

Feb. 6, 1940.

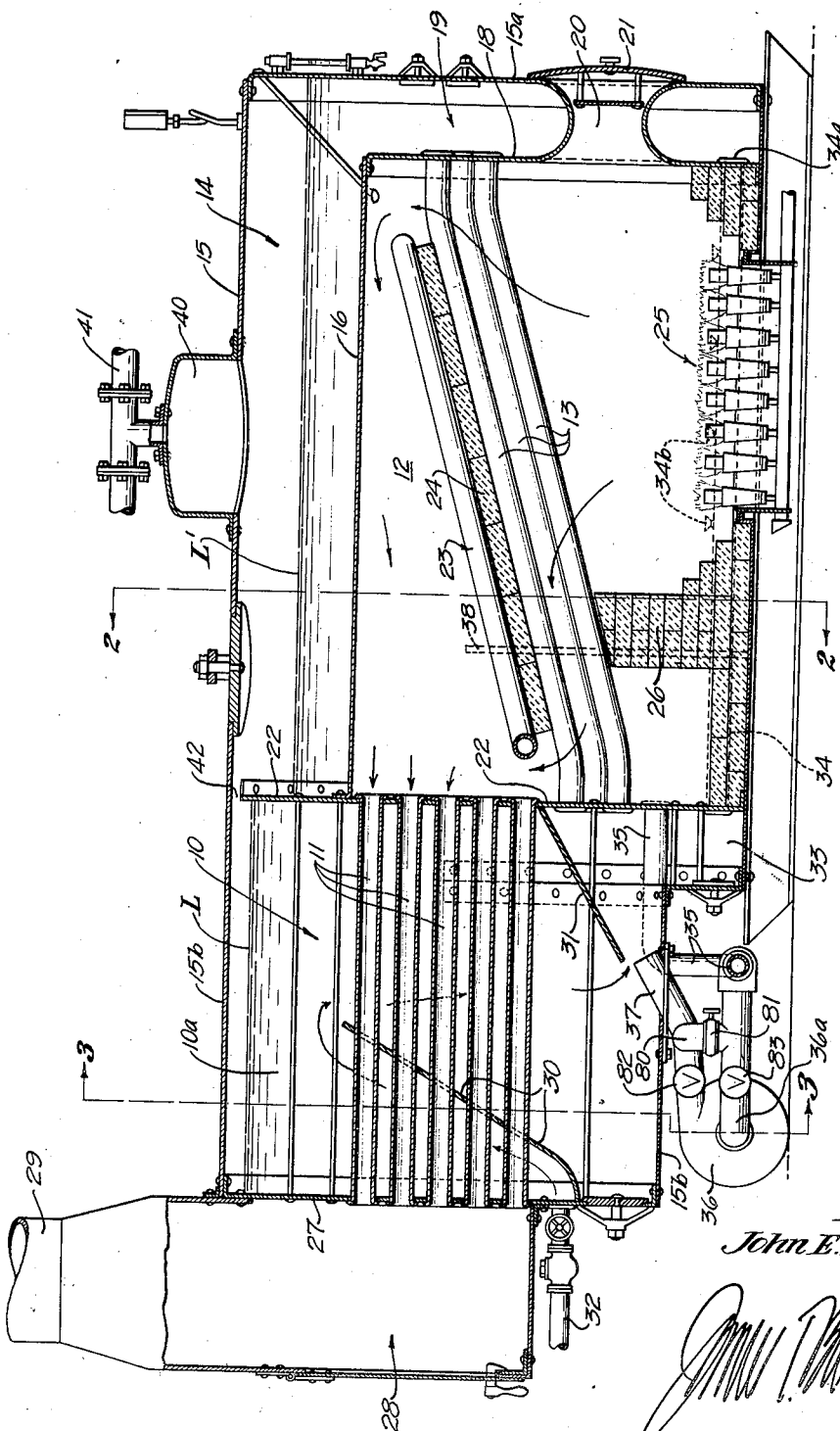
J. E. BRANTLY

2,189,443

STEAM BOILER

Filed May 31, 1938

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

Fig. 2.

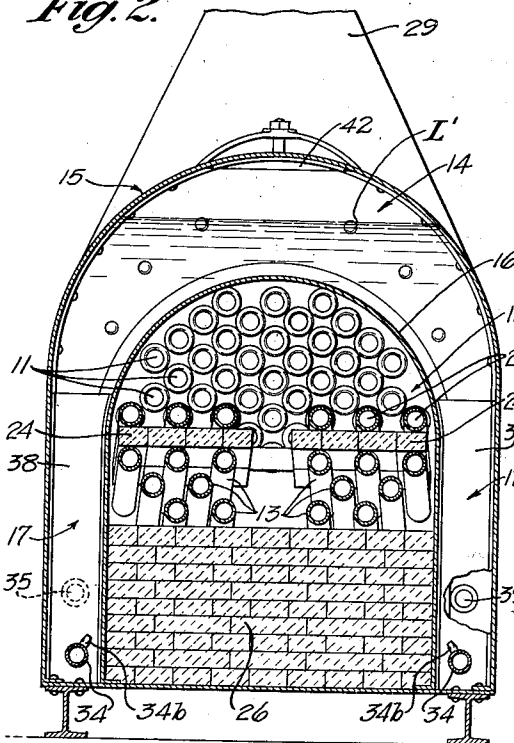


Fig. 3.

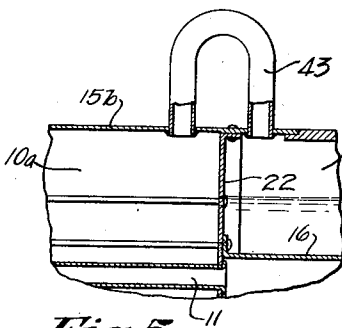
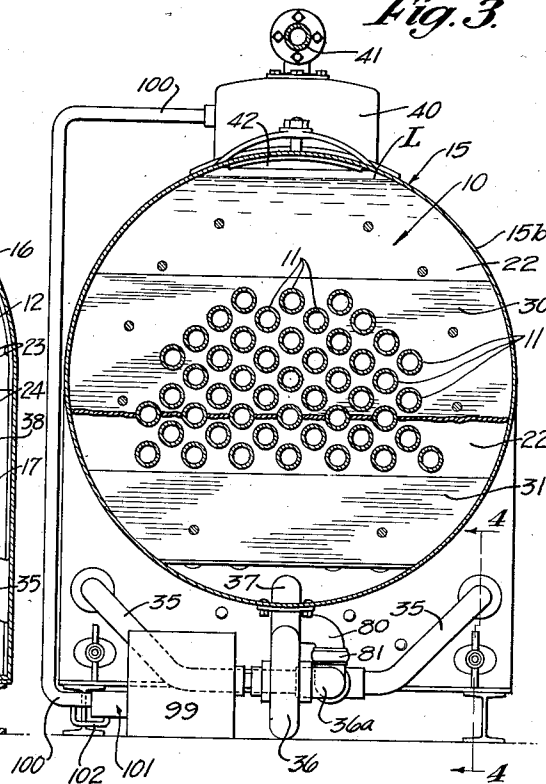


Fig. 5.

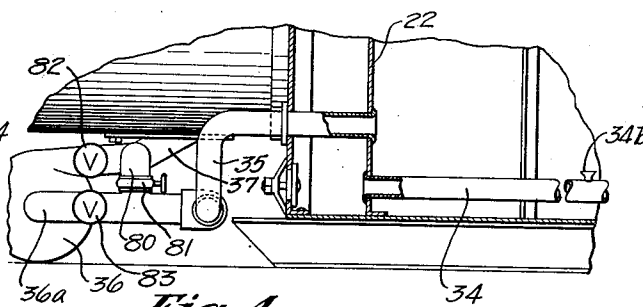


Fig. 4.

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Fig. 6.

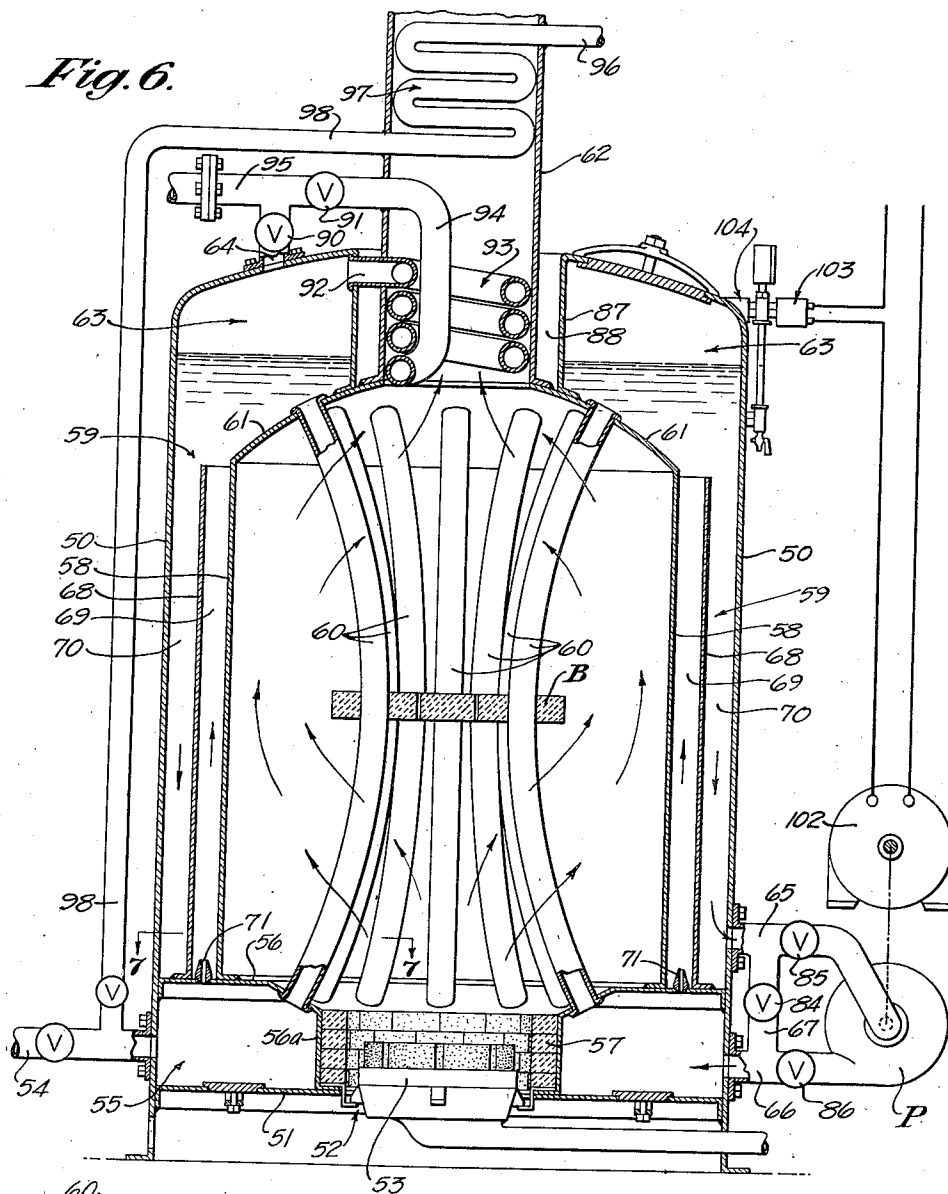


Fig. 7.

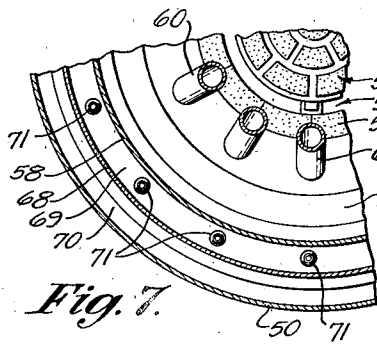


Fig. 8.

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UNITED STATES PATENT OFFICE

2,189,443

STEAM BOILER

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Application May 31, 1938, Serial No. 210,896

25 Claims. (Cl. 122-406)

This invention relates generally to steam boilers, and has for its general purpose to provide improvements whereby for given horse-power rating, it is possible to materially reduce the size, weight and cost of the boiler, and to increase the pounds of steam generated per square foot of heating surface. These advantages are of particular importance in portable type boilers, although it is to be understood that the invention is applicable to boilers of various types, including stationary boilers.

The invention is concerned primarily with boilers in which the fire box or fuel combustion zone is enclosed by a water jacket, and the water is heated within tubes in the combustion zone, and also within the water jacket by direct heat transference from the fire box wall. Preferably, the feed water first is introduced to a chamber wherein the water may become preheated. From this chamber the water flows through the tubes contained in the fire box, and also into water leg portions of the fire box jacket directly adjacent the sides of the fire box wall. Steam generated in the tubes and water jacket rises into a steam chamber within the upper interior of the jacket shell. Boilers having this general construction are disclosed in my copending application, Ser. No. 164,673, filed September 20, 1937, on Boiler.

My primary object is to increase heat transfer rates from the combustion gases to the water, and to thereby increase the boiler efficiency, by maintaining continuous water circulation between the fire box jacket or water legs, and the feed water supply chamber. By so keeping the water in a state of continuous flow through the jacket, I am able to maintain water velocities along the outer heating surfaces of the fire box shell, sufficient to remove steam bubbles and stagnant water films from those surfaces and thereby greatly increase the rates of heat transfer to the water. In order to maintain desirably high water velocities, I preferably employ means, such as a pump, for creating positive water circulation between the fire box water jacket and the feed water chamber. At the same time I maintain forced circulation through the water tubes, thus increasing the rate of heat transfer through the tubes as well as through the fire box wall.

The invention includes various additional features, all contributing to increased thermal efficiency of the boiler, but these as well as the objects mentioned above, will be explained to better advantage and understood more readily from the following detailed description of the invention in certain typical and illustrative forms. Through-

out the description, reference is had to the accompanying drawings, in which:

Fig. 1 is a view in longitudinal section showing one embodiment of the invention in a typical form of horizontal boiler;

Figs. 2 and 3 are vertical sections on lines 2-2 and 3-3 of Fig. 1;

Fig. 4 is a fragmentary section on line 4-4 of Fig. 3;

Fig. 5 is another fragmentary view showing a modified feature of the invention;

Fig. 6 is a sectional view showing another embodiment of the invention in a vertical type of boiler;

Fig. 7 is a fragmentary section on line 7-7 of Fig. 6; and

Fig. 8 is a fragmentary view illustrating a variational form of certain parts of the boiler shown in Fig. 6.

The boiler shown in Fig. 1 may be described generally as including a preheating section 10 within which the feed water is heated by contact with the fire tubes 11, and a fire box section 12 containing tubes 13 through which water flows from the preheating section 10 into the steam chamber 14. The boiler comprises an outer shell 15 enclosing both the preheating section 10 and the fire box 12, the latter however being directly defined by a shell 16 spaced from the top of shell 15 to form the steam chamber 14, and spaced at 17 from the sides of the outer shell to form what may be referred to as side water legs continuing below the steam chamber. One end 18 of the fire box shell is spaced at 19 from the end wall 15a of the outer shell to form an end water leg in open communication with the side water legs and steam chamber. The interior of the fire box is accessible through a manhole 20 normally closed by cover plate 21.

The opposite end of the fire chamber is enclosed by a tube sheet 22 into which the lower ends of the inclined water tubes 13 are expanded. As illustrated, the upper ends of the tubes are expanded into the outer end wall 18 of the fire box. The fire box may contain a suitable superheating coil, conventionally illustrated at 23 above the inclined baffle wall 24. Hot combustion gases from the multiple burner unit 25 set within an opening in the floor of the fire box, flow in paths indicated by the arrows along tubes 13 below the baffle wall toward the upper end of the combustion chamber, and oppositely along the tubes between baffle 24 and the baffle wall 26.

The preheating section 10 within the cylindric portion 15b of the outer shell, contains a plurality

of horizontal fire tubes 11 extending through tube sheets 22 and 27. The hot combustion gases leaving the fire box chamber 12 flow through tubes 11 into the smoke box 28 and out through the stack 29. The preheating section 10 contains a pair of baffles 30 and 31 which cause the boiler feed water introduced through line 32 to flow upwardly and transversely of the outer portions of tubes 11, and to then flow downwardly in contact with the inner extents of the tubes. The water then passes beneath baffle 31 into the lower ends of the water tubes 13. A portion of the preheated water also is discharged directly from the lower portion 23 of the preheating chamber into the lower portions of the water legs 17 at the sides of the fire box, and also if desired, into water leg 19. For this purpose I provide tubes 34 having discharge orifices or nozzles 34b, extending longitudinally within the bottoms of the side water legs through tube sheet 22 and end wall 18 of the fire box. The ends 34a of tubes 34 may be closed or open, depending upon whether it is desired to maintain an upward circulation of water from the preheating section 10 within the end water leg 19.

Suitable provision is made for recirculating water from the side water legs 17 into the preheating section 10, as by way of pipes 35, see Fig. 3, connected to the inlet 35a of a pump 36 which discharges through pipe 37 into the preheating chamber below or at the lower end of baffle 31. Pump 36 may be of any suitable type, either of a positive displacement or centrifugally operating design. The showing in the drawings may be regarded as a diagrammatic illustration of a positive displacement rotary pump. The pump inlet 35a and pipe 37 may be connected by a normally closed by-pass line 38 containing a valve 31 which may be opened to permit natural or convection circulation if the pump is not in operation. Valves 32 and 33 may be closed to cut out the pump, or to permit removal of the pump for replacement or repair. Preferably, pipes 35 connect with the lower portions of the water legs 17 so that the pump operates to recirculate the relatively cooler water. Baffles 38 placed within the side water legs toward the inner ends thereof require the water being discharged from tubes 34, as will presently appear, to flow upwardly within the greater longitudinal extents of the water legs without interference by the pump suction through pipes 35. The recirculated water then reverses its path in flowing over the baffles 38 and downwardly between the baffles and the tube sheet 22, to the pipes 35.

In the operation of the boiler, the feed water is preheated in flowing through section 10 as previously described, and the greater portion of the preheated water then is discharged through tubes 13 into the end water leg 19 and steam chamber 14. In flowing through the tubes, the water is partially converted to steam which rises into the steam chamber and dome 42 to the steam supply line 41. Pump 36 operates to maintain increased rate of circulation through the water tubes by virtue of the high velocity of the water stream discharged by the pump toward the tubes, and also by virtue of the greater static head and pressure existing in the preheating section developed by the discharge pressure of the pump. Thus as illustrated, the water in chamber 19a within section 10 may stand at a level L substantially higher than the water level L' in the steam chamber 14. Communication between the two chambers may be maintained in any suit-

able manner, for the purpose of venting into the steam chamber any steam that may be generated in the preheating chamber, as by terminating the upper edge of tube sheet 22 below the crown of shell 15 to provide an opening at 42. If desired, provision may be made for increasing the static head in the preheating chamber 19a by extending the effective height of the water column therein above the top of shell 15. For example, as shown in Fig. 5, tube sheet 22 may be extended to the top of shell 12 and the chambers at opposite sides of the tube sheet interconnected by a pipe 43 which may extend upwardly any distance in accordance with the desired water head to be maintained in the preheating section.

In the fire box section of the boiler the preheated water is heated to higher temperatures and converted to steam in circulating through tubes 13 and the side and end water legs at 17 and 19. The high efficiency of the boiler is due largely to the fire box being water jacketed, so that in addition to the water being heated within tubes 13, there is a direct transference of heat through the fire box wall 16 to the water standing in the enclosed jacket. One of my primary objects is to further increase the boiler efficiency by maintaining forced circulation of water through tubes 13 and within the water jacket so as to materially increase the rates of heat transfer.

Under the combined effects of the relatively high velocity of water discharged by the pump 36, and the increased static head of the water in the preheating section 10, the water forced into tubes 34 is discharged upwardly from nozzles 34b at fairly high velocity along the outer surfaces of the fire box shell 15. Water discharged from the ends 34a of tubes 34 maintains an upward circulation at substantial velocity within the lower portion of the end water leg 19 and along the outer surface of the fire box wall 18. The effect of upward forced circulation of water along the outer surfaces of the fire box is to substantially increase the rate of heat transfer from the combustion gases and fire box wall to the water, by continuously removing from the surface of the wall steam bubbles and superheated water films that otherwise would materially reduce the heat transfer rate. The rate of water discharge from pipes 34 and the spacing between shell 15 and the side and end walls of the fire box, are such as to maintain a rate of upward circulation within the water legs sufficient to effectively free the exposed fire box surface of insulating steam particles and thermally stagnant water film.

Nozzles 34b are shown to be positioned between baffles 38 and the fire box and wall 18, so that the circulated water being discharged by the nozzles flows upwardly toward the top of the fire box and then reverses its flow in passing downwardly between the baffles and the tube sheet 22. If desired, pipes 34 may be provided with discharge nozzles between baffles 38 and the tube sheet 22, although the downward circulation of the water being taken into pipes 35 ordinarily will be sufficient to maintain efficient heat transfer from the fire box wall.

Figs. 6 and 7 show another embodiment of the invention in a vertical type water tube boiler similar to the previously described form in that the fire box is water jacketed, and forced recirculation of water is maintained between a feed water inlet chamber and the legs of the water

jacket. The boiler in Fig. 6 comprises an outer shell 50 containing a floor plate 51 having an opening 52 within which is placed a suitable burner unit 53. The feed water is introduced from line 54 to chamber 55 enclosed by an annular plate 56, the inner vertically extending portion 56a of which is lined with fire brick 57 and forms the burner housing. Here the fire box is formed by a cylindric shell 58 positioned concentrically within and annularly spaced at 59 from the outer shell 50. The water tubes 60, which may be of any suitable form and shape, are expanded within plate 56 and within the crown sheet 61 of the fire box shell. Hot combustion gases flow upwardly from the burner unit 53 through the fire box and along the water tubes 60, and are discharged through the stack 62. Preferably I provide within the fire box a fire brick baffle B positioned, as illustrated, to direct the rising combustion gases outwardly toward and along the jacketed wall of the shell.

Water flowing upwardly through the tubes 60 is discharged into the annular steam chamber 63, the latter having an outlet 64 and being in open communication with space 59 which forms an annular water leg directly surrounding the fire box shell. A continuous circulation of water from space 59 into the feed water chamber 55, and then upwardly along the surface of the fire box shell 58, is maintained by a suitable pump, diagrammatically indicated at P. Water is taken by the pump, preferably at a point or points toward the lower end of the water leg, through pipe 65, and is discharged through pipe 66 into the chamber 55. A by-pass line 67, having a normally closed valve 84 may be provided in order that if it is not desired to maintain positive or mechanical circulation of the water, the pump may be shut down, valves 85 and 86 closed and the valve 84 opened to permit convection or thermosiphonic circulation through the by-pass line. I preferably provide within space 59 an annular baffle 68 spaced at 69 and 70 from the fire box and outer shell 50, in order that rapid upward circulation of water may be maintained along the surface of the fire box, and the water then recirculated downwardly to the pump inlet without interference with the upwardly flowing stream.

The combined fresh feed and recirculated water are forced through the water tubes 60 and also through circularly spaced nozzles 71 which discharge the water upwardly in high velocity streams within space 69 along the outer surface of the fire box shell 58. As in the previously described form of the invention, the pump maintains a forced circulation of water from the nozzles at sufficient velocity to continuously remove from the surface of the shell 58 steam bubbles and superheated water films that otherwise would diminish the heat transfer rate.

Where the boiler is designed for relatively low pressure steam generation, the lower extent of the stack 62 may form the inner wall of the annular steam chamber 63, but if extremely high pressure steam is to be generated, it may be desirable to remove the stack from exposure to the steam, and thus avoid overheating and resultant failure of that portion of the steam chamber wall about the stack. Accordingly, as shown in Fig. 6, I may provide a separate inner steam chamber wall 87 spaced at 88 from the stack 62 so that all portions of the steam chamber shell not contacted by water, are removed from direct heat transference from the combustion gases discharged through the stack. As an alternative, I

may in effect water jacket the bottom portion of the stack 62 within the steam chamber, as shown in Fig. 8, by providing an annular baffle or bell 89 overlying the upper ends of tubes 60 and directing the water discharged from the tubes upwardly along the surface of the stack. The water spills over the upper edge of the baffle 89 into the steam chamber and, by direct contact with the stack, prevents it from becoming overheated.

Further heat economies may be effected by utilizing the heat contained in the combustion gases flowing through the stack to superheat the steam and also, if desired, to preheat the boiler feed water. Thus, by closing valve 90 and opening valve 91, the steam may be discharged at 92 from the top of chamber 63 through a superheater coil 93 within which the steam passes counterflow to the stack combustion gases and is discharged through pipe 94 to the supply line 95. Feed water may be passed from pipe 96 through the preheating coil 97 and then through pipe 98 into the boiler water chamber 55.

In both the described forms of the invention, the rate of water circulation within the boilers may be automatically controlled in accordance with the steam pressure so that as the steam pressure builds up beyond a predetermined limit, the water circulation rate, and consequently the rate of steam generation, will be reduced; and conversely as the steam pressure falls below that predetermined limit. To accomplish this object, I may regulate the speed of operation of the water circulating pump in accordance with the boiler steam pressure by any suitable type of automatic control, various forms of which (per se) are known and in common use. For example, as shown in Fig. 3, the pump 36 may be driven by an engine 99 supplied with steam from the boiler through line 100. The supply of steam to the engine is regulated by a suitable control, diagrammatically illustrated at 101, which in turn is connected by pipe 102 to the steam line 100 so as to operate to reduce the supply of steam to the engine, and therefore the engine speed, when the steam pressure in line 100 increases, and conversely when that steam pressure decreases below a predetermined limit. In Fig. 6, the pump P may be driven by an electric motor 102, the speed and supply of current to which may be automatically regulated by a suitable pressure responsive control device, conventionally illustrated at 103, connected at 104 with the boiler steam chamber 63. As before, the motor and pump speeds are thus controlled to automatically reduce the rate of water circulation within the boiler under the influence of the pump when the steam pressure becomes excessive, and to increase the water circulation rate when the steam pressure drops.

As will be seen from the foregoing, in both the described forms of the invention, the water is heated and converted to steam in flowing through tubes within the combustion chamber or fire box, and also in being maintained in a state of circulation within the water legs directly adjacent the outside of the fire box shell. By providing forced recirculation both through the tubes and within the water legs, I am able to establish maximum heat transfer rates from the combustion gases to the water, and by virtue of the jacketed fire box construction, utilize a maximum of the heat content of the combustion gases. Because of the greater heat efficiency afforded by these features, it is made possible in designing a boiler for given horse-power rating to substan-

tially reduce the size and weight, as well as the cost of the boiler, as compared with other boilers of corresponding horse power.

I claim:

1. In a boiler, the combination comprising walls forming a fire box, walls spaced from said fire box forming a steam chamber and a water leg extending below the steam chamber and directly exposed to the side of the fire box wall, means forming a water chamber having a feed water inlet, a baffle extending upwardly within said water leg, means including a pump for recirculating water from said water leg at one side of the baffle into the water chamber, and means for discharging water under the influence of said pump from said water chamber into the water leg at the opposite side of said baffle and along the surface of the fire box wall.

2. In a boiler, the combination comprising walls forming a fire box, walls spaced from said fire box forming a steam chamber and a water leg extending below the steam chamber and directly exposed to the side of the fire box wall, means forming a water chamber having a feed water inlet, a smoke box, fire tubes extending from said fire box through the water chamber to the smoke box, a vertical baffle extending upwardly within said water leg, means including a pump for recirculating water from said water leg at one side of the baffle into the water chamber, and means for discharging water under the influence of said pump from said water chamber into the water leg and along the surface of the fire box wall at the other side of the baffle.

3. In a boiler, the combination comprising walls forming a fire box, walls spaced from said fire box forming a steam chamber and a water leg extending below the steam chamber and directly exposed to the side of the fire box wall, means for withdrawing water from one location within said water leg, and means for so discharging water into another location within said water leg that the water discharged flows upwardly therein directly adjacent and along the surface of the fire box wall.

4. In a boiler, the combination comprising walls forming a fire box, walls spaced from said fire box forming a steam chamber and a water leg extending below the steam chamber and directly exposed to the side of the fire box wall, means for withdrawing water from one location within said water leg, and means for so discharging water into another location within said water leg that the water discharged flows upwardly therein directly adjacent and along the surface of the fire box wall, the last mentioned means comprising a nozzle through which the water is discharged upwardly within a lower portion of the water leg at relatively high velocity.

5. In a boiler, the combination comprising walls forming a fire box, walls spaced from said fire box forming a steam chamber and a water leg extending below the steam chamber and directly exposed to the side of the fire box wall, a baffle within said water leg, means for withdrawing water from the water leg at one side of said baffle, and means for discharging water into said water leg at the opposite side of the baffle and along the surface of the fire box wall.

6. In a boiler, the combination comprising walls forming a fire box, walls spaced from said fire box forming a steam chamber and a water leg extending below the steam chamber and directly exposed to the side of the fire box wall, means forming a water chamber having a feed water inlet, means

for recirculating water from one location within said water leg into the water chamber, and means for so discharging water from said water chamber into the lower portion of the water leg at a location different from the first mentioned location that the water discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

7. In a boiler, the combination comprising walls forming a fire box, walls spaced from said fire box forming a steam chamber and a water leg extending below the steam chamber and directly exposed to the side of the fire box wall, means forming a water chamber having a feed water inlet, means including a pump for recirculating water from one location within said water leg into the water chamber, and means for so discharging water under the influence of said pump from said water chamber into the lower portion of the water leg at a location different from the first mentioned location that the water discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

8. In a boiler, the combination comprising walls forming a fire box, walls spaced from said fire box forming a steam chamber and a water leg extending below the steam chamber and directly exposed to the side of the fire box wall, means forming a water chamber having a feed water inlet, means for recirculating water from one location within said water leg into the water chamber, and means for so discharging water from said water chamber in a plurality of high velocity streams into the lower portion of the water leg at a location different from the first mentioned location that the water discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

9. In a boiler, the combination comprising walls forming a fire box, outer walls spaced from said fire box forming a steam chamber and a water leg extending below the steam chamber and directly exposed to the side of the fire box wall, means forming a water chamber having a feed water inlet, water tubes extending within said fire box and interconnecting said water chamber and the space between said outer walls and fire box so that water is delivered through the tubes from the water chamber into said space, means for recirculating water from one location within said water leg into the water chamber, and means for so discharging water from said water chamber into the lower portion of the water leg at a location different from the first mentioned location that the water discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

10. In a boiler, the combination comprising walls forming a fire box, outer walls spaced from said fire box forming a steam chamber and a water leg extending below the steam chamber and directly exposed to the side of the fire box wall, means forming a water chamber having a feed water inlet, water tubes extending within said fire box and interconnecting said water chamber and the space between said outer walls and fire box so that water is delivered through the tubes from the water chamber into said space, means including a pump for recirculating water from one location within the lower portion of said water leg into the water chamber, and means for so discharging water under the influence of said pump from said water chamber into the lower portion of the water leg at a location different from the first mentioned location that the water

discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

11. In a boiler, the combination comprising walls forming a fire box, outer walls spaced from said fire box forming a steam chamber and a water leg extending below the steam chamber and directly exposed to the side of the fire box wall, means forming a water chamber having a feed water inlet, water tubes extending within said fire box and interconnecting said water chamber and the space between said outer walls and fire box so that water is delivered through the tubes from the water chamber into said space, means including a positive displacement pump for recirculating water from one location within said water leg into the water chamber, and means for discharging water under the influence of said pump from said water chamber into a lower portion of the water leg at a location different from the first mentioned location and upwardly along the surface of the fire box wall.

12. In a boiler, the combination comprising walls forming a fire box, outer walls spaced from said fire box forming a steam chamber and water legs below the steam chamber and directly exposed to opposite sides of the fire box wall, means forming a water chamber having a feed water inlet, water tubes extending within said fire box and interconnecting said water chamber and the space between said outer walls and fire box so that water is delivered through the tubes from the water chamber into said space, means for recirculating water from locations within said water legs into the water chamber, and means for so discharging water from the water chamber into the lower portions of said water legs at locations different from the first mentioned locations that the water discharged is caused to flow upwardly within the water legs along the surface of the fire box wall.

13. In a boiler, the combination comprising walls forming a fire box, outer walls spaced from said fire box forming a steam chamber and water legs below the steam chamber and directly exposed to opposite sides of the fire box wall, means forming a water chamber having a feed water inlet, water tubes extending within said fire box and interconnecting said water chamber and the space between said outer walls and fire box so that water is delivered through the tubes from the water chamber into said space, means including a pump for recirculating water from locations within said water legs into the water chamber, and means for so discharging water under the influence of said pump from the water chamber into the lower portions of said water legs at locations different from the first mentioned locations that the water discharged is caused to flow upwardly within the water legs along the surface of the fire box wall.

14. In a boiler, the combination comprising walls forming a fire box, outer walls spaced from said fire box forming a steam chamber and water legs below the steam chamber and directly exposed to opposite sides of the fire box wall, means forming a water chamber having a feed water inlet, water tubes extending within said fire box and interconnecting said water chamber and the space between said outer walls and fire box so that water is delivered through the tubes from the water chamber into said space, means including a pump for recirculating water from locations within said water legs into the water chamber, and means including nozzles for so discharging water under the influence of said

pump from the water chamber into the lower portions of said water legs at locations different from the first mentioned locations that the water discharged is caused to flow upwardly at high velocity along the surface of the fire box wall.

15. In a boiler, the combination comprising walls forming a fire box, outer walls spaced from said fire box forming a steam chamber and water legs below the steam chamber and directly exposed to opposite sides of the fire box wall, means forming a water chamber having a feed water inlet, water tubes extending within said fire box and interconnecting said water chamber and the space between said outer walls and fire box so that water is delivered through the tubes from the water chamber into said space, means for recirculating water from locations within said water legs into the water chamber, and means including separate series of nozzles for so discharging water from the water chamber into the lower portions of said water legs at locations different from the first mentioned locations that the water discharged is caused to flow upwardly within the water legs at high velocity along the surface of the fire box wall.

16. In a boiler, the combination comprising walls forming a fire box, outer walls spaced from said fire box forming a steam chamber and water legs below the steam chamber and directly exposed to opposite sides of the fire box wall, means forming a water chamber having a feed water inlet, water tubes extending within said fire box and interconnecting said water chamber and the space between said outer walls and fire box so that water is delivered through the tubes from the water chamber into said space, means including a pump for recirculating water from said water legs into the water chamber, and means for discharging water under the influence of said pump from the water chamber into said water legs at points along the lower portions of said water legs and upwardly along the surface of the fire box wall.

17. In a boiler, the combination comprising walls forming a vertically extending fire box, walls annularly spaced from the sides and top of said fire box to form a steam chamber and an annular water leg surrounding and directly exposed to the fire box wall, means forming a water chamber having a feed water inlet, means for recirculating water from one location within said water leg into the water chamber, and means for so discharging water from said water chamber into the lower portion of the water leg at a location different from the first mentioned location that the water discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

18. In a boiler, the combination comprising walls forming a vertically extending fire box, walls annularly spaced from the sides and top of said fire box to form a steam chamber and an annular water leg surrounding and directly exposed to the fire box wall, means forming a water chamber having a feed water inlet, means including a pump for recirculating water from one location within said water leg into the water chamber, and means for so discharging water under the influence of said pump from said water chamber into the lower portion of the water leg at a location different from the first mentioned location that the water discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

19. In a boiler, the combination comprising

walls forming a vertically extending fire box, walls annularly spaced from the sides and top of said fire box to form a steam chamber and an annular water leg surrounding and directly exposed to the fire box wall, means forming below said water leg a water chamber having a feed water inlet, means including a pump for recirculating water from one location within said water leg into the water chamber, and means for so discharging water under the influence of said pump from said water chamber into the lower portion of the water leg at a location different from the first mentioned location that the water discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

20. In a boiler, the combination comprising walls forming a vertically extending fire box, outer walls annularly spaced from the sides and top of said fire box to form a steam chamber and an annular water leg surrounding and directly exposed to the fire box wall, means forming a water chamber having a feed water inlet, water tubes extending upwardly within said fire box and interconnecting said water chamber and the space between said outer walls and fire box so that water is delivered through the tubes from the water chamber into said space, means for recirculating water from one location within said water leg into the water chamber, and means for so discharging water from said water chamber into the lower portion of the water leg at a location different from the first mentioned location that the water discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

21. In a boiler, the combination comprising walls forming a vertically extending fire box, outer walls annularly spaced from the sides and top of said fire box to form a steam chamber and an annular water leg surrounding and directly exposed to the fire box wall, means forming a water chamber having a feed water inlet, water tubes extending upwardly within said fire box and interconnecting said water chamber and the space between said outer walls and fire box so that the water is delivered through the tubes from the water chamber into said space, means including a pump for recirculating water from one location within said water leg into the water chamber, and means for so discharging water under the influence of said pump from said water chamber into the lower portion of the water leg at a location different from the first mentioned location that the water discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

22. In a boiler, the combination comprising walls forming walls forming a vertically extending fire box, outer walls annularly spaced from the sides and top of said fire box to form a steam chamber and an annular water leg surrounding and directly exposed to the fire box wall, means forming directly below said water leg a water chamber having a feed water inlet, water tubes extending upwardly within said fire box and

interconnecting said water chamber and the space between said outer walls and fire box so that the water is delivered through the tubes from the water chamber into said space, means for recirculating water from one location within said water leg into the water chamber, and means for so discharging water from said water chamber into the lower portion of the water leg at a location different from the first mentioned location that the water discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

23. In a boiler, the combination comprising walls forming a vertically extending fire box, outer walls annularly spaced from the sides and top of said fire box to form a steam chamber and an annular water leg surrounding and directly exposed to the fire box wall, means forming directly below said water leg a water chamber having a feed water inlet, water tubes extending upwardly within said fire box and interconnecting said water chamber and the space between said outer walls and fire box so that water is delivered through the tubes from the water chamber into said space, means including a pump for recirculating water from one location within said water leg into the water chamber, and means for so discharging water under the influence of said pump from said water chamber into the lower portion of the water leg at a location different from the first mentioned location that the water discharged is caused to flow upwardly within the water leg along the surface of the fire box wall.

24. In a boiler, the combination comprising walls forming a vertically extending fire box, a shell annularly spaced from said fire box forming a steam chamber and an annular water leg extending below the steam chamber and directly exposed to the side of the fire box wall, walls forming a water chamber below said water leg, water tubes extending upwardly within said fire box and interconnecting the water chamber with the space between said shell and the fire box wall, means for feeding water to said water chamber, and means for so passing water from said water chamber upwardly into the water leg that the water is directed in a rapidly flowing stream along the outer surface of the fire box wall.

25. In a boiler, the combination comprising walls forming a vertically extending fire box, a shell annularly spaced from said fire box forming a steam chamber and an annular water leg extending below the steam chamber and directly exposed to the side of the fire box wall, walls forming a water chamber below said water leg, water tubes extending upwardly within said fire box and interconnecting the water chamber with the space between said shell and the fire box wall, a pump for forcing water into said water chamber, and means for discharging water under the influence of said pump upwardly and in a high velocity stream from said water chamber into the lower portion of said water leg and along the fire box wall.

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