

March 24, 1953

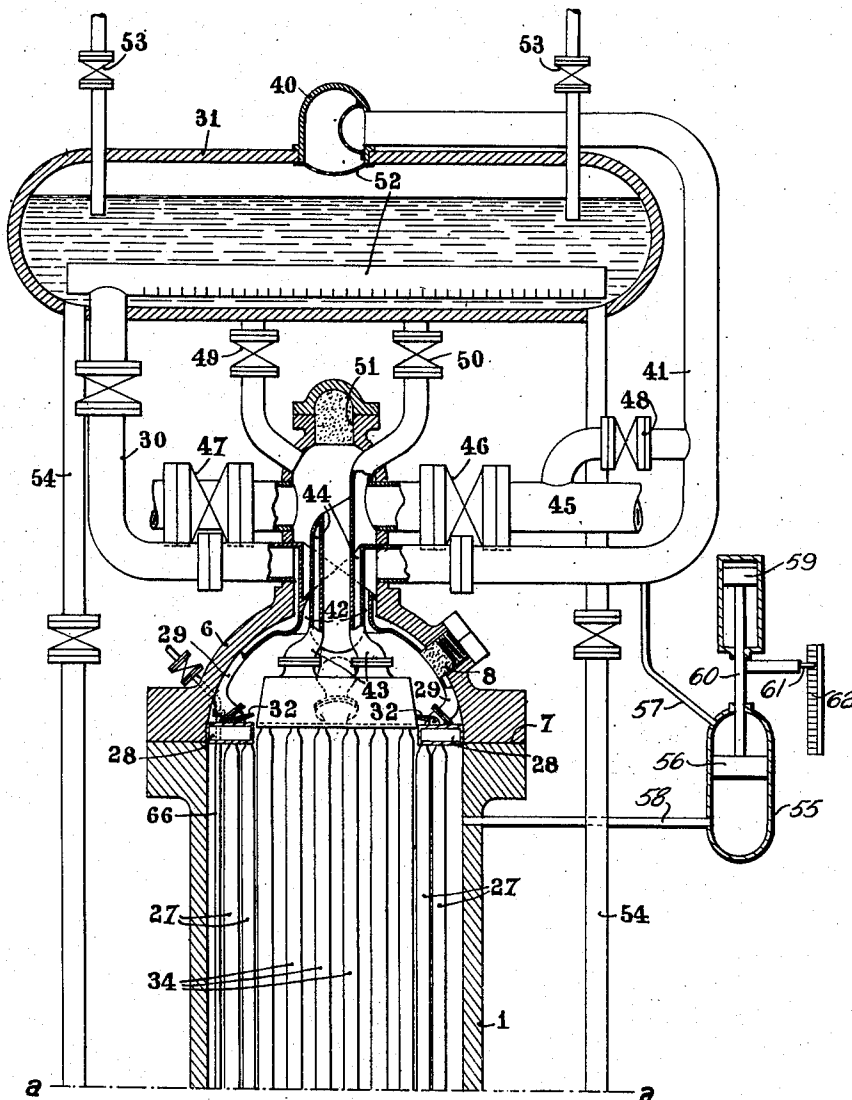
E. MERCIER
STEAM BOILER SUPPLIED WITH COMBUSTION
GASES AT ELEVATED PRESSURE

2,632,427

Filed Aug. 6, 1947

4 Sheets-Sheet 1

Fig1.



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4 Sheets-Sheet 2

Fig. 1^a

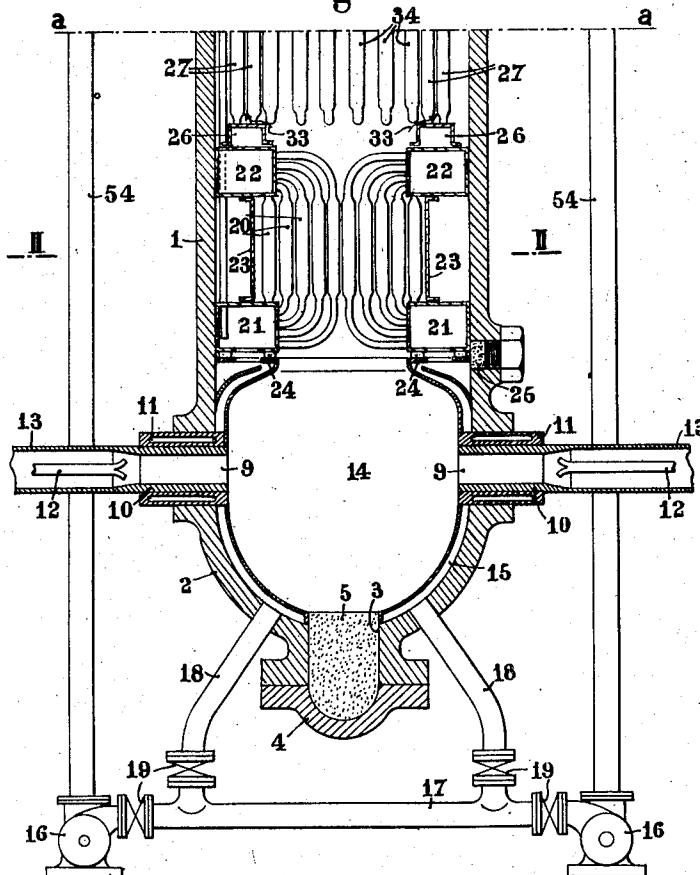
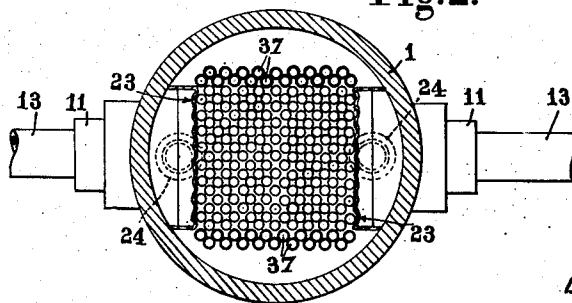


Fig. 2.



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March 24, 1953

Filed Aug. 6, 1947

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2,632,427

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Fig. 1^b

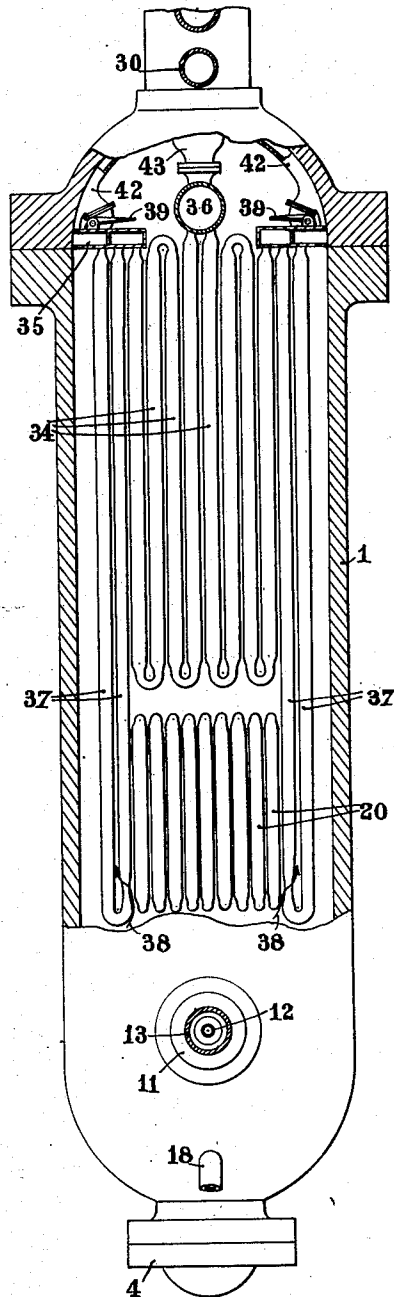


Fig. 4.

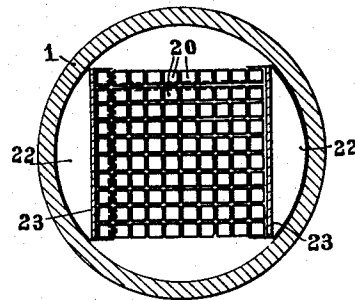
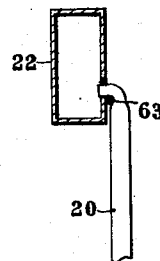


Fig. 5.



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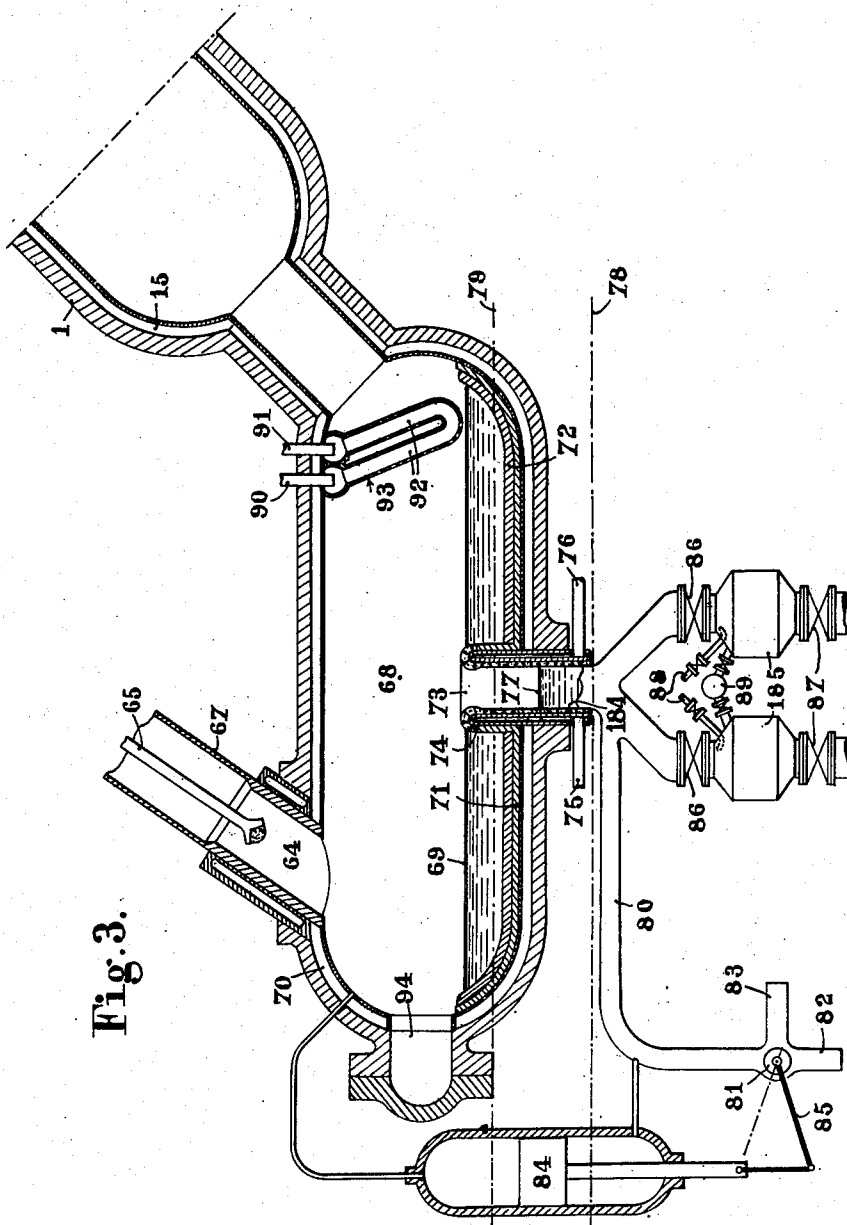
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4 Sheets-Sheet 4

Fig. 3.



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UNITED STATES PATENT OFFICE

2,632,427

STEAM BOILER SUPPLIED WITH COMBUSTION GASES AT ELEVATED PRESSURE

Ernest Mercier, Paris, France, assignor to Moore, Inc., Atlanta, Ga., a corporation of Georgia

Application August 6, 1947, Serial No. 766,673
In France March 3, 1945Section 1, Public Law 690, August 8, 1946
Patent expires March 3, 1965

25 Claims. (Cl. 122-283)

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The present invention has for an object new forms of construction of the type of boiler functioning with combustion gas under high pressure such as has been described in the co-pending application Serial No. 472,217, now abandoned, and more particularly of boilers of the type where equality between the pressure of the combustion gas and the steam produced is accomplished. The application of Ernest Mercier, Serial No. 103,893, filed July 9, 1949, now Patent No. 2,547,135 issued April 3, 1951, which is a continuation in part of the application Serial No. 472,217 discloses a plant utilizing a boiler generating steam at "equipressure" or approximating the pressure of the gas in the combustion chamber.

The boilers of the invention are capable of operation with all fuels, solid, liquid or gaseous.

The liquid to be vaporized likewise may be of any kind. In particular they may be hydrocarbons and the general principles of the invention may be used to produce apparatus for ordinary or catalytic cracking.

These boilers may in particular be applied very satisfactorily to the use of mercury vapor and this is one of the particularly important features. They permit on the one hand a considerable reduction of the weight of the mercury necessary for a given power and on the other hand, by providing if necessary a small excess of pressure of the gas above the pressure of the vapor, they make much less frequent the loss of mercury by the rupture of tubes.

The following description relates to two aspects or embodiments, one to the use of liquid fuels and the other to the use of solid fuels.

First aspect—Liquid fuels

Figures 1 and 1a of the annexed drawings represent together a view of the whole installation including the piping pertaining thereto and the accessories, in vertical section through the axis, the two figures joining along line *aa*.

Figure 1b is a section in a plane perpendicular to that of Figure 1.

Figure 2 is a transverse section on line II—II of Figure 1 at the center of the bundle of evaporating tubes.

Figure 3 is a longitudinal section of the end of the combustion chamber and of the chamber for the deposit of slag which is produced in the use of solid fuels.

Figure 4 represents a transverse section through the center of the bundle of evaporating tubes of a modification.

Figure 5 is a detail of the installation of a

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sweeping device or soot blower in the case of solid fuels.

1 is the cylindrical body of the casing.

2 is the hemispherical lower wall of the casing.

5 It is formed in one piece with the cylindrical body of the casing. It is provided with a man-hole 3 closed by a cover 4 protected by a block of refractory 5.

6 is a hemispherical top wall of the casing. It is demountable by means of the joint 7. All of the boiler elements are suspended from this top wall as may be seen in the drawing. They can be disconnected by virtue of the joints to which access is obtained through one or several hand holes such as 8.

9 are the burners. They are each composed of a refractory muff or sleeve 10 placed at the interior of the steel cylinder 11 cooled by water circulation. Into the burner the fuel is delivered by way of pipe 12 and the air for combustion by way of pipe 13. On starting, and until the refractory sleeves 10 are incandescent, readily inflammable fuel, such as petrol is injected.

The burners are placed in pairs at opposite extremities of the same diameters of the combustion chamber. They are oriented in a manner to produce good turbulence.

The length of the flame is only a few centimeters when the pressure within the combustion chamber is of the order of 80 to 100 kgs. cm.² (kilograms per square centimeter).

The burners discharge into a chamber 14 entirely surrounded with a water wall 15. This water wall is provided with longitudinal partitions in such a manner as to assure the proper distribution of the liquid. The feed water and the circulating water are fed into the water wall by the circulating pump 16 by virtue of the header 17 and branches 18 furnished with the necessary sectionalizing valves as indicated at 19.

20 is the evaporator tube bundle. It is composed of vertical cylindrical tubes such as 20 disposed in quincunx arrangement connected to the lower headers 21 and to the upper headers 22 by horizontal bends at their ends of reduced diameter. The exterior diameter of the vertical tubes will be, for example, 5 cm. and those of the horizontal extremities 4 cm. The odd exterior tube rows (those closest to the casing) are joined in such a manner as to form a protective screen for the casing. This screen is completed by the steel plates 23 and by insulation if there is need. The lower headers 21 are placed in communication with the water wall by means of the annular packing joints 24. Hand holes such as 25 pro-

vide access to these joints. The sections of the tubes are determined in such a manner that notwithstanding the vaporization of which they are the seat the velocity of circulation of the emulsion, that is, the steam and water mixture, in the tubes may be substantially the same as in ordinary boilers.

The steam and water mixture in leaving each of the upper collectors 22 passes by way of demountable joints into the boxes 26 from which lead two rows of vertical tubes 27. These two rows are joined and thus constitute a protective screen for the casing but they provide between themselves a free space which permits passage of a part of the gas leaving the vaporizing tube bundle thus partially shortcircuiting the superheater tube bundle. The rows of tubes 27 discharge into boxes 28 which through conduit 29 communicate with the pipe 30 conducting the steam water mixture to the steam and water drum 31. Valves 32 controlled by thermostats serve to regulate the delivery of the gas which short circuits the superheater tube bundle. The entrance of the gas is effected along the path indicated by the arrows 33.

34 are the tubes of the superheater tube bundle. They are arranged in serpentine form between the inlet box 35 for the saturated vapor and the superheated vapor header 36. The two first branches of each serpentine tube 37 descend to the bottom of the vaporizing tube bundle. These lengths are joined to correspond to the joined tubes 27 and form thus a protective element for the casing but they provide between themselves a free passage through which a certain amount of hot gases may be admitted, thus partially short-circuiting the evaporator tube bundle. The entrance of this part of the gas is effected as indicated by the arrows 38, Fig. 1b. The delivery of this gas is regulated by the valves 39 controlled by thermostats for regulating correctly the exit temperature.

Saturated steam leaves the dome 40 and the drum 31 by way of the pipe 41 and the annular passages 42 thus completing the protection of the upper cap.

The super-heated steam passes by way of the tubular members 43 and the annular tube 44 to the steam header 45.

All of the pipes are provided with sectionalizing valves so that the drum 31, in case of shutting down, may be completely shut off thus making possible an important saving of heat.

46 is a stop valve for the steam.

47 is a stop valve for the gas.

48 is a mixing valve for regulating superheat.

49 is a safety valve for the gas.

50 is a safety valve for the steam.

51 is a manhole.

52 are the usual separators for separating the steam from the water.

53 are the feed water regulators.

54 are the delivery pipes under pressure of the circulating pump.

55 at the right of Figure 1 is a regulating apparatus intended to maintain under all circumstances the equality of the pressure of the steam and the gas if other proper means have developed defects (for example the admission regulators of the turbines if there are any). It is composed of cylindrical body 55 in the interior of which the piston 56 moves. This piston receives on its upper face the action of the pressure of the steam by way of the pipe 57 and on its other face the action of the pressure of the gas by way of the

pipe 58. If a difference of pressure is established the piston 56 begins to move in the direction toward the lower pressure imposed upon it. It is rigidly connected to the auxiliary piston 59 by the connecting rod 60. The piston 59 moves in a cylinder filled with air under an appropriate pressure. By virtue of the piston 59 for each value of the difference of pressure acting on the piston 56 there exists one position only of equilibrium of the device formed by the two pistons and the connecting rod 60. The latter carries an arm 61 provided with a rubbing member or brush which moves over a keyboard 62 by which are transmitted the necessary actions to activate the regulating devices and in particular the principal valves 46 and 47 and the safety valves as the case may be.

There will be noted among other details the arrangement of the outlets for the gas and the steam and the inlet for the saturated vapor by means of the concentric tubular passages which simplifies very much the openings which have to be formed in the cap, thus assuring the protection of the latter and the reduction of the loss of heat to a minimum.

There are not provided in this boiler tubular economizer elements because of the elevated temperature which it is desired to provide in the gases leaving the boiler.

66 (Figure 1) shows by way of example the arrangement of a cleaning tube.

Second aspect for solid fuels

In the case of the solid fuels the general disposition already described maintains. It is necessary only to introduce the modifications which provide for the elimination of slag produced concomitantly with combustion of the fuel in a combustion chamber and for the displacement of soot and cinders.

To facilitate the elimination of soot and cinders it is proposed to give to the axis of the casing an inclination of 45° to the horizontal (Figure 3). In order to sweep by means of steam jets it is necessary to modify the quincunx arrangement of tubes. Tubes of square section (Figure 4) will be used, only the horizontal extremities being circular. These tubes can be made by welding after being drawn out. They can also be cast directly to their form as a special casting. The sweeping tubes or soot blowers in the steam generating tube bundle are disposed as indicated at 63 (Figure 5). They are thus protected and not exposed so as to be burned. The sweeping is done with steam at a pressure of 10 kgs. above the pressure of the boiler. The length of the steam generating tube bundle being of the order of one meter, these precautions will suffice and the expense will be small.

64 (Figure 3) is a section of a burner which as may be seen acts as an element of the combustion chamber.

65 is a pipe for feeding pulverized coal mixed with air.

67 is a pipe for feeding auxiliary air.

68 is the chamber for combustion of the fuel and for disposition of slag. The temperature in this chamber is of the order of 2000° C. for the radiation is too small sensibly to cool the gaseous mass. The section of this chamber is sufficient so that the velocity of the gas may be less than 1 m. s. (meter per second). The slag is eliminated in the liquid state.

69 is the bath of liquid slag. The axis of the burners is inclined towards the rear in order to

oblige the hot gas to impinge upon the surface of the bath throughout its whole length.

70 is a continuous water wall which lines all walls and which is traversed by the circulating water as in the preceding aspect.

71 is a protective covering for the bottom which is of cast refractory.

72 is a refractory protective covering.

73 is a discharge orifice for the melted slag forming a dam over which the slag must overflow.

74 is a cylindrical metallic muff or sleeve for circulation of water in cooling relation to the dam.

75 is the inlet for the circulating water.

76 is the outlet for the circulating water.

77 is a water bath which may vary between the two levels 78 and 79.

This water bath may be placed in communication by way of the pipe 80 and the 3-way valve 81 either with the water inlet under pressure (the pressure of the boiler) 82 or with a discharge 83. The valve 81 is controlled by a float 84 connected by means of an articulated transmission 85 to maintain the water at approximately constant level.

The water bath serves to quench the slag. The position of the water level is altered in two ways, by the entrance of the slag which tends to raise the level and by the evaporation produced by this quenching of the slag which tends to lower the water level.

184 is the refractory protection maintained upon the walls of the sleeve 74 by metallic pegs welded to the internal wall of the sleeve 74.

185 are chambers which are alternately filled with quenched slag under the combined operation of the admission valves 86 and the discharge valves 87. The slag being constituted by very sharp glass in small fragments, special precautions must be taken for the coverings of the valves which have to be changed frequently.

88 are air vents.

89 is a piping system for filling the chambers with water under pressure. After each operation of emptying the corresponding chamber may be completely filled with water in order to avoid a useless loss of water under pressure.

All of the operations of discharge of slag may be made automatic without difficulty.

90 is the inlet pipe for cooling water.

91 is the discharge pipe of cooling water.

92 is a double screen of cooling tubes connected to said pipes.

93 is a refractory covering maintained on the surface of the tubes and of the headers of the screen by means of pegs welded on their walls.

The screen thus covered is intended to stop the major part of the small drops of melted slag which may still exist in the gas when it arrives at this point.

94 is a manhole provided with its cover for access to the combustion chamber 68.

What I claim as my invention and desire to secure by Letters Patent is:

1. A vapor generator comprising a cylindrical gas confining chamber, vapor generating tubes disposed within said chamber with their lengthwise extent generally parallel to the axis of said cylindrical gas chamber and distributed throughout a space of predetermined cross section transversely of said axis within and less than the circular cross section of said gas confining chamber, conduits within said gas confining chamber respectively disposed in circumferentially separated spaces at opposite sides of the axis of said chamber outwardly of said predetermined space with

respect to said axis, said conduits extending lengthwise of said axis and being connected at one end thereof to said vapor generating tubes to conduct the vapor and liquid mixture from said vapor generating tubes toward an end of said chamber, means connected to said conduits at the other end thereof to receive said vapor and liquid mixture therefrom for separating the vapor generated from said liquid, and vapor heating tubes within said gas confining chamber respectively disposed at opposite sides of the axis of said chamber outwardly of said predetermined space with respect to said axis in oppositely disposed spaces which are circumferentially intermediate between said oppositely disposed spaces containing said conduits, said vapor heating tubes being connected to said separating means to receive therefrom the separated vapor for heating said vapor.

2. A vapor generator comprising a cylindrical gas confining chamber, inlet headers disposed at opposite sides of the axis of said chamber, outlet headers disposed respectively at the same opposite sides of said chamber as said inlet headers and in spaced relation along the length of said chamber from the respective inlet headers, vapor generating tubes within said chamber connecting said inlet headers respectively to the outlet headers which are disposed at the same side of said chamber as said inlet headers, said tubes having the lengthwise extent thereof generally parallel to the axis of said cylindrical gas confining chamber and distributed in spaced relation to each other throughout a space of predetermined shape and cross section transversely of said axis within and less than the circular cross section of said gas confining chamber, conduits within said gas confining chamber respectively disposed in circumferentially separated spaces at said opposite sides of the axis of said chamber outwardly of said predetermined space with respect to said axis, said conduits extending lengthwise of said axis and being connected at one end thereof to said outlet headers to conduct the vapor and liquid mixture from said outlet headers toward an end of said chamber, means connected to said conduits at the other end thereof to receive said vapor and liquid mixture therefrom for separating the vapor from the liquid, and vapor heating tubes within said gas confining chamber respectively disposed at opposite sides of the axis of said chamber outwardly of said predetermined space with respect to said axis in oppositely disposed spaces which are circumferentially intermediate between said oppositely disposed spaces containing said conduits, said vapor heating tubes being connected to said separating means to receive therefrom the separated vapor for heating said vapor.

3. A steam generator comprising a cylindrical gas confining chamber, inlet headers disposed at opposite sides of the axis of said chamber and circumferentially spaced about said axis, outlet headers disposed respectively at the same opposite sides of said chamber as said inlet headers and circumferentially spaced about said axis and in spaced relation along the length of said chamber from the respective inlet headers, steam generating tubes extending generally parallel to said axis and connecting said inlet headers respectively to the outlet headers which are disposed at the same side of said chamber as said inlet headers, at least some of said tubes being formed in U-shape with the legs of the U's respectively connected to said inlet and outlet headers, said legs in different tubes being of different lengths

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to distribute said steam generating tubes in spaced staggered relation to each other throughout a space of rectangular cross section transversely of said axis within the circular cross section of said gas confining chamber, conduits within said gas confining chamber respectively disposed in circumferentially separated spaces at said opposite sides of the axis of said chamber outwardly of said rectangular space with respect to said axis, said conduits extending lengthwise of said axis and being connected at one end thereof to said outlet headers to conduct the steam and water mixture from said outlet headers toward an end of said chamber, means connected to said conduits at the other end thereof to receive the steam and water mixture therefrom for separating the steam from the water, and steam heating tubes within said gas confining chamber respectively disposed at opposite sides of the axis of said chamber outwardly of said rectangular space with respect to said axis in oppositely disposed spaces which are circumferentially intermediate between said oppositely disposed spaces containing said conduits, said steam heating tubes extending also in the oppositely disposed circumferentially separated spaces which are intermediate between said oppositely disposed headers to which said steam generating tubes are connected.

4. A steam generator comprising a cylindrical gas confining chamber, inlet headers disposed at opposite sides of the axis of said chamber and circumferentially spaced about said axis, outlet headers disposed respectively at the same opposite sides of said chamber as said inlet headers and circumferentially spaced about said axis and in spaced relation along the length of said chamber from the respective inlet headers, steam generating tubes extending lengthwise of said chamber and connecting said inlet headers respectively to said outlet headers which are disposed at the same side of said chamber as said inlet headers, at least some of said steam generating tubes being formed in U-shape with the legs of the U's respectively connected to said inlet and outlet headers, said legs in different tubes being of different lengths to distribute said steam generating tubes in spaced staggered relation to each other throughout a space of rectangular cross section within the circular cross section of said gas confining chamber, two opposite sides of said rectangular space respectively being adjacent said opposite sides of said chamber, conduits within said gas confining chamber respectively disposed in the spaces exterior to and adjacent said two opposite sides of said rectangular space and connected to and extending respectively from said outlet headers toward an end of said chamber to conduct the steam and water mixture from said outlet headers, means connected to said conduits to receive said steam and water mixture therefrom for separating the steam from the water, steam heating tubes within said gas confining chamber respectively disposed at opposite sides of the axis thereof exterior to and adjacent the other oppositely disposed sides of said rectangular space, and a bundle of superheating tubes connected to said steam heating tubes to receive steam therefrom, said bundle being disposed within the portion of said gas confining chamber which is spaced along the length thereof from said rectangular space containing said steam generating tubes and at opposite sides of which portion respectively said conduits and said steam heating tubes are disposed, and means connected to said

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bundle of superheating tubes for collecting the superheated steam from said bundle.

5. A vapor generator as defined in claim 1 which comprises means cooperating with said vapor generating tubes and said vapor heating tubes to provide gas confining partitions to confine the gas in heat exchanging relation to said vapor generating tubes within said space of predetermined cross section.

6. A vapor generator as defined in claim 5 which comprises means for confining gas in heat exchanging relation to said vapor heating tubes separately from the gas confined in heat exchanging relation to said vapor generating tubes.

7. A steam generator as defined in claim 4 which comprises means for delivering gas at elevated temperature in heat exchanging relation to said steam generating tubes for flow thereover in the direction lengthwise of the cylindrical gas confining chamber and thereafter over said bundle of superheating tubes, means cooperating with said conduits to form partitions dividing the flow of said gas through said chamber and for confining a portion of said gas to flow over said conduits, and means for regulating the flow of said portion of said gas flowing over said conduits.

8. A steam generator as defined in claim 4 which comprises means for delivering gas at elevated temperature in heat exchanging relation to said steam generating tubes for flow thereover in the direction lengthwise of the cylindrical gas confining chamber and thereafter over said bundle of superheating tubes, means cooperating with said steam heating tubes which are disposed adjacent said other oppositely disposed sides of said rectangular space so as to form partitions dividing the flow of said gas to confine a portion of said gas to flow over and in heat exchanging relation to said oppositely disposed steam heating tubes, and means for regulating the flow of said portion of said gas flowing over said oppositely disposed steam heating tubes.

9. A steam generator comprising walls forming a cylindrical gas confining chamber, steam generating tubes disposed within said chamber in a given portion of the lengthwise extent thereof and with their lengthwise extent generally parallel to the axis of said cylindrical gas chamber, said tubes being distributed symmetrically with respect to said axis throughout a predetermined part of the circular cross section of said portion of said gas confining chamber and with tubes which are peripherally disposed in said cross section in spaced relation to the walls of said cylindrical chamber to form spaces disposed with respect to each other at opposite sides of the axis of said chamber, saturated steam headers disposed within said chamber in locations spaced along said chamber from said steam generating tubes and at opposite sides of the axis thereof corresponding to the location of said oppositely disposed peripheral spaces, steam heating tubes extending lengthwise of said chamber within said oppositely disposed peripheral spaces and connected at one end thereof to said saturated steam headers to receive the saturated steam therefrom, a bundle of superheating tubes within said gas confining chamber in the portion of the lengthwise extent thereof adjacent to said given portion occupied by said steam generating tubes and between said oppositely disposed steam heating tubes in said spaces, said bundle of tubes being connected to the other ends of said steam heating tubes to receive heated steam therefrom, means cooperating with said steam heating tubes

to form a partition for dividing the gas space within said chamber for confining gas in contact with said steam heating tubes separated from the gas in contact with said steam generating tubes, means for effecting flow of heated gas through said chamber in the direction from said steam generating tubes toward said superheating tube bundle and in heat exchanging relation to said steam generating tubes and said superheating tubes, and means cooperating with said partition for directing and regulating flow of a portion of said heated gas in heat exchanging contact with said steam heating tubes.

10. A steam generator comprising a cylindrical gas confining chamber as defined in claim 9 which comprises conduits extending lengthwise of said chamber within oppositely disposed spaces which are intermediate between and peripherally displaced with respect to said oppositely disposed steam heating tubes and connected at one end thereof to said steam generating tubes to receive the steam and water mixture therefrom, collecting headers respectively disposed adjacent said opposite intermediate peripheral spaces and connected to said conduits at the opposite ends thereof from said steam generating tubes to receive the steam and water mixture from said conduits, means connected to said collecting headers to receive said steam and water mixture therefrom for separating the steam from the water, means connecting said separating means to said saturated steam headers to deliver the separated steam to said steam heating tubes, and means connected to said superheating tube bundle to conduct the superheated steam therefrom.

11. A vapor generator as defined in claim 1 in which said vapor heating tubes are connected by partition elements to form therewith partitions separating said vapor heating tubes from the central portion of said gas confining chamber, means for effecting flow of heating gas lengthwise through said chamber in heat exchanging contact with said vapor generating tubes and said vapor heating tubes, and dampers cooperating with said partitions to control the flow of said gas over said vapor heating tubes.

12. A vapor generator comprising a cylindrical gas confining chamber, vapor generating tubes disposed within said chamber with their lengthwise extent generally parallel to the axis of said cylindrical gas chamber and distributed throughout a space of predetermined cross section transversely of said axis within and less than the circular cross section of said gas confining chamber, conduits within said gas confining chamber respectively disposed in circumferentially separated spaces at opposite sides of the axis of said chamber outwardly of said predetermined space with respect to said axis and between said space and the periphery of said chamber, said conduits extending lengthwise of said axis and being connected at one end thereof to said vapor generating tubes to conduct the vapor and liquid mixture from said vapor generating tubes toward an end of said chamber, and means connected to said conduits at the other end thereof to receive said vapor and liquid mixture therefrom.

13. A vapor generator as defined in claim 12 in which said conduits are connected by partition elements to form therewith partitions separating said conduits from the central portion of said gas confining chamber, means for effecting flow of heating gas lengthwise through said chamber in heat exchanging contact with said vapor gen-

erating tubes and said conduits, and dampers cooperating with said partition to control the flow of said gas over said conduits.

14. A vapor generator as defined in claim 12 which comprises a water wall extending upon the inner surface of the wall of said gas confining chamber in a part of the lengthwise extent of said chamber spaced therealong from said vapor generating tubes, means for effecting combustion of fuel in the space defined by said water wall, means for effecting flow of the combustion gases from said combustion space to flow in heat exchanging relation to said vapor generating tubes, means for delivering liquid to be vaporized to said water wall, and means within said gas confining chamber connecting said water wall to said conduits for delivering to said conduits the vapor generated in said water wall.

15. A vapor generator as defined in claim 14 which comprises means within said chamber connecting said water wall to said vapor generating tubes for flow of the liquid heated in said water wall and any vapor generated therefrom through said vapor generating tubes for delivery to said conduits.

16. A vapor generator as defined in claim 12 in which said cylindrical gas confining chamber is constructed to confine the gas at a pressure of the degree of the pressure of the vapor generated in said vapor generating tubes.

17. A vapor generator as defined in claim 12 in which said cylindrical gas confining chamber is constructed to confine the gas at a pressure of the degree of the pressure of the vapor generated in said vapor generating tubes, said vapor generating tubes being of rectangular cross section and arranged with the walls of adjacent tubes in spaced parallel relation and with the spaces between said parallel walls providing gas flow passages extending lengthwise of the tubes.

18. A vapor generator as defined in claim 2 in which said cylindrical gas confining chamber is constructed to confine the gas at a pressure of the degree of the pressure of the vapor generated in said vapor generating tubes, said inlet and outlet headers being disposed within said gas confining chamber and being of rectangular cross section to provide flat surfaces to receive the ends of said vapor generating tubes.

19. A vapor generator as defined in claim 1 in which said cylindrical gas confining chamber is constructed to confine the gas at a pressure of the degree of the pressure of the vapor generated in said vapor generating tubes, headers within said chamber connected to said conduits to receive said vapor and liquid mixture therefrom, and means connecting said headers to said separating means to deliver said vapor and liquid mixture thereto, said connecting means extending upon the inner surfaces of the end wall of said chamber at portions thereof disposed at opposite sides of the axis of said chamber to effect cooling of said portions of said end wall.

20. A vapor generator as defined in claim 1 in which said cylindrical gas confining chamber is constructed to confine the gas at a pressure of the degree of the pressure of the vapor generated in said vapor generating tubes, saturated vapor headers within said gas confining chamber each having a flat wall in a plane transverse to said vapor heating tubes at the ends thereof, said vapor heating tubes at said ends thereof being connected in said flat walls of said saturated vapor headers to receive the saturated vapor therefrom, means connecting said separating

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means to said saturated vapor headers for conducting the separated vapor to said saturated vapor headers, said conducting means extending upon the inner surfaces of the end wall of said gas confining chamber at portions thereof disposed at opposite sides of the axis of said chamber to effect cooling of said portions of said wall.

21. A steam generator comprising walls forming a cylindrical gas confining chamber, steam generating tubes disposed within said chamber, said gas confining chamber being constructed to confine the gas at a pressure of the degree of the pressure of the steam generated in said steam generating tubes, walls forming a cylindrical combustion chamber constructed to confine the combustion gases at a pressure of the degree of the pressure of the steam generated in said steam generating tubes and having a gas outlet opening connected to the space within said gas confining chamber, means for effecting combustion within said combustion chamber of slag producing fuel to produce combustion gases at said pressure, means for effecting delivery of the combustion gases from said combustion chamber to said gas confining chamber for flow of said gases substantially at said pressure in heat exchanging relation to said steam generating tubes, means cooperating with said combustion chamber walls to form in the bottom portion thereof a slag well and an overflow dam having a wall extending about a slag discharge opening, means for cooling said wall of said dam, and a water wall extending about said combustion chamber for heating therein the water to be vaporized and concomitantly cooling the walls of said combustion chamber.

22. A steam generator as defined in claim 21 which comprises means cooperating with said dam wall for maintaining within said slag discharge opening water at a level adjacent but below the rim of the dam for quenching the slag which overflows the dam, and means cooperating with said water maintaining means for effecting discharge of the quenched slag while maintaining the combustion gases confined within said combustion chamber substantially at said pressure.

23. A steam generator as defined in claim 21 which comprises a screen of tubes within said combustion chamber positioned adjacent said gas outlet opening to intercept the slag particles entrained by said combustion gases flowing toward said opening, and means for effecting flow of water through the tubes of said screen to effect cooling thereof.

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24. A vapor generator as defined in claim 23 which comprises a bundle of superheating tubes disposed within a portion of said gas confining chamber spaced along the axis thereof from said vapor generating tubes and between said oppositely disposed lengthwise extending conduits, said bundle of superheating tubes being connected to said means receiving said vapor and liquid mixture to receive the vapor therefrom for superheating said vapor, and means for withdrawing the superheated vapor from said bundle of superheating tubes.

25. A vapor generator comprising walls forming a cylindrical gas confining chamber, vapor generating tubes disposed in said chamber in a given portion of the lengthwise extent thereof and with their lengthwise extent generally parallel to the axis of said cylindrical gas chamber, said tubes being distributed symmetrically with respect to said axis throughout a predetermined part of the circular cross section of said portion of said gas confining chamber and with tubes which are peripherally disposed in said cross section in spaced relation to said walls of said cylindrical chamber to form spaces disposed with respect to each other at opposite sides of the axis of said chamber, vapor heating tubes extending lengthwise of said chamber within said oppositely disposed peripheral spaces and connected at one end thereof to said vapor generating tubes to receive the saturated vapor therefrom, and a bundle of superheating tubes within said gas confining chamber in a portion of the lengthwise extent thereof adjacent to said given portion occupied by said vapor generating tubes and between said oppositely disposed vapor heating tubes in said spaces, said bundle of tubes being connected to the other ends of said vapor heating tubes to receive heated vapor therefrom, and means for withdrawing the superheated vapor from said bundle of superheated tubes.

ERNEST MERCIER.

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Number	Name	Date
703,362	Altmann	July 1, 1902
1,075,151	Jorgenson	Oct. 7, 1913
1,886,670	Goetz	Nov. 8, 1932
2,195,274	Ferguson	Mar. 26, 1940

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