

Aug. 17, 1948.

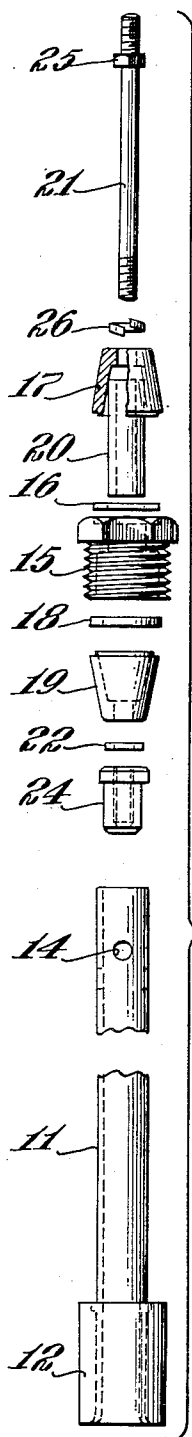
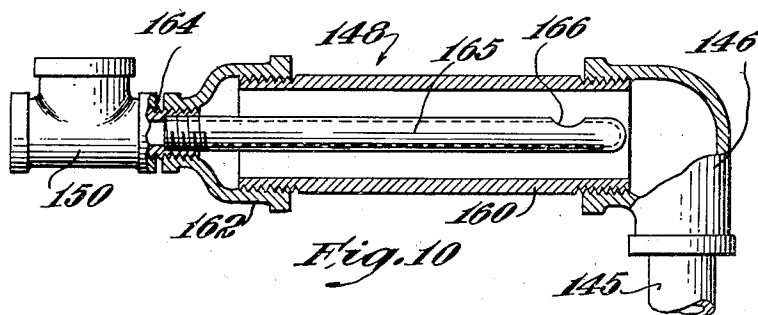
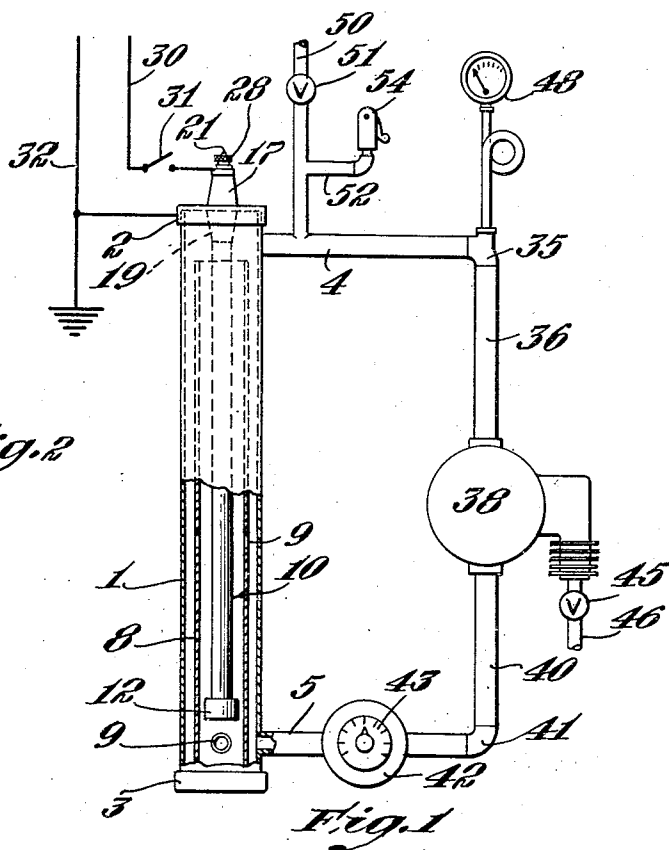
R. W. E. VICKERY

2,447,294

SELF-REGULATING ELECTRIC STEAM GENERATOR

Filed Feb. 20, 1946

6 Sheets-Sheet 1



Inventor
 Ralph W. E. Vickery
 by Robert, Cushman & Glover
 Att'ys.

Aug. 17, 1948.

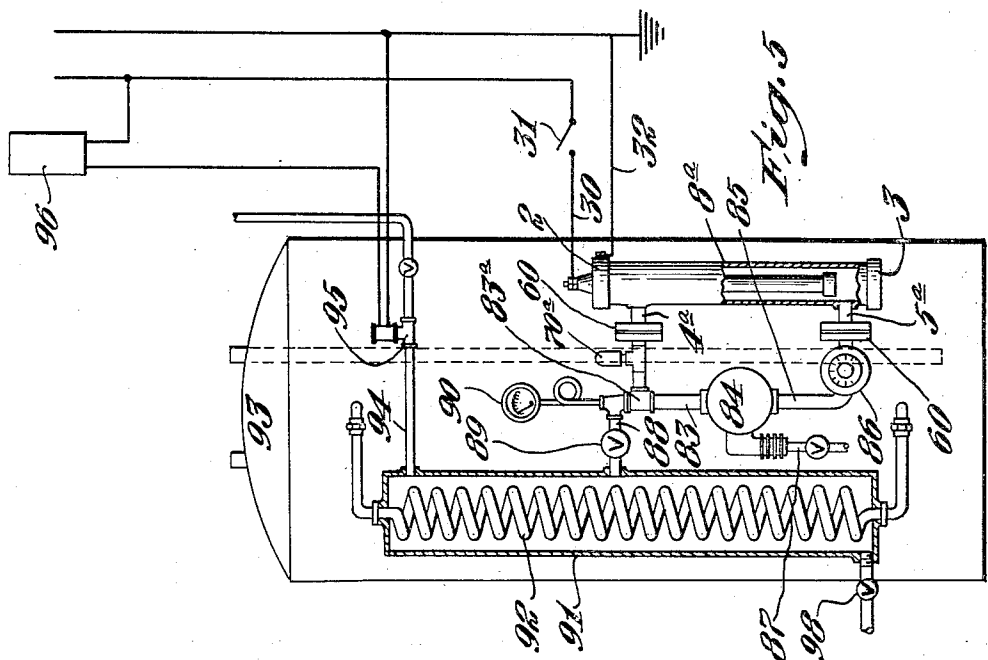
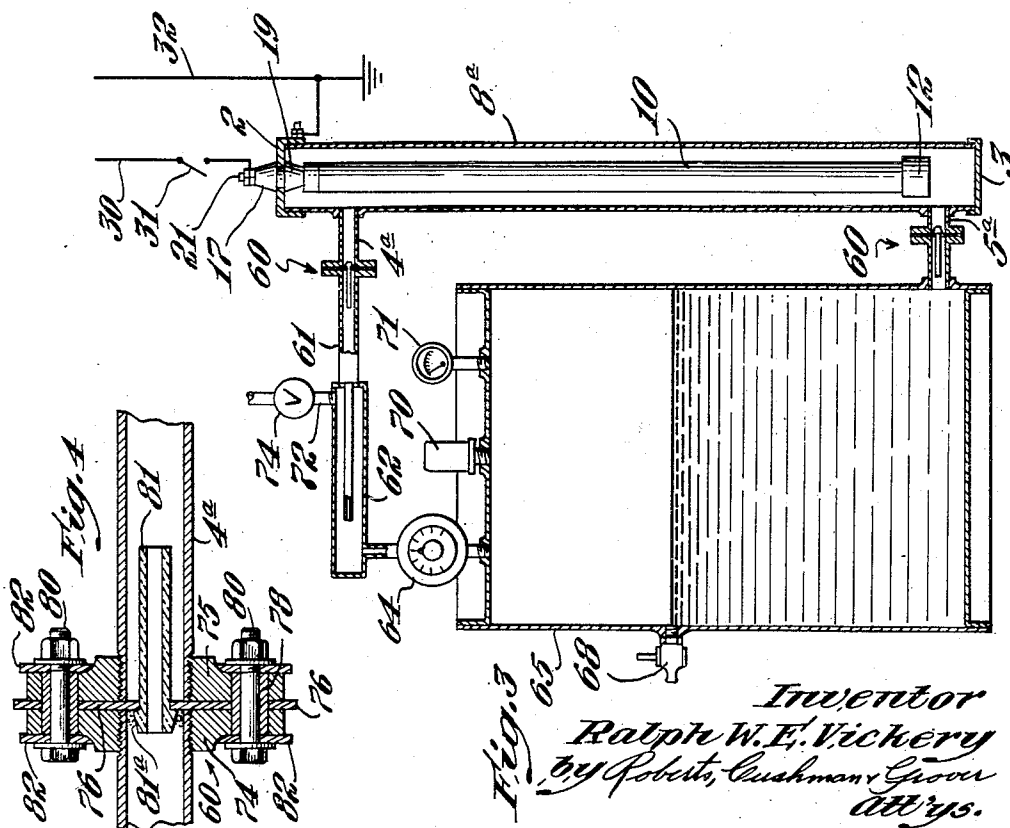
R. W. E. VICKERY

2,447,294

SELF-REGULATING ELECTRIC STEAM GENERATOR

Filed Feb. 20, 1946

6 Sheets-Sheet 2



Inventor
Ralph W. E. Vickery
by Robert, Cushman & Grover
Attys.

Aug. 17, 1948.

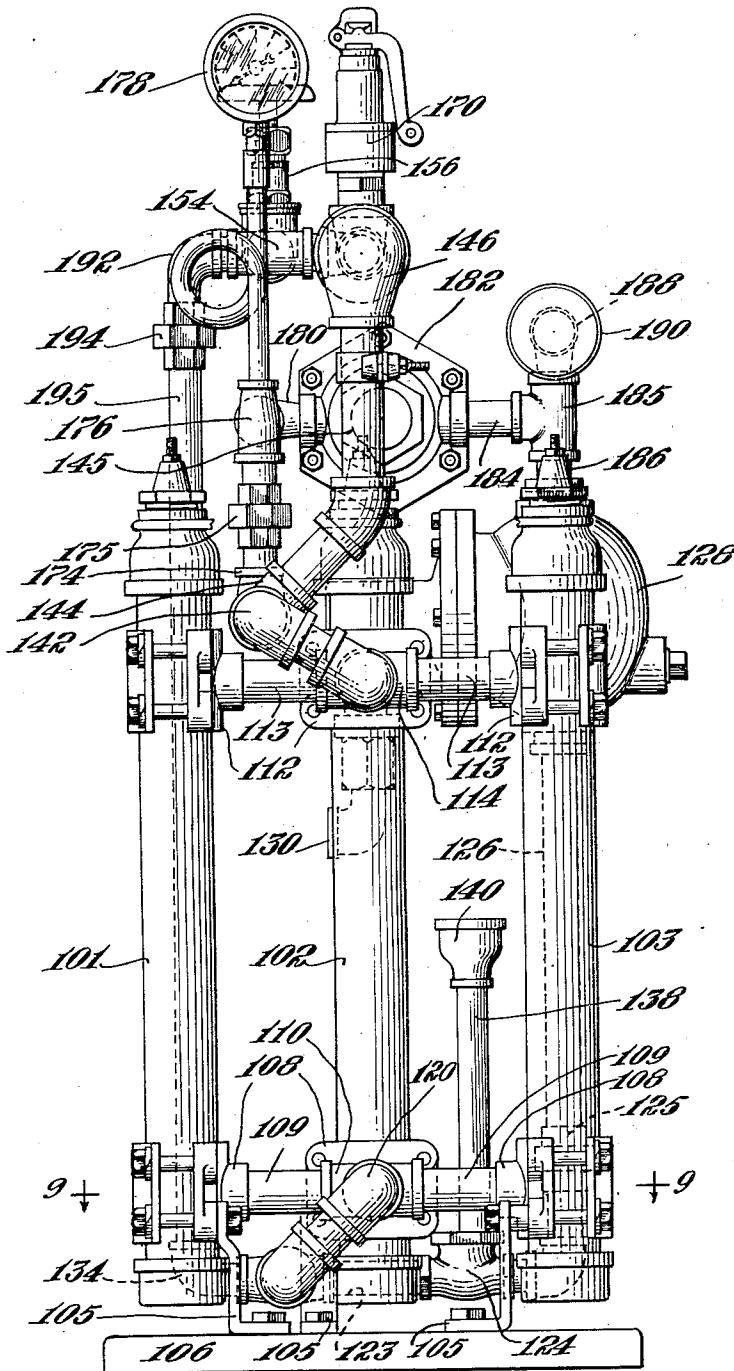
R. W. E. VICKERY

2,447,294

SELF-REGULATING ELECTRIC STEAM GENERATOR

Filed Feb. 20, 1946

6 Sheets-Sheet 3



Inventor
Ralph W. E. Vickery
by Robert Cushman & Glover
Att'ys.

Aug. 17, 1948.

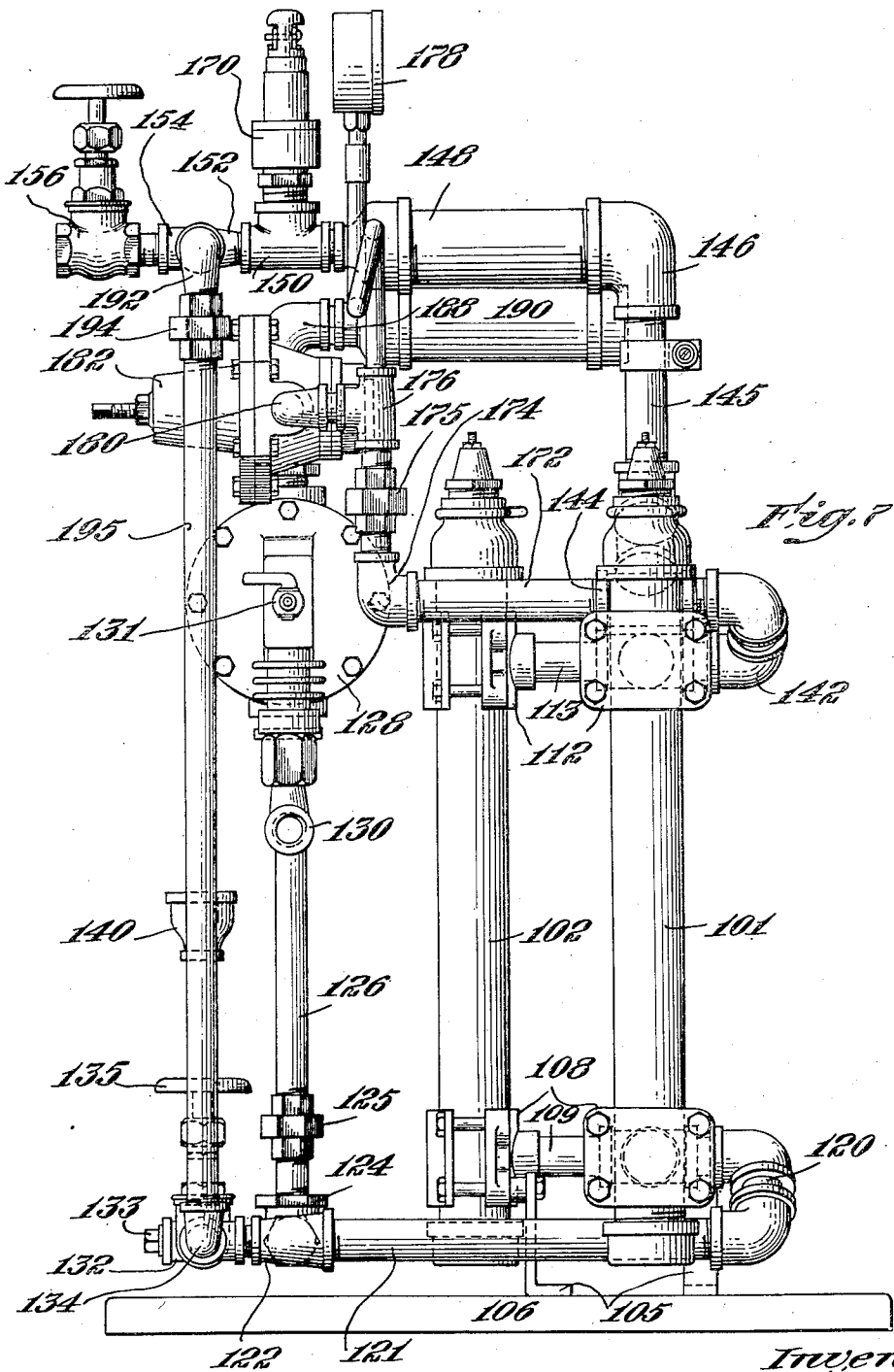
R. W. E. VICKERY

2,447,294

SELF-REGULATING ELECTRIC STEAM GENERATOR

Filed Feb. 20, 1946

6 Sheets-Sheet 4



Inventor
Ralph W. F. Vickery
by Robert Cushman & Co.
Att'ys.

Aug. 17, 1948.

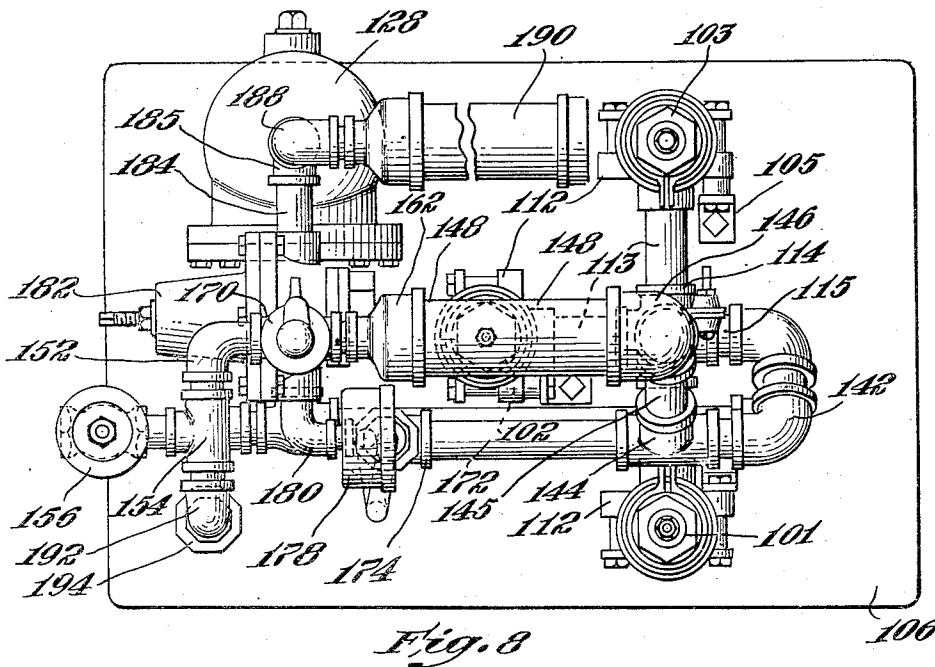
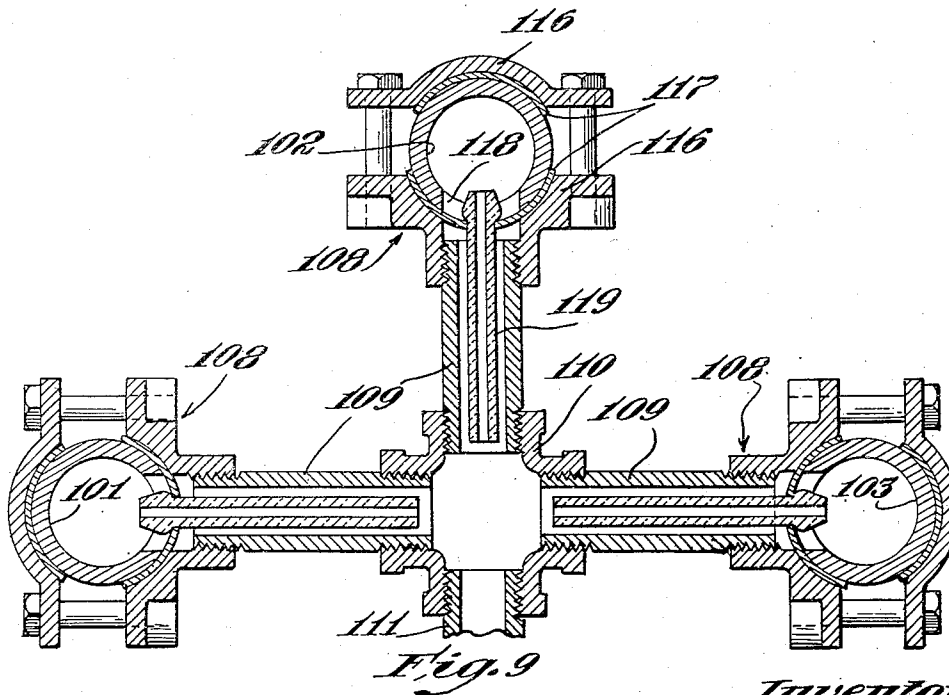
R. W. E. VICKERY

2,447,294

SELF-REGULATING ELECTRIC STEAM GENERATOR

Filed Feb. 20, 1946

6 Sheets-Sheet 5

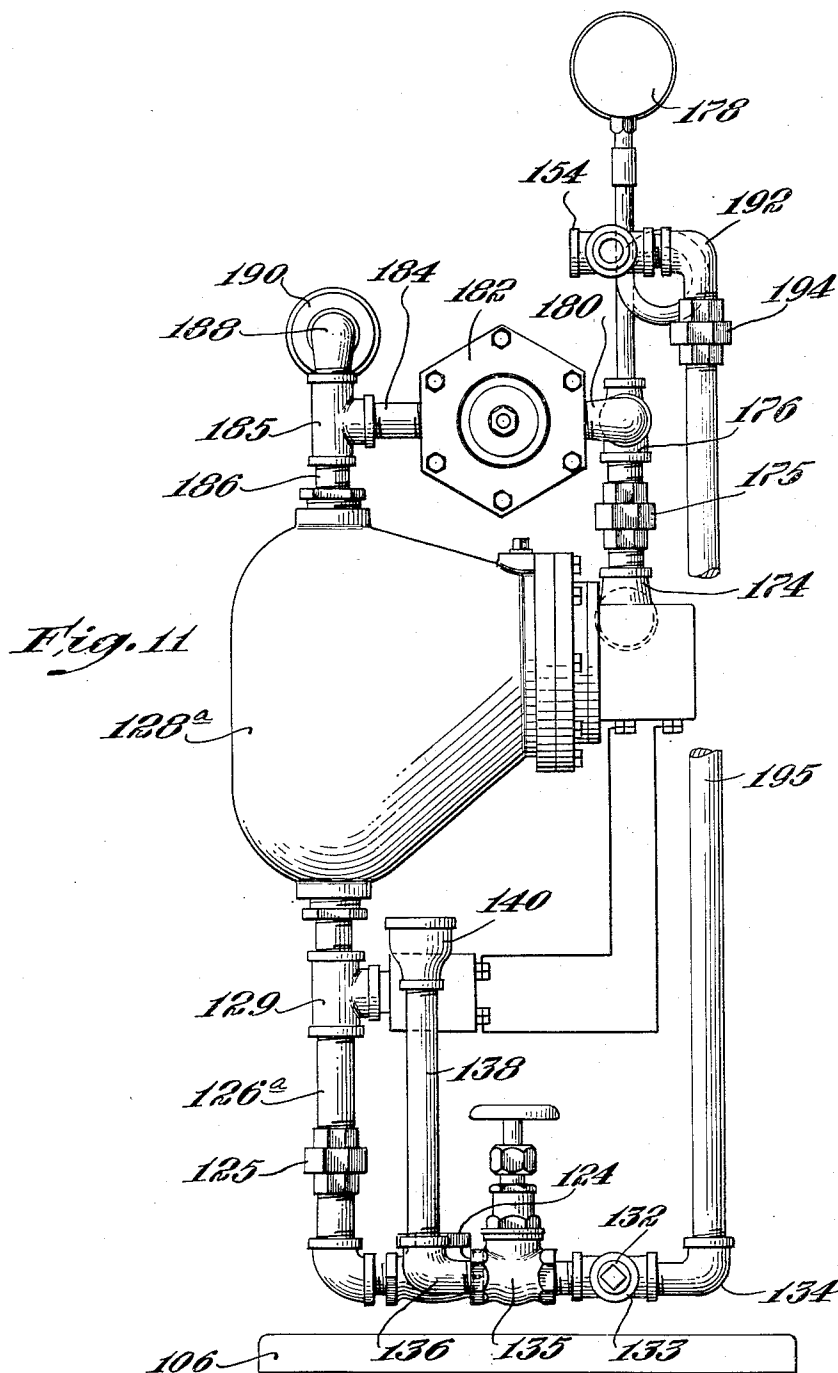


Inventor
Ralph W. F. Vickery
by Robert, Crushman & Grove
Att'ys.

Filed Feb. 20, 1946

ATING ELECTRIC STEAM GENERATOR

6 Sheets-Sheet 6



Inventor
Ralph W. F. Vickery
by Roberts, Cushman & Givner
att'ys.

UNITED STATES PATENT OFFICE

2,447,294

SELF-REGULATING ELECTRIC STEAM GENERATOR

Ralph W. E. Vickery, Brockton, Mass.

Application February 20, 1946, Serial No. 648,977

15 Claims. (Cl. 219—40)

1

This invention relates to an electric steam generator of the type illustrated in Patent No. 1,862,071, granted to me June 7, 1932.

The principal objects of the invention are to provide a reliable and efficient electric steam generator which is automatically self-regulating; to provide a steam generator which is designed to meet the several public safety requirements, both with respect to electrical and mechanical hazards; to provide an apparatus which is adapted for a wide variety of uses requiring operating pressures which may vary from a few pounds to several hundred pounds; and to provide an apparatus which is of relatively simple design and which can be manufactured at a relatively low cost without the use of skilled workers.

Further objects relate to various features of construction and will be apparent from a consideration of the following description and the accompanying drawings, wherein—

Fig. 1 is an elevation, with parts broken away and shown in section, of one embodiment of the invention particularly suitable for use with sterilizers, cookers and other apparatus having a relatively steady demand and low steam consumption;

Fig. 2 is an exploded view of a preferred form of electrode;

Fig. 3 is a side elevation, partly in section, of another embodiment of the invention;

Fig. 4 is an enlarged section through one of the insulating coupling members;

Fig. 5 is an elevation, partly in section, of another embodiment of the invention applied to a water heating device;

Fig. 6 is a front elevation of another embodiment of the invention particularly suitable for use in connection with installations having a relatively high steam consumption;

Fig. 7 is a side elevation of the apparatus shown in Fig. 6;

Fig. 8 is a top plan view of the apparatus;

Fig. 9 is an enlarged section on the line 9—9 of Fig. 6;

Fig. 10 is a sectional view of a preferred form of a trap; and

Fig. 11 is an elevation of a float switch and associated parts which may be substituted for the float valve and associated parts shown in Figs. 6 to 8.

In accordance with the present invention my improved steam generator comprises a plurality of electrodes which may be mounted within a suitable casing or housing, or one of the electrodes may of itself provide a casing, but in any event

2

the electrodes are suitably insulated from each other and define a steam-generating chamber having fluid inlet and outlet lines respectively connected with the lower and upper parts of the chamber. The number and arrangement of electrodes may vary, depending upon the type of alternating current to be employed, and for general use, I prefer tubular electrodes telescopically disposed and suitably insulated from each other with the annular space between the outer face of the inner electrode and the inner face of the outer electrode defining the steam-generating chamber or zone.

The outlet and inlet lines may be directly connected by a suitable conduit, a supply tank, a steam-consuming apparatus, or any other means which with the inlet and outlet lines provides an exterior fluid circuit between the upper and lower parts of the steam-generating chamber. The outlet line may provide or be connected with a steam discharge line, depending upon the particular construction, and the inlet line is connected or associated with means for admitting water or electrolyte to a predetermined initial fluid-level within the steam-generating chamber above the lower parts of the electrodes and at a level greater than that required for normal operation of the apparatus. To this end the inlet line may be connected with a conventional float valve associated with a water supply, or a tank, reservoir or the like adapted to supply water to the required level. Means are also provided to eliminate excess fluid in the form of vapor or liquid after a predetermined operating pressure has been reached, so as to reduce the fluid content of the chamber to a level below the initial fluid-level, but above the minimum level which permits the passage of an electric current through the electrodes. To this end a vapor blow-off valve may be connected either in the outlet line or the inlet line, or the latter may be so designed as to permit such excess fluid to back into a reservoir, tank or the like.

A pressure-regulating valve is connected in the fluid circuit, preferably in one of the lines and is operable to close the line when a predetermined pressure within the chamber is reached, thereby effecting an automatic regulation of the apparatus in the manner presently to be described. Water or electrolyte in the steam-generating chamber at or above the initial fluid-level is heated up by the passage of the alternating current therethrough, and when boiling occurs, the pressure starts to build up. When the pressure

reaches the point for which the regulating valve is set, the latter closes, although the pressure may continue to build up to a few pounds in excess of that for which the regulating valve is set. The pressure thus produced is effective either to operate the blow-off valve or back excess fluid into the inlet line, depending upon the particular design of the apparatus, but in either case sufficient fluid is discharged or consumed to reduce the fluid-level to a point below the initial fluid-level, but above the minimum level necessary to maintain contact with the electrodes. As the fluid-level decreases, the current consumption is reduced correspondingly so that by the time the minimum operating level is reached, the current consumed and consequently the amount of steam generated is merely that necessary to maintain the operating pressure and compensate for heat losses. Since at least a part of the electrodes are at all times emerged in the electrolyte, it might seem that the pressure would nevertheless continue to build up in the absence of unusual heat losses. However, it has been observed that the upper part of the electrolyte which would normally surround the lower part of the electrodes is in the form of a mass of froth or bubbles of reduced electrical conductivity and functions to reduce the current consumption to a minimum. If the pressure within the chamber drops below the operating pressure for which the regulating valve is set, the latter opens sufficiently to permit or cause enough fluid to be admitted into the chamber to raise the liquid level and the superposed froth-like mass, thus increasing the overall conductivity of the fluid within the chamber with a consequent increase in current consumption and generation of steam, until the aforementioned normal operating pressure is again reached.

When the steam discharge line is open, there is of course a slight drop in pressure within the chamber, and hence the regulating valve immediately opens to permit or cause more fluid to enter the chamber thus effecting an increased generation of steam until normal operating pressure is again established, whereupon the generation of steam is reduced to an amount equal to the steam output plus that necessary to compensate for heat losses. Thus, by a simple manipulation of the regulating valve, the steam generator may be set so as automatically to maintain a desired operating pressure for any output reasonably within the capacity of the apparatus.

Referring to Figs. 1 and 2, the embodiment shown therein comprises a tubular casing 1, such as a length of two-inch standard pipe, the ends of which are provided with caps 2 and 3. The upper part of the casing 1 is connected with a fluid outlet line 4 and its lower part is connected with a fluid inlet line 5.

Mounted coaxially within the casing 1 and welded, brazed or otherwise suitably secured to the inner face of the cap 3 so as to provide a good electrical contact, is an upstanding tubular outer electrode 8, the upper end of which terminates below the inlet line 4 and the side wall of which is formed with a plurality of spaced openings 9. An inner electrode 10, depending from the cap 2, is telescopically disposed within the outer electrode 8 with its lower end terminating above the inlet line 5 and defining an annular steam-generating chamber within the casing 1.

The electrode 10, as shown in Fig. 2, comprises a tubular member or pipe 11, the lower end of which carries a porcelain insulating sleeve 12, and its upper end is provided with an opening 14. The

upper part of the electrode is rigidly secured to but insulated from the cap 2 by an assembly which projects through an opening in the cap 2. The insulating assembly comprises a screw-threaded bushing 15, the upper face of which carries an asbestos washer or gasket 16 and a generally conical insulator 17. An asbestos washer 18 and another conical insulator 19 are disposed against the lower face of the bushing 15 and a porcelain sleeve 20 extends through these parts. A threaded stud 21 extends through the sleeve 20 and a small asbestos washer 22 into a metal bushing 24, the lower end of which has a pressed fit within the upper end of the electrode tube 11 so as to provide a good electrical connection therewith. A nut 25 and lock washer 26 carried by the upper end of the stud hold the parts in assembled relation, the threaded upper end of the stud 21 carrying a clamping screw 28 (Fig. 1) and thus provides a terminal or binding post to which one of a pair of single phase alternating current power lines 30, 32 is connected. A switch 31 is connected in the power line 30, and the power line 32 is connected in any suitable manner with the cap 2 and is also grounded, as illustrated.

The outlet line 4 is connected by a T or Y 35 with a pipe 36 which in turn is connected with the upper port of a conventional float valve 38. The lower or discharge port of the float valve is connected by pipe 40 and elbow 41 to one side of a pressure-regulating valve 42, the other side of which is connected to the inlet line 5. The pressure-regulating valve 42 may be of conventional design and construction, such as an "Acme" regulating valve, and is preferably provided with an index finger and dial 43 designed to show the pressure for which the operating spring is set.

The inlet line to the float valve 38 is connected through a shut-off valve 45 to a service line 46 or other suitable source of water supply. The pipes 4, 36, 40 and 5, together with the included float and pressure-regulating valves, provide an exterior fluid circuit between the top part of the casing 1 and its lower part, which circuit is open so long as the pressure therein is below that for which the regulating valve 42 is set.

A pressure gauge 48 may be connected to the Y 35 and a steam discharge line 50 is connected to the outlet line 4, the line 50 being provided with a shut-off valve 51 and a branch 52 which carries a safety valve 54 normally set to pop or open at a pressure slightly greater than that for which the pressure-regulating valve 42 is set.

The construction and arrangement of parts are such that the float valve 38 is positioned to admit water into the casing 1 or steam-generating chamber to a predetermined initial fluid-level somewhat in excess of that required for normal operation, and it will be observed that in this particular embodiment the safety valve 54 is directly connected with the outlet 4 so that excess fluid in the form of steam or vapor may be eliminated when the specified pressure is reached. If desired, the valve 51 may be used to accomplish the same end, but in either case the design permits reducing the fluid content of the casing 1 to its normal operating level which is between the initial fluid-level defined by the float valve 38 and the top of the insulating sleeve 12.

The mode of operation of this apparatus is as follows:

Assuming that the pressure-regulating valve 42 is set to close at 15 pounds per square inch

pressure, that the valve 54 is set to pop at 18 pounds per square inch pressure, that valves 45 and 51 are closed, and that switch 31 is open—the valve 45 is first opened to admit water through float valve 38, pipe 40, regulating valve 42 and line 5 into the casing 1. When the water level in the casing 1 reaches the level of the float valve 38, the latter shuts off the water and the switch 31 may now be closed. The current passing through the water about the electrodes 8 and 10 heats the water and soon causes it to boil thus building up pressure within the system. It will be observed that since the circuit through the pipe 4, 36, 40 and 5 is open, pressure throughout the system is equalized, but after the pressure reaches 15 pounds per square inch, the regulating valve 42 closes and the pressure then continues to climb slightly until the safety valve operates to relieve the excess pressure, or the valve 51 is manually opened to consume the steam thus generated. If desired, blowing off the excess fluid may be accomplished by manual manipulation of the safety valve 54, but in any case the excess vapor is discharged with a corresponding decrease in the fluid-level about the electrodes, thus conditioning the apparatus for normal operation. Should the pressure tend to climb up, the valve 54 operates further to eliminate excess fluid so that ultimately the fluid-level in the casing is reduced to a point where the current consumption and consequent generation of steam is the minimum necessary for maintaining a pressure of 15 pounds. When it is desired to utilize the steam, the valve 51 is opened and consequently a slight drop of pressure within the casing takes place, whereupon the regulating valve 42 opens sufficiently to admit enough water into the casing 1 to increase the fluid-level about the electrodes with a consequent increase in the rate of generation of steam until the pressure again reaches 15 pounds at which point the regulating valve closes the inlet line 5. The operation thus continues indefinitely so long as the consumption of steam is within the capacity of the apparatus.

It will be noted that the rate of generation of steam is governed by the fluid-level about the electrodes and this level varies in accordance with the demand. If the demand drops, the prevailing pressure is nevertheless maintained and hence the regulating valve remains closed, thus preventing admission of water into the casing 1. Since no water is being admitted to compensate for the steam consumed, the fluid-level about the electrodes is reduced and as the fluid-level drops the power consumption likewise drops until it reaches the minimum. Thus, the apparatus is automatically regulating at the specified pressure for which the valve 42 is set throughout its rated capacity.

The embodiment shown in Figs. 3 and 4 is the same in principle as that shown in Fig. 1, but is designed for use where there is no available water supply line. In this embodiment the outer electrode 8^a constitutes the casing and hence its upper part is directly connected with the outlet line 4^a and its lower part is connected with inlet line 5^a. The opposite ends of the electrode 8^a are provided with caps 2 and 3, the cap 2 supporting the inner electrode 10 which has the same construction as the inner electrode of the embodiment of Fig. 1, and power lines 30, 32 are connected with the electrodes, as shown.

The outlet 4^a is connected through an insulating coupling 60, pipe 61, trap 62 and pressure-

regulating valve 64 with the upper part of a water supply tank or reservoir 65, and the inlet line 5^a is connected through another insulating coupling 60 with the lower part of the tank 65. The regulating valve 64 is the same type as that described in connection with the embodiment of Fig. 1 and may also be provided with a dial and index to indicate the pressure for which it is set. The tank 65 is provided with a cock 68 which may not only be used for filling the tank to the desired level, but also provides means for determining the maximum fluid-level within the electrode chamber 8^a. The upper end of the tank 65 may also be provided with a safety or blow-off valve 70 and a pressure gauge 71 and the entire apparatus may be so constructed as to provide a portable unit.

The inner end of the trap 62 is connected with a steam discharge line 72 which may be provided with a shut-off valve 74 and the power line 30 may include the usual operating switch 31, it being understood that the power lines 30, 32 are connected with a suitable source of alternating current such, for example, as a 220 volt, 60 cycle single phase transmission line or generator.

The insulating couplings 60 are provided to protect the user against the electrical hazard which might otherwise be present and, as shown in Fig. 4, each coupling comprises a pair of flange flanges 74, 75 having an interposed disk of asbestos or the like insulating material 76 formed with a central opening. Insulating sleeves 78 extend through circumferentially spaced aligned openings in the flanges 74, 75 and interposed disk 76 and bolts 80 extend through the sleeves 78 to hold the parts in assembled relation, the opposite ends of the bolts being insulated from the flanges 74, 75 by insulating gaskets 82. A tubular porcelain insulator 81 extends through the central opening in the disk 76, and its end is sealed to the disk by a suitable insulating cement or adhesive designated by the numeral 81^a.

It will be noted that the pipes 4^a and 61, trap 62, regulating valve 64, tank 65 and line 5^a provide a fluid circuit connecting the upper and lower parts of the electrode chamber, and this circuit remains open so long as the pressure therein is below that for which the regulating valve 64 is set.

In order to operate this apparatus the regulating valve 64 is first set to the desired operating pressure, for example, 25 pounds per square inch, and water is admitted to the tank 64 and the electrode chamber 8^a to the level of the cock 68, after which the cock is closed. The switch 31 is next closed, thereby causing the water about the electrodes to be heated. As pressure builds up in the system no appreciable change in the fluid-level about the electrode takes place since the fluid circuit remains open, but when the pressure reaches 25 pounds per square inch (the pressure for which the regulating valve 64 is set), the fluid circuit is closed, and as the pressure continues to climb, excess fluid, i. e., water in the electrode chamber is backed up into the tank 65, thus reducing the fluid-level in the electrode chamber to the minimum required to maintain the specified pressure. The apparatus is now in condition for normal operation and the valve 74 may be opened to discharge steam to be consumed. The drop in pressure thereby produced causes regulating valve 64 to open, whereupon water is admitted to the electrode chamber through the line 5^a in an amount sufficient to raise the fluid-level

about the electrodes so that increased generation of steam takes place. When the pressure again builds up to 25 pounds per square inch the pressure-regulating valve 64 closes thus preventing further admission of water into the electrode chamber until such time as consumption of steam causes a pressure drop with consequent opening of regulating valve 64. The operation thus continues so long as the steam consumption is within the capacity of the apparatus.

The embodiment shown in Fig. 5 illustrates the application of my steam generator for use as a water heater, as well as to provide steam for heating or other purposes and as a source of distilled water or condensate. In this embodiment the steam generator, per se, may be the same as that of the embodiment of Fig. 3, except that the outlet and inlet lines 4^a and 5^a are connected in a fluid circuit comprising blow-off valve 70^a, T 83^a, pipe 83, float valve 84, pipe 85 and regulating valve 86. The float valve 84 is connected with the water supply line 87 as in the embodiment of Fig. 1, and a steam discharge line 88 is connected with the line 4^a and includes a shut-off valve 89 and pressure gauge 90.

The steam discharge line 88 is connected with a column 91 containing a heating coil 92, the upper and lower ends of which are connected with the top and bottom of a hot water tank 93. The upper end of the column 91 is connected with a steam line 94 leading to a steam-consuming device, such as a radiator or the like, and a solenoid valve 95, connected in the line 94, is controlled by a thermostat 96 or the like switch suitably connected to the power lines 30, 32, as shown. The lower end of the column may be provided with a tap 98 by means of which condensate from the column may be withdrawn for use.

The operation of the system is substantially identical to that described in connection with the embodiment of Fig. 1, the pressure-regulating valve 86 being effective to maintain the desired operating pressure throughout the rated capacity of the apparatus.

The embodiment shown in Figs. 6 to 10 is designed for high steam consumption applications and is for use with a three-phase power line. In this embodiment three pairs of electrodes 101, 102 and 103 are employed, each pair of electrodes, i. e., the outer electrode and the inner electrode, are preferably of the same construction as shown in the embodiment of Fig. 3, the outer electrode constituting a casing enclosing the steam generating chamber. The three-phase circuit may have either a Δ or Y connection with the electrodes, and suitable switches and other electrical controls (not shown) may be connected in the circuit in any well known manner.

Each of the electrodes is supported on a bracket 105 carried by the base 106, and their lower parts carry coupling saddles 108 connected through nipples 109 with three of the branches of a cross 110, the fourth branch of the cross being connected to a nipple 111 which is hereinafter referred to as the main inlet line since it is connected with the three branch inlet lines to the electrode chambers. The upper parts of the outer electrode likewise carry coupling saddles 112 (Fig. 8) connected through nipples 113 with three of the branches of a cross 114, the fourth branch of the cross being connected with a nipple 115 which is hereinafter referred to as the main outlet line. As shown in Fig. 9, each of the coupling saddles comprises a pair of yokes 116

both having a heavy layer of asbestos or the like insulating material 117 between their inner faces and the outer faces of the associated electrode. The inner yoke 116 is formed with a threaded opening aligned with an opening 118 in the wall of the companion electrode, the opening 118 receiving the end of the associated nipple 109 or 113, as the case may be. The insulating gasket 117 is formed with an opening through which projects one end of the tubular porcelain insulator 119, the opposite end of the insulator extending into the associated nipple. This construction and arrangement of parts has been found not only to afford satisfactory protection against electrical hazards which might otherwise be present, but also to provide a pressure-tight connection capable of withstanding several hundred pounds pressure.

The nipple 111 or the main inlet line is connected through a bend 120 (Fig. 7), pipe 121, one branch of a reducing T 122, nipple 123 (Fig. 6), an apertured check valve 124, union 125 (Figs. 7 and 11) and pipe 126 to the lower outlet port of a float valve 128 having an inlet port 130 (Fig. 6) adapted to be connected with a water supply or service line (not shown), and a petcock or valve 131. The other branch of the T 122 (Fig. 7) is connected with a cross 132, one branch of which has a plug 133 which may be removed for the purpose of cleaning out the apparatus, another branch of which is connected with a reducing street L 134 (Fig. 11), and the remaining branch of the T 122 is connected through a shut-off valve 135 and street L 136 (Fig. 11) with a pipe 138, the upper end of which is provided with a reducing coupling 140. The parts 135—140 provide an overflow and hence a means for determining the water level within the electrode chambers, and also a convenient means by which the apparatus may be blown out or quickly emptied simply by swinging the pipe from vertical position to an inclined position and opening the valve 135.

The main outlet line or nipple 115 is connected through a bend 142 (Fig. 7) with a T 144 (Fig. 8) having one branch connected with a steam discharge line comprising a pipe line 145, reducing elbow 146, trap 148, one branch of a T 150, a street L 152, one branch of a T 154 and shut-off valve 156. The trap 148, as shown in Fig. 10, comprises a length of pipe 160, such as a 2" long nipple, one end of which is connected to the enlarged end of the reducing L 146 and the other end to a reducing coupling 162 connected with a close nipple 164. A closed end tube 165 has a pressed fit within the nipple 164 and extends into the pipe 160, as shown, the tube 165 having an outlet opening 166 on its upper wall adjacent to its inner end. The other branch of the T 150 is coupled with a safety or blow-off valve 170 (Fig. 7) which is set to pop at a pressure a few pounds greater than the normal operating pressure of the apparatus.

The other branch of the T 144 is connected through pipe 172 (Fig. 8), reducing elbow 17 and union 175 (Figs. 6, 7 and 11) with a T 176. One branch of the T 176 is connected with a pressure gauge 178, and its other branch is connected through street L 180 with one side of a pressure-regulating valve 182 (Figs. 6 and 7). The other side of the pressure regulating valve 182 is connected through a nipple 184 (Fig. 6), one branch of a T 185, and nipple 186 with the upper port of the float valve 128. The other branch of

185 is connected through street L 188 (Fig. 8) to an expansion head 190 (Figs. 6, 8 and 11).

The side branch of T 154 (Figs. 7 and 11) is connected through street L 192 and union 194 with the top of an upstanding rod (or plugged pipe) 195, the lower end of which has a screw-threaded connection with the street L 134. The purpose of the rod 195 is solely to lend rigidity to the apparatus and provide a partial support for the parts connected with the T 154.

The modified arrangement shown in Fig. 11 merely consists in substituting a float switch 128^a and an associated solenoid-operated valve 129 in place of the float valve 128, it being understood that these parts are connected with the water supply line in any suitable manner. It will be noted that such substitution simply requires the insertion of the assembled float switch 128^a and valve 129 between the union 125 and nipple 186. Suitable electrical connections, as indicated, are provided between the parts so that they function in the same manner as float valve 128.

It will be observed that the main inlet line 111 and the main outlet line 115 are respectively connected with the bottom and top parts of the electrode chambers, that the steam discharge line (145—156) are directly connected with the outlet line 115, and that the inlet and outlet lines are connected to each other through an exterior fluid circuit comprising the parts 172—176, the pressure regulating valve 182, float valve 128 and parts 120—126. Thus, the construction and arrangement of parts correspond with those of the previously described embodiment.

The operation of the apparatus is as follows:

Assuming that the electrode chambers are empty, that valves 131, 135 and 156 are closed, that the pressure regulating valve 182 is set for 100 pounds per square inch pressure, that the safety valve 170 is set to pop at 110 pounds pressure, and that the water line to port 130 is closed—the valve 135 is first opened and the water line to port 130 may then be opened to admit water through float valve 128 into the electrode chambers until it reaches the proper level, as indicated by overflow 140, whereupon the water supply line and valve 135 are shut off. The control switch for the three-phase power line may now be closed and within a few minutes steam is being generated within the electrode chambers. As the pressure is building up, either valve 156 or safety valve 170 may be momentarily opened to vent the system of entrapped air.

So long as the pressure within the system is below that for which the regulating valve 182 is set, the exterior circuit between the inlet and outlet lines 111 and 115 remains open, but when the pressure builds up to 100 pounds per square inch, the regulating valve 182 automatically closes the exterior circuit, and as a result, excess water in the electrode chambers is forced back through inlet line 111, the apertured check valve 124 and pipe 126 into the float valve 128 and expansion head 190, leaving enough water in the electrode chamber to form a conductive medium (consisting of an aqueous froth of steam bubbles above the water which surrounds the lower part of the inner electrodes). The minimum fluid level thus established permits sufficient steam generation to compensate for all heat losses, and the apparatus is thus conditioned for normal operation. The water supply line to port 130 may now be opened, but since the water level in the float valve 128 is above its operating level, the valve remains closed.

Upon opening the valve 156 to deliver steam for consumption, there is a slight drop in pressure sufficient to open the regulating valve 182 to allow water to pass through inlet line 111 into the electrode chambers, thereby increasing the rate of steam generation until the normal operating pressure of 100 pounds per square inch is reached, whereupon the regulating valve 182 closes. The operation thus continues with the pressure regulating valve periodically opening to permit water to enter the electrode chambers in accordance with the steam demand, thereby maintaining the desired operating pressure. During the course of operation, the water level in the float valve 128 periodically drops so as to actuate the valve to admit more water from the supply line and thus insure an adequate amount of water in the exterior circuit for proper operation. Should the steam output suddenly be reduced, as by closing valve 156, a slight excess pressure is created within the electrode chambers which forces excess fluid back through inlet line 111 into the float valve 128 and expansion head 190, thus automatically reducing the fluid level within the electrode chambers to the minimum necessary to maintain the desired operating pressure.

While I have shown and described several desirable embodiments of the invention, it is to be understood that this disclosure is for the purpose of illustration and that various changes and modifications may be made without departing from the spirit and scope of the invention as set forth in the appended claims.

I claim:

1. A steam generator comprising spaced electrodes defining a steam generating chamber, outlet and inlet lines respectively connected with the upper and lower parts of said chamber, means connecting said inlet and outlet lines so as to provide an exterior fluid circuit between the upper and lower parts of said chamber, and a pressure-regulating valve connected in said fluid circuit and operative in response to a drop in pressure below a predetermined pressure to open so as to permit fluid to pass through said inlet line into said chamber so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when said predetermined pressure has been reached, thereby to arrest the flow of fluid through said inlet line.

2. An electric steam generator comprising a plurality of electrodes defining a steam generating chamber, fluid inlet and outlet lines respectively connected with the lower and upper part of said chamber, means connecting said inlet and outlet lines so as to provide an exterior fluid circuit between the upper and lower parts of said chamber, means connected with the inlet line for admitting fluid to a predetermined fluid-level within said chamber, means for discharging fluid from said chamber, and a pressure regulating valve connected in said circuit and operative in response to a drop in pressure below that for which it is set to permit fluid to pass through said inlet line into said chamber so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when the pressure for which it has been set is reached, thereby to arrest the flow of fluid through said inlet line.

3. An electric steam generator comprising a casing having spaced electrodes defining a steam generating chamber, fluid inlet and outlet lines respectively connected with the lower and upper

part of said chamber, means connecting said inlet and outlet lines so as to provide an exterior fluid circuit between the upper and lower parts of said chamber, means connected with the inlet line for admitting fluid to a predetermined initial fluid-level within said chamber in excess of that required for normal operation, means for eliminating excess fluid within said chamber so as to reduce the fluid content therein to a level below said initial fluid-level, and a pressure regulating valve connected in one of said lines and operative in response to a drop in pressure below that for which it is set to permit fluid to pass through said inlet line into said chamber so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when the pressure for which it has been set is reached, thereby to arrest the flow of fluid through said inlet line.

4. An electric steam generator comprising an inner electrode, an outer electrode electrically insulated from but surrounding the inner electrode and defining therewith a steam-generating chamber, fluid inlet and outlet lines respectively connected with the lower and upper part of said chamber, means connecting said inlet and outlet lines so as to provide an exterior fluid circuit between the upper and lower parts of said chamber, means connected with the inlet line for admitting fluid to a predetermined fluid-level within said chamber, a discharge conduit connected with the upper part of said chamber, and a pressure regulating valve connected in one of said lines and operative in response to a drop in pressure below that for which it is set to permit fluid to pass through said inlet line into said chamber so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when the pressure for which it has been set is reached, thereby to arrest the flow of fluid through said inlet line.

5. A steam generator comprising spaced electrodes defining a steam-generating chamber, outlet and inlet lines respectively connected with the upper and lower parts of said chamber, means connecting said inlet and outlet lines so as to provide an exterior fluid circuit between the upper and lower parts of said chamber, a fluid-supply line connected in said circuit, a pressure-regulating valve connected in said fluid circuit and operative in response to a drop in pressure within said chamber below a predetermined pressure to open so as to permit fluid to be admitted through said inlet pipe into said chamber so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when the pressure for which it has been set is reached, thereby to arrest the flow of fluid through said inlet line, and means operative to discharge excess fluid from said chamber in response to a pressure higher than said predetermined pressure.

6. An electric steam generator comprising a plurality of electrodes defining a steam-generating chamber, fluid inlet and outlet lines respectively connected with the lower and upper parts of said chamber, means connecting said inlet and outlet lines so as to provide an exterior fluid circuit between the upper and lower parts of said chamber, means connected with the inlet line for admitting fluid to a predetermined initial fluid-level within said chamber, a steam discharge line connected with said outlet line, and a pressure-regulating valve connected in said inlet line and operative in response to a drop in pressure below that for

which it is set to permit fluid to pass through said inlet line into said chamber so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when the pressure for which it has been set is reached, thereby to arrest the flow of fluid through said inlet line.

7. An electric steam generator comprising a plurality of electrodes defining a steam-generating chamber, fluid inlet and outlet lines respectively connected with the lower and upper parts of said chamber, a source of water supply, means connecting said inlet and outlet lines with said water supply so as to provide an exterior fluid circuit between the upper and lower parts of said chamber, said water supply being arranged to supply water through said inlet line to said chamber to a predetermined fluid-level, a steam discharge line connected with said outlet line, and a pressure-regulating valve connected in said circuit and operative in response to a drop in pressure below that for which it is set to permit fluid to pass through said inlet line into said chamber so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when the pressure for which it has been set is reached, thereby to arrest the flow of fluid through said inlet line.

8. An electric steam generator comprising a plurality of electrodes defining a steam-generating chamber, fluid inlet and outlet lines respectively connected with the lower and upper parts of said chamber, a source of water supply, means connecting said inlet and outlet lines with said water supply so as to provide an exterior fluid circuit between the upper and lower parts of said chamber, said water supply being arranged to supply water through said inlet line to said chamber to a predetermined fluid-level, a steam discharge line connected with said outlet line, and a pressure-regulating valve connected in said circuit between said inlet line and said source of water supply, said pressure-regulating valve being operative in response to a drop in pressure below that for which it is set to permit fluid to pass through said inlet line into said chamber so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when the pressure for which it has been set is reached, thereby to arrest the flow of fluid through said inlet line.

9. An electric steam generator comprising a plurality of electrodes defining a steam-generating chamber, fluid inlet and outlet lines respectively connected with the lower and upper parts of said chamber, a source of water supply, means connecting said inlet and outlet lines with said water supply so as to provide an exterior fluid circuit between the upper and lower parts of said chamber, said water supply being arranged to supply water through said inlet line to said chamber to a predetermined fluid level, a steam discharge line connected with said outlet line, and a pressure-regulating valve connected in said circuit between said steam discharge line and said source of water supply, said pressure-regulating valve being operative in response to a drop in pressure below that for which it is set to permit fluid to pass through said inlet line into said chamber so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when the pressure for which it has been set is reached, thereby to arrest the flow of fluid through said inlet line.

10. An electric steam generator comprising a plurality of electrodes defining a steam-generating chamber, fluid inlet and outlet lines respectively connected with the lower and upper parts of said chamber, a float valve having means for connection with a water supply line, means connecting said inlet and outlet lines with the discharge port of said float valve thereby providing an exterior fluid circuit between the upper and lower parts of said chamber, said float valve being arranged to supply water through said inlet line to said chamber to a predetermined level, a steam discharge line connected with said outlet line, and a pressure-regulating valve connected in said circuit and operative in response to a drop in pressure below that for which it is set to permit fluid to pass through said inlet line into said chamber so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when the pressure for which it has been set is reached, thereby to arrest the flow of fluid through said inlet line.

11. An electric steam generator comprising a plurality of electrodes defining a steam-generating chamber, fluid inlet and outlet lines respectively connected with the lower and upper parts of said chamber, a float valve having means for connecting with a water supply line, means connecting said inlet and outlet lines with the discharge port of said float valve thereby providing an exterior fluid circuit between the upper and lower parts of said chamber, said float valve being arranged to supply water through said inlet line to said chamber to a predetermined level, a steam discharge line connected with said outlet line, and a pressure-regulating valve connected in said circuit between said inlet line and float valve, said pressure-regulating valve being operative in response to a drop in pressure below that for which it is set to permit fluid to pass through said inlet line into said chamber so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when the pressure for which it has been set is reached, thereby to arrest the flow of fluid through said inlet line.

12. A steam generator comprising a plurality of steam generating chambers, each having a pair of spaced electrodes, the lower parts of said chambers being connected with a common inlet line and the upper parts of said chambers being connected with a common outlet line, an exterior fluid circuit connecting the inlet and outlet lines, a pressure regulating valve connected in said fluid circuit and operative in response to a drop in pressure below a predetermined pressure to open so as to permit fluid to pass through said inlet line into said chambers so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when said predetermined pressure has been reached thereby to arrest the flow of fluid through said inlet line, and a steam discharge line connected to said fluid circuit between said outlet line and pressure regulating valve.

13. A steam generator comprising a plurality of steam generating chambers, each having a pair of spaced electrodes, the lower parts of said chambers being connected with a common inlet

line and the upper parts of said chambers being connected with a common outlet line, an exterior fluid circuit connecting the inlet and outlet lines, said fluid circuit including a pressure regulating valve operative in response to a drop in pressure below a predetermined pressure to open so as to permit fluid to pass through said inlet line into said chambers so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when said predetermined pressure has been reached thereby to arrest the flow of fluid through said inlet line connections for introducing water into said fluid circuit when the liquid level therein drops below a predetermined level, and a steam discharge line connected to said outlet line.

14. A steam generator comprising a plurality of steam generating chambers, each having a pair of spaced electrodes, the lower parts of said chambers being connected with a common inlet line and the upper parts of said chambers being connected with a common outlet line, an exterior fluid circuit connecting the inlet and outlet lines, said fluid circuit including a pressure regulating valve operative in response to a drop in pressure below a predetermined pressure to open so as to permit fluid to pass through said inlet line into said chambers so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when said predetermined pressure has been reached thereby to arrest the flow of fluid through said inlet line, a float valve for introducing water into said fluid circuit when the liquid level therein drops below a predetermined level, and a steam discharge line connected to said outlet line.

15. A steam generator comprising a set of three steam generating chambers, each having a pair of spaced electrodes adapted for connection with a three-phase power line, the lower parts of said chambers being connected with a common inlet line and the upper parts of said chambers being connected with a common outlet line, an exterior fluid circuit connecting the inlet and outlet lines, a pressure regulating valve connected in said fluid circuit and operative in response to a drop in pressure below a predetermined pressure to open so as to permit fluid to pass through said inlet line into said chambers so as to contact said electrodes and thereby effect the generation of steam, said pressure-regulating valve automatically closing when said predetermined pressure has been reached thereby to arrest the flow of fluid through said inlet line, and a steam discharge line connected to said fluid circuit between said outlet line and pressure regulating valve.

RALPH W. E. VICKERY.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,597,362	Henriksson	Aug. 24, 1926
1,665,793	Sandborgh	Apr. 10, 1928
1,862,071	Vickery	June 7, 1932
1,902,842	Eaton	Mar. 28, 1933