Oct. 28, 1952 H. C. A. MEYER 2,616,023

INSTANT LIQUID HEATER

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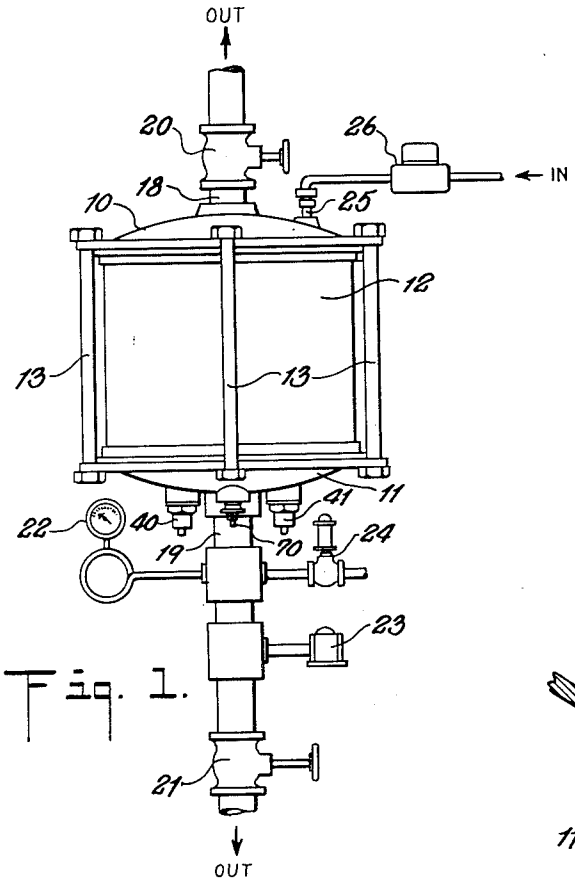


Fig. 1.

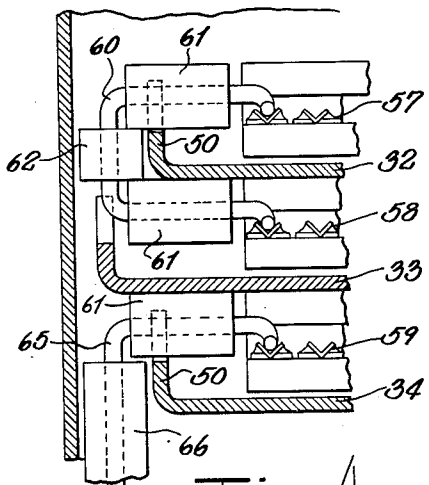


Fig. 4.

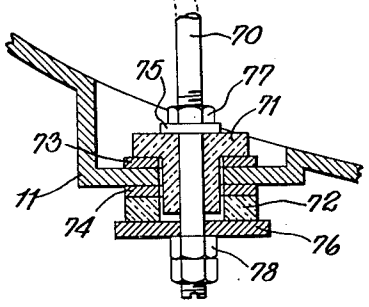
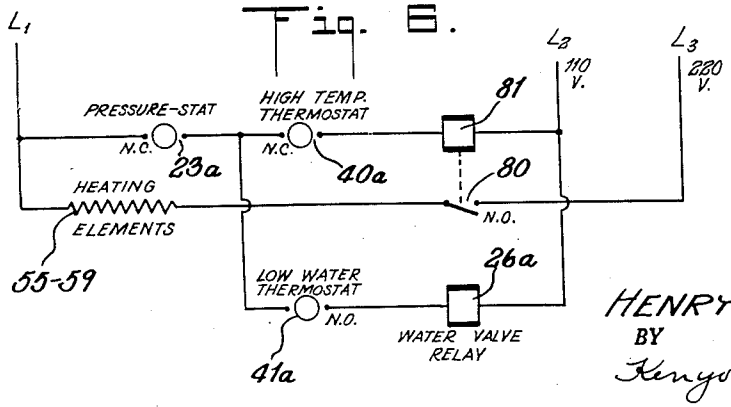


Fig. 5.

Fig. 6.



INVENTOR.
HENRY C. A. MEYER
BY
Kenyon & Kenyon
ATTORNEYS

Oct. 28, 1952 H. C. A. MEYER 2,616,023

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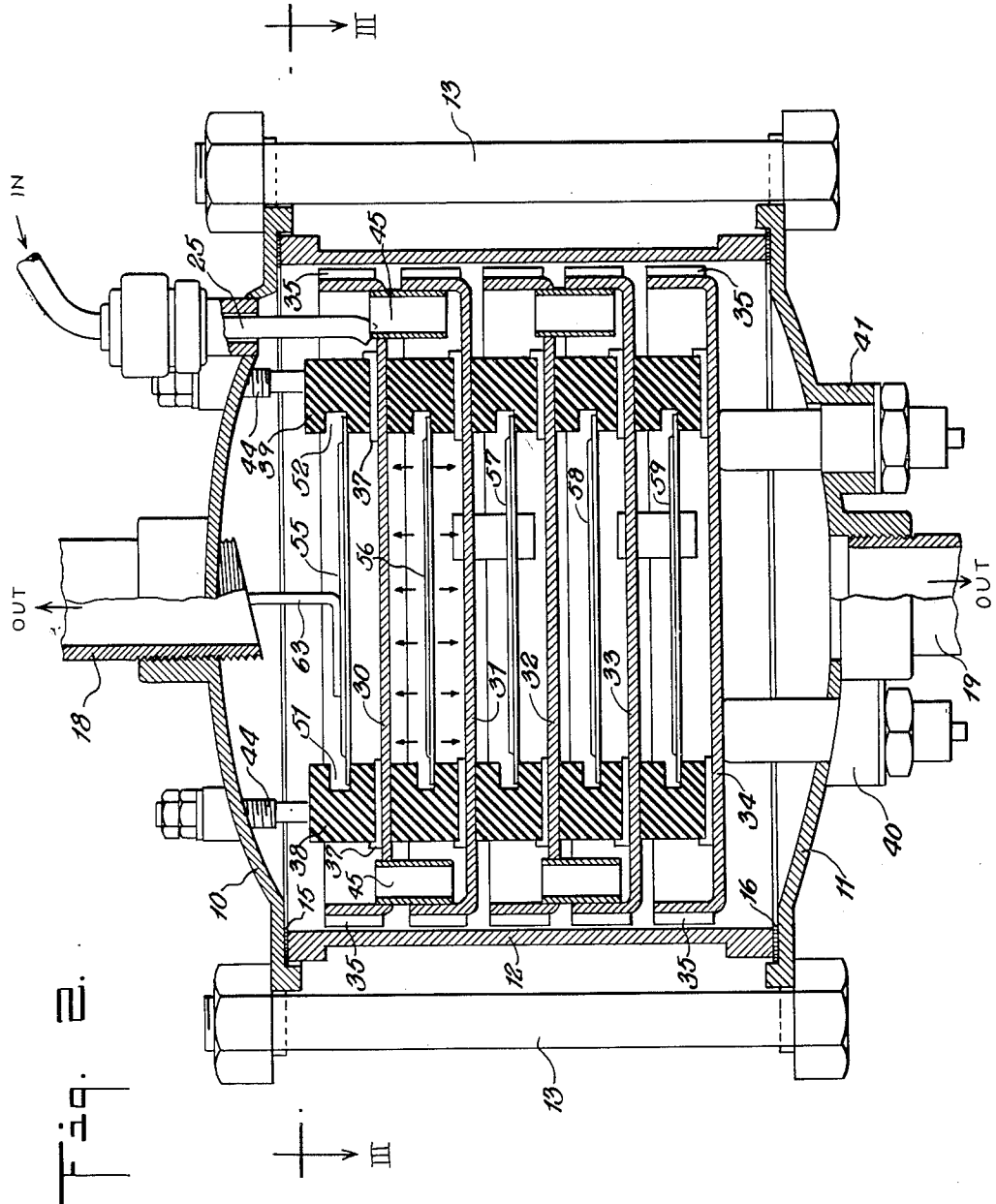


Fig. 2.

INVENTOR.
HENRY C. A. MEYER
BY
Kenyon & Kenyon
ATTORNEYS

Oct. 28, 1952 H. C. A. MEYER 2,616,023

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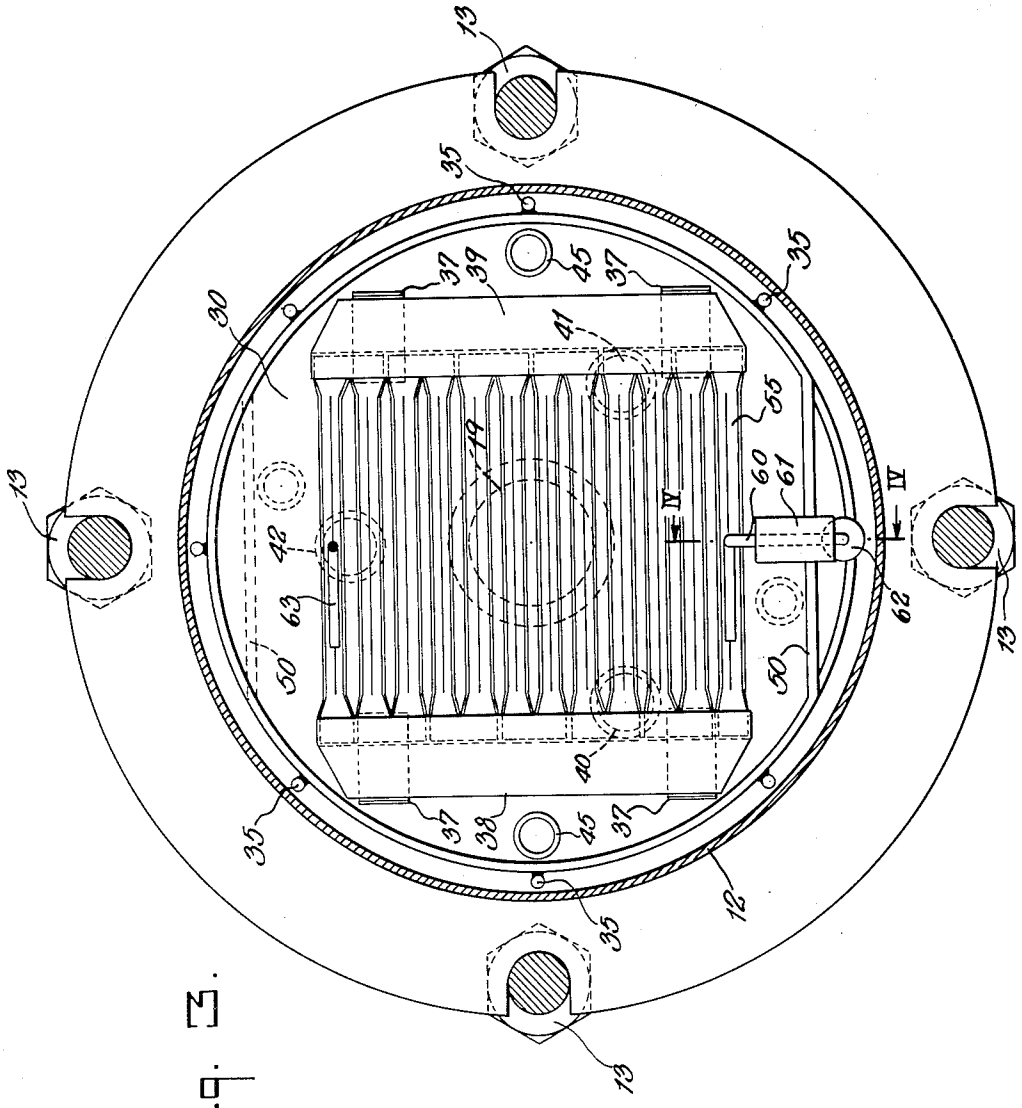


Fig. 3.

INVENTOR.
HENRY C. A. MEYER
BY
Kenyon & Kenyon
ATTORNEYS

Oct. 28, 1952 H. C. A. MEYER 2,616,023

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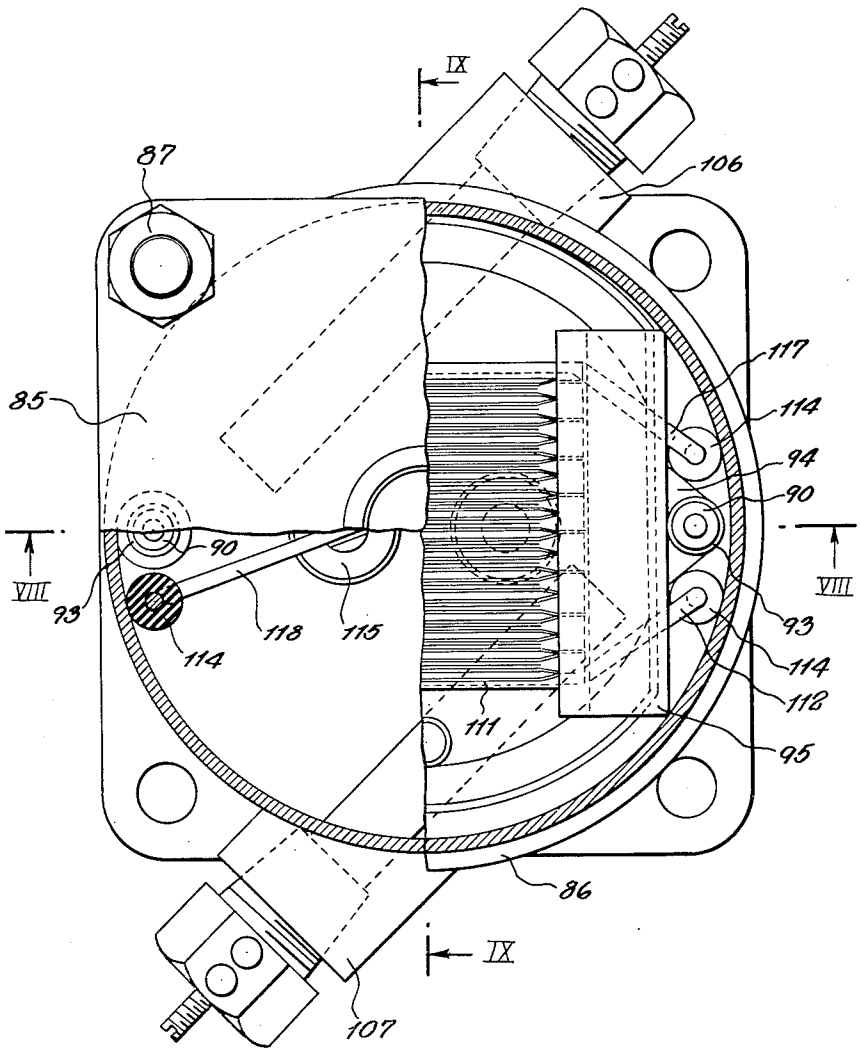


Fig. 7.

INVENTOR.
HENRY C. A. MEYER
BY
Kenyon & Kenyon
ATTORNEYS

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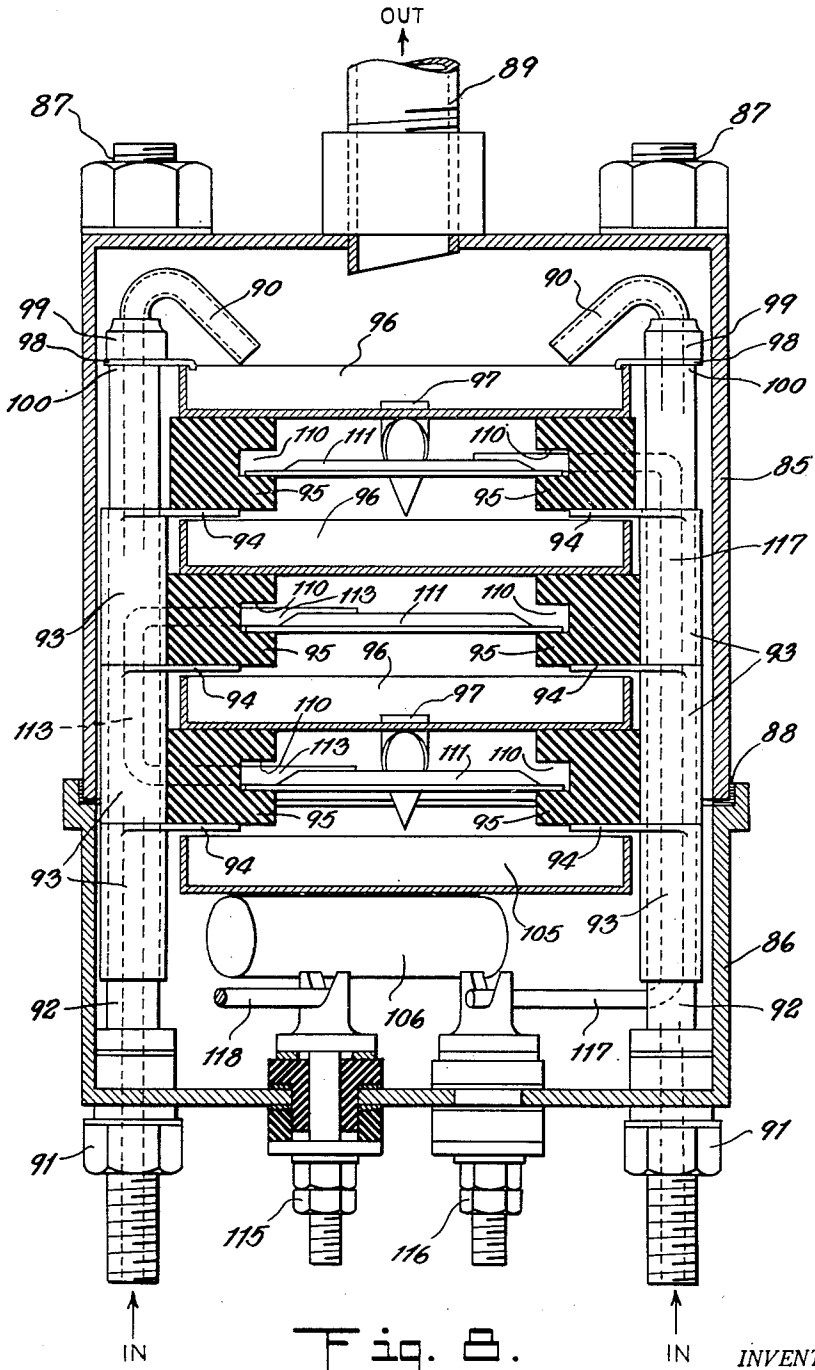


Fig. 8.

INVENTOR.
HENRY C. A. MEYER
BY
Kenyon & Kenyon
ATTORNEYS

Oct. 28, 1952 H. C. A. MEYER 2,616,023

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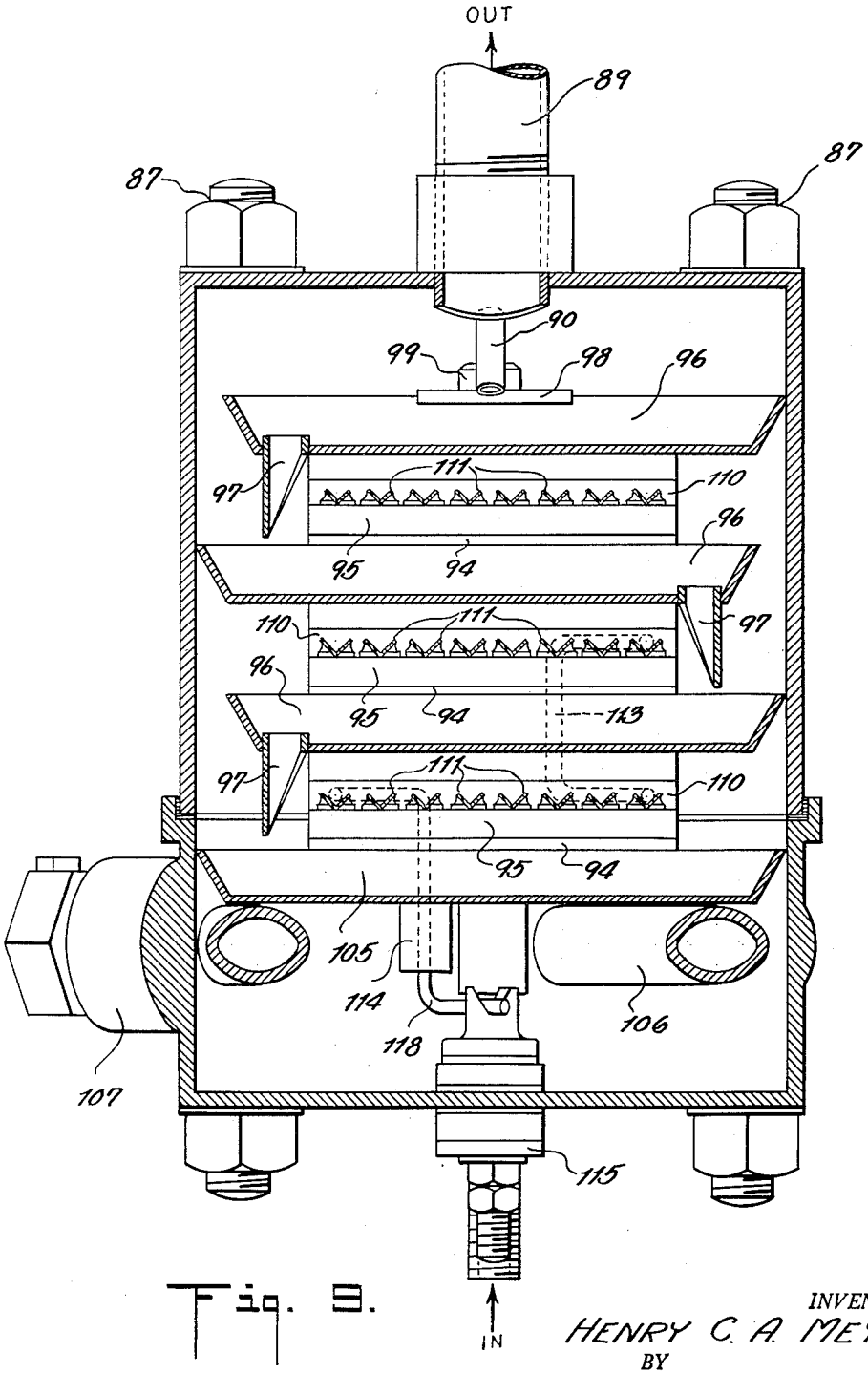


Fig. 3.

INVENTOR.
HENRY C. A. MEYER
BY
Kenyon & Kenyon
ATTORNEYS

Patented Oct. 28, 1952

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UNITED STATES PATENT OFFICE

2,616,023

INSTANT LIQUID HEATER

Henry C. A. Meyer, Syracuse, N. Y.

Application June 22, 1950, Serial No. 169,707

12 Claims. (Cl. 219—38)

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This invention relates to instant liquid heaters for generating vapor, and more particularly to water heaters of the quick response type for generating steam.

One object of my invention is to provide a quick response steam generator provided with heating elements having a high B. t. u. input per unit of volume.

Another object of my invention is to provide such a steam generator employing a minimum amount of liquid per B. t. u. of input capacity.

Another object of my invention is to provide such a steam generator in which the heating elements are out of contact with the liquid and yet one in which structural elements directly opposing and exposed to the heating elements can be protected, by contact of a surface of the element with a layer of the liquid, against heat-induced fatigue of the material of which the element is composed.

A further object of my invention is to provide such a steam generator having easily removable and replaceable liquid pans or trays for the retention of the liquid during the heating thereof, and having such relative placement of the heating elements and the pans that salts or other deposits from the liquid do not retard the heat-transfer rate.

Still a further object of my invention is to provide such a steam generator in which the steam may be superheated.

These and other objects of my invention will be more apparent from the following description when taken with the accompanying drawings, in which:

Fig. 1 shows a side elevation view of a steam generator in accordance with my invention;

Fig. 2 is a vertical cross section of the view through the body of the steam generator;

Fig. 3 is a cross-sectional view along plane III—III of Fig. 2;

Fig. 4 is a partial vertical cross-sectional view along plane IV—IV of Fig. 3;

Fig. 5 is a vertical cross-sectional view showing the terminal construction for the electrical connections;

Fig. 6 is a wiring diagram of the control circuit for the steam generator;

Fig. 7 is a partially cut-away plan view of an alternative embodiment for developing superheated steam;

Fig. 8 is a vertical cross-sectional view taken along plane VIII—VIII of the alternative embodiment of Fig. 7; and

Fig. 9 is a vertical cross-sectional view taken along plane IX—IX of the alternative embodiment of Fig. 7.

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Referring now to Figs. 1 and 2, the body of the steam generator comprises upper and lower dished heads 10 and 11 securing a cylindrical shell 12 therebetween as by means of bolts and nut connections 13. As shown in Fig. 2, metallic ring gaskets 15 and 16 are provided between cylindrical shell 12 and heads 10 and 11, respectively, to seal the unit thus formed against the steam pressure which is developed therewithin. Outlet pipes 18 and 19 are provided from the upper and lower heads respectively and valve 20 is connected to control the discharge from outlet pipe 18 and valve 21 is similarly connected to control the discharge from outlet pipe 19. Between outlet pipe 19 and valve 21 are preferably connected a steam gauge 22, a pressure-sensitive device or switch 23, hereinafter termed a pressurestat, and a safety valve 24. An inlet pipe 25 is provided in upper head 10 and an electrically-operated control valve 26 is connected in the inlet pipe or line 25 to control the flow of the liquid into the steam generator in a manner described hereinafter in detail in connection with its operation.

The details of the internal construction of the steam generator are shown in Fig. 2, to which reference is now made. Mounted within the cylindrical shell 12 are a plurality of pans or trays 30—34 arranged vertically one above the other, as shown, in a stack. Inlet pipe 25 extends down so as nearly to touch the bottom of upper pan 30. At the periphery of each pan or tray 30—34 are provided a number of spacer bars 35 (see also Fig. 3) to center the generally circular pans within the cylindrical shell 12. On the bottom of each pan 30—34 are disposed four metallic separator clips 37, as best seen in Fig. 3, and mounted upon these clips 37 are two parallel ceramic insulating heating element holders 38 and 39 (see also Fig. 3). The lowermost or inferior pan 34 rests upon and is supported by the responsive elements of three temperature-sensitive devices 40—42, hereinafter called thermostatic switches or thermostats. These three thermostatic switches 40—42 are preferably arranged at the apices of a triangle and indicated in dotted outline in Fig. 3. A plurality of hold-down screws 44 are provided extending through the upper head 10 and bearing against the ceramic holders 38 and 39 of the uppermost or superior pan 30 in order to hold the pans 30—34 firmly in the position shown when these hold-down screws 44 are tightened. Two overflow

pipes 45 are provided in the bottom of each pan 30—33, these preferably being placed diametrically opposite one another and adjacent opposite edges of each pan. The upper edge or lip of each overflow pipe 45 is preferably raised only slightly above the bottom of its tray so that only a thin layer or film of the liquid will cover the tray or pan bottom.

As shown in Figs. 3 and 4, each pan or tray 30—34 is not perfectly circular but has a portion of its periphery provided with a chord-like straight wall portion 50, and to provide clearance for the electrical connections between the heating elements successive pans, from the top to the bottom of the stack, are so positioned that the straight wall portion 50 of one pair is disposed 180° from, or diagonally opposite to, the straight wall portion 50 of the next succeeding pair.

Referring again to Fig. 2, channels 51 and 52 are cut in the inner sides of each of insulating holders 38 and 39, respectively, to receive electric heating elements 55—59, respectively, which as shown are of the grid type (see plan view of element 55 in Fig. 3). These heating elements are all connected in series, in the manner illustrated in respect of some of the elements by Figs. 3 and 4. Thus, as shown in plan view in Fig. 3, a U-shaped connection 60 is connected to one end of a heating element and then passes above wall 50 of pan 30, thereafter extends downwardly and inwardly as shown in Fig. 4 to connect with the adjacent end of the next inferior grid heating element. The other end of the latter grid heating element is then connected in a similar manner by a connection 60 to the adjacent end of the next inferior heating element. Suitable insulators 61 and 62 are provided on these connections 60 between adjacent heating elements, as illustrated in Figs. 3 and 4, to prevent each connection 60 from touching the adjacent pans.

The uppermost grid is provided at its other or free end with a connection 63 which is in turn connected to a terminal (not shown) extending through the upper head 10 in a manner similar to that in which the connection from the lowermost grid 59 is brought out through bottom head 11 and as shown in Figs. 4 and 5. As there illustrated, the free end of lowermost heating element 59 has electrical connection 65 attached thereto and leading through insulators 61 and 66 for connection to terminal 70 of Fig. 5 as indicated by the dotted lines. Terminal 70 extends through lower head 11 and includes a ceramic insulator bushing 71, a ceramic washer 72 and metallic washers 73 and 74, preferably of copper disposed on opposite sides of head 11 and between bushing 71 and washers 73 and 74, respectively. The central conductor of terminal 70 is threaded and provided with inner and outer washers 75 and 76 respectively, washer 75 also being preferably of copper. When the assembly is tightened in place by means of nuts 77 and 78 the copper washers 73, 74 and 75 seal the assembly to the lower head 11 to seal the steam generator against the pressure therewithin.

Note that as shown best in Figs. 3 and 4 the grid-type electric heating elements 55—59 lie generally in a plane between and parallel to pans or trays 30—34. While the heating elements may be of the flat grid type, I prefer to form them of a cross section as shown best in Fig. 4 by bending each transverse portion extending between the insulating holders upward in a V-shape. This results in additional clearance between adjacent heating elements at their portions where they are unsupported, thus reducing the hazard of electrical shorting between these adjacent portions. Note that as indicated by the heavy arrows in Fig. 2 adjacent heating element 56 the heat from the element travels both upwardly and downwardly therefrom to heat the bottom of the pan above and the water of the pan below. The shape and configuration of the grid which I use thus provides a maximum heating surface and its placement in the manner described insures protection of the metal surfaces being heated because they are in contact with a layer of liquid. The only exception to this is the top dished head 10 which is directly exposed as shown in Fig. 2 to the upward radiation of heat from the uppermost heating element 55. However, head 10 may be somewhat cooled by being exposed to the surrounding air if enclosing insulation is not used, and in addition is made of heavier gauge material than the individual pans inasmuch as it must withstand the pressure within the steam generator. Alternatively, if desired and its heating effect is not needed, uppermost heating element 55 may be omitted, thereby providing protection by contact with a layer of liquid for all surfaces directly opposing and exposed to the heating elements.

It will be observed from Figs. 2 and 3 that the overflow pipes 45 are disposed away from the heating elements 55—59 and further in alternate trays or pans the heating elements are protected from possible splashing of the water dropping from the end of the overflow pipe 45 because of the interposition of the insulating heating element holders.

While not shown because not susceptible of illustration, I preferably polish the inside surface of upper and lower heads 10 and 11, respectively, and cylindrical shell 12, as well as blackening the top and bottom of each of pans or trays 30—34. This increases the rate of heat transfer to each pan (and thus to the water contained therein) while reducing the heat losses through the walls of the steam generator.

The operation of my steam generator is best explained by reference to Fig. 6, which is a circuit diagram of the electrical circuit controlling its automatic operation. As there shown, the circuit is supplied from a conventional three-wire, 110–220 volt system with the heating elements 55—59 supplied from the 220-volt line L_1—L_3 and the control elements supplied from line L_1—L_2, L_1 being the common or neutral wire. The application of power to heating elements 55—59 is controlled by means of contacts 80 under control of relay coil 81, relay contacts 80 being normally open, as indicated by the letters "N. O." Relay coil 81 is connected in series with contacts 23*a* of pressure-stat 23 (Fig. 1) and contacts 40*a* of high temperature thermostat 40 (Figs. 1 and 2). Contacts 23*a* and 40*a* are normally closed, as indicated by the letters "N. C." A second series circuit between lines L_1 and L_2 is provided including the relay coil 26*a* of water valve relay 26 (Fig. 1), contacts 41*a* of low water thermostat 41 (Figs. 1 and 2), and the same contacts 23*a* of pressure-stat 23. Contacts 41*a* are normally open. It will be noted that only thermostats 40 and 41 of Fig. 2 have been referred to and shown as controlling contacts 40*a* and 41*a* of Fig. 6, respectively. The third thermostat 42, shown in Fig. 3, is preferably reserved as a spare and its controlling function therefore not utilized although, as pointed out above, it

does serve as a support for the lowermost or inferior pan 34.

In the normal operation of my steam generator, switches (not shown) are initially closed to apply power to lines L_1, L_2, and L_3 of Fig. 6. Each of pans 30—34 are already filled with a film of water from previous operation, and since contacts 41*a* controlling water valve relay 26*a* are normally open, no further water initially flows into these pans. Contacts 23*a* and 40*a*, being normally closed, however, cause current to flow through relay coil 81 and thus close contacts 80, thereby applying power to heating elements 55—59. Contacts 80 will remain closed until a too-high pressure is built up within the steam generator, causing pressure-stat contacts 23*a* to open, or until the temperature of the lowermost pan 34 becomes too high, resulting in contacts 40*a* opening. Pressure-stat 23 is, of course, adjusted to operate at a desired maximum pressure and high temperature thermostat 40 is similarly set at the desired maximum temperature of the lowermost pan 34. Low water thermostat 41 is set to operate at a predetermined temperature of lowermost pan 34, this temperature, of course, being lower than the maximum temperature at which high temperature thermostat 40 is set to operate. When lowermost pan 34 reaches this predetermined temperature, contacts 41*a* close and, since contacts 23*a* are normally closed, water valve relay 26*a* is then energized, resulting in water being supplied to the pans 30—34 through electrically-operated water control valve 26 (Fig. 1). As shown best in Fig. 2, the water flows from the end of inlet pipe 25 into the uppermost pan 30, forms a thin layer or film of water in this pan as controlled by the height of the upper lip of overflow pipe 45, and then flows through overflow pipes 45 into the next lower pan 31. Each of pans 30—33 feed the next inferior pan until finally each of pans 30—33 is covered with a thin layer or film of water of the desired depth. Pan 33, due to being provided with overflow pipes 45, of course causes water to flow into lowermost or inferior pan 34, resulting in a dropping of the temperature of this pan. When the temperature of pan 34 drops below that predetermined value at which low water thermostat 41 is set to operate, contacts 41*a* open and the flow of water into the steam generator is shut off. Preferably, this predetermined temperature at which low water thermostat 41 is set to operate is fixed such that the level of water required to reduce the temperature of pan 34 to this predetermined temperature during normal operation of the steam generator is slightly less than the level of water maintained in each of pans 30—33 by the overflow pipes 45. The operation of the steam generator then continues automatically, additional water being supplied as necessary when the water in the pans is boiled away and the temperature of pan 34 therefore increased. In normal operation, with steam being withdrawn from my generator as it is produced, contacts 23*a* and 40*a* remain closed with contacts 41*a* opening and closing as necessary to provide the required amount of water to generate the steam withdrawn.

Note that pressure-stat contacts 23*a* are common to both the heating element and water supply control circuits and thus, in the event that the pressure within the container or enclosure reaches the desired maximum pressure, both further application of power to the heating elements and further admission of water to the pans is prevented. Thus, when my steam generator is turned on but steam is not being withdrawn therefrom, these pressure-stat contacts 23*a* are effectively the controlling elements of the control circuit. This is because as rapidly as the water in the pans is converted to steam, lowermost pan 34 heats up and causes additional water to be admitted to the generator, and in the absence of a pressure-controlling element such as I have provided, this process would continue if steam were not being withdrawn until such a pressure were developed that the generator would explode.

The above description of the operation of my steam generator has assumed that the pans 30—34 are initially filled with a film of water, as they usually are due to previous use of the generator. The only difference in operation in case that these pans are not so filled is that lowermost pan 34 will more quickly reach the predetermined temperature at which contacts 41*a* close, whereupon water valve relay 26*a* will be energized to supply water to the pans until each is filled with a film of water as described above, the operation otherwise being the same as just described.

An alternative embodiment of a steam generator in accordance with my invention and providing a tortuous path for the steam over the heating elements in order to produce superheating is shown in Figs. 7, 8 and 9.

Fig. 7 is a partially cut-away plan view with the detail of the pan or tray and heating element placement relative to one another shown in the first and second quadrants, a view of the bottom interior from beneath the lowermost pan being shown in the third quadrant, and a view from above of the complete assembly being shown in the fourth quadrant. Vertical cross-sectional views taken along planes VIII—VIII and IX—IX are illustrated in Figs. 8 and 9. The construction of this alternative embodiment can best be understood by reference to all three figures.

As there shown, this alternative embodiment of a steam generator in accordance with my invention comprises upper and lower cup-shaped container members 85 and 86 held together by means of bolt and nut connections 87 at the four corners thereof and sealed at their joint by means of a metallic ring gasket 88. Note that lower container member 86 is provided with an integral encircling collar at its end abutting member 85 and surrounding this abutting end of the latter to strengthen the joint and retain the metallic sealing ring 88 between members 85 and 86. An outlet pipe 89 is threaded in the center of the upper end of top container member 85 and has its lower end beveled to provide a downwardly-extending lip in order to insure that any condensate formed in outlet pipe 89 drips into the uppermost pan or tray of the unit. Two diagonally-disposed tubes 90 each positioned adjacent the inner wall surface of the generator, as best illustrated in Figs. 7 and 8, are reversely bent at their upper ends and extend through apertures provided in the lower end of container member 86, being threaded thereat and sealed to and positioned in member 86 by means of the nut and sealing washer arrangement 91 illustrated. Each tube 90 is provided with a shoulder 92 adjacent the bottom of member 86 and interiorly thereof. Three ferrules 93 are stacked one atop another on each tube 90 with the bottom of the lowermost ferrule 93 abutting shoulder 92. Each ferrule 93 is also provided with an integral generally tri-

angularly-shaped shelf-like planar portion 94 disposed at the upper end thereof upon which a ceramic insulating heating element holder 95 is supported, as illustrated in Figs. 7 and 8.

A pan or tray 96 is supported by and atop each pair of holders 95 disposed in the same horizontal plane. Each pan 96 is provided with arc-like inclined ends and straight vertically-disposed sides, the sides being positioned parallel to holders 95, as may be seen best in Figs. 7 and 8. The three pans 96 are staggered with alternate opposite ends touching the adjacent inner surface of container member 85, as shown best in Fig. 9, in order to provide a tortuous path from beneath the lowermost pan 96 around the left end thereof (Fig. 9), thence to the right between lowermost and middle pans 96 and around the right end of middle pan 96, thereafter to the left between uppermost and middle pans 96, and finally around the left end of uppermost pan 96 to the upper interior portion of container member 85, from whence the contained vapor is discharged through outlet pipe 89.

An overflow pipe 97 is provided in the bottom of each pan 96 with the pans preferably disposed such that the overflow pipes 97 of adjacent pans are positioned diagonally opposite one another and at respective opposite ends of adjacent pans, as shown in Fig. 9. Note that as was the case in the embodiment of Figs. 1–5, the upper edge or lip of each overflow pipe 97 is preferably raised only slightly above the bottom of its pan so that only a thin layer or film of the liquid being evaporated will cover the pan bottom. The pan assembly thus far described is firmly positioned together and secured in place by means of respective hold-down clamps 98 encircling each tube 90 and secured adjacent the top of the straight portion thereof by means of a nut 99. Each hold-down clamp 98 abuts a second shoulder portion 100 of its tube 90 and overlies and is bent slightly around the upper edge of the adjacent side of the uppermost pan 96, as best illustrated in Figs. 8 and 9.

A fourth pan or tray 105 is positioned beneath the lowermost pan 96 and atop the responsive elements of two temperature-sensitive devices 106 and 107, hereinafter called thermostatic switches or thermostats. Pan 105 is shaped similarly to pans 96 except that it is longer between its ends so that both its ends abut opposite sides of the interior surface of container member 86, as shown in Fig. 9, in order to define the lower boundary of the tortuous path above described. It is to be noted that, as best shown in Fig. 7, each heating element holder 95 and each planar portion 94 of ferrules 93 extend in a chord-like fashion adjacent the sides of each pan 96 and provide the sealing side boundaries for the tortuous path above described.

A channel 110 is cut in the inner side of each insulating holder 95 to receive an end of the respective electric heating element 111, which is of the same grid type described above (see plan view of element 111 in Fig. 7). Three of these heating elements 111 are provided, one between the uppermost and middle pans 96, one between the lowermost and middle pans 96, and one between the lowermost pan 96 and pan 105 immediately thereunder. Heating elements 111 are all connected in series, U-shaped connection 112 being provided from one end of uppermost heating element 111 to the adjacent end of the middle heating element 111, as shown in Fig. 7, and the diagonally-opposite end of middle heating element 111 being connected to the adjacent end of lower heating element 111 by means of U-shaped connector 113, which may be seen in Figs. 8 and 9. Note that a tubular insulating member 114 is provided around the central portion of each electrical connector, although these are visible only in Fig. 7.

Terminals 115 and 116 are provided sealed in the bottom of container member 86, their construction being similar to that of terminal 70 described above in connection with Fig. 5. U-shaped connector 117 connects terminal 116 to the free end of uppermost heating element 111 (see Figs. 7 and 8) and a shorter U-shaped connector 118 connects terminal 115 to the free end of lowermost heating element 111 (see Fig. 9).

The operation of the steam generator of Figs. 7–9 is similar to that of the embodiment of Figs. 1–5 described above in connection with Fig. 6, and hence will not be repeated here in detail except to point out that the water inlet connections are made to the lower ends of each of tubes 90 and the water flow is controlled by a suitable electrically-operated water valve (not shown) similar to water valve 26 of Fig. 1. Also, a suitable pressure-stat (not shown) similar to pressure-stat 23 of Fig. 1 is connected to outlet pipe 89. The control circuit is the same as that shown in Fig. 6 with one of thermostats 106, 107 being adjusted to operate as the high temperature thermostat and the other adjusted so as to operate as the low water thermostat, the respective switch contacts of each being normally closed or normally open as required and indicated in Fig. 6 for its particular function. Note that, as described above, the feed water initially flows into the uppermost pan 96, forming a film on the bottom thereof, and overflows from each superior pan into the next inferior pan, the level of the water in the lowermost pan 105 being controlled by the combined action of the two thermostats 106, 107. Note again that due to the tortuous path provided, as explained above, vapor or steam produced in the lowermost pan 105 is superheated as it successively passes adjacent the two upper heating elements 111. Similarly, the steam produced in lowermost pan 96 is superheated as it passes adjacent the uppermost heating element 111.

Thus I have provided in the embodiment shown in Figs. 7–9 a steam generator which is very easily and quickly assembled and disassembled. In the initial assembly, thermostats 106 and 107 are first inserted in their respective apertures provided in container member 86. Pan 105 is then placed within container member 86 atop the responsive elements of thermostats 106, 107. Next the three ferrules 93 are slid over each tube 90, and each tube assembly thus formed then secured in the apertures provided in the bottom of the container member 86 by means of its nut and sealing washer connection 91. An insulating holder 95 is next positioned atop each of opposed planar shelf portions 94 of ferrules 93, and a pan 96 placed atop each pair of holders 95 disposed in the same horizontal plane. Hold-down clamp 98 and nut 99 are then slipped in turn over the upper end of each tube 90 and the assembly thus far described secured in place by tightening each nut 99. The three heating elements 111 are next inserted in the opposed channels 110 provided in each pair of insulating holders 95 lying in the same horizontal plane and the electrical series connections thereafter made between the respective

heating elements 111 and terminals 115 and 116. Lastly, cup-shaped container member 85 is placed over the assembly as shown with gasket 88 positioned between members 85 and 86 and the unit thus formed secured together by means of bolt and nut connections 87.

Note particularly that in the embodiment of Figs. 7–9, since no heating elements are positioned above uppermost pan 96 or below lowermost pan 105, protection is provided by contact with a layer of liquid for all surfaces directly opposing and exposed to the heating elements 111.

While I have described particular embodiments of my invention as required, the principles of my invention are of broader application in ways which will be apparent to those skilled in the art. Numerous additional applications of these principles will occur to those skilled in the art and no attempt has here been made to exhaust such possibilities. The scope of my invention is defined in the following claims.

What I claim is:

1. A liquid heater including in combination: a container; a plurality of pans disposed at different levels within said container; means for maintaining a layer of liquid in said pans; and a radiant heating element positioned within said container at a level between the bottom of an upper one of said pans and the exposed surface of the liquid in the next lower of said pans, said bottom and said surface being exposed to said element for radiation heating thereby.

2. A liquid heater including in combination: a container; a plurality of pans disposed at different levels within said container; means for supplying liquid to said pans; means for limiting the depth of liquid accumulating in each of said pans; and a radiant heating element positioned within said container at a level between the bottom of an upper one of said pans and the exposed surface of the liquid in the next lower of said pans, said bottom and said surface being exposed to said element for radiation heating thereby.

3. A liquid heater including in combination: a container; a plurality of pans disposed at different levels within said container; means for supplying liquid to said pans; means for limiting the depth of liquid accumulating in each of said pans and including control means for said first-mentioned means and responsive to the presence of liquid in the lowermost of said pans for maintaining a layer of liquid in each of said pans; and a radiant heating element positioned within said container at a level between the bottom of an upper one of said pans and the exposed surface of the liquid in the next lower of said pans, said bottom and said surface being exposed to said element for radiation heating thereby.

4. A liquid heater including in combination: a container; a plurality of pans disposed at different levels and parallel to one another within said container; means for supplying liquid to said pans; and a radiant heating element positioned within said container at a level between the bottom of an upper one of said pans and the exposed surface of the liquid in the next lower of said pans, said heating element lying generally in a plane parallel to said bottom of an upper one of said pans and said exposed surface of the liquid in the next lower of said pans and having its opposed surfaces directly exposed thereto.

5. A steam generator comprising in combination: a container having water inlet and steam outlet openings; a plurality of pans disposed at different levels within said container with the uppermost of said pans being fed from said water inlet; overflow means for each superior pan feeding the next inferior pan; a radiant electric heating element positioned between each pair of adjacent pans to heat the bottom of the superior pan and the water surface of the inferior pan; a thermostatic switch including a responsive element disposed within said container abutting the lowermost pan and electric contacts controlled thereby; and an electric circuit including in series said heating element and the electric contacts of said thermostatic switch to control the application of power to said heating element in accordance with the temperature of said lowermost pan.

6. A steam generator comprising in combination: a container having water inlet and steam outlet openings; a valve connecting said water inlet to a water source, and including electrically-operated actuating means therefor; a plurality of pans disposed at different levels within said container with the uppermost of said pans being fed from said water inlet; overflow means for each superior pan feeding the next inferior pan; a radiant electric heating element positioned between each pair of adjacent pans to heat the bottom of the superior pan and the water surface of the inferior pan; a thermostatic switch including a responsive element disposed within said container abutting the lowermost pan and electric contacts controlled thereby; and an electric circuit including in series said electrically-operated actuating means of said valve and the electric contacts of said thermostatic switch to control the flow of water into the pans of said container in accordance with the temperature of said lowermost pan.

7. A liquid heater and vapor generator comprising in combination: a container having liquid inlet and vapor outlet openings; a plurality of pans disposed at different levels within said container with the uppermost of said pans being fed from said liquid inlet; overflow means for a superior pan feeding the next inferior pan and positioned to maintain a layer of liquid of limited depth in the superior pan; and a radiant heating element positioned between said pair of pans to heat the bottom of the superior pan and the liquid surface of the inferior pan, said bottom and said surface being exposed to said element for radiation heating thereby.

8. A steam generator comprising in combination: a container having water inlet and steam outlet openings; a valve connecting said water inlet to a water source, and including electrically-operated actuating means therefor; a plurality of pans disposed at different levels within said container with the uppermost pan fed from said water inlet; overflow means for a superior pan feeding the next inferior pan; a radiant electric heating element positioned between said pair of pans to heat the bottom of the superior pan and the water surface of the inferior pan; first and second thermostatic switches, each including a responsive element disposed within said container abutting said inferior pan and electric contacts; and a first electric circuit including in series said heating element and the electric contacts of said first thermostatic switch and a second electric circuit including in series said electrically-operated actuating means of said valve and the electric contacts of said second thermostatic switch to control the application of power

to said heating element and to control the flow of water into the pans of said container, respectively, in accordance with the temperature of said inferior pan.

9. A steam generator comprising in combination: a container having water inlet and steam outlet openings; a pressure-sensitive switch connected to said outlet opening and including electric contacts; a valve connecting said water inlet to a water source, and including electrically-operated actuating means therefor; a plurality of pans disposed at different levels within said container with the uppermost pan fed from said water inlet; overflow means for a superior pan feeding the next inferior pan; a radiant electric heating element positioned between said pair of pans to heat the bottom of the superior pan and the water surface of the inferior pan; first and second thermostatic switches, each including a responsive element disposed within said container abutting said inferior pan and electric contacts controlled thereby; a first electric circuit including in series said heating element, the electric contacts of said pressure-sensitive switch, and the electric contacts of said first thermostatic switch to control the application of power to said heating element in accordance with the temperature of said inferior pan and the pressure developed within said container; and a second electric circuit including in series said electrically-operated actuating means of said valve and the electric contacts of said second thermostatic switch to control the flow of water into the pans of said container solely in accordance with the temperature of said inferior pan.

10. A liquid heater and vapor generator comprising in combination: a container having liquid inlet and vapor outlet openings; a plurality of pans disposed at different levels within said container with the uppermost of said pans being fed from said liquid inlet; overflow means for a superior pan feeding the next inferior pan and positioned to maintain a layer of liquid of limited depth in the superior pan; and a radiant electric heating element for and positioned above each pan to heat the liquid surface of the pan.

11. A liquid heater and superheated vapor generator comprising in combination: a container having liquid inlet and vapor outlet openings; a plurality of pans disposed at different levels within said container with the uppermost of said pans being fed from said liquid inlet, each superior pan being of less width than said container and said superior pans being staggered vertically within said container with respective opposite ends of adjacent superior pans abutting opposite sides of said container to form a tortuous path for the vapor from the bottom to the top of the container; sealing means disposed between adjacent sides of adjacent pans to confine the vapor to said tortuous path; overflow means for each superior pan feeding the next inferior pan and positioned to maintain a layer of liquid of limited depth in the superior pan; and a radiant electric heating element positioned between each pair of adjacent pans to heat the bottom of the superior pan and the water surface of the inferior pan and the vapor therebetween.

12. A superheated steam generator comprising in combination: a container having water inlet and steam outlet openings; a pressure-sensitive switch connected to said outlet opening and including electric contacts; a valve connecting said water inlet to a water source, and including electrically-operated actuating means therefor; a plurality of pans disposed at different levels within said container with the uppermost pan fed from said water inlet, each superior pan being of less width than said container and said superior pans being staggered vertically within said container with respective opposite ends of adjacent superior pans abutting opposite sides of said container to form a tortuous path for the steam from the bottom to the top of the container; sealing means disposed between adjacent sides of adjacent pans to confine the steam to said tortuous path; overflow means for each superior pan feeding the next inferior pan; a radiant electric heating element positioned between each pair of adjacent pans to heat the bottom of the superior pan and the water surface of the inferior pan and the steam therebetween; first and second thermostatic switches, each including a responsive element disposed within said container abutting the lowermost pan and electric contacts controlled thereby; a first electric circuit including in series said heating element, the electric contacts of said pressure-sensitive switch, and the electric contacts of said first thermostatic switch to control the application of power to said heating element in accordance with the temperature of said lowermost pan and the pressure developed within said container; and a second electric circuit including in series said electrically-operated actuating means of said valve and the electric contacts of said second thermostatic switch to control the flow of water into the pans of said container solely in accordance with the temperature of said lowermost pan.

HENRY C. A. MEYER.

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