March 19, 1963 H. N. SHAW 3,082,312

STORED HEAT STEAM GENERATOR

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Fig. 1.

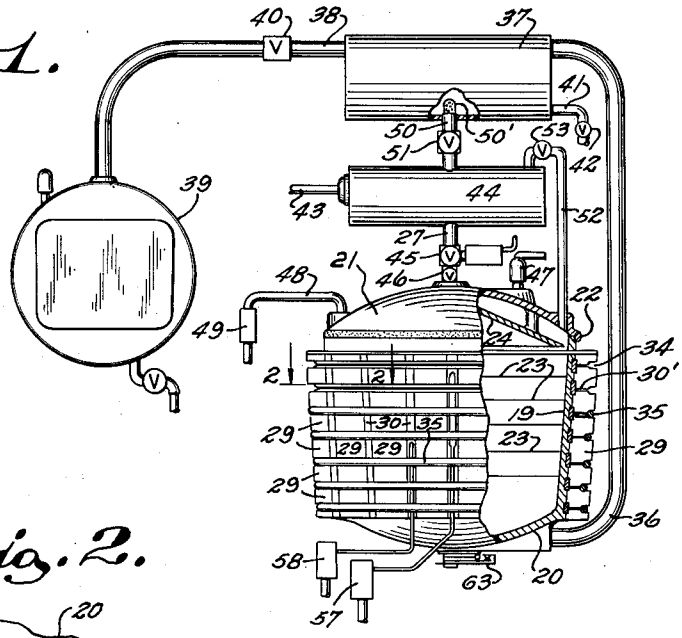


Fig. 2.

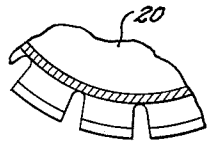


Fig. 3.

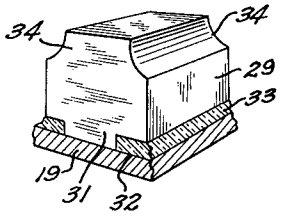
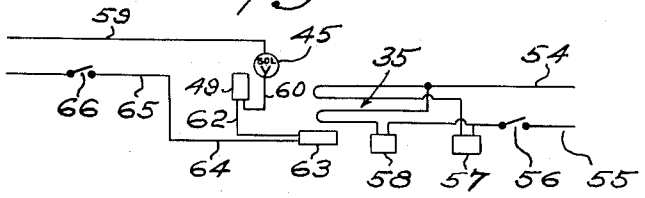


Fig. 4.



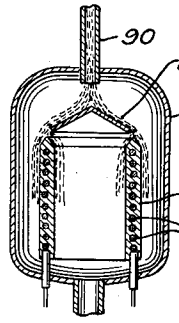


Fig. 5.

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Fig. 6.

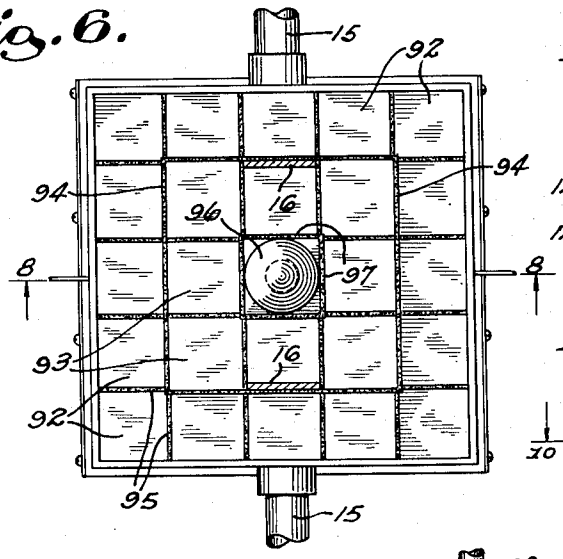


Fig. 10.

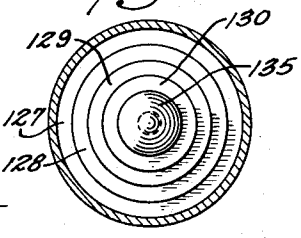


Fig. 9.

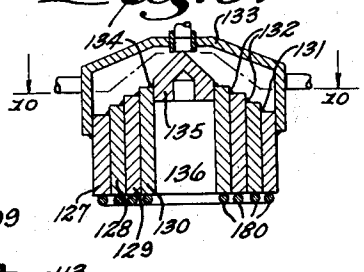
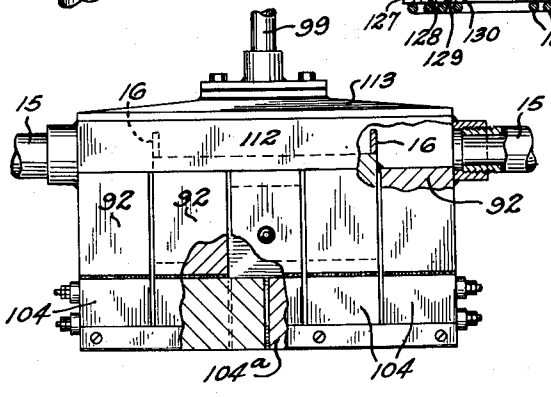


Fig. 7.



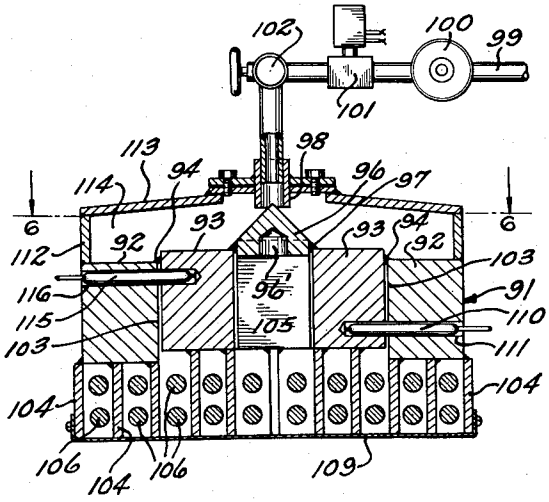


Fig. 8.

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Fig. 11.

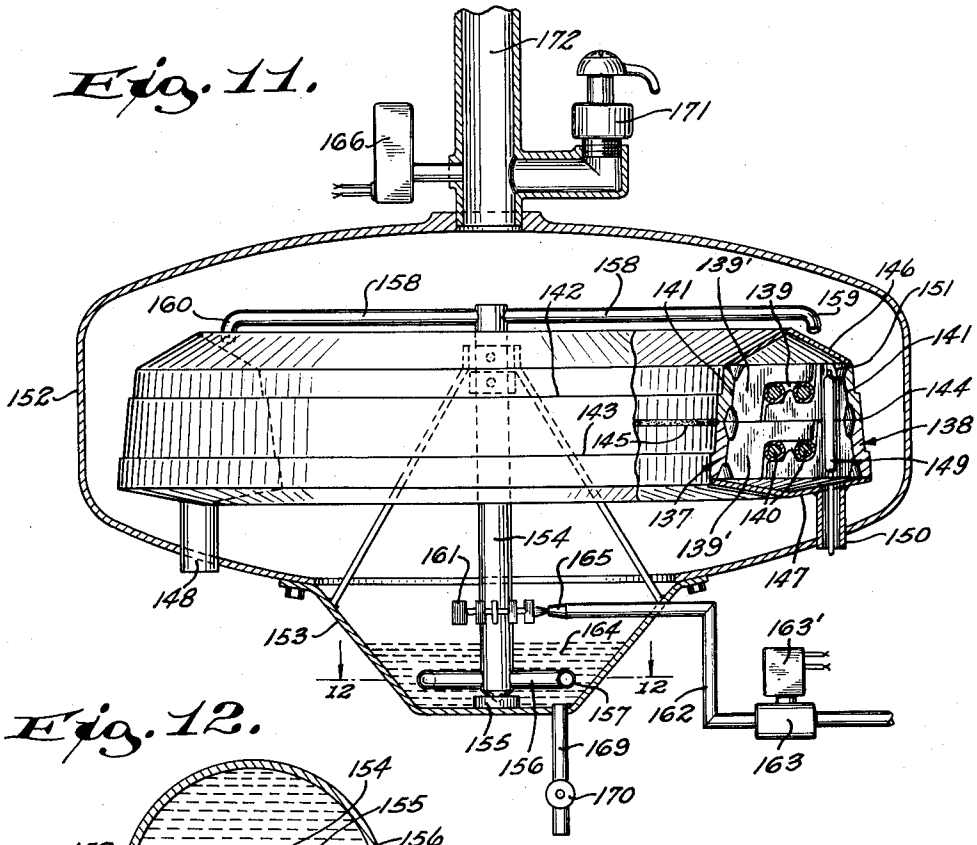
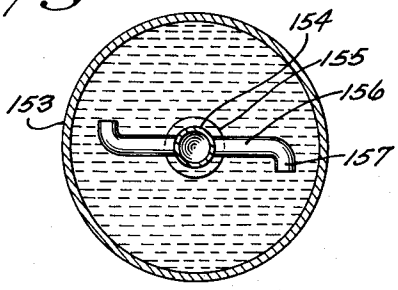


Fig. 12.



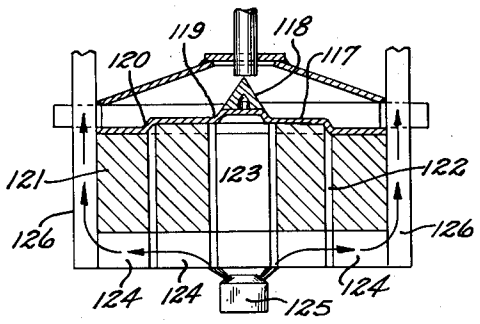


Fig. 14.

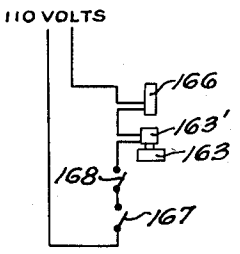


Fig. 13.

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3,082,312

STORED HEAT STEAM GENERATOR

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Filed Dec. 31, 1959, Ser. No. 863,345
10 Claims. (Cl. 219—39)

This invention relates to improvements in stored heat steam generators, and is a continuation in part of application Serial No. 704,768, filed December 23, 1957, now Patent No. 2,920,179 (Re. 24,861).

In pressure cookers, sterilizers, and other steam heated devices it is desirable to bring the heating chamber up to pressure as quickly as possible. This is particularly true with frozen foods where once the steam is up to pressure, the cooking time is short, and where slow preheating may more than double the time the food is exposed to the steam. Such lengthy exposure is undesirable as steam leaches out vitamins and other nutrients.

In cases where a pressure cooker is connected to a relatively large boiler, or to a small high pressure boiler, through the use of a reducing valve, the steam can usually be built up to a required pressure in a matter of seconds. Where there is a full load of frozen food a large volume of steam is usually required as it condenses as fast as it enters the cooking chamber, and at least the outer surface of the food must heat up before the rate of condensation slows down enough to allow the steam pressure to rise.

If a boiler is operated at the same pressure as the cooker, the pressure must drop when the steam valve is opened and it will continue to drop until the steam generated by the stored heat in the water equals the steam demand of the cooker. If the apparatus which is being used to heat the boiler is on at the time the valve is opened then this heat input may minimize the pressure drop. Usually, however, by the time the controls have turned on the heat, the boiler pressure has dropped considerably. The larger the boiler and the greater the heat input the less the pressure drop, but with a small boiler the pressure drops to zero almost instantaneously so that the capacity of the heating equipment for the boiler determines the rate of heating of the cooker.

In cases where a boiler is operated at higher pressure than that of the cooker, the cooker may come up to pressure before the boiler pressure has dropped to that of the cooker. Therefore, fast heating results, but a reducing valve is required to allow the boiler to be reheated above the cooker pressure. It is, however, undesirable to operate any equipment at a pressure materially higher than that of the cooker as high pressures are dangerous and there are special code requirements for high pressure boilers which makes them expensive.

It is a principal object of the present invention to provide a steam generator having a source from which heat can be drawn for a quick build up of steam pressure, to which source heat can be delivered while the pressure is being maintained for cooking or other heating operations, whereby heat stored in said source during the cooking or heating operation can be subsequently used for quick preheating of the next batch of food, assuming the device is being used with a pressure cooker.

It is a further object of the present invention to provide a steam generator which draws heat from hot metal rather then from hot water, there being little need to depend on the heat supply while the cooker is being heated up.

A further object of the invention is to provide a device as above described wherein heat is stored in a relatively light mass of metal which has been heated to a temperature several hundred degrees higher than that of steam and above the "critical temperautre" at which a film of steam insulates the heating surface from the water to prevent effective steam generation. This "critical temperature" may be 45° above the boiling point of about 290° F. for low pressure steam generators. It may, however, be above or below this temperature depending upon the condition of the heating surface. In accordance with the present invention it is desirable to heat the metal to at least 600° F.

A further object of the invention is to provide a device as above described wherein a metal heating surface is employed, with a stream of water flowing down the surface by gravity so that some steam is generated by the cooled upper part of the surface, and as the descending water passes beyond the "critical temperature" line, it boils violently and is thrown away from the surface. Any water which falls back into engagement with the heating surface at a point below this line rolls down in the form of balls so that relatively little steam is generated thereby. With the above arrangement, beginning a short distance above the "critical temperature" line steam generataion is very rapid (more than ten times the rate of heat generation in the average boiler), and this makes it possible to employ hot metal as a heat source in a steam generator.

Inasmuch as a thick metal plate which is kept relatively cold above a predetermined line and very hot below said line would be subjected to severe strains and would probably buckle or crack, it is a further object of the invention to provide a steam generator of the class described having a heating surface with all the advantages of thick metal which is so formed as to eliminate the above objections.

A further object of the invention is to provide a device of the class described wherein pressure is built up as stored heat is used, as distinguished from conventional boilers where pressure falls as it is used, the device also being such that heat can be stored without building up pressure, as the device is dry until ready for use.

A further object of the invention is to provide a stored heat steam generator wherein the water initially contacts a relatively thin section so that this section will cool below the critical temperature point in a second or two to allow wetting of the surface for free flow and uniform water distribution.

A further object of the invention is to provide in a device of the class described a relatively flexible heating surface, part of which is thin enough to flex under the stress of rapid temperature changes, one side of said surface being contacted by the water and the other side having heat storage lugs extending therefrom which lugs are spaced apart to allow for free movement relative to one another and independently of the heating surface as they heat or cool.

A further object of the invention is to provide a stored heat steam generator wherein the heating surface has horizontal steps and wherein the water flows by gravity from one step to another, the steps being opposite the heat storage lugs where the heat conduction is the greatest.

A further object of the invention is to provide a device as above described wherein the portion of the heating surface which is initially contacted by the water is relatively thin and has no lugs projecting from the opposite side thereof.

A more specific object of the invention is to provide as one form of the invention a device wherein the steam generating surface is in the shape of a relatively flat, stepped cone or pyramid down which water is allowed to slowly cascade from a pyramidal or conical apex to thereby insure suitable coverage of the surface with a relatively small volume of water.

A further more specific object of the invention is to provide in one form of invention a pyramidal steam generator formed of blocks which are welded together at

their upper edges only to provide a pressure-tight, relatively flexible heating surface, the remainder of the blocks being free from one another for relative movement so that the heating surfaces can buckle down as the result of sudden cooling, the blocks being preferably higher than they are wide to prevent cracking strains.

A still further object of the invention is to provide, as another form of the invention, a ring shaped steam generator having means for pumping water from a sump within a pressure chamber and for spreading this water onto a steam generating surface in the form of a wave which follows the spreader, this arrangement providing for deep water on every part of the ring once during each turn of the spreader, the device requiring but a small volume of water, and excess water being continuously recirculated.

With the above and other objects in view, the invention consists of the improved stored heat steam generator, and all of its parts and combinations, as set forth in the claims, and all equivalents thereof.

In the accompanying drawings, illustrating several embodiments of the invention, in which the same reference numerals designate the same parts in all of the views:

FIG. 1 is a partially diagrammatic view shown a stored heat steam generator as used in conjunction with a pressure cooker, part of the generator being broken away and shown in vertical section;

FIG. 2 is a fragmentary horizontal sectional view taken on line **2—2** of FIG. 1;

FIG. 3 is a fragmentary perspective view showing one of the lugs which projects from the steam generator.

FIG. 4 is a wiring diagram showing the hook-up for the equipment of FIG. 1;

FIG. 5 is a fragmentary vertical sectional view showing another type of steam generator embodying features of the present invention;

FIG. 6 is a view of a pyramidal type of steam generator taken on the line **6—6** of FIG. 8;

FIG. 7 is a side view of the form of the invention of FIG. 6, parts being broken away and shown in section;

FIG. 8 is a vertical sectional view taken approximately on the line **8—8** of FIG. 6;

FIG. 9 is a vertical sectional view through another modified form of the invention showing a conical form of generator;

FIG. 10 is a sectional view taken approximately on the line **10—10** of FIG. 9;

FIG. 11 is a vertical sectional view through the housing of another form of steam generator having a rotating pump and spreader, part of the generator being broken away and shown in section;

FIG. 12 is a sectional view taken on line **12—12** of FIG. 11;

FIG. 13 is a wiring diagram for use with the form of invention of FIG. 11; and

FIG. 14 is a vertical sectional view through another generator of the pyramidal type wherein the heating is by a gas burner.

Referring first more particularly to FIGS. 1 and 3 of the drawing, this form of the device includes a cup shaped receptacle **20** of metal, preferably aluminum, closed by a head **21**. The head is preferably welded to the top of the receptacle by an annular line of weld **22** within a V groove as shown. The side wall **19** of the receptacle which constitutes a steam generating surface is circular in horizontal cross section, and the wall tapers inwardly somewhat in a downward direction. The interior surface of the side wall is stepped to provide annular ledges **23**.

Suitably supported from the top **21** is a conical water spreader **24** having a central spreader cone. With this arrangement water entering through the water inlet pipe **27** is spread by the cone so that it flows all portions of the conical spreader surface **24**. The water then falls off of the annular edge of the spreader in an annular sheet and is directed simultaneously against all upper portions of the interior of the side wall of the heat generator. This water is adapted to cascade down the wall from one step **23** to another.

Cast integrally with the sides of the receptacle **20** are annular horizontal rings or lugs **29**, separated from each other by vertical radial slots **30**. The lugs of one ring are separated from the lugs of an adjacent ring by an annular horizontal space or slot **30'**.

Referring more particularly to FIG. 3, each lug is generally T-shaped and is connected to the wall **19** by a relatively narrow neck portion **31** which is integral with the wall. A slot **32** which extends from the upper portions of the necks of one ring of lugs to the lower portions of the necks of the ring of lugs thereabove is formed by casting with asbestos **33** therein. The outer corners of adjacent rings of lugs are machined out as at **34** to provide annular grooves for receiving annular rod-type heating elements **35**. The latter are omitted from the upper two grooves of FIG. 1 and in order to show the grooves more clearly. The horizontal slots **30'** between rings of lugs allow the lugs to move independently as the receptacle shrinks at the steaming line. The vertical radial slots **30** divide the rings of lugs into relatively short lug units so as to eliminate any strains resulting from the lugs being hotter than the receptacle proper. Any heat from a lug must flow through the relatively narrow neck **31** into the cylinder.

In FIG. 1 an outlet line **36** for wet steam connects with a steam separator **37**, the latter being connected by a dry steam pipe **38** with a pressure cooker **39**, there being a steam valve **40** in the line. The function of the steam separator is to provide a large cross-section so as to reduce the steam velocity to a point where the water is allowed to settle out so that relatively dry steam is delivered to the cooker **39**, the separator also providing water for the feed tank **44**. The wet steam line **36** carries the excess water which is blown off of the generator bottom by the high velocity steam. The steam valve **40** provides means for closing the steam outlet when the heating operation is completed. A drain line **41** extends from the bottom of the steam separator and has a sediment drain valve **42** therein. A water feeder **43**, from any suitable source to provide make-up water, feeds into a hot water feed tank **44** from the bottom of which the inlet line **27** leads to the top of the generator, there being a solenoid valve **45** in the line **27** and a throttling valve **46** below the solenoid valve.

The top **21** of the steam generator has a safety valve **47** fitted therein and there is also a line **48** connecting the interior of the steam generator with a pressure control switch **49**.

A conduit **50** connects the bottom of the steam separator with the top of the hot water feed tank, there being a one-way check valve **51** in said line to prevent steam leaving tank **44**. The upper end of the pipe **50** is provided with a perforated strainer **50'** above the bottom of the separator tank to prevent sediment from flowing to the feed water tank **44**. A vacuum breaker line **52** leads from the interior of the steam generator to the top of the hot water feed tank, there being a one-way check valve **53** in said line to prevent steam leaving tank **44**.

Referring now to the wiring diagram of FIG. 4, wires **54** and **55** leading from a suitable source of current, supply electricity to the heating element **35** which is around the steam generator receptacle **20**, there being a switch **56** in the line **55**. Also connected to the line **55** is a heater thermostat **57**, and another heater thermostat **58** is inserted in the line **55**. A wire **59** extending from a suitable source connects with one side of the solenoid operated valve **45** in the water inlet line to the steam generator. The other side of the solenoid operated valve **45** is electrically connected by a wire **60** with one side

of the electrically operated pressure control switch 49. The other side of said switch is connected by a wire 62 with one side of a low temperature thermostat 63. The other side of the thermostat 63 is connected by a wire 64 with the other source wire 65 there being a switch 66 in the line 65.

A thermostat 63 is connected to the bottom of the steam generator and is adapted to open when the receptacle is cold and to close when the receptacle is hot.

In the form of the invention of FIG. 5, the steam generator includes an outer casing 86 within which a cylindrical heating surface 87 is suitably supported, there being a heating element 88 within the wall 87. Above the cylinder 87 a spreading cone 89 is suitably supported. Feed water from the inlet pipe 90 is intercepted by the cone and falls off of the periphery of said tone in a circular sheet, part of which flows down the inner surface of the cylinder 87 and part down the outer surface. The construction, therefore, provides a double surface steam generator.

Operation of FIG. 1

Referring to FIGS. 1 to 4, when the valve 40 is opened steam flows through the dry steam line 38 to the cooker 39 or other device requiring steam. When this occurs the pressure in the steam separator 37 drops and check valves 51 and 53 close so the pressure in the feed tank 44 does not drop immediately. When the pressure in the steam generator receptacle 20 drops the pressure control switch 49 closes and opens solenoid operated valve 45 to allow water to flow into the steam generator. The throttling valve 46 is adjusted to limit the water flow to that required for efficient steam generation on the cylinder walls.

Water then flows onto the spreader cone 24 and from the spreader to the annular wall of the receptacle 20. As soon as the top portion of the annular upright wall is cooled below the "critical temperature" steam is generated on a circular line around the wall, which circular line progresses downwardly as the wall is progressively cooled, the water boiling violently and being thrown away from the surface below the "critical temperature" line. Any water which might fall back on the heating surface rolls down the surface in the form of a ball and generates very little steam. Just above "critical temperature" line the steam generation is very rapid, up to 396,000 B.t.u. per square foot per hour. This is over ten times the rate of heat transfer in the average boiler and this is what makes it practical to use hot metal as a heat source in a steam generator.

Since most of the steam is generated just above the critical line on the upright heating surface, the rating of the team generator is determined by the length of this line rather than by the area o fthe heating surface. Tests have shown this rating to be about 3,500 B.t.u. per hour per inch of length. The rating would vary, however, with the maximum metal temperature and also with the thickness and heat conductivity of the metal, as considerable heat is transferred by conduction from the hot metal to the cooled metal above the critical line. Below the said line the metal is dry and hot. The more heat which is conducted under the critical line the wider the steaming band and the slower the advance of the "critical temperature" line. The rate of downward advance of the critical line is also effected by the thickness of the metal back of the heating surface as the thicker the metal the slower it will cool off. A thick metal plate which is kept relatively cool on one side of the critical line and relatively hot on the other side would be subjected to severe internal strains and would probably buckle or crack. With the present invention, however, the advantages of a thick metal plate are obtained through use of the lug arrangement shown in FIGS. 1, 2 and 3, which is so worked out to eliminate internal strain. For a practical stored heat cylinder of the type with which the present invention is concerned the thickness of the wall of the receptacle 20 would have to be about one inch and the use of the lugs makes it possible to use such a thickness without problems.

The weight of water flowing down the cylinder must be considerably greater than the weight of the steam generated as the water which is actually converted to steam would form only a thin film on the cylinder and there would be no simple way of insuring a uniform flow down to the critical line. Inasmuch as the excess water which is required to maintain a uniform flow is heated to steam temperature it would be inefficient to discard this hot water. With the present invention the steam pressure generated within the receptacle 20 serves to blow this excess water into the steam separator 37 which is then fed downwardly through the pipe 50 into the feed water tank 44 to be used as feed water in the next heating operation.

The thermostat 63 at the bottom of the steam generator prevents the water valves from feeding water into the receptacle 20 until the wall is hot enough to generate sufficient steam to blow excess water off of the bottom. If such excess water were allowed to accumulate on the bottom then it would continue to boil after the desired pressure had been reached and the safety valve 47 would blow off.

If water level drops in the feed tank 44 the pressure above the water falls below that in the steam generator 20 and the water would stop flowing. By using the check valve 53 in the vacuum breaker line 52 this will open to keep the pressure in the feed tank at least as high as that in the generator so as to allow the water to flow down by gravity. The thermostats 57 and 58 control the electric heating elements 35. The receptacle 20 is kept hot at all times, and when the upper part above the critical line is cooled by the water the thermostat 57 turns on a heating element for the upper portion of the receptacle. When the lower portion of the receptacle is cool the thermostat 58 turns on the lower section of the heating element. The thermostat 63 at the bottom of the steam generator is in series with the pressure control switch 49 and opens to close the feed water valve 45 to stop the flow of water when the bottom of the receptacle 20 has cooled below 250° F. This prevents flooding of the bottom when the generator is too cool to generate enough steam to blow the water off of the botom. The safety valve 47 has sufficient capacity to prevent excess pressure build up if water should accidentally flow into the hot generator when the valve 40 is closed. When the valve 40 is closed steam ceases to flow from the separator, the pressure builds up, and check valve 51 opens. Then the water in the separator 37 flows into the feed tank 44 through valve 51 to provide water for the next operation.

It is important that the head 21 of the upper portion of the cylinder adjacent the weld 28 be relatively thin so that this section will cool quickly below the "critical temperature" and allow high volume steaming to start.

The improved generator provides a large volume of steam the instant the valve 40 is opened, which steam is generated by heat drawn from hot walls of the receptacle 20. The use of hot water under pressure in the feed tank also increases steam volume, as some of this water flashes into steam as it leaves the valve 45 so that no more heat is required to bring this water to the boiling point. The main volume of steam, however, is produced as the water flows down the hot upright wall of the receptacle 20. When the water reaches the point where the receptacle temperature is higher than the "critical temperature" then the water is thrown away from the wall by a violent action similar to the sizzling of water on a hot iron where the water rolls in balls on the hot surface.

Referring now more particularly to the form of invention of FIGS. 6 to 8, inclusive, this illustrates a pyramid-shaped steam generator. It comprises essentially an assemblage of rectangular blocks 91 which have square upper ends and which are elongated in a vertical direction.

There is an outer series of blocks **92** arranged in a square and at the lowest elevation, and there are one or more series of blocks **93** arranged in a square within the first series but at a somewhat greater elevation, as is clear from FIG. 8. The square of blocks **93** is welded within the square of blocks **92** by means of side welds **94**, and the blocks of one series are welded to each other by means of flush welds **95**. In the center of the assemblage is a shallow block **96** having a hollow interior **96'** and having a square base, the latter being so disposed as to be a step above the blocks **93** and being welded thereto by side welds **97**. The top of the block **96** is conical to form a water spreading cone onto which water is directed from a nozzle **98** on a water supply line **99**. In the line **99** is a water pressure reducing valve **100**, a solenoid-operated valve **101**, and a throttling valve **102**.

Water from the tube **98** is adapted to cascade down the water spreading cone **96**, then onto the steaming surfaces formed by the square upper ends of the blocks **93**, and then down onto the steaming surfaces formed by the square upper ends of the blocks **92**. This flow is under the influence of gravity, and due to the relatively flat angle of the pyramid the flow is relatively slow so that there is good water coverage for all of the steaming surfaces with but a small amount of water.

It is to be noted that the only connection between the blocks is through the welds **94**, **95** and **97**, there being spaces **103** between the lower portions of the blocks which form the equivalent of the lugs **29** of FIG. 1. This eliminates expansion strains.

Welded to the lower ends of the blocks are vertical fins **104**, the fins on one block being entirely separate from the fins on an adjacent block. At the very center there are fins which project laterally below the open center space **105** as at **104***a*. Electric heating elements **106** extend between the fins as illustrated in FIG. 8 and there is a bottom reflector plate **109** to prevent heat loss. The ends of the heating elements are connected to the supply circuit through a heating element thermostat **110**, the latter having its sensing bulb located in a hole **111** in lower block portions.

Welded to the upper ends of the outer blocks **92** are side wall members **112**, and a cover plate **113** is welded to the upper ends of the side walls **112**. In use of this form of the invention steam is discharged from both ends of the steam chamber **114** through discharge pipes **15**, there being water dams **16** to prevent water from being blown out with the steam.

The solenoid valve **101** is connected to a power source in series with a suitable control switch and also in series with a solenoid thermostat having its bulb **115** located in an opening **116** in upper portions of the blocks. This thermostat is provided to shut off the flow in case of abnormal flooding.

A somewhat similar construction, illustrated in FIG. 14, is adapted to be heated by some source other than electricity, such as gas. In this form of the invention there may be a formed steaming plate **117** with a spreader cone **118** projecting from its center. The plate is shaped to provide steps **119** and **120**. The blocks **121** have their upper ends brazed to the underside of the plate as illustrated, the blocks being otherwise spaced from one another as at **122**. Here there is a center open space **123** and there are fins **124**. Heat from a gas burner **125** is adapted to pass into the center space and also beneath the blocks, as illustrated by the arrows, and up through the flues **126**. The operation of this form of the invention is otherwise similar to that of the form of FIG. 6.

Operation of FIG. 6 Device

Referring more particularly to the form of FIG. 6, power is fed to the solenoid valve **101** through a central switch, with the solenoid thermostat **115** in series. When the valve is opened, water flows from the water supply onto the spreader cone **96**. The rate of flow is manually adjusted by the throttling valve **102** so as to prevent too much excess over the rate of steam generation. The water pressure reducing valve is adjusted to the desired steam pressure so that the water stops flowing when this pressure has been reached, to thus stop steam generation. If the temperature of the metal of the heating surface is not above the critical temperature for steam generation, then the solenoid thermostat **115** is open so no electricity goes to the solenoid and no water flows.

The heating elements **106** are controlled by the heating element thermostat **110** at a temperature of between 500 and 600° F. The heating elements and the thermostat **110** are connected to the line through a suitable switch which is normally left on all the time that steam is required.

As water flows down over the water spreading cone **96**, it cools very rapidly due to its hollow center and relative lack of mass. Then the water wets the surface of and flows evenly over the blocks **93**. The upper ends of these blocks cool quite rapidly to the "critical temperature" for steam generation and then heat flows at a high rate from the hot lower portions of the blocks to the relatively cool top portions by conduction through the solid metal of the blocks. Some water runs onto the lower blocks **92** and the same action again takes place.

Considerable steam is produced by water sizzling on surfaces which are above the "critical temperature," but the rate of steam generation is more than twice as rapid after the heating surface **93** or **92** has cooled to the "critical temperature" for steam generator as there is faster steam generation at this "critical temperature" point and faster heat flow. This "critical temperature" is the temperature at which a film of steam insulates the heating surface from the water to thereby prevent effective steam generation. This critical temperature is in the neighborhood of 45° F. above the boiling point or about 290° F. for low pressure steam generators. It may, however, be somewhat above or below this temperature depending upon the condition of the heating surface.

Due to the pyramid shape of the heating surface as shown in FIGS. 8 and 14, the effective heating area becomes greater as the water flows downwardly. In other words, the total area of the upper ends of the blocks **92** are substantially greater than the total area of the upper ends of the blocks **93**. Thus the rate of cooling slows down as the lowest tier is reached but the rate of steam generation becomes greater providing there is enough water flowing onto the last tier of blocks. If there is too much water, then the excess will be blown out of the outlets **15** with the steam.

After the steam pressure in the chamber **114** reaches the pressure at which the water pressure reducing valve **100** is set, the flow of water stops and steam generation stops until the pressure drops to allow additional water to flow. The steam pressure usually rises above water pressure due to steam generated from the water on the pyramid after the control pressure has been reached.

An important feature of this invention is the fact that its high steam capacity makes it practical to employ a steady flow of water or a wave-like flow without flooding. In prior devices it has usually been considered necessary to use a spray of water, necessitating the employment of spray nozzles with fine holes. These are inclined to clog and difficult to control.

With the present invention, steam is generated at about the same rate regardless of whether the heat source is on or off (providing the blocks are still hot) as most of the heat is drawn from heat stored in the hot metal.

The form of the invention shown in FIGS. 9 and 10 is similar to that of FIG. 6, except that instead of blocks, a conical heating surface is formed by welding the upper ends only of concentric cylinders **127**, **128**, **129** and

130 together by circular welds 131 to 134, inclusive, there being a hollow central conical water spreading block 135 and there being a hollow central space 136. In other respects, the form of the invention of FIGS. 9 and 10 is the same as in FIGS. 6 to 8, inclusive, and it may be equipped with the same controls and with any heating means such as the circular electric heating elements 180.

Referring now to FIGS. 11 to 13, inclusive, these illustrate an application of the invention of FIG. 5. Here the heat storage ring is formed of stacks of inner metal rings 137 and outer rings 138 which elements are L-shaped in cross section and fit together to provide internal spaces 139 for the heating elements 140. It is to be noted that each of the rings is so shaped as to provide a relatively narrow neck portion 141 opposite the steps 142 and 143. These narrow necks produce the equivalent of the necks 31 of FIGS. 1 and 3 so that FIG. 11 has, for all practical purposes, the same T-shape as shown in FIG. 3 to provide in effect inner lugs near the heating elements connected to the steam generating surface by the small neck 141. The rings 137 and 138 are welded together as at 144 and 145 and they are also welded to a circular top cover 146 and to a circular bottom cover 147, the former of which is an inverted V in cross section, and the latter which is V-shaped as shown. The rings 137 and 138 are free to expand and contract independently of each other and independently of the heating elements 140. The heavy sections of these rings are slotted as at 139', FIG. 11, to form radial lugs to allow free expansion similar to slots 30 in FIG. 1. The narrow neck portions 141 allow for flexing of the rings as the critcial temperature line progresses downwardly during use. The connections for the heating elements are brought out through a tube 148, and a thermostat 149 is adapted to be inserted through the other tube 150 and into holes 151 in the rings. This thermostat is adapted to control the heating elements. The entire structure is welded pressure tight and is enclosed in a shell 152 having a sump 153.

Suitably supported for rotation centrally of the heating surface rings is a vertical pump tube 154 having its lower end supported in a pivot bearing 155. Water intake tubes 156, having L-shaped ends 157, project from the lower end of the tube 154 and communicate with its interior. Projecting in opposite directions from the upper end of the tube and communicating with its interior are spreader tubes 158 having downwardly bent ends 159 and 160. The end 159 is adapted to discharge water onto the outer side of the cover to flow down the outside wall and the end 160 is adapted to discharge water on the inner side of the cover to flow down the inside wall.

Attached to the tube-shaft 154 and projecting radially therefrom above its lower end is a water wheel 161. Water under pressure from a supply conduit 162 under the control of a solenoid-operated valve 163 is directed forcibly against the wheel 161 to rotate the tube-shaft 154. This causes rotation of the intake tubes 156 and the pickup of water 164 from the sump 153. This water is forced up the tube 154 and out of the ends 159 and 160 of the spreader tubes 158. The flow of water is, of course, deepest directly below the bent ends 159 and 160 of the spreader tube. However, with a fairly rapid spinner speed the rings 137 and 138 are kept covered with water all the way around, more or less in the form of a wave.

In the operation of this latter form of the invention when the solenoid valve 163 is opened, and with the sump 153 initially dry, water will flow from the nozzle 165 without causing any pumping up through the tube 154 until the water level in the sump rises to a level above the level of the intake tubes 156. Thereafter, pumping of water up the tube 154 starts. When the required steam pressure has been reached within the casing 152, the electric pressure control switch 166 is influenced by the pressure and acts to turn off the solenoid 163' of the solenoid-operated valve 163, the solenoid 163 being in series with the pressure control switch 166, as shown in FIG. 13. A line switch 167 in the circuit serves to start and stop the steam generator, and the switch 168 is automatically controlled by the thermostat 149 of FIG. 11. Unless water is being pumped, no steam is being generated. An additional thermostat similar to 149, acting through the switch 168, serves to turn off the power to the solenoid 163' if the temperature of the rings 137 and 138 is too low to generate steam. This prevents flooding.

A drain tube 169 leads from the sump and is under the control of a drain valve 170. The water well should be drained after operations to prevent the accumulation of lime and excess water.

As long as the rings 137 and 138 are hot, water flows thereover from the spreader tubes 158, and steam is generated until the pressure control switch 166 turns off the water valve 163. Then the spinner 158 stops and any excess steam is released by a suitable safety valve such as the valve 171. A steam valve is not normally required in the steam outlet 172 as the pressure is usually allowed to drop when no steam is required, and the pressure will build up rapidly when needed. In this form of the invention, steam is generated on both sides of the rings and the critical temperature lines advances down the inner and outer surfaces of the rings just as in the form of the invention of FIG. 1, the form of the invention of FIG. 11 having steps 142 and 143 which correspond to the steps 23 of FIG. 1.

In all forms of the invention the water contacts a relatively thin section first so that this section will cool below the critical temperature in a second or two. Also, in all forms of the invention there is a relatively flexible heating surface with heat storage lugs extending from the opposite sides. In the form of the invention of FIG. 11, the relatively narrow neck portions 141 connect the heating surface with the inner portions of the rings which are the equivalent of the lugs.

In all forms of the invention the water cascades by gravity. The forms of the invention of FIGS. 8, 9, and 14 merely provide for slower cascading of the water than the form of the invention of FIG. 1. It will also be noted that the fins or lugs are opposite the steps such as the steps 94 and 97 of FIG. 8, 142 and 143 of FIG. 11, and 23 of FIG. 1. With this arrangement, the steps check the flow of water at those locations where heat conduction from the lugs or fins is the greatest.

It is to be understood that the present invention is not to be limited to the exact details of construction shown and described for obvious modifications will occur to persons skilled in the art.

What I claim is:

1. A stored heat steam generator comprising: a wall formed of surrounding tiers of blocks one within another with the upper ends of the blocks connected to provide a stepped steam generating surface disposed so that water may flow by gravity down said surface, from one tier to another, the lower portions of said blocks forming heat storage lugs, means for heating said lugs so that heat is conducted from said lugs to said steam generating surface, a relatively thin upper conical water receiving surface positioned in the center of the surrounding tiers to direct water therefrom onto all portions of said steam generating surface, means for directing water onto said conical water receiving surface to flow therefrom onto said steam generating surface and progressively cool the latter, means for controlling the quantity of water directed onto the water receiving surface so that the water will cover said portion of the wall which has been cooled to a temperature under the critical temperature for steam generation to cause the critical temperature line to progress downwardly, and means for discharging generated steam.

2. A stored heat steam generator comprising: a pyramid of blocks with the upper ends connected to provide a

stepped pyramidal steam generating surface disposed so that water may flow by gravity down said surface, the lower portions of the blocks forming heat storage lugs, means for heating said lugs so that heat is conducted from said lugs to said steam generating surface, a relatively thin upper water receiving surface member at the apex of the pyramid positioned to direct water therefrom onto all portions of said steam generating surface, means for directing water onto said water receiving surface to flow therefrom onto said steam generating surface and progressively cool the latter, means for controlling the quantity of water directed onto the water receiving surface so that the water will cover said portion of the wall which has been cooled to a temperature under the critical temperature for steam generation to cause the critical temperature line to progress downwardly, and means for discharging generated steam.

3. A stored heat steam generator comprising: a plurality of concentric cylinders with upper ends stepped and connected to provide a conical steam generating surface disposed so that water may flow by gravity down said surface, the lower portions of said cylinders forming heat storage lugs, means for heating said lugs so that heat is conducted from said lugs to said steam generating surface, a relatively thin conical upper water receiving surface positioned at the apex of said steam generating surface to direct water therefrom onto all portions of said steam generating surface, means for directing water onto said conical water receiving surface to flow therefrom onto said steam generating surface and progressively cool the latter, means for controlling the quantity of water directed onto the water receiving surface so that the water will cover said portion of the wall which has been cooled to a temperature under the critical temperature for steam generation to cause the critical temperature line to progress downwardly, and means for discharging generated steam.

4. A stored heat steam generator comprising: a wall having a side forming a steam generating surface disposed so that water may flow by gravity down said surface, heat storage means projecting from the opposite side, electric heating means adjacent said heat storage means so that the latter may conduct heat to said steam generating surface to initially raise the temperature of the latter above the critical temperature for steam generation, means for directing a sheet of water onto all portions of the upper part of said steam generating surface to gravitate downwardly thereon and progressively cool said surface, means including a solenoid operated valve having an electric circuit for controlling the quantity of water to cause the critical temperature line to progress downwardly on said steam generating surface, an electric circuit for said electric heating means and solenoid operated valve, a thermostat in said circuit of said solenoid operated valve and positioned in portions of said heat storage means relatively close to the steam generating surface, and a thermostat positioned in said heat storage means remote from said heating surface and in the circuit to said electric heating means for controlling the latter.

5. A stored heat steam generator comprising a circular wall having a side forming a steam generating surface and disposed so that water may flow from an upper portion by gravity down said surface, means for heating said steam generating surface to initially raise the temperature of the latter above the critical temperature for steam generation an outer receptacle forming a steam chamber within which said surrounding wall is located, said container having a sump, a rotatably mounted tubular shaft mounted axially in said wall and having its lower end in said sump, a tubular rotor on the upper end of said shaft having a nozzle positioned to discharge water onto an upper portion of said circular wall as the rotor rotates, and means on the lower end of the tubular shaft for pumping water from said sump up said tubular shaft to said nozzle.

6. A stored heat steam generator comprising a circular wall having a side forming a steam generating surface disposed so that water may flow from an upper portion by gravity down said surface, means for heating said steam generating surface to initially raise the temperature of the latter above the critical temperature for steam generation, an outer receptacle forming a steam chamber within which said surrounding wall is located, said container having a sump, a tubular shaft mounted for rotation axially of said circular wall and having its lower end in said sump, pump means on the lower end of said tubular shaft communicating with its interior and adapted to pump water from the sump up through the shaft when the shaft is rotated, means for rotating said tubular shaft, and a tubular rotor carried by the upper end of said shaft and having a nozzle positioned to discharge said pumped water onto an upper portion of said circular wall as the rotor rotates.

7. A stored heat steam generator comprising: a circular wall having a side forming a steam generating surface disposed so that water may flow from an upper portion by gravity down said surface, means for heating said steam generating surface to initially raise the temperature of the latter above the critical temperature for steam generation, an outer receptacle forming a steam chamber within which said surrounding wall is located, said container having a water sump, a tubular shaft mounted for rotation axially of said circular wall and having its lower end disposed in said sump, a water wheel on said shaft adjacent said sump, water pump means on the lower end of said tubular shaft communicating with its interior and adapted to pump water from said sump up said shaft when the shaft is rotated, means for discharging water under pressure on said water wheel to rotate the shaft, and a tubular rotor on the upper end of said shaft in communication with the interior thereof and having a nozzle positioned to discharge water onto an upper portion of said circular wall as the rotor rotates.

8. A stored heat steam generator comprising: a wall formed of surrounding tiers with one tier within another and with the upper ends of the tiers connected to provide a stepped steam generating surface disposed so that water may flow by gravity down said surface, from one tier to another, the lower portions of said tiers forming heat storage means, means for heating said lower portions so that heat is conducted from said portions to said steam generating surface, a relatively thin upper conical water receiving surface positioned in the center of the surrounding tiers to direct water therefrom onto all portions of said steam generating surface, means for directing water onto said conical water receiving surface to flow therefrom onto said steam generating surface and progressively cool the latter, means for controlling the quantity of water directed onto the water receiving surface so that the water will cover said portion of the wall which has been cooled to a temperature under the critical temperature for steam generation to cause the critical temperature line to progress downwardly, and means for discharging generated steam.

9. A stored heat steam generator comprising: a plurality of concentric cylinders with upper ends stepped and connected to provide a conical steam generating surface disposed so that water may flow by gravity down said surface, the lower portions of said cylinders forming heat storage means, means for heating said lower portions so that heat is conducted from said lower portions to said steam generating surface, a relatively thin conical upper water receiving surface positioned at the apex of said steam generating surface to direct water therefrom onto all portions of said steam generating surface, means for directing water onto said conical water receiving surface to flow therefrom onto said steam generating surface and progressively cool the latter, means for controlling the quantity of water directed onto the water receiving sur-

face so that the water will cover said portion of the wall which has been cooled to a temperature under the critical temperature for steam generation to cause the critical temperature line to progress downwardly, and means for discharging generated steam.

10. A stored heat steam generator comprising a circular wall having a side with concentric ledges of progressively increasing diameter downwardly forming a steam generating surface and disposed so that water may flow from an upper portion by gravity down said surface from one ledge to another, said circular wall also having projecting lugs positioned to transmit heat to said steam generating surface means for heating said lugs and hence said steam generating surface to initially raise the temperature of the latter above the critical temperature for steam generation, an outer receptacle forming a steam chamber within which said circular wall is located, and

having a lower portion, and means providing for recirculation of water from said lower portion onto an upper portion of said same circular wall.

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