July 5, 1966 D. DALIN 3,259,107

STEAM AND HOT WATER BOILER

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Fig. 1.

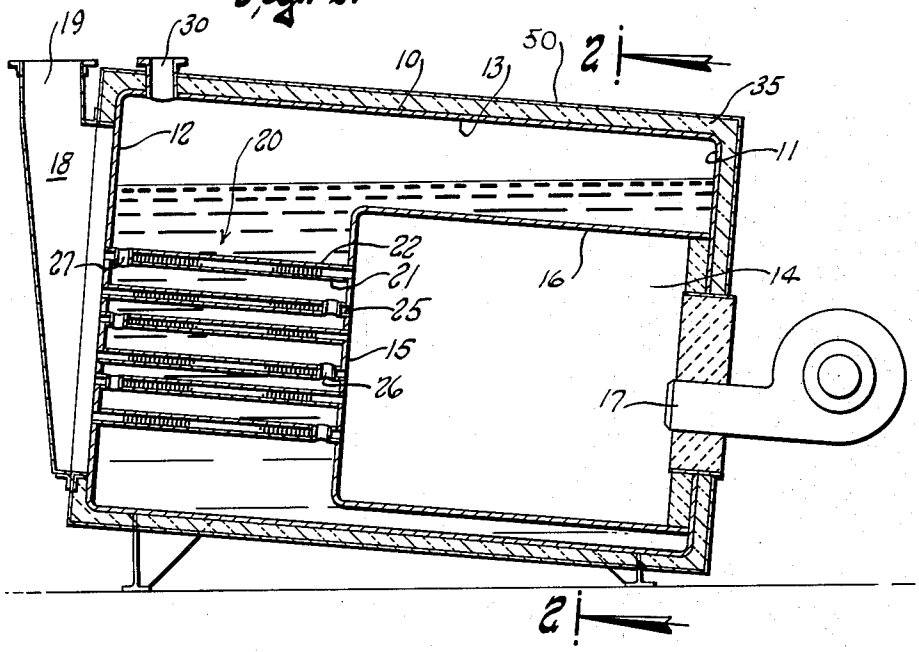
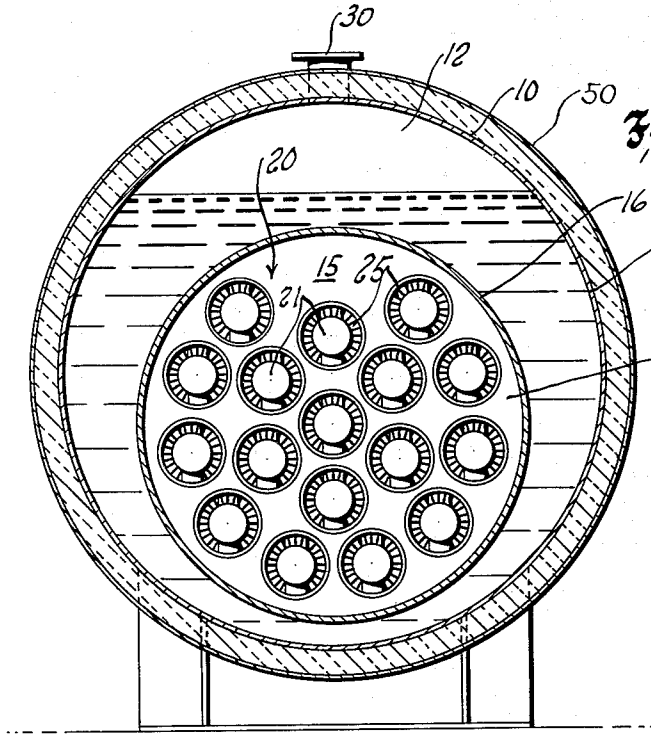


Fig. 2.



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Fig. 3.

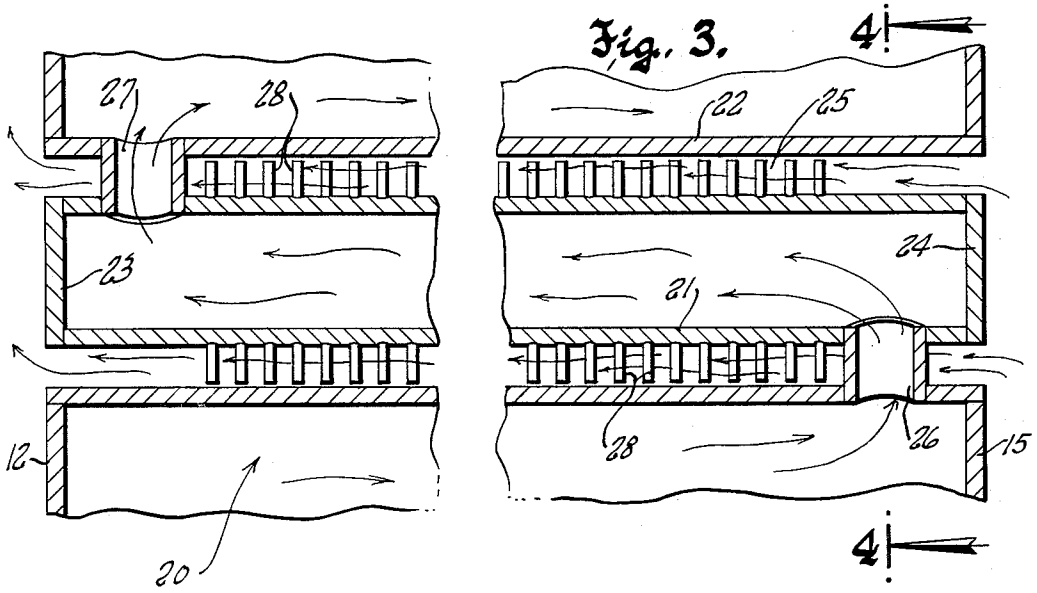
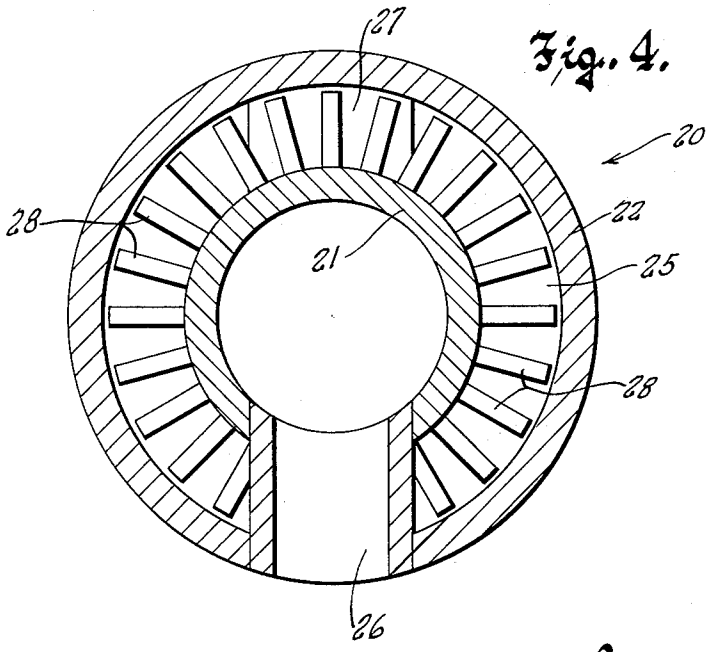


Fig. 4.



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Fig. 5.

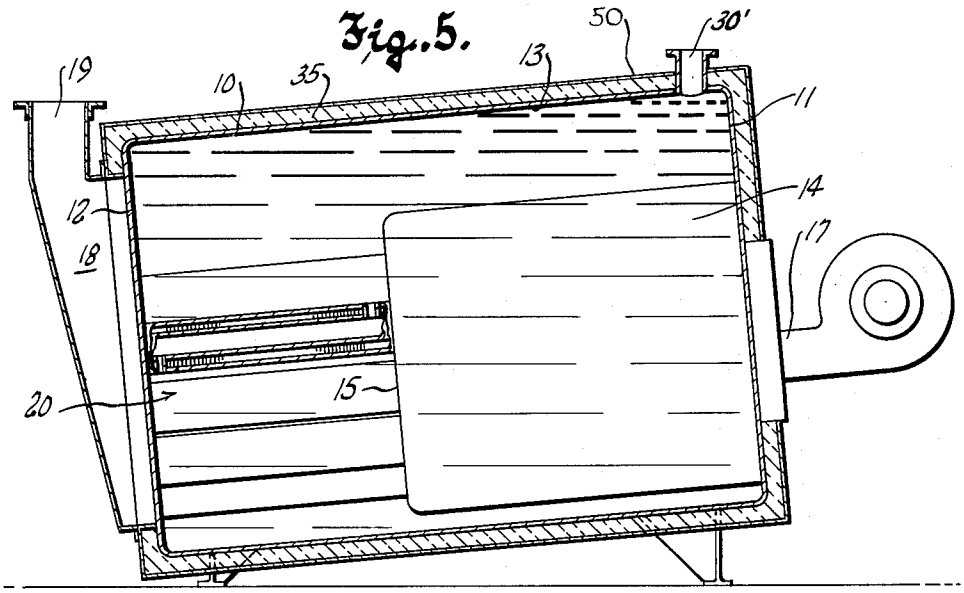


Fig. 6.

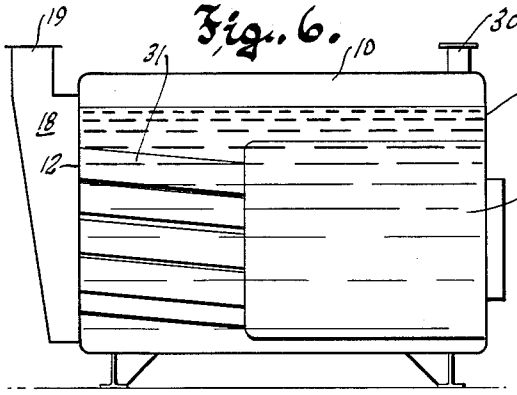


Fig. 7.

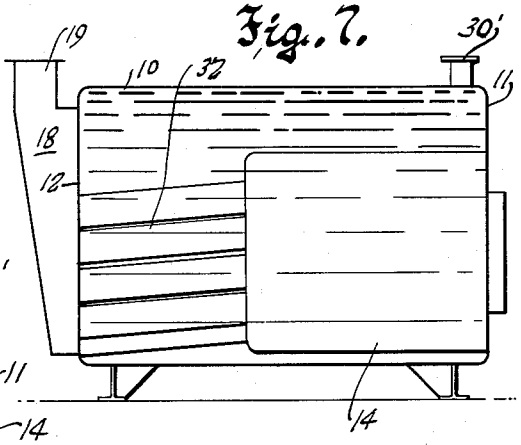
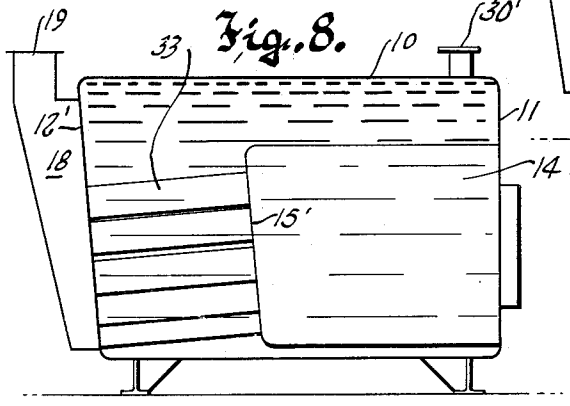


Fig. 8.



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United States Patent Office 3,259,107 Patented July 5, 1966

3,259,107

STEAM AND HOT WATER BOILER

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Filed Aug. 2, 1963, Ser. No. 299,642
10 Claims. (Cl. 122—136)

This invention relates to steam and hot water boilers, and especially to boilers of the horizontal type in which the tubes are oriented in a generally horizontal direction.

Heretofore horizontal boilers usually were of the fire-tube variety, and in an effort to achieve compactness and overall size reduction, were so constructed that the hot gases emanating from the combustion chamber made several passes back and forth before entering the flue gas receiving chamber or smoke box. However, even with this multiple pass arrangement, the ratio of capacity-to-size was small in these boilers. This was due principally to the gas flow being lengthwise of the heating surfaces, which were primarily the surfaces of the fire tubes. For heat transfer purposes, this is the poorest arrangement possible.

Another disadvantage of the conventional horizontal fire tube boilers was their lack of any definite water circulation.

With a view toward overcoming the aforementioned deficiencies in boilers of the horizontal type heretofore available, this invention has as one of its objects to provide a boiler having a novel and improved heat exchanger by which heat is efficiently transferred from the hot combustion gases to the water, and by which a large portion of the water in the boiler is given a definite and pronounced circulation.

More specifically, it is an object of this invention to improve the capacity-to-size ratio of fire tube boilers by incorporating water tubes in the boilers, with the water tubes inside the fire tubes.

In this connection, it is also an object of this invention to increase the rate of heat transfer between the hot combustion gases and the water in the boiler by providing the water tubes with extended surface, and preferably extended surface elements of the pin or wire type such as those of Patent No. 2,584,189, issued to David Dalin, February 5, 1952.

The increased heat transfer that results from the novel combination of fire and water tubes which characterizes this invention, makes possible the attainment of an objective always sought by boiler manufacturers—namely, overall size reduction without loss of capacity.

Another object of this invention is to provide a boiler having tubular water passages or tubes extending lengthwise of the boiler in indirect heat-exchange relation with hot combustion gases emanating from the combustion chamber and positioned in such a way that the resulting thermally-produced flow through the water passages induces a well defined circulation of a large portion of the water in the boiler.

A further object of this invention is to increase the radiant heating surface of a boiler of the fire tube variety and, by the same means, produce turbulence in the gas flow and a definite circulation of a substantial portion of the water in the boiler, all with a view towards increasing heat transfer efficiency.

With these and other objects in view which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiments of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate several complete examples of the physical embodiments of the invention, constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

FIGURE 1 is a longitudinal sectional view through a horizontal boiler in which fire tubes and water tubes are combined in accordance with this invention, to provide an improved steam boiler;

FIGURE 2 is a cross sectional view through FIGURE 1 on the plane of the line 2—2;

FIGURE 3 is a longitudinal sectional view through one of the tubular water passages or tubes of the steam boiler shown in FIGURE 1, and its associated flue gas passage, drawn to a larger scale;

FIGURE 4 is a cross sectional view through FIGURE 3 on the plane of the line 4—4;

FIGURE 5 is a view similar to FIGURE 1, but illustrating the invention embodied in a hot water boiler;

FIGURE 6 is a view similar to FIGURE 1, but somewhat more diagrammatic, illustrating a modified form of the steam boiler embodiment of this invention;

FIGURES 7 and 8 are more or less diagrammatic longitudinal sectional views illustrating modified embodiments of the hot water boiler shown in FIGURE 5.

Referring now particularly to the accompanying drawings in which like numerals indicate like parts, the numeral **10** designates a substantially cylindrical vessel having front and rear end walls **11** and **12**, respectively, and a cylindrical side wall **13**. In the lower part of the front end portion of the vessel **10** is a substantially cylindrical combustion chamber **14** having a flat inner or rear end wall **15** and a cylindrical side wall **16**.

Being located in the lower part of the vessel, the combustion chamber is thus disposed eccentrically within the vessel **10**. The front end of the combustion chamber opens through the front wall **11** of the vessel to accommodate a burner nozzle **17** which projects its flame and products of combustion into the chamber **14**; and the rear end wall **15** of the combustion chamber, though located somewhat near the middle of the vessel, is nevertheless spaced a substantial distance from and is parallel to the rear wall **12** of the vessel.

Mounted on the rear of the vessel is a flue gas receiving chamber or smoke box **18** with an outlet **19** connectable with a stack (not shown) in the conventional manner.

Extending between the rear wall **12** of the vessel and the rear wall **15** of the combustion chamber are a number of novel heat-exchange units, indicated generally by the numeral **20**. These heat-exchange units are in effect combined water and fire tubes since they provide for flow of both water and hot combustion gases in indirect heat exchange relation to one another. As best seen in FIGURES 3 and 4, each of these novel heat exchange units comprises a pair of concentric spaced apart inner and outer tubes **21** and **22**, respectively. The outer tubes **22** have their opposite ends welded to the walls **12** and **15** in line with holes therein, just as ordinary fire tubes would be, so that the walls **12** and **15** may be considered tube sheets.

The inner tubes **21** are closed at their ends, preferably in line with the walls or tube sheets **12** and **15**, as at **23** and **24**. Consequently, the communication which the outer tubes **22** afford between the combustion chamber and the combustion gas receiving chamber or the smoke box **18** comprises only the annular space **25** between the inner and outer tubes.

Each of the inner tubes has its interior communicated with the exterior of its companion outer tube and hence with the inside of the vessel generally, by means of short

tubes **26** and **27** respectively located at the front and rear ends of the tube, and welded into aligned holes cut into the inner and outer tubes, as shown in FIGURES 3 and 4. Hence, liquid (water) in the vessel may enter all of the inner tubes at one end thereof, to flow lengthwise therethrough and back into the vessel at the opposite end; and since the inner tubes are surrounded by the hot flue gases flowing through the annular spaces **25** between the inner and outer tubes, it will be evident that the water in the inner tubes will be very effectively heated.

Optimum heat transfer from the hot flue gases to the water in the tubes and also the water in contact with the outer tubes, is assured by the provision of pin-type extended surface elements **28** such as those produced by the method covered by the aforesaid Patent No. 2,584,-189. The extended surface elements **28** are thus formed of copper or other suitable high conductivity metal and have one end thereof welded to one of the tubes, preferably the inner tube. With the pins **28** welded to the inner tubes fabrication is facilitated, since it is then necessary only to slip the inner tube with its extended surface pins **28** already in place thereon, into the outer tube and then secure the tubes together by welding in the tubular connectors **26** and **27**.

Because of the presence of the extended surface elements or pins **28**, the heat abstracted from the hot gases flowing through the annular spaces **25** and transferred to the water both inside the water tubes **21** and surrounding the fire tubes **22**, will be far greater than it would be without these extended surface elements.

The reason for this improved heat transfer, which is explained at length in the Dalin et al. Patent No. 2,469,-635, briefly resides in the fact that the most efficient way of abstracting heat from hot gases is to cause the gases to flow crosswise over round-surfaced heat absorbing bodies, and especially small diameter bodies. To illustrate the advantage of using small diameter bodies, a 3/16" diameter wire placed crosswise to the gas flow will absorb approximately twice the heat per unit of surface area as a 1" tube, likewise positioned.

Not only do such small diameter extended surface elements improve the heat transfer from the gases to the water in the water tubes **21**, to which the elements are welded, due to their conductive relationship to the walls of these tubes, but because of the turbulence they create in the gas flow, they also improve the heat transfer from the gases to the water surrounding the fire tubes **22**.

In addition to greatly improving the heat transfer between the hot gases and the water by virtue of the novel construction of the heat exchange units **20**, this invention also effects a definite natural circulation of the water in the vessel to thereby insure most efficient heating of the water. This circulation may be accomplished by the simple expedient of disposing all of the tubular heat exchange units at an inclination—and in the same direction—to the horizontal. In that embodiment of the invention illustrated in FIGURES 1 and 2, this inclination of the heat exchange units **20** is obtained by mounting the entire boiler on a slope with its front end lower than its rear end. This disposition of the boiler and consequently of the tubular heat exchange units **20** assures that water will continually flow into the tubes **21** at their front ends and out of the tubes at their rear ends, and this flow will induce a definite circulation of a large portion of the water contained in the vessel **10**.

With the boiler oriented as in FIGURE 1, assurance is had that the combustion chamber will be wholly beneath the water level when the boiler is used for the generation of steam, as is the case in the boiler of FIGURE 1, wherein the steam outlet **30** is located at the upper rear end of the vessel. The inlet for make-up water (not shown) may be located wherever feasible.

Tilting the entire boiler in the opposite direction, as illustrated in FIGURE 5, adapts the same best for use as a hot water boiler. In this case there is, of course, no problem of keeping the combustion chamber covered, since the entire vessel **10** is filled with water. Also, with the boiler tilted to dispose its front end at a higher level than its rear end, the flow in the water tubes **21** is counter to the flow of the hot gases through the fire tubes **22**, which is especially desirable in a hot water boiler wherein the temperature of the water is by no means the same in all parts thereof. The outlet **30'** for the hot water, in this case, is located at the top of the front end of the vessel where the water is hottest.

The modified embodiments of the invention shown in FIGURES 6, 7 and 8, illustrate different ways in which the desired slope of the tubular heat exchange units **20** may be obtained to produce the desired natural circulation without having to tilt the entire boiler. Thus, in FIGURE 6, the tubular heat exchange units **31** are disposed at an angle to the tube sheets **12** and **15** which they connect, and which as in the previous embodiments of the invention, are normal to the longitudinal axis of the vessel.

In FIGURE 7 the construction is identical with that of FIGURE 6, except that the tubular heat exchange units **32** slope in the opposite direction.

The construction of FIGURE 8 is somewhat more desirable than those of FIGURES 6 and 7 from the standpoint of fabrication, since it places the tube sheets **12'** and **15'** normal to the tubular heat exchange units **33**; but otherwise the construction of FIGURE 8 follows that of FIGURE 7.

In all of the boilers of this invention, the vessel **10** is suitably encased in a conventional heat-insulating jacket **50**.

From the foregoing description taken in connection with the accompanying drawings, it will be apparent to those skilled in the art that this invention provides a significant improvement in steam and hot water boilers of the horizontal type, since it provides assurance of natural circulation of the boiler fluid—water and/or a steam-water emulsion, and in addition achieves optimum heat transfer between the flue gases and the water due to its employment of the most efficient type of extended surface yet devised for use in steam and hot water boilers.

What is claimed as my invention is:

1. A boiler comprising:

(A) a generally horizontally elongated vessel adapted to contain liquid to be heated and having front and rear ends;

(B) means in the front end portion of the vessel defining a combustion chamber having outer and inner ends, the means defining the inner end of the combustion chamber comprising a tube sheet spaced from the front and rear ends of the vessel;

(C) means defining a flue gas receiving chamber adjacent to the rear of the vessel, said last named means comprising a second tube sheet, near the rear of the vessel;

(D) a plurality of substantially parallel fire tubes extending between the tube sheets and providing passages through which combustion gases can flow from the combustion chamber to the flue gas receiving chamber in heat exchange relation with liquid in the vessel, said fire tubes being inclined so that one end of each is higher than its other end;

(E) a plurality of water tubes, said water tubes being disposed in the fire tubes with their axes parallel to those of the fire tubes and their walls radially spaced from those of the fire tubes so that combustion gases flowing through the fire tubes move in heat exchange relation to the water tubes, each of said water tubes

(1) having a length substantially equal to that of the fire tube in which it is disposed, and

(2) having its opposite ends closed;

(F) a pair of tubular laterally extending bridging members for each water tube, one near each end thereof, each communicating the interior of its water tube with the exterior of the fire tube in which the water tube

is disposed, to provide for thermal circulation of liquid from the interior of the vessel upwardly along the inclined water tubes in heat exchange relation with combustion gases flowing through the fire tubes; and

(G) extended surface in the space between the fire and water tubes having intimate contact with at least one of said tubes.

2. The boiler of claim 1, wherein said extended surface comprises pins of metal having high heat conductivity fixed to the water tubes and projecting substantially radially therefrom.

3. The boiler of claim 1,

(A) wherein the vessel is substantially cylindrical and its ends are closed by substantially flat walls normal to the axis of the vessel,

(B) wherein the tube sheets are likewise perpendicular to the axis of the vessel and the tubes are parallel to the axis of the vessel, and

(C) wherein the entire vessel is positioned with its axis inclined to the horizontal to give the tubes their stated inclination.

4. The boiler of claim 1,

(A) wherein the vessel is substantially cylindrical and its axis is horizontal; and

(B) wherein said tube sheets are parallel and perpendicular to the axially inclined tubes.

5. The boiler of claim 1, wherein the entire vessel is inclined to dispose its fore and aft axis in parallel relationship to the axially inclined tubes so that one end of the vessel is higher than the other.

6. The boiler of claim 5, wherein the inclination of the vessel is such that the front end thereof is uppermost, and further characterized by means at the upper front end of the vessel providing an outlet for liquid in the vessel.

7. The boiler of claim 5, wherein the inclination of the vessel is such that the rear end thereof is uppermost, and further characterized by means at the upper rear end of the vessel providing an outlet for steam generated in the boiler.

8. The boiler of claim 6, wherein the vessel is substantially cylindrical and its rear end is substantially flat and also constitutes the second tube sheet.

9. The boiler of claim 7, wherein the vessel is substantially cylindrical and its rear end is substantially flat and also constitutes the second tube sheet.

10. The boiler of claim 7, wherein the combustion chamber is in the lower part of the front end portion of the vessel so as to be spaced farther from the top of the vessel than from the bottom thereof to facilitate maintaining the water level in the vessel above the top of the combustion chamber.

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