest upon insulating washers 64 lying against the header 42. At the other end, each bolt 60 is provided with a similar insulating washer 65, a metallic washer 66 above the same, and suitable tension devices. These last mentioned devices include a helical spring 67 which surrounds the bolt and rests upon the metallic washer 90 66. Another metallic washer 66 rests upon the top of the spring, and screwed upon the bolt and resting upon the last mentioned washer 67 is a nut 68. By screwing down the nut 68 any suitable tension may be placed upon the spring. 100 This tension must be great enough to secure the plates together with a pressure sufficient to prevent leakage, while at the same time, the springs allow for normal expansion and contraction of the heater. 105

Each bolt 60 is provided at one end with an insulating sleeve or bushing 69 which passes through the header 40, and at the other end with a similar insulating sleeve 69 passing through the corresponding hole in the header 42. The 110 purpose of these insulating sleeves is to prevent loss of electrical energy to the ground and in the heater itself.

To secure the elements of the heater together, the bolts 60 are inserted in the holes in the headers, the bushings 69, and the nuts, washers and springs are put upon the bolts in their proper order. By tightening either or both of the nuts 61 and 68, any desired pressure can be applied 115 to the springs 67, thereby securing the elements of the heater together with the degree of pressure required in each particular case, and yet permitting proper expansion and contraction of the parts. 120

Casing

In the form of the invention here shown, the heating unit is surrounded by a suitable casing consisting of a cylindrical body 70, a top 71 and a bottom 72. The top 71 does not extend over 130 the cover plate 48 but contacts with the outside of the extension or chamber 47. The bottom 72 is provided with an opening through which the pipe 46 extends, and to which the water pipe 47 is secured. The top 71 is provided with openings 135 at 73 through which the upper ends of the clamping bolts or rods 60 extend, and nuts 74 thereon secure the top 71 in position. The outlet pipe 51 extends through a suitable opening in the side of the casing 70, and its inner end is screw-threaded into an opening extending through the wall of the annular extension 57 on header 40. It is to be understood however that this particular form of casing, and the particular manner 140 in which the inlet and outlet pipes are shown, are not of the essence of the invention, and may be varied at the will of the user. In fact, it is not essential that an outer casing be provided, although such a casing is to be preferred. And the space between the casing and the heater proper 150

may be looked upon as a heat insulating chamber, for preventing undue radiation of the heat.

Electrical connections

5 As explained above, the plates 10 with their perforations 14, and the plates 11 with their perforations 15, when piled alternately as described form a sinuous conduit or passageway through which the fluid to be heated is forced
10 to flow. These plates are connected in the circuit in varying combinations to suit the conditions under which the heater is used. The ohmic resistance of the plates 10 and 11, if made of iron, is considerable, and therefore a certain
15 amount of heat is generated in the plates themselves; thus, while the heating effect is produced primarily in the mass of fluid passing through the heater, that heat which is generated in the plates 10 and 11 due to the resistance thereof, is
20 utilized to raise the temperature of the fluid as it passes through the apparatus.

These plates 10 and 11 may each be provided with a single terminal, or they may carry any desired number of terminals. In the form here
25 illustrated, each plate is provided with two terminals 76 arranged at substantially opposite points thereon. These terminals are connected in parallel so that the plates are supplied with current at a plurality of points. This is particularly desirable where iron plates are used, because of the comparatively high resistance of the material of which they are composed.

In heaters of this type, as heretofore constructed and when used as water heaters, there
35 has been an objectionable and serious loss of current through the water to the pipes which are grounded in the earth. One of the objects of this invention is to reduce this leakage of current to a minimum, and this is effected in a manner which will now be described.

The headers 40 and 42 are of course connected to the pipe system of the water supply and these pipes in use are always grounded. In the ordinary commercial electrical distribution systems,
45 a three wire circuit is used. One of the lines, usually termed the neutral line, leads back to the generator and is grounded. There is a difference of potential of 220 volts between the two so-called outside or power lines, and a difference of
50 110 volts between each of the outside lines and the neutral line. This circuit is well known, and is used with electric ranges and similar appliances. It is well known that lamps or other apparatus intended to be used with a difference of
55 potential of 110 volts may be connected between either outside line and the neutral line; and that electrical appliances intended to be used on 220 volts can be coupled directly between the so-called outside lines.

60 In the embodiment of my invention taken for explanation herein, the three wire distribution system of 110-220 volts potential is used to illustrate the heater connections, but my heater can be used on a two wire 110 volt system, or on any common distributing system of any potential,
65 with practically the same results and efficiency. However, the 110-220 volt system is preferable for domestic use, owing to the smaller wires which may be used to carry the same wattage consumption.

70 In my invention, advantage is taken of this common distribution circuit to so connect the elements of the heater as to limit or reduce to a minimum the leakage of current. To this end, the plates 10 and 11 of the heater are all insulated

each from the other by the gaskets 20; and the plates are insulated from the headers 40 and 42 by annular gaskets 20, identical, or substantially identical, with the gaskets 20 between the elements. This prevents leakage from the plates
80 10 and 11 to the headers 40 and 42 and thus to ground through a direct metal conductor. But inasmuch as the current is passing through the fluid, and the fluid is passing through the pipes of the distributing system, there is a possibility, in
85 fact a probability, of current leaking through the water to the grounded pipe, and thence to the ground and through the ground to the transformer which is always grounded, thus possibly causing electrolysis where the current passes
90 from the pipe to the ground and vice versa.

To reduce this leakage to a negligible amount, the plates of the heater are connected in the manner shown in Fig. 5, to which reference will now be made. This figure illustrates the electrodes or plates 10 and 11 and the circuits therefor diagrammatically. And for convenience of
95 reference the several plates are numbered serially from (101) to (119), inclusive. It is to be understood, however, that while 19 plates are here illustrated, any suitable number may be used; the numbering here used being employed merely for convenience in describing the circuit connections.

The top plate 101 is insulated from the header 105 40, and the bottom plate 119 is insulated from the rings 30, which in turn are insulated from the header 42 by the gaskets 20, as shown in Fig. 1. The plates that are nearest the headers 40 and 42, that is (101), (119), respectively, are both
110 connected, as by conductors 142 (Fig. 2), to the neutral, center or 110 volt line of the distributing system, which gives them a neutral or substantially neutral potential. The outside or 220 volt lines are connected to certain of the other plates
115 in varying combinations, depending upon the character of the fluid being heated and the amount of heat it is desired to impart to the fluid, and the amount of electrical energy it is desired to consume over a given period, and other considerations. In the arrangement here shown
120 (Figs. 2, 4 and 5), the one side of the 220 volt line is connected by conductors 141 in multiple with two heater plates, namely (105), which is near the top thereof, and (113) which is near the middle thereof; and the other 220 volt line is similarly
125 connected by conductors 141 with the plate (109) near the middle of the heater and with the plate (116) near the bottom thereof. But these particular connections are illustrative only, and various other combinations may be employed.

By these connections, it will be noticed that while the plates (101) and (119) are of neutral or nearly neutral potential, there will be a difference of potential of 110 volts between the
135 top plate (101) and the plate (105), and between the bottom plate (119) and the plate (116); and under this difference of potential a certain amount of current will flow, depending upon the resistance of the fluid being heated.
140 By varying the number of intervening plates and the length of the liquid path, this resistance may be varied at will, and consequently the amount of current also varied as required by the conditions of any particular situation.
145 Under this difference of potential, a certain limited amount of current will flow between plates (101) and (105) at the top, and plates (116) and (119) at the bottom; but there will be little tendency for current to flow from the end
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plates to ground, as the resistance of the wire or wires connected to plates (101) and (119) and thence direct to the transformer will always be considerably less than the total resistance of the rings 30, the headers 40 and 42, the pipes 44, 46 and 47 and the liquid contained therein. But while there is a difference of only 110 volts between the groups of plates just referred to, there is a difference of 220 volts between other groups of plates; for instance, there is a difference of 220 volts between plates (105) and (109); and between the plates (109) and (113); and between plates (113) and (116). Inasmuch as the voltage between the last mentioned groups is double that between the upper and the lower groups, the tendency of the current will be to flow between these plates (105) to (116), rather than between plates (101) to (105) and (116) to (119); or between the individual plates (101) and (119) to the ground, as represented by the inlet and outlet pipes connected to the heater. By thus providing for the maintenance of potential differences of various degrees in different parts of the heater a substantial gain in efficiency is accomplished as pointed out herein-after.

In the particular arrangement here shown, the fluid is supposed to enter at the bottom and pass out at the top of the heater, although the circulation may be in the reverse direction if desired. Most fluids when cold normally have a higher resistance than when heated; therefore, a smaller number of unconnected plates are shown between the connected ones at the bottom of the heater, than there are unconnected plates at the top of the heater, where the fluid has become heated.

By using a large number of plates, and coupling these in circuit as demanded by the circumstances, it is possible to adapt heaters of this kind to widely varying conditions; it being merely necessary to determine by test the best combination for any particular heater or particular location, temperature of, or quantity of heated fluid desired, and then couple in the plates in accordance with the requirements of that situation, and the requirements of the user as to the desired temperature of the fluid and wattage consumption.

The plates, conductors or electrodes 10 and 11 may be connected in circuit in any suitable way. As here shown, the heater casing carries on one side thereof a terminal box and coupling devices for connecting the plates in circuit as desired. These parts are shown in section in Fig. 1 and in front view in Fig. 2.

Referring more particularly to this feature, the casing 70, Figs. 1 and 4, has secured thereto a board or panel 130 of insulating material by means of bolts 131. Mounted on the board or panel 130 is another board or panel 132 of insulating material, and upon this last mentioned board or panel are three conducting strips or bus bars 133, 134, 135 (Fig. 2), which are terminals respectively of the three wires of the distributing circuit. Bus bars 133, 135 are the terminals of the two 220 volt wires, respectively, and 134 is the terminal of the neutral wire. These bars have secured therein suitable binding posts 138; and the insulating panel 132 carries a number of binding posts 139, one for each heating element 10 and 11. As here shown, there are a large number of these binding posts 139; for while the heater shown in Fig. 1, is provided with only 19 plates, as ex-

plained before, this is merely illustrative, and a much larger number may be used.

All of the binding posts on panel 132 are indicated by the numerals 139; but in Fig. 2, those particular binding posts which are selected for use with the plates of this heater are also numbered with the numbers of the several plates, as shown in Fig. 5, so that the several circuits may be more easily traced. Thus the post 139 which is connected to plate 101 is marked (101); that connected to plate 105 is marked (105); that connected to plate 109, as (109); and so forth throughout the series. In fact, all of the plates of the heater are in practice preferably connected to the correspondingly numbered binding posts 139, so that any connections necessary can be readily made.

Each of the series of plates 10, 11, is connected by a conductor 140 to one of the series of binding posts 139. As shown in Fig. 4, these conductors 140 are carried into the heater from panel 132 through an opening 150 in casing 70. Three of said conductors 140 are there shown, each connected with two binding posts 76 in the rim (preferably diametrically opposite each other) of one of the plates. Each of said plates 10, 11, is similarly connected with its own binding post on panel 132.

Conductors 141 (Fig. 2) connect certain of the binding posts 139 and the electrodes connected thereto, these being selected as herein indicated according to the local conditions and requirements, with one or the other of the terminal bars 133, 135 of the 220 volt lines of the three-wire power circuit; conductors 142 connect other binding posts and electrodes, selected according to the same conditions and requirements, with the terminal 134 of the neutral or 110 volt line. By means of these terminals and circuit connections, as shown more in detail in Fig. 2, it is possible to connect the heating plates or electrodes in various groupings or combinations with the power circuit, so as to obtain in each case the particular variation of potential differences in different parts of the heater that are best suited to the local requirements.

It is impossible to show all of the circuit connections in Figs. 1 and 4; but a clear understanding thereof may be had by referring to Figs. 2 and 5, which, for convenience of description, may be considered together; Fig. 2 representing the terminal board or panel, and Fig. 5 the plates in diagram. The connections are indicated for the particular heating plates selected for description in this specification, it being understood that these connections may be varied at will.

Conductors 140 connect the top plate (101) and bottom plate (119) of the heater with binding posts 139 on the terminal board 132, and these in turn are connected by connectors 142 to the neutral or 110 volt bus bar 134; and the other plates (105), (109), (113), and (116) are connected by other wires 140 to their respective binding posts 139 on terminal board or panel 132, and thence by connectors 141 to the binding posts 138 on one or the other of the 220 volt bus bars 133 or 135, as may be desired. In this instance plates (105) and (113) are shown connected to bar 133, and plates (109) and (116) to bar 135.

Assuming the parts to be connected as shown, current will flow between the several plates connected directly to the two sides of the 220 volt lines. For instance, current will flow from the

220 volt line connected to bar 133, through the connections 141 to the binding posts 139 (105) and (113) on board or panel 132, thence through conductors 140 to the plate (105) and (113) in parallel, through the heater to the plates (109) and (116), through other conductors 140 back to binding posts 139 (109) and (116) on board or panel 132, through connectors 141 to the bar 135, to the other side of the 220 volt line.

- 10 With the active plates referred to connected to the opposite sides of the 220 volt circuit, and the end plates (101) and (119) connected to the neutral line, the tendency is for the current to pass between the plates having the greatest difference of potential; so that, as in all three wire distributing circuits, no current or substantially no current, will pass through the neutral line; but the end plates (101) and (119) are connected to the neutral line so that stray currents, or currents due to an unbalanced condition of the system, will make circuit through the end plates (101) and (119), through their respective conductors 140, to their binding posts 139 (101) 139 (119), connectors 142, to bus bar 134, which is connected through the neutral line to the transformer.

The plates (101) and (119) and the headers 40 and 42 are always at neutral potential, therefore there is no difference of potential between the plates and the headers, and therefore there is no tendency for current to pass from plates to the headers, and thence through the pipes to the ground. Thus these end plates connected in this manner and insulated from the headers, act as screens to prevent the flow of current into the pipe system and to ground.

As explained above, not all the plates 10 and 11 are usually in circuit at the same time, and the unconnected plates are merely idle plates, considered strictly as electrodes. They nevertheless serve an important purpose, whereby the efficiency of the heater is substantially increased; for as the current passes between the active plates it will flow partly through the liquid in the heater and partly through the intervening plates. There being a continuous liquid path through the holes 14 and 15, part of the current will take this path, while another portion will pass from the active plates directly through the liquid to the next adjacent plates, thence from plate to liquid and liquid to plate to the next active plate.

By means of the above described construction and circuit connections, advantage is taken of the fact that when current passes from one medium to another, as from solid to liquid and vice versa, there is always a definite fall of potential and a consequent dissipation of energy at the point of transit. In a heater constructed according to the present invention such a fall of potential takes place at several points, the energy thereby generated being transformed into heat, which is absorbed by the liquid passing through the heater. It has been found in practice that a heater thus constructed is considerably more efficient than one in which the current is forced to flow through the fluid only, or through a resistance element only.

Having thus described my invention, what I claim is:—

1. In an electric heating system, the combination of a plurality of electrodes, means for circulating the substance to be heated between the same, means for insulating the electrodes from the system, means for maintaining the ends of

the heater at low or zero potential; and means for passing current between the electrodes at any desired rate within the capacity of the generator and through any desired section or sections of the heater.

2. In an electric heater, the combination of a plurality of electrodes between which the medium to be heated may flow, means for connecting the electrodes near the ends to the neutral line of a three wire distributing system, and means for connecting intervening electrodes to the other lines of the system.

3. In an electric heater, the combination of a plurality of plates spaced apart and having openings therein so that when secured together a tortuous path for the flow of fluid is provided, means for insulating the plates each from the other, means for maintaining the plates near the end of the heater at or near zero potential, means for maintaining the other plates at different potentials so that current will flow through the heater between the last mentioned plates.

4. In an electric heater, the combination of a plurality of plates spaced apart and having openings therein so that when secured together a tortuous path for the flow of fluid is provided, means for insulating the plates each from the other, means for maintaining the end plates at low or zero potential, means for maintaining a definite but variable potential difference between certain of the other plates and the end plates, and means for maintaining a definite but variable and greater potential difference between the other plates of the heater.

5. In a water heating system, the combination of a supply pipe and a discharge pipe, a heater comprising a plurality of plates between which the water may flow located between the supply and discharge pipes, means for insulating the plates from each other, means for insulating the heater from the supply and discharge pipes, means for maintaining the ends of the heater at neutral potential, and means for maintaining other of the plates at substantial potential.

6. In a water heating system, the combination of a supply pipe and a discharge pipe, a heater comprising a plurality of plates between which the water may flow located between the supply and discharge pipes, means for insulating the plates from each other, means for insulating the heater from the supply and discharge pipes, means for connecting the ends of the heater with a source of neutral potential, and means for connecting other of the plates with a source of higher potential.

7. In a submerged type of electric heater, the combination of a plurality of plates or electrodes insulated from each other, a terminal board, and means for connecting the plates or electrodes in sections or groups with the terminals of the board, so that in each section or group there may be maintained a definite but variable wattage consumption for each section or group independently of the others.

8. In a submerged type of electric heater, the combination of a plurality of plates or electrodes insulated from each other, a terminal board, and means for connecting the plates or electrodes with the terminals of the board so as to maintain any predetermined temperature in the material being heated irrespective of the conductivity thereof.

9. In a submerged type of electric heater, the combination of a plurality of plates or electrodes insulated from each other, a terminal board, and

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means for connecting the plates or electrodes with the terminals of the board so that the plates may be variably connected in circuit to maintain a given wattage consumption whatever the conductivity of the material being heated may be.

10. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage between the electrodes for the flow of the liquid to be heated; means for connecting the end electrodes of those which are connected to circuit to the neutral line of a supply circuit; and means for connecting an electrode intermediate of said end electrodes to a power line of the supply circuit.

11. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage between the electrodes for the flow of the liquid to be heated; means for connecting the end electrodes of those which are connected to circuit to the neutral line of a supply circuit; and means for connecting two or more electrodes intermediate of said end electrodes each to a power line of the circuit.

12. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage between the electrodes for the flow of the liquid to be heated; means for connecting the end electrodes of those which are connected to circuit to the neutral line of a supply circuit; means for connecting two or more electrodes which are intermediate of said end electrode to a power line of said supply circuit; and means for connecting two or more other electrodes which are intermediate of said end electrodes to another line of said supply circuit, said intermediate electrodes which are connected to one line alternating with said intermediate electrodes which are connected to the other line.

13. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage between the electrodes for the flow of the liquid to be heated; means for connecting the end electrodes of those which are connected to circuit to the neutral line of a three-wire supply circuit; means for connecting an electrode intermediate of said end electrodes to one of the power lines of said supply circuit; and means for connecting another electrode intermediate of said end electrodes to the other power line of said supply circuit.

14. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage between the electrodes for the flow of the liquid to be heated; means for connecting the end electrodes of those which are connected to circuit to the neutral line of a three-wire supply circuit; means for connecting two electrodes intermediate of said end electrodes to one of the power lines of said supply circuit; and means for connecting another electrode intermediate of said two electrodes to the other power line of said supply circuit.

15. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage between the electrodes for the flow of the liquid to be heated; means for connecting the end electrodes of those which are connected to circuit to the neutral line of a three-wire supply circuit; means for connecting two or more electrodes which are intermediate of said end electrodes to one of the power lines of said supply circuit; and means for connecting two or more other electrodes which are

intermediate of said end electrodes to the other power line of said supply circuit, said electrodes which are connected to one power line alternating with said electrodes which are connected to the other power line.

16. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage between the electrodes for the flow of the liquid to be heated; means for connecting one end electrode of those which are connected to circuit to the neutral line of a three-wire supply circuit; means for connecting another electrode to one of the power lines of said supply circuit; and means for connecting another electrode to the other power line of said supply circuit.

17. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage between the electrodes for the flow of the liquid to be heated; means for connecting one end electrode of those which are connected to circuit to the neutral line of said supply circuit; means for connecting two or more other electrodes to one of the power lines of said supply circuit; and means for connecting two or more other electrodes to the other power line of said supply circuit, said electrodes connected to one power line alternating with said electrodes connected to the other power line.

18. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage for the flow of the liquid to be heated; means connecting certain selected electrodes with the power lines of a three-wire supply circuit; and means connecting one of the end electrodes of those connected to circuit with the neutral line of said supply circuit.

19. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage for the flow of the liquid to be heated; means connecting certain selected electrodes with the power lines of a three-wire supply circuit; and means connecting the last electrode of those connected to circuit at the hot end of the heater with the neutral line of said supply circuit.

20. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage for the flow of the liquid to be heated; means for connecting certain selected electrodes with the power lines of a three-wire supply circuit; and means for connecting the end electrode of those connected to circuit with the neutral line of said supply circuit.

21. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage between the electrodes for the flow of the liquid to be heated; means for connecting one of said electrodes to one line of a supply circuit; means for connecting another of said electrodes to another line of said supply circuit, there being interposed between said electrodes one or more electrodes which are not connected to said supply circuit.

22. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage between the electrodes for the flow of the liquid to be heated; means for connecting a plurality of said electrodes to one line of a supply circuit; means for connecting another plurality of said electrodes with another line of said supply circuit, the electrodes connected with the two lines of the

supply circuit alternating with each other, and there being others of said electrodes not connected to the supply circuit and interposed between some or all of said electrodes which are connected to the supply circuit.

23. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage for the flow of the liquid to be heated; means for connecting certain selected electrodes with circuit conductors of different potential; and one or more unconnected electrodes interposed between said connected electrodes.

24. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage for the flow of the liquid to be heated; means for connecting certain selected electrodes with circuit conductors of different potential; means for maintaining the end electrodes of those connected to circuit at low or zero potential, and one or more unconnected electrodes interposed between said connected electrodes.

25. In an electric heater, the combination of

a plurality of electrodes insulated from each other and spaced apart to form a passage for the flow of the liquid to be heated; means for connecting certain selected electrodes with circuit conductors of different potential; means for maintaining one of the end electrodes of those connected to circuit at low or zero potential, and unconnected electrodes interposed between said connected electrodes.

26. In an electric heater, the combination of a plurality of electrodes insulated from each other and spaced apart to form a passage for the flow of the liquid to be heated; means for connecting certain selected electrodes with circuit conductors of different potential; means for maintaining the end electrodes of those connected to circuit at low or zero potential; an unconnected electrode or electrodes interposed between the electrodes of said connected group; and other unconnected electrodes interposed between the group of connected electrodes and each of said end electrodes.

GEORGE NORRELL SEXTON.

5	80
10	85
15	90
20	95
25	100
30	105
35	110
40	115
45	120
50	125
55	130
60	135
65	140
70	145
75	150