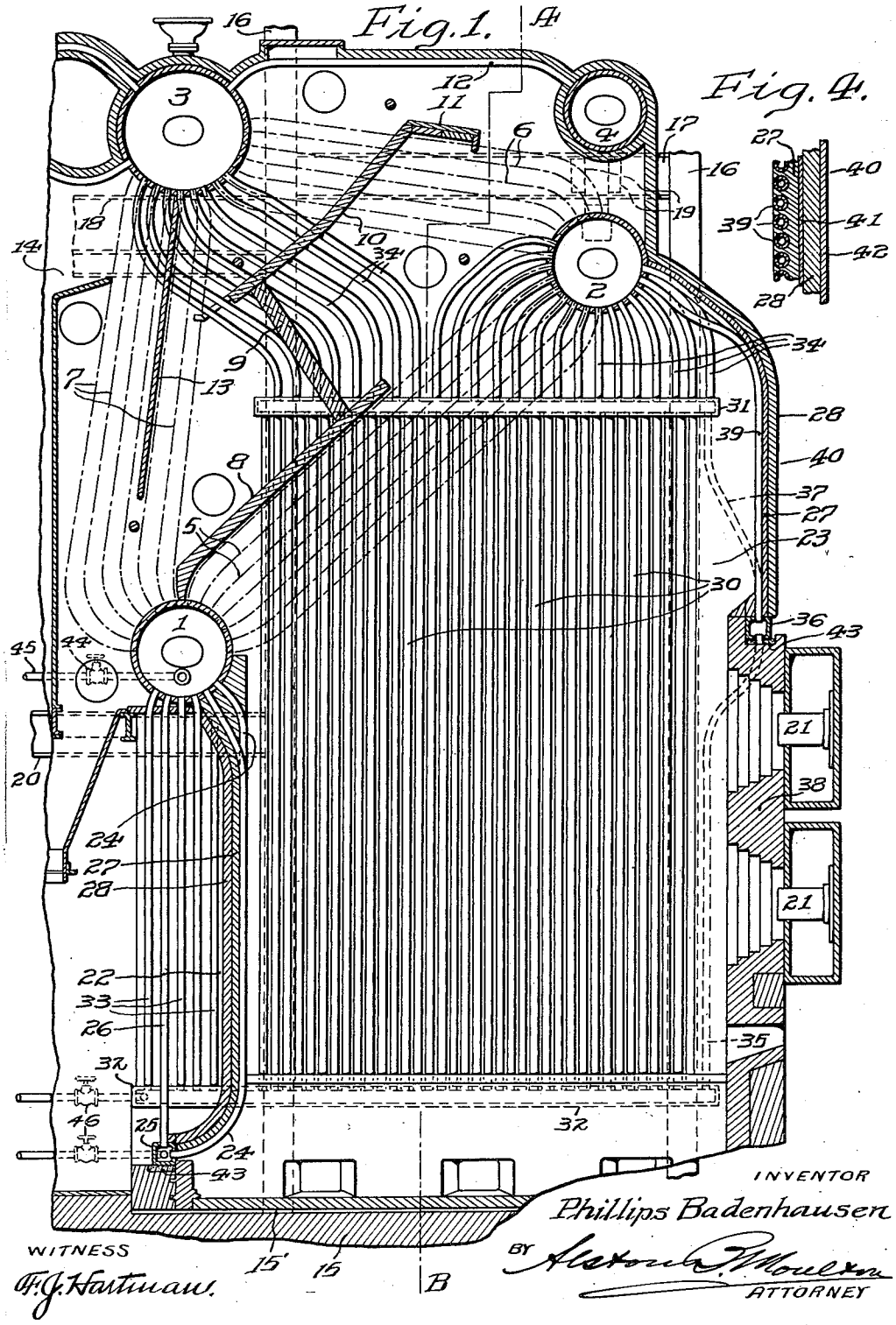
Feb. 18, 1930. P. BADENHAUSEN 1,747,612

STEAM BOILER

Filed Aug. 30, 1927 3 Sheets-Sheet 1



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STEAM BOILER

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Fig. 2.

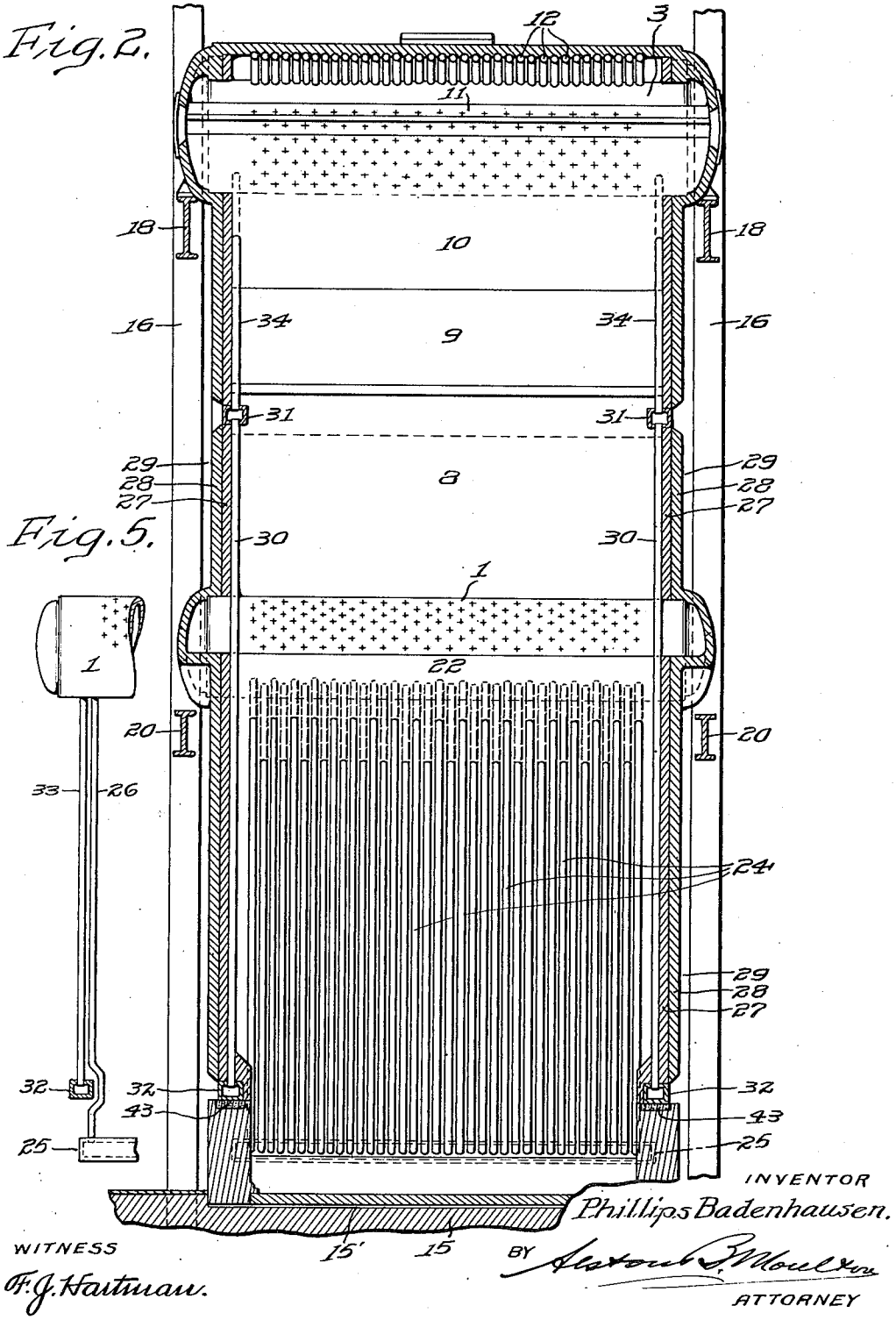

Fig. 5.

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STEAM BOILER

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Fig. 3.

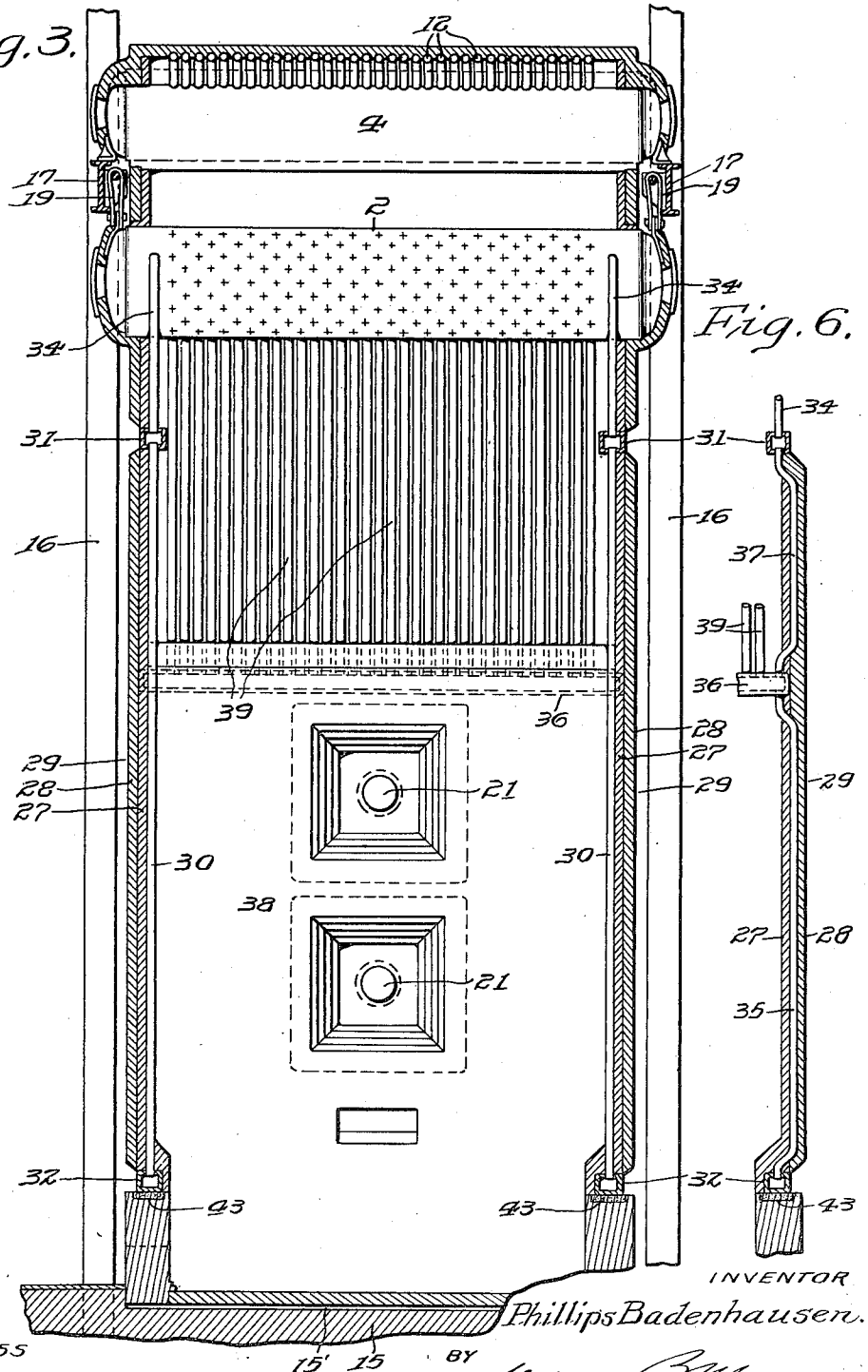

Fig. 6.

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UNITED STATES PATENT OFFICE

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STEAM BOILER

Application filed August 30, 1927. Serial No. 216,353.

My invention relates to steam boilers, and more particularly to the construction of the fire box of water-tube boilers.

The object of my invention is to provide a water-tube boiler having an upper steam-drum and a lower water-drum, and preferably an upper water-drum, connected by tubes wherein the steam is generated, with boiler walls enclosing a fire box on all four sides, each wall comprising or embodying a series or bank of closely arranged parallel vertical tubes to the lower ends of which water from the coolest portion of the boiler is supplied to the walls, the water being conveyed to the lower ends of the vertical tubes by conduits which are shielded or heat insulated from the inside of the fire box so that the water in the vertical tubes or walls may absorb as much as possible of the heat which otherwise is lost by radiation into the surrounding atmosphere.

Further objects of my invention will appear in the specification and claims below.

Referring now to the drawings forming a part of the specification and in which the same reference characters are employed throughout the various views to designate the same parts,

Fig. 1 is a vertical sectional view through the boiler at substantially the middle of it.

Fig. 2 is a vertical sectional view of the rear end of the boiler, the section being taken on the line A—B of Fig. 1.

Fig. 3 is a vertical sectional view, taken on the same line, A—B of Fig. 1, but looking toward the front of the boiler.

Fig. 4 is a fragmentary view showing, in detail, the refractory filling in the spaces between the row of tubes forming a middle wall of the fire box and the backing of the outer sides of the same with suitable heat-insulating material on the outer side of the wall so formed, and is to be considered as exemplary of the way in which all the fire box walls are preferably filled and backed.

Fig. 5 is a fragmentary view showing the manner of connecting the lower water-drum with the rear ends of the lower header of the side walls and with the ends of the header of the back wall.

Fig. 6 is a fragmentary view of the cooling connection from the front ends of the lower headers of the side walls with the ends of the transverse headers of the front wall and the connection between the latter and the top headers of the side walls.

In Fig. 1 is shown a typical layout of a water-tube boiler provided with my improved fire box having water-cooled walls. In this drawing, the pipes or tubes comprising the steam-generating-section are indicated in dot-and-dash lines so that the fire box tubes of my invention, shown in full lines, may not be confused with the ordinary boiler tubes. Briefly, the boiler comprises a lower water-drum 1, an upper water-drum 2, a steam-drum 3, above the level of the drum 2, and a superheater steam-drum 4. A bank of tubes 5 extend from the lower water-drum 1 to the upper water-drum 2. A bank of tubes 6 connect the upper water-drum 2 with the steam-drum 3 and a bank of tubes 7 connecting the lower side of the steam-drum 3 with the lower water-drum 1. The circulation of the water in the steam-generator of the boiler is from water-drum 1 upwardly through the banks of tubes 5 to the upper water-drum 2. This bank of tubes is the first to which the heat of the fire box is communicated and partially absorbed, the baffle plate 8 directing the flames upwardly toward the upper drum 2. After passing between the baffle 8 and the upper water-drum 2, the hot gases of combustion pass through the front end of the bank of tubes 6, being directed by the baffles 9, 10 and 11. After passing from the forward end of the bank of tubes 6, the hot gases pass rearwardly over the superheater tubes 12, connecting the steam-drum 3 with the superheater drum 4. Thence the hot gases are conducted downwardly again through the bank of tubes 6 at the rear end thereof, the direction being imparted thereto by the baffles 10. After passing the baffle 10, the gases are conducted downwardly through the rear half of the bank of tubes 7, traveling in the main, longitudinally thereof to the bottom of the baffle 13, whereupon the direction of the gas is reversed and they travel upward longitudinally of the rear half of the bank

of tubes 7 toward the smoke and gas outlet 14. During this heating of the steam-generating-section of the boiler, the general direction of the water being heated in the tubes and drums is through a substantially circular or triangular path from drum 1 through the bank 5 to drum 2; thence through the bank 6 to steam-drum 3; and thence through bank 7 to water-drum 1. The steam generated by the boiler is transferred from the upper part of the steam-drum 3 to the super-heater drum 4 by the pipes 12.

The boiler is of the suspended type. The bottom of the boiler does not rest directly on the foundation 15. A heavy structural steel framework, comprising two parallel series of vertical struts 16, supports two or more horizontal beams 17. From the rear uprights 16, may extend backwardly, two sets of horizontal beams 18 and 20, supported at their rear ends by another set of uprights (not shown), for supporting the economizer-section (not shown). The steam drum 3, is supported by the beams 18; the super-heater 4, by the beams 17, and the upper water drum 2, is suspended from the upper beams 17, by straps 19, shown in Figs. 1 and 3. The lower water drum 1, however, hangs from the drums 2 and 3, suspended by the water tubes 5 and 7. It does not rest on the beam 20. Thus the whole steam generating section is suspended from the top thereof on a structural metal frame work. This makes possible the use of relatively light walls also virtually suspended from the top of the boiler and operable to confine the heat to the interior of the boiler, and to more completely prevent the transference of heat to the surrounding atmosphere through the said walls.

In order to simplify the drawings, I have illustrated a boiler wherein the fuel is liquid and in Figs. 1 and 3, I have diagrammatically indicated two burners 21, arranged one above the other, and from which flames produced by burning oil are directed toward the rear wall 22 of the fire box 23. By illustrating this type of boiler, it has been unnecessary to confuse the drawing by showing a grate, although my invention is equally applicable to a boiler using solid fuel and provided with a grate.

The back wall 22 of the fire box comprising a straight series, row or bank of parallel vertical tubes 24, having their upper ends communicating with the lower side of the water-drum 1 and having their lower ends communicating with a hollow seamless forged steel header 25, rectangular in transverse cross-section and extending for substantially the full width of the fire box 23 and parallel to and below the drum 1. This header 25 is preferably placed in communication with the bottom of the water drum 1 by a series of tubes 26, spaced for instance, one tube to every five or six of the tubes 24, the latter being spaced about an inch apart.

The spaces between the tubes 24 are preferably filled with suitable plastic refractory material 27, such as monobrick or plibrico. The row is then covered on the side remote from the interior of the fire box with a layer of the same plastic material, which is preferably backed by a layer 28 of heat-insulating material, such as asbestos-felt.

My preferred construction of plastic material 27 and heat-insulating material 28, will be referred to again after the arrangement of the tubing has been described.

The tubes 26 are heat-insulated from the fire box by the rear wall 22.

The side walls 29 of the fire box 23 also each comprise a series of vertically disposed closely arranged tubes 30, the upper ends of which communicate respectively with a longitudinally extending upper steel header 31, hollow and rectangular in cross-section and the lower ends of the tubes 30 are similarly in communication with a lower steel header 32 also rectangular in cross-section at the bottom of the fire box. This lower header 32 is somewhat longer than the upper header 31 and extends rearwardly behind the rear wall 22 of the boiler and under the ends of the lower water-drum 1. Extending downwardly from each end of the said water-drum 1 and heat-insulated from the fire box by the back wall 22, is a relatively small bank or row of tubes 33, generally vertically disposed and having their lower ends in communication with the rearward extensions of the lower headers 32. On the upper sides of the upper headers 31, there is a series or row of vertically extending tubes 34, the upper ends of some of which are in communication with the upper water-drum 2, while toward the rear end of the upper headers 31, the upper ends of said tubes 34 communicate with the bottom of the steam-drum 3. These banks of tubes 34 extend vertically from the upper sides of the headers 31 and communicate at their upper ends with the drum 2 or the drum 3. The spaces between these tubes 34 are preferably greater than that between the tubes 30 of the side walls 29 of the fire box.

At the forward ends of the lower headers 32 of the side walls are arranged vertically extending pipes 35, one on each header, and having their upper ends communicating respectively with the opposite ends of a steel transverse header 36, and also extending upwardly from the upper sides of the opposite ends of this front wall header 36 are two tubes 37, one at each end respectively, communicating with the forward ends of the upper headers 31 of the side walls 29. This front transverse header 36 is preferably disposed just above the heavy front wall 38 of refractory blocks surrounding the openings in which are mounted the oil burners 21.

These tubes 35 and 37 are also preferably heat-insulated from the interior of the fire box by being embedded in the heat-insulating material forming the outside facing of the side walls 29.

Also extending upwardly from the front transverse header 36 and between the pipes 37 is a vertical series of tubes 39 forming the upper front wall 40 of the furnace of the fire box 24 above the burners 21. These tubes 39 forming the front wall 40 are connected at their upper ends with the upper water-drum 2. In Fig. 4, I have indicated, in detail, the way in which the bank of tubes forming the walls are embedded in the plastic material and how the wall for each bank of tubes is preferably constructed. Thus, Fig. 4 may be taken to be a section through the front wall 40 above the burners 21. The spaces between the tubes 39 are filled with the plastic material 27, such as plibrico, as above stated. Back of this may be placed a steel plate 41 secured thereto in any suitable manner. Next to this is a layer of flexible asbestos 28 of which the thickness may be as great as three inches and over this may be secured a layer of plaster 42, one-half of an inch thick, more or less. All of the walls of the fire box are so constructed and, as will be readily perceived, are comparatively thin, their purpose being merely to heat-insulate the fire box from the surrounding atmosphere for they are not required to be as heavy and thick as would be required were their function also to support the weight of the boiler. Since the boiler and the walls of the fire box are all suspended from the frame work of vertical supports and beams above described, the expansion of the tubes forming the walls of the fire box will be in a vertical direction and downwardly. Under the headers 25 and the headers 32 and the header 36, I may provide spaces which may be packed with a filler 43 of asbestos or similar yielding incombustible material, its function being to close the spaces directly beneath said headers but to permit of a slight downward movement of the headers due to expansion of the tubes when the boiler is heated. Feed water is admitted from time to time as required by valve 44 in a feed water pipe 45 communicating with the lower water-drum 1 where, of course, the water is cooler than in any other part of the steam-generating-section of the boiler.

I preferably provide the lower steel headers 25 and 32 with suitable blow-off valves 46 to take care of the ordinary sediment which collects in the boiler.

The substantially circular course which the water takes through the steam-generating-section of the boiler (from drum 1 to drum 2 to drum 3 to drum 1) substantially assists in the circulation of the water through the tubes in the walls of the fire box. The heating of the water in the tubes 24 of the back wall 22 of the fire box will cause the water in the bank of tubes to rise and discharge water into the lower water-drum 1, thus producing a movement of the cooler water in the drum 1, downwardly through the cooler pipes 26 to the ends of the header 25 and thence upwardly through the row of tubes 24 back to the water-drum 1. The rear wall 22, therefore, will be composed of a bank of tubes 24, heat-insulated on the rear side thereof and through which the water from the coolest part of the boiler is heated and returned to the drum 1.

Similarly, the tubes 30 in the side walls 29 of the fire box become heated and the heated water therein rises from the lower header 32 to the upper header 31 and thence to the drums 2 and 3 and water is supplied to the lower headers 32 by the small bank of tubes 33 extending vertically downwardly from the lower water-drum 1. The lower headers 32 are thus kept supplied from the lower water-drum 1 which circulates upwardly through the side walls to the upper headers 31. From these upper headers 31 the rising water follows two courses, through the banks of tubes 34, to wit, (1) to the upper water-drum 2 and (2) to the upper steam-drum 3. In entering the drums 2 and 3, the water from the side walls commingles with the water being circulated in the steam-generating-section of the boiler.

Some of the water from the lower headers 32 is conducted through the upwardly rising pipes 35 to the opposite ends of the front header 36. Here the water passes upwardly through the tubes 39 to the upper water-drum 2 but to maintain communication between the front transverse header 36 and the upper headers 31, the pipes 37 connect the opposite ends of the front header 36 with the forward ends of the upper headers 31 respectively.

This upward circulation of the water in the walls of the fire box is operative to absorb heat from the walls and transfer it directly back into the steam-generating-section of the boiler, thus utilizing for the conversion of water into steam, the heat which would otherwise radiate into the surrounding atmosphere. The walls of the boiler are, therefore, cool and thin as compared with those made of ordinary construction.

It is to be noted that all of the water supply pipes leading to the various headers are not substantially subjected to the direct heat of the fire box. Thus, the tubes 26 and the small bank of tubes 33 are located to the rear of and behind the rear wall 22. The pipes 35, which supply the water to the lower header 36 of the front wall, are in the side walls and embedded in the heat insulating material of the side walls, as clearly indicated in Fig. 6. Similarly, the pipes 37 for supplying water to the upward forward ends of the upper

headers 31 of the side walls are also embedded in the heat-insulating material of the side walls, as indicated in Fig. 6 and are thus maintained cooler than the pipes forming the inner face of the various walls. All of the walls of the fire box are virtually suspended from the steam-generating-section of the boiler and are not required to support the weight of the boiler. In fact, I prefer to so arrange the walls of the fire box that they extend into but do not quite bottom on a recess 15' provided therefor in the foundation 15, as clearly indicated in Figs. 1, 2 and 3, to allow for the expansion and contraction of the walls under varying operative conditions.

In a fire box construction as above described, the water is supplied to the bottom headers continuously and the flow of water so supplied is unrestricted. Since much of the water flowing from the side walls is discharged through the pipes 34 into the water-drum 2 and because the water in the steam-generating section of the boiler is moving in a circular path through the drums and steam-generating tubes from the water-drum 2 up toward the steam-drum 3, the circulation of the water in the steam-generating section tends to draw along with it the water from the side walls and thus assist in the circulation of water through the side walls. Because so much of the heat as is imparted to the walls is absorbed by the water flowing through the side walls there cannot be any overheating of the side of the fire box.

Having thus described my invention, what I claim and desire to protect by Letters Patent of the United States is:

1. In a boiler, the combination of a steam-generating-section, comprising a lower water-drum, an upper water-drum, a steam-drum, and water-tubes connecting said upper water-drum with said steam-drum, connecting said steam-drum with said lower water-drum and connecting said lower water-drum with said upper water-drum, a rigid structural steel framework upon which said steam-generating-section is mounted and supported, walls enclosing said boiler on four sides and each comprising substantially vertical rows of tubes backed on the outer sides with heat-insulating material and hanging substantially suspended from said steam-generating-section, conduits heat-insuluated from the interior of the fire box for conducting water from the coolest portion of the steam-generating-section to the bottoms of said tubes in said walls, and means to convey the water from the tops of said tubes back into the steam-generating-section of the boiler.

2. In a water-tube boiler the combination of a lower water-drum, an upper water-drum, a steam-drum on a higher level than said upper water-drum, water-tubes connecting said steam-drum with said water-drums respectively, water-tubes connecting said water-drums and a fire box comprising a rear and front and two side substantially vertical walls, a row or series of substantially vertically spaced parallel water-tubes forming the inner side of each wall, the spaces between said tubes being filled and the outer sides of said rows being covered with refractory heat-insulating material, a separate lower header heat insulated from the fire box for each bank of tubes and to which the lower ends of the bank are connected, means heat insulated from the fire box to supply the lower headers of the rear and side walls with water from the lower water-drum of the boiler, and means heat insulated from the fire box to supply the lower header of the front wall with water from the lower headers of the side walls.

3. In a water-tube boiler, including a lower water-drum, an upper water-drum and a steam-drum on a higher level than said upper water-drum, water-tubes connecting said steam-drum with said water-drums respectively, water-tubes connecting said water-drums, a feed opening in the front of the fire box through which fuel is introduced into the fire box, the combination with a back wall and a front wall, of side walls comprising each a row of closely arranged vertically extending spaced tubes, an upper horizontal header for each row and to which the upper ends of the tubes of the row are connected, a lower horizontal header for each row of said tubes to which the lower ends of said tubes of the row are connected respectively, said lower headers being longer than the upper headers and extending rearwardly below said lower water-drum, a row of tubes extending upwardly from and connected to the upper side of said upper headers of which those near the front of the boiler connect with said upper water-drum and those at the rear of the boiler connect with the steam-drum, a thin wall of refractory heat-insulating material, closing the spaces between each of the tubes of said side walls and forming a facing on the outer sides thereof, above and below said upper side header, and means insulated from the fire box to conduct water from the cool part of the boiler to the lower headers of said side walls, said lower headers being also heat insulated from the interior of the fire box.

4. In a water-tube boiler, the combination of a lower water-drum, an upper water-drum, water-tubes connecting said drums, a steam-drum, and water-tubes connecting said steam-drum to said water-drums respectively, and a fire box having a fuel opening in the front thereof through which fuel is introduced into said fire box, and provided with a front wall consisting of a transverse water header extending horizontally over said fuel opening for the width of the boiler and heat insu-

lated from the fire box, a row of parallel vertically extending spaced but closely arranged tubes extending upwardly from said header and connecting the same with said upper water-drum, said wall being made of refractory heat-insulating material substantially filling the spaces between the tubes and forming a relatively thin facing on the outer side of the row from said transverse header to said upper water-drum, and forming a facing between said lower header and the interior of said fire box and means heat-insulated from the fire box for conducting water from the coolest portion of the steam-generating-section to opposite ends of said transverse header.

5. In a boiler, the combination of a lower water-drum, an upper water-drum, a steam-drum, water-tubes connecting said drums respectively, a superheater drum, and tubes connecting said superheater drum to said steam-drum, a rigid structural steel framework upon which said drums rest and upon which the weight of said drums and tube is supported, of a fire box for said boiler comprising substantially vertical front, back and side walls, each composed of a row of vertical tubes spaced but arranged close to each other, the spaces between said tubes being filled and the outer sides thereof being backed with a relatively thin course of refractory heat-insulating material, a transverse header below and parallel to said lower water-drum and to which the row of tubes of the back wall communicate, means behind said back wall to supply said transverse header of the rear wall with water from the lower water-drum, said back wall being virtually suspended from said lower water-drum, two side walls comprising each a row of parallel vertical tubes spaced but close together, a pair of headers, one at the top and one at the bottom of each of said rows respectively and with which the row respectively communicates, means behind said rear wall to supply the lower header on each of the side walls with water from said lower drum, a row of vertically extending tubes extending upwardly from each upper header of said side walls, the tubes above the forward portion of said header being connected to the upper water-drum and the tubes above the rear portion of said upper headers being connected to said steam-drum, the spaces between the tubes of said side walls being filled with and the row backed with refractory heat-insulating material, said side walls being virtually suspended from said steam-drum, and said upper water-drum, and a front wall similarly comprising a vertically extending row of tubes, and a transverse header to which the lower ends of said tubes communicate, the upper ends of said tubes being in communication with said upper water-drum and the spaces between said tubes being filled and the outer sides being backed with refractory heat-insulating material, means heat-insulated from the fire box by the side walls to supply the transverse header of said front wall with water from the lower headers of said side walls, and means heat-insulated from the fire box by said side walls to transfer water from the ends of said transverse header of the front wall to the front ends respectively of the upper headers of the side walls, said front wall being also virtually suspended from the upper water-drum of the boiler.

6. In a water-tube boiler, including a lower water-drum, an upper water-drum and a steam-drum on a higher level than said upper water-drum, water-tubes connecting said drums in a substantially triangular series, a fire box and fuel opening in the front of said fire box through which fuel is introduced into said fire box, the combination of a back wall comprising a row of closely arranged but spaced substantially vertically disposed tubes connected at their upper ends to said lower water-drum, a transverse header arranged below and parallel to said lower water-drum and to which the lower ends of said tubes are connected, a relatively thin wall of refractory heat-insulating material closing the spaces between said tubes and forming a backing for said tubes, a pipe at each end of said header extending upwardly behind said wall and connected respectively to the end of said lower water-drum which is thereover, side walls comprising each a row of closely arranged but spaced vertically extending tubes, an upper horizontal header for each row and to which the upper ends of the tubes of the row are connected, a lower horizontal header for each row of tubes, to which the lower ends of said tubes of the row are connected respectively, said lower headers extending to the rear of said rear wall and below said lower water-drum, a row of tubes extending upwardly from and connected to the upper side of said upper header, the portion of said upwardly extending tubes near the upper water-drum being connected thereto and the portion of said upwardly extending tubes near the steam-drum being connected thereto, a thin wall of refractory heat-insulating material closing the spaces between the tubes of each side wall and forming a facing on the outer sides thereof above and below said upper side header, tubes connecting the ends of the lower water-drum respectively to the rearwardly extending ends of said lower headers of said side walls, and a front wall comprising a transverse header extending horizontally over the said fuel openings, a row of parallel closely arranged but spaced tubes extending upwardly from said header and connecting the same with the said upper water-drum, thin walls of refractory heat-insulating material closing the spaces between the tubes of the said front wall and forming a facing on

the outer side of said row from said transverse header to said lower water-drum, a tube extending upwardly from the forward ends of each lower header of said side walls and connecting said forward ends with the adjacent ends of said transverse header of said front wall and a tube extending upwardly from each end of said front transverse header and connecting the same with the forward ends respectively of the adjacent upper headers of the side walls.

In witness whereof, I have hereunto set my hand this first day of August, 1927.

PHILLIPS BADENHAUSEN.