Oct. 27, 1931. C. E. LUCKE 1,828,814

SINGLE CIRCUIT WATER TUBE BOILER

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Fig 1

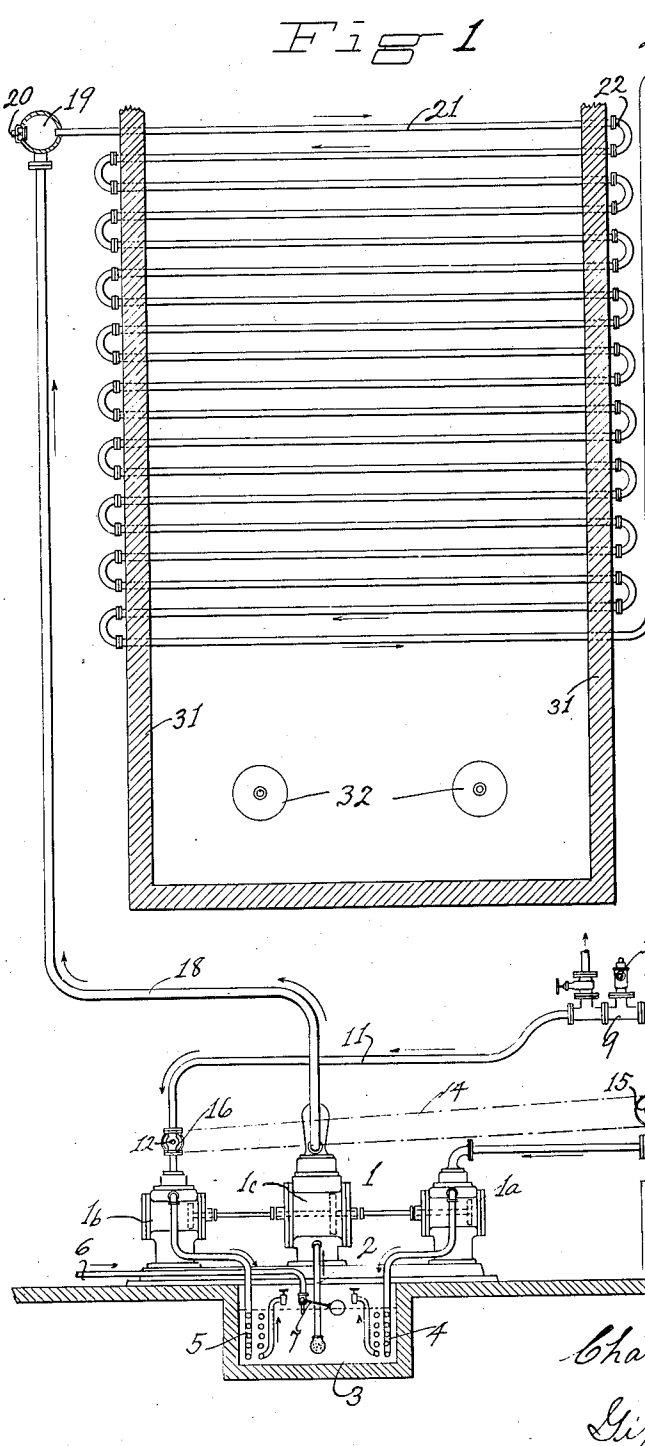


Fig 2

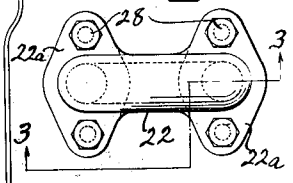
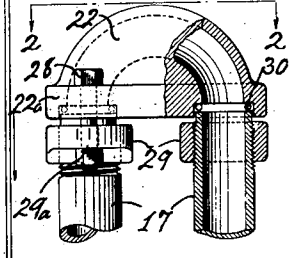


Fig 3



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Fig. 4

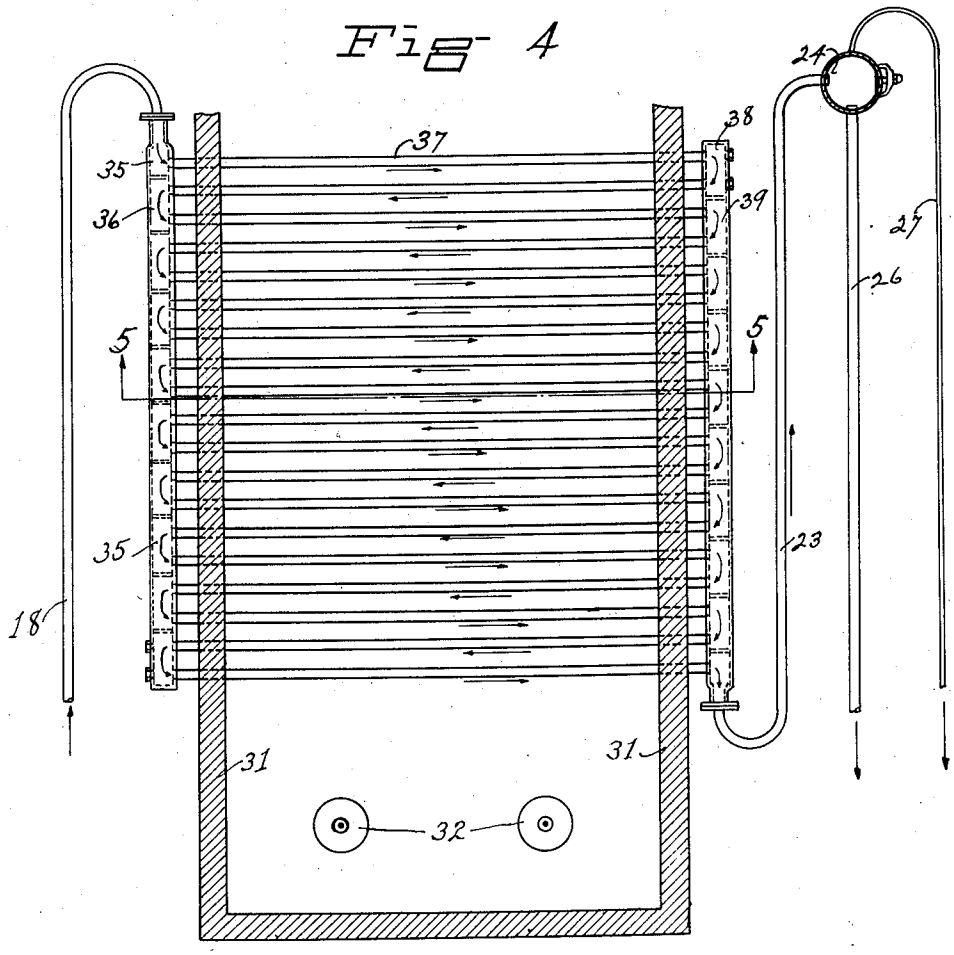


Fig. 5

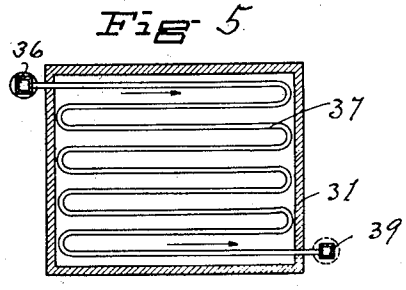
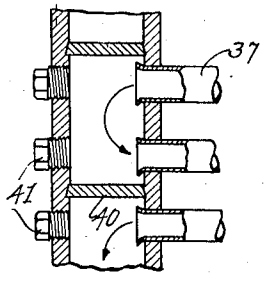


Fig. 6



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Fig. 8.

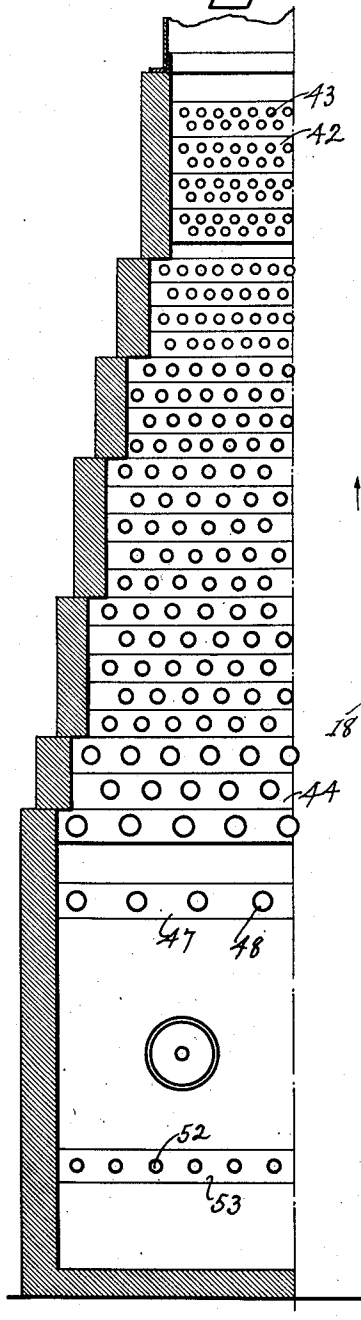


Fig. 7.

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UNITED STATES PATENT OFFICE

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SINGLE CIRCUIT WATER TUBE BOILER

Application filed January 3, 1927. Serial No. 158,468.

This invention relates to steam boilers of the forced circulation series type, in which there are water tubes connected end to end through which water is forced by means of a pump which feeds water to replace steam produced and also operates as a circulating pump to circulate unvaporized water that has already passed through the tubes. The pump for circulating the water through the tubes receives the water to be circulated from a separator which, in turn, receives steam and excess or unvaporized water from the tubes. Control of the amount of water withdrawn from the separator for circulation is by means other than a bleeding orifice that would discharge water at a substantially constant rate and therefore result in a wide variation in the ratio of circulation to boiler feed. The means provided herein for controlling the circulation rate is such as to increase circulation as evaporation and feed are increased, and to assure positive circulation by making it depend on a pump.

The invention will be understood from the description in connection with the accompanying drawings, in which Fig. 1 is a vertical section through an illustrative embodiment of the invention; Fig. 2 is a plan view of one of the connectors for the tubes; Fig. 3 is a section along the line 3—3 of Fig. 2; Fig. 4 is a vertical section of a modification of coils; Fig. 5 is a section on a smaller scale along the line 5—5 of Fig. 4; Fig. 6 is a vertical section on an enlarged scale showing the tube connectors; Fig. 7 is a vertical section of a modification of tube arrangement showing a furnace with tubes in its sides associated with coils filling the hot gas passageway and Fig. 8 is a section along the line 8—8 of Fig. 7 partly broken away.

In the drawings, reference character 1 indicates a pump that is used for forcing feed water into the water tubes, and also for circulating the excess or unvaporized water therethrough. This pump is provided with a cylinder 1*a* that is operated by water under pressure, cylinder 1*b* that is operated by steam from the steam main and cylinder 1*c* that forces water into the tubes. The feed water to be forced into the tubes to replace steam that has been made is drawn through the suction pipe 2 from the water supply tank 3 below the pump. The hot water from the cylinder 1*a* of the pump passes through the coil 4 and into the tank, while steam from the cylinder 1*b* passes through the coil 5 into the same tank. Feed water is supplied to the tank 3 through the pipe 6 that is provided with a float valve 7 for regulating the level of water in the tank. After the water has been forced through the boiler and some of it has become evaporated into steam, the mixture of steam and water that results passes to a separator 8 in the bottom of which the water collects and from which it passes through the cylinder 1*a* of the pump, while the steam passes to the steam main 9 that is provided with a valve. A safety valve 10 of the usual type is provided. Steam passes through the pipe 11 that is provided with a valve 12 to the steam cylinder 1*b* of the pump.

The valve 12 is controlled by a float 13 in the separator 8 by means of a chain 14 and the sprockets 15 and 16, so that as the water level falls in the separator due to an increase in steam produced in proportion to boiler feed, the valve 12 is opened by the falling float to make the pump run faster. At the same time an increased amount of water per minute will be withdrawn from the separator 8 by the cylinder 1*a*, discharged into the tank 3 and returned to the tubes with a proportionate amount of new feed water by cylinder 1*c* which has a larger displacement than 1*a* by the amount of feed water per stroke.

The pump forces water from the feed tank 3 through pipe 18 to a distributing header 19 that is provided with handholes 20. A row of tubes 21 leads from the distributing header 19 across the hot gas passage from the furnace, and their ends are connected by connectors 22 to another row of tubes that likewise extend across the hot gas passage and have their ends connected to another row, and so on, thus providing a number of vertical rows of tubes across the furnace, which are connected by pipes 23 to a header 24 that is provided with handholes 25. In this way sets of tubes are provided with their ends con-

nected, thus forming what may be termed coils, in this case flat coils of straight tubes that can be internally inspected and easily cleaned. The several coils in this illustration are connected in parallel, each coil receiving water from the distributing header 19 and delivering steam and water to the collector 24. The collector 24 is connected by a pipe 26 to the steam and water separator 8, and the collector 24 is also provided with a top vent connection 27 to the steam space of the separator 8 to facilitate smooth flow and to aid in separating steam and water.

The tube connectors 22 for connecting the ends of the tubes in this illustration are shown in detail in Figs. 2 and 3. The ends of the semi-circular connector 22 are provided with laterally extending lugs 22*a* that are provided with holes through which bolts 28 extend, and connect the connectors to the rings 29 that are threaded upon the ends of the tubes 21 and are provided with laterally extending lugs 29*a* with holes therein to receive the bolts 28. Packing rings 30 may be located between the ends of the tubes 21 and seats provided therefor in the ends of the connectors 22.

The tubes 21 extend across a hot gas passage whose walls are shown at 31, so that hot gases from the furnace below contact with the tubes and generate steam in them. The furnace may be heated in any convenient manner. It is illustrated as being heated by means of fuel burners 32.

To meet varying conditions of practice the tube and coil arrangements can be modified so as to produce results that will be best for any given circumstances without departing from the major features of the system of steam generation with pump circulation controlled to keep pace with boiler load. The tubes may be straight or curved, the former being best for conditions where scale may be deposited, while the latter have some advantage in subdivision of gas stream and in reducing the stress between two fixed points due to expansion, and may be used when scale does not deposit. The tube connectors may be individual, equivalent to return bends or may be unitary equivalent to headers with or without partitions.

The coils may be flat and tubes in general may lie parallel. They may be at right angles in different layers. All the tubes may be in series, thus filling the gas passage with a single coil. This arrangement gives the water the maximum length of travel, and the highest velocity of flow over the hot surfaces for a given tube size and total heating surface. This also results in the maximum of flow resistance and pump work. By putting two or more coils in parallel, flow resistance and also flow velocity are reduced for a given tube size. With this arrangement the water and steam must be properly distributed between as many sections as may be in parallel. By choosing appropriate relations between tubes in series forming one coil, with or without some tubes in parallel in one coil, and a number of coils connected in parallel, it is possible to meet any requirements of flow velocity to insure the safety of tubes against burning, and of flow resistance with corresponding power of pump.

Referring to Fig. 1, there are nineteen tubes shown in series in one vertical flat coil and as many such flat coils in parallel as may be desirable are placed side by side in the gas passage. In Figs. 4 and 5 there are shown nine tubes in series in one horizontal layer and nineteen such layers in series, thus providing one hundred and seventy one tubes all in series.

When the water delivered by the pump to the tubes is much below the boiling point for the boiler pressure, it is advantageous to feed the water in a generally countercurrent direction with reference to the hot gases. This is indicated in the drawings, but it is not essential, and becomes of lesser advantage as the water supply becomes hotter. After the water flowing through the tubes has reached steam temperature any direction of flow may be used with no heat absorbent advantage one way as compared with another, so arrangement of flow may be selected with reference to convenience or advantage in other directions.

As the gases cool in their flow across the water tubes the temperature difference between gases and water will become less, and the heat absorbed per square foot will decrease in proportion. It is possible to get more capacity from this heating surface by increasing the mass flow of the gases and this is conveniently done by decreasing the cross section of the gas passage in the direction of gas flow.

In the modification shown in Figs. 4 and 5, the coils of the tubes extend horizontal across the furnace instead of vertically, as illustrated in Fig. 1, and the tubes are bent along semi-circular arcs. Feed water from the pump passes through the pipe 18 to the upper compartment 35 of the vertically-disposed distributing header 36, from which it passes to the uppermost coil 37, back and forth across the furnace to the upper compartment 38 of the vertically-disposed header 39, thence into the next coil, as most clearly shown in Fig. 6, thence zig-zag across the furnace to the header 36 into the next lower coil, and so on, until the mixture of steam and water passes through the pipe 23 into the header 24 and then to the separator. The headers 36 and 39 are provided at intervals with partitions 40 and with handholes 41, as shown in Fig. 6. In the modification shown in Figs. 4 and 5, the water passes in

series through all the tubes that extend across the hot gas passage.

In the modification shown in Figs. 7 and 8, the pipe 18 from the pump is connected to a distributing header 42, from which one or more rows of tubes 43 extend to a similar header 44. This header 44 is connected by short nipples 45 to a similar header located below it, from which header one or more rows of tubes extend to a header located below the header 42 that is connected by nipples to a lower header, and so on. In this way, two sides of a flue are formed by the headers 42 and 44 and the tubes 43 extend across the flue. In this modification, two rows of tubes are shown connecting each pair of headers near the upper end of the flue, and only one row of tubes connects the other pairs of headers. The headers are made progressively longer toward the bottom of the flue, and the tubes connecting the headers are made progressively larger. The lowermost header 44 is connected by nipples 46 to a header 47, from which header a row of tubes 48 extends across the top of the furnace into a header 49, thus forming a slag screen. The header 49 is connected by the tubes 50 to a header 51, from which a row of tubes 52 which form a water screen leads to the header 53 that is connected by means of the pipe 23 to the collector 24.

In boilers constructed in accordance with this invention, the forced circulation provided by the pump will insure a high enough velocity in all tubes to materially reduce scale deposition or eliminate it, and will also insure that all heated tube surface is regularly wetted by the excess of water circulated over what is evaporated and so the surface is made safe against burns. Tube sizes, number and arrangement may be selected wholly without regard to the limitations that are usual in boilers with natural circulation, so that boilers constructed in accordance with the present invention may be suitable for conditions of service of wider range.

I claim:

1. The process of steam generation which comprises forcing water in excess through a heated zone, withdrawing steam and unevaporated water from said zone, separating said steam and water and utilizing said separated water in the forcing of water through said zone.

2. The process of steam generation which comprises forcing water in excess through a heated zone, separating the steam and water from said zone, reducing the pressure on the separated water to atmospheric pressure, and circulating it together with fresh feed water through the zone, the amount of circulating water and fresh feed water varying directly with each other.

3. A process of generating steam which includes forcing an excess of water under pressure through a heating and steam generating zone, separating the steam so generated from the unevaporated water, utilizing the unevaporated water under pressure for aiding in the forcing of the water through said zone, decreasing the pressure of said unevaporated water to a pressure below that of the water in the zone and mixing said unevaporated water with additional water before it enters the zone.

4. The combination with a water tube boiler of a steam and water separator for receiving a mixture of steam and water therefrom, a steam and water driven pump for feeding water through said tubes, means for utilizing both steam and water from said separator for operating said pump, and means for combining the exhaust from the steam and water driven means of said pump with fresh feed water.

5. The combination with a water tube boiler of a steam and water separator for receiving a mixture of steam and water therefrom, a water driven feed pump for forcing water through said tubes, means for bleeding water from said separator and delivering said bleed water to the driven part of said pump, and means for mixing said bleed water with the feed water supplied to said pump.

6. The combination with a water tube boiler of a steam and water separator for receiving a mixture of steam and water therefrom, a feed pump for forcing water through said tubes, a feed water tank for supplying feed water to said pump, an operating cylinder for said pump, means for bleeding water under pressure from said separator to said cylinder in the operation of said pump, and means for delivering the exhaust water from said cylinder to said tank.

7. The combination with a water tube boiler of a steam and water separator for receiving a mixture of steam and water therefrom, a water driven pump for feeding water through said tubes and means for bleeding water from said separator and utilizing the same in the operation of said water driven feed pump.

8. The combination with a water tube boiler of a steam and water separator for receiving a mixture of steam and water therefrom, a feed water piston and cylinder for feeding water through said tubes, a second piston and cylinder for operating said feed water cylinder, means for bleeding water from said separator to said second cylinder and for subsequently mixing said bleed water with the feed water entering said feed cylinder, said cylinders being so arranged as to maintain a fixed relationship between the volume of water bled from said separator and the volume of feed water delivered to said pump.

9. The combination with a water tube boiler of a steam and water separator for receiv-

ing a mixture of steam and water therefrom, a feed pump for feeding water through said boiler, a feed water tank for delivering water to said pump, separate power cylinders for operating said pump, means for delivering steam from said separator to one of said cylinders, and means for delivering water from said separator to the other of said cylinders.

10. The combination with a water tube boiler of a steam and water separator for receiving a mixture of steam and water therefrom, a feed pump for forcing water through said boiler, a feed water tank under atmospheric pressure for delivering feed water to said pump, separate operating cylinders for said pump, means for delivering steam from said separator to one of said cylinders, means for delivering water from said separator to the other of said cylinders, and means for delivering the exhaust from each of said cylinders to the feed water in said tank.

11. The combination with a water tube boiler of a steam and water separator for receiving a mixture of steam and water therefrom, a feed pump for forcing water through said boiler, separate operating cylinders for operating said feed pump, means for delivering steam from said separator to one of said cylinders, means for delivering water from said separator to the other of said cylinders, and means for varying the delivery of steam to said steam cylinder by and in accordance with variations in the water level in said separator.

12. A forced circulation boiler including a plurality of series flow conduits, and pumping means delivering water through all of said conduits and automatically maintaining a predetermined relationship between the volume of water circulated and the volume of water evaporated, said pumping means being proportioned so that the volume of water circulated continuously exceeds the volume of water evaporated.

13. A forced circulation boiler including a plurality of series flow conduits, and pumping means delivering water through all of said conduits and automatically maintaining a fixed predetermined relationship between the volume of water circulated and the volume of water evaporated, said pumping means being proportioned so that the volume of water circulated continuously exceeds the volume of water evaporated.

14. A forced circulation boiler including a plurality of series flow conduits, and pumping means delivering water through all of said conduits and automatically maintaining a predetermined minimum relationship between the volume of water circulated and the volume of water evaporated, said pumping means being proportioned so that the volume of water circulated continuously exceeds the volume of water evaporated.

15. A forced circulation boiler in combination with means maintaining a predetermined relationship between the volume of water circulated and the volume of water evaporated, said means including a water driven pump having a driving and a driven end, the driving end connected to receive its operating water from the boiler circuit, a source of make-up water connected to the driven end of said pump, a discharge line connected between said source and the driving end of said pump for delivering water exhausted from said driving end to said source, the capacity of the driven end being larger than that of the driving end whereby the volume of water circulated is greater than that evaporated.

16. A forced circulation boiler in combination with means maintaining a predetermined relation between the volume of water circulated and the volume of water evaporated, said means including a water driven pump having a driving and a driven end, means leading the water from the boiler circuit through the driving end to actuate the same and discharging into a receiving means, a source of make-up water, a connection between the driven end of said pump and said receiver and a connection between the discharge of the driven end of said pump and the boiler, the relative capacities of the driving and driven ends of said pump being in a ratio to deliver the combined volume from the receiver to the boiler.

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