Oct. 28, 1930. P. G. KAISER 1,779,939

BOILER

Filed Sept. 13, 1926 3 Sheets-Sheet 1

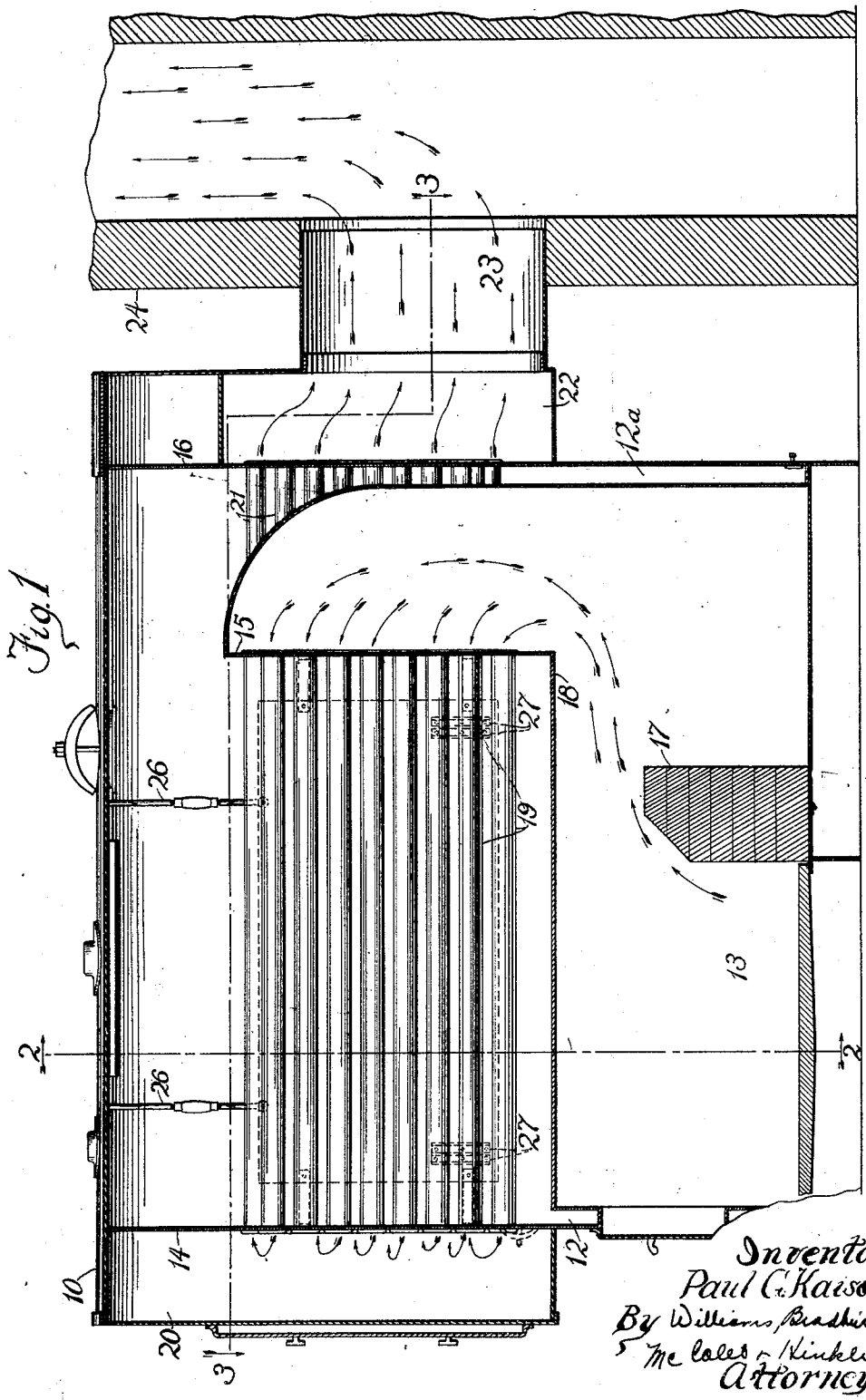


Fig. 1

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BOILER

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Fig. 3

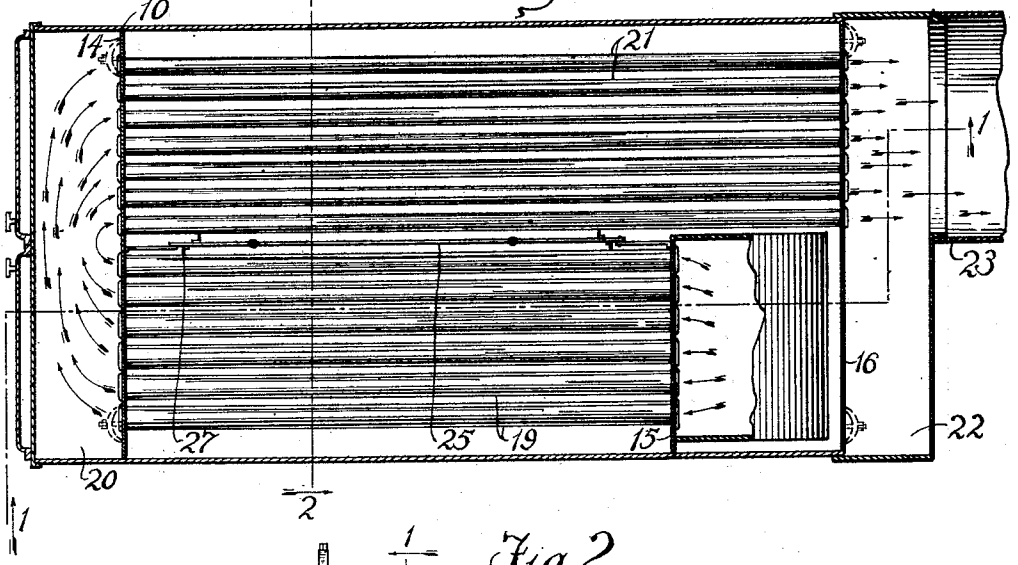
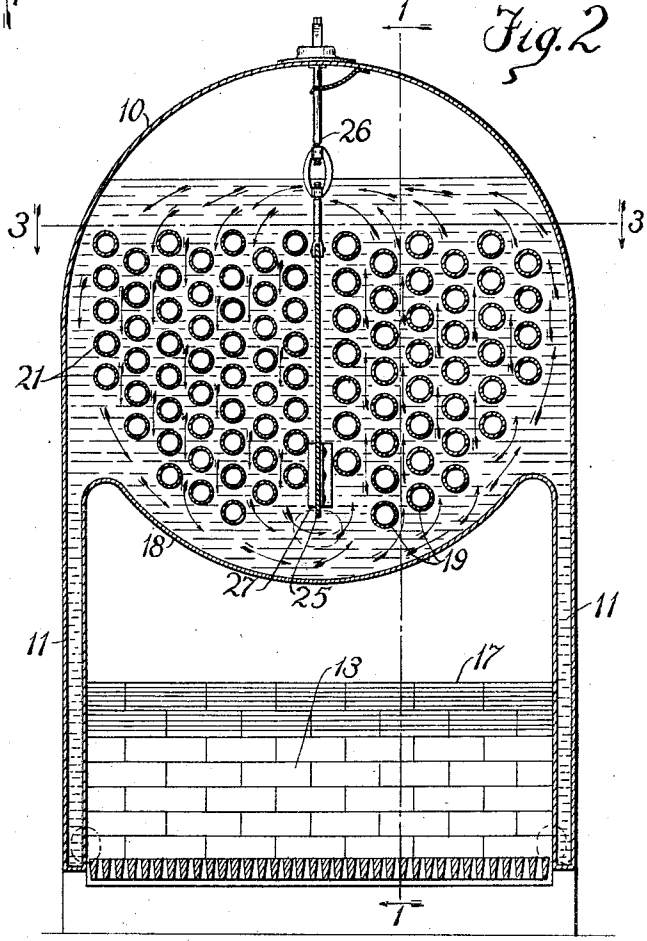


Fig. 2



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BOILER

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Fig. 4.

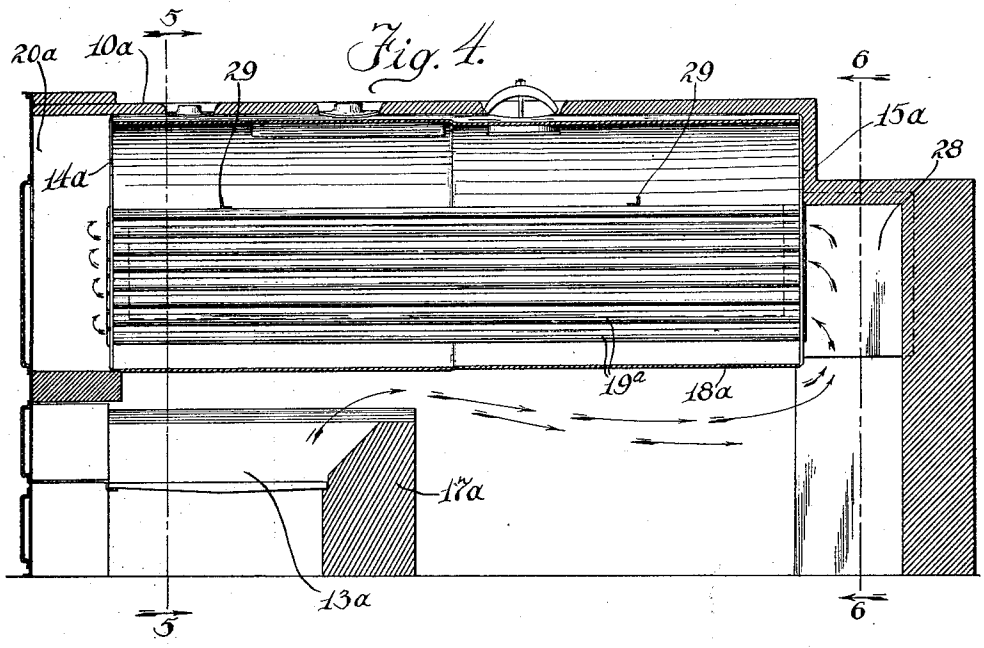


Fig. 5.

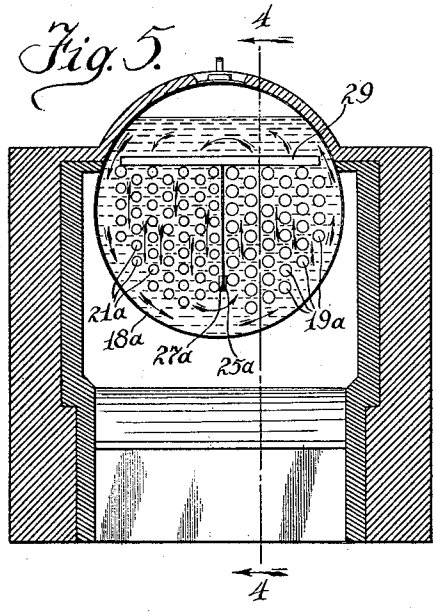
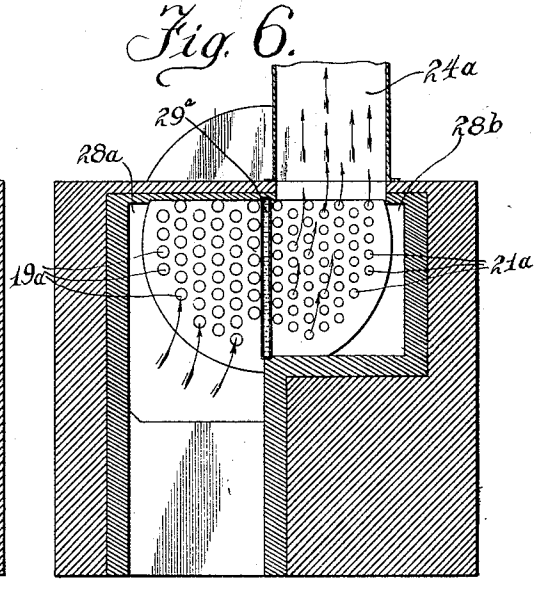


Fig. 6.



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Patented Oct. 28, 1930 1,779,939

UNITED STATES PATENT OFFICE

PAUL G. KAISER, OF CHICAGO, ILLINOIS

BOILER

Application filed September 13, 1926. Serial No. 135,076.

My invention relates to fire tube boilers, either heating or power generating and has for its object an increased capacity made possible by a more rapid circulation of the water within the boiler which permits a higher temperature gradient between them and the water.

Another object of my invention is to prevent the collection of sediment and scale on the heating surfaces, by the rapid circulation of water.

Another object of my invention is the provision of a boiler in which the fire tubes are segregated in a plurality of groups through which the heated gas is passed in succession, thereby heating different sets of tubes to different temperatures, resulting in differential rates of vapor production in different sections of the boiler and consequent thermo-siphon circulation of the working fluid.

It is also an important object of my invention to provide a water baffle or baffles in combination with such groups of fire tubes differentially heated to direct and assist the flow of the water in convection currents resulting from the unequal production of water vapor bubbles adjacent the different groups of tubes.

A further important object of my invention is to provide for the adaptation of the said invention to existing types of boilers without the necessity of extensive alterations of the present structure, thereby procuring the beneficial results above described in existing structures at a minimum cost.

Briefly described, I secure my improved results by dividing the fire tubes vertically into groups, the combustion gases passing through these groups in series, and in using a vertical baffle in the water between these groups of fire tubes to establish a rotary circulation of the water around the baffle.

The foregoing, and also other features and advantages of my invention, are set forth in the following description of a heating system boiler embodying my invention and illustrated in the accompanying drawings. My invention can be incorporated in a high pressure cylinder boiler and many other types of boilers, also in existing boiler structures.

Figure 1 of these drawings is a vertical elevation through a complete boiler assembly which may be considered as being taken on the line 1—1 of Figure 2 slightly to one side of the axis of the boiler.

Figure 2 is a transverse elevation taken on the lines 2—2 of Figures 1 and 3; and

Figure 3 is a plan view taken on the lines 3—3 of Figures 1 and 2.

Figure 4 is a vertical elevation through a complete boiler assembly which may be considered as being taken on the line 4—4 of Figure 5 slightly to one side of the axis of the boiler, showing a preferred modification of my invention applicable to existing boiler structures.

Figure 5 is a transverse front elevation showing a section of the modification taken on the lines 5—5 of Figure 4.

Figure 6 is a transverse rear elevation showing a section of this modification taken on the lines 6—6 of Figure 4.

In the embodiment disclosed in Figures 1 to 3, the shell of the boiler 10 is in general cylindrical, but it has lateral water legs 11 and front and rear water legs 12 and 12ª enclosing the fire box 13.

At the forward end of the boiler all of the fire tubes extend from a common front head 14, but at the rear the fire tubes on the right hand do not extend as far as do those on the left, but terminate in an auxiliary rear head 15 some distance inwardly from the rear head 16 to which extend the fire tubes on the left hand side of the boiler. In operation, therefore, the combustion gases pass over the bridge wall 17 around the rear end of the crown sheet 18, forwardly through the fire tubes 19 at the right half of the boiler, into the forward smoke box 20, crossing over to the left and passing rearwardly through the left side fire tubes 21 into the rear smoke box 22. From the rear smoke box the combustion gases pass through the bridging 23 and upwardly through the stack 24. It is to be noted that the bridging 23 which forms the outlet opening for the combustion gases as they pass out from the left hand tubes 21, is offset downwardly quite noticeably in reference to the left hand group of tubes,

as is shown in Fig. 1. The purpose of this is to draw the combustion gases downwardly so that some of the hot gases will pass through the lowermost tubes 21 also, thereby opposing the tendency of the combustion gases to pass through only the uppermost tubes of the group. The effect of this drawing down of the combustion gases is also reflected in the right hand group of fire tubes 19 with the result that there also is a greater tendency for more of the hot gases to pass through the lowermost tubes.

In general the gases passing through the right hand tubes 19 (Fig. 2) are much hotter than those passing through the left hand tubes 21. I prefer to take advantage of this fact by making the fire tubes 19 somewhat larger in diameter than the fire tubes 21, although making them fewer in number. The result I thereby secure is to make a considerably larger aggregate cross sectional area of the fire tube for the passage of combustion gases in the right hand tubes 19 as compared with the left hand tubes 21. But at the same time the aggregate heat transfer area—that is, the total outside circumferential areas of the tubes—is less in the case of the right hand tubes 19 than in the case of the left hand tubes 21. This relation between the two groups of tubes is advantageous because the gases passing through the right hand tubes 19 are considerably hotter than the relatively spent gases passing through the left hand tubes 21. This requires less heat transfer area on the right hand tubes than on the left hand tubes. Also the gases being hotter in the right hand tubes than in the left hand tubes they should have a larger aggregate cross sectional area in the right hand tubes than in the left hand tubes to compensate for contraction in cooling.

In practice, I prefer to accentuate this relation, and in the drawings I have shown the left hand tubes 21 as being considerably longer than the right hand tubes 19 so that the aggregate exterior area of the left hand tubes is made greater by the increased length notwithstanding, of course, that the volume of the left hand tubes 21 is made greater by the increased length of the tubes.

In other words, if I make the tubes on both sides of the same length, I secure this advantageous relation between heat transfer areas and fire tube cross sectional areas; and if I make the left hand tubes longer than the right hand tubes, I can accentuate the advantages of this relation by adding to the aggregate or sum total exterior areas of the left hand tubes while not increasing their aggregate cross sectional areas.

To be more specific, it will be seen from Fig. 2 that the left hand group of tubes 21 collectively occupy substantially as much of the cross sectional area of the boiler as a whole as do the right hand tubes 19. I have shown, for example, forty right hand tubes 19 of 3½″ outside diameter, and 52 left hand tubes 21 of 3″ diameter. Standard tubes for fire tube boilers having 3″ outside diameter have 2.78″ inside diameter. Standard boiler tubes 3½″ outside diameter have inside diameter of 3.26″. Tabulating this for convenient reference we have:

	Left hand tubes 21	Right hand tubes 19
Number of tubes	52	40
Outside diameter	3.00	3.50
Inside diameter	2.78	3.26
Inside cross-sectional area	6.08	8.35
Aggregate inside cross-sectional area	316.16	334.00
Outside circumference	9.42	10.99
Aggregate outside circumferences	489.84	439.60

From the above table we see that the aggregate inside cross sectional areas—the total area for the passage of flue gases—for the left hand tubes is about 6½% less than that of the right hand tubes.

We also see that the aggregate outer circumferences—the heat transfer areas—of the left hand tubes is about 11½% more than that of the right hand tubes. (Of course, the aggregate circumferences of the tubes would have to be multiplied by their lengths in order to give the true value of the heat transfer areas, but since I am discussing for the present the relation between the two sets of tubes were the tubes of the same length, it is obvious that it is not necessary to determine the exact area in order to determine the proportions between the two total heat radiating areas.) The 6½% less and the 11½% more, as taken from the above figures, means, in effect, an advantage of about 18% in the relation which I have described between the two sets of tubes.

Now by making the left hand tubes 21 longer than the right hand tubes 19 I have, of course, greatly exaggerated that advantage. I can, therefore, secure such an advantage in any one of three ways. First, by using larger but fewer tubes on one side than on the other side, or second by using the same number of tubes and same size of tubes on one side as on the other side, or third by combining the two ideas as I have shown specifically in the drawings.

While the arrangement of fire tubes as thus far described is of itself a great advantage, its principal purpose is in serving to effect a more perfect circulation of the water in the boiler so that the volume of the boiler and the heat contact areas of the fire tubes can be utilized to the fullest extent.

As the fire tubes 19 are considerably hotter than the fire tubes 21, there is a higher temperature gradient between the former tubes and the working fluid than in the latter, producing increased heat transfer to the fluid,

and consequently an increased production of water vapor and air bubbles adjacent the hotter group of tubes. On the other hand, while the heated gases are secondarily directed through the second group of tubes, abstracting as much of their heat as is possible with the heat transfer surface available, still the heating of the water and the formation of water vapor and air bubbles by the latter group of tubes is greatly less than that of the hotter group of tubes, resulting in a boiling up of the water adjacent the right hand tubes and its return to the base of the boiler on the left hand side. I take advantage of this fact by placing a vertical baffle 25 along the interior of the boiler between the two groups of fire tubes. This baffle 25 extends from the uppermost fire tubes to a point a sufficient distance from the bottom of the boiler or crown sheet 18 to permit a substantial volume of water flow across the bottom of the boiler. Instead of suspending the baffle 25 from cross members resting on the uppermost adjacent fire tubes, I prefer in new boiler construction to suspend them from the top of the boiler, by turn buckle rods 26 as shown in Figs. 1 and 2, thereby providing for the adjustment of the baffle to such level relative to the normal water level as will most greatly aid increased circulation. I prefer to terminate the baffle 25 short of the front and back heads 14 and 15 and space them from the headers by short horizontal strips extending from the end edges of the baffle plate to the respective headers 14 and 15 as shown in dotted lines on Figure 1 to permit some circulation of water across the ends of the boiler. Rattling of the baffle against the adjacent fire tubes may be precluded by the use of angle irons 27 or other spacers secured to the sides of the baffle to hold it securely intermediate the fire tubes.

The greater tendency of the water to flow upwardly on the right hand side across the hot tubes 19 than on the left hand side across the cooler tubes 21 results in a rotary circulation of the water which is counter-clockwise in Fig. 2 as indicated by the arrows. This rotary circulation has the two-fold advantage of utilizing to the fullest extent the heat transfer areas of the fire tubes and to prevent the accumulation of deposit in the bottom of the boiler, that is, on the crown sheet 18.

In the preferred modification shown in Figures 4 to 6 my invention is shown applied to an existing boiler structure.

The shell of the boiler 10^a is in general cylindrical and is here shown without water legs as in the previous modification. At the forward end of the boiler all of the fire tubes extend from a common front head 14^a and in this modification the fire tubes are shown of equal length and equal size terminating in an auxiliary rear head 15^a. In order to provide for the direction of the heated gases successively through the two groups of tubes, the structure supporting and enclosing the rear end of the boiler may be changed to provide for a gas chamber 28 in which the fire tubes 19^a and 21^a terminate. This gas chamber may be constructed of the usual masonry lined with fire brick and is divided at its upper end into two separate chambers by the water wall 29^a which consists of a rectangular water container in open relation with the end of the boiler through an opening made in the rear head 15 between the ends of the groups of tubes to be segregated. The water wall 29^a thus provides a means for dividing the chamber 28 into two separate chambers with a relatively thin partition capable of attachment to the boiler between the ends of the tubes 19^a and 21^a and which will not burn out due to the presence of circulating water in its interior.

In operation, therefore, the combustion gases pass over the bridge wall 17^a around the rear end of the ground sheet 18^a into the left hand (Fig. 5) portion 28^a of the chamber 28, forwardly through the fire tubes 19^a on the right side of the boiler into the forward smoke box 20^a, crossing over to the left and passing rearwardly through the left side fire tubes 21^a into the rear smoke box 28^b, thence upwardly through the stack 24^a. Thus the heated gases are first directed through the tubes on one side of the boiler and thence returned through the tubes on the other side, with the same results previously described in Figs. 1 to 3.

Provision may also be made in this modification, if desired, for a rear smoke box 28^b which is offset downwardly in reference to the fire tubes 21^a for the purpose of drawing the combustion gases downwardly and opposing the tendency of combustion gases to pass through only the uppermost tubes of the group.

For the same purpose as in the previous modification, my improved boiler here is provided with a water baffle 25^a extending in the interior of the boiler from the uppermost fire tubes to a point a sufficient distance from the bottom of the ground sheet 18^a to permit a substantial volume of water to flow across the bottom of the boiler. This baffle may be made adjustable as in Figs. 1 to 3 but in applying my invention to existing boiler structures, I prefer to suspend the baffle 25^a from two or more cross members 29 thereby supporting the baffle without further modification of the boiler to insert supporting rods. Rattling of the baffle against adjacent fire tubes is here likewise precluded by the use of angle irons 27^a or other spacers secured to the sides of the baffle to hold it securely intermediate the fire tubes. I have thus provided my invention which may be readily applied to existing boilers and which will result in a rapid circulation of the water (counter-clockwise

as viewed from the front of the boiler), giving increased efficiency of operation and preventing the accumulation of deposit in the bottom of the boiler. This circulation is further substantially aided by the cross section of the boiler being circular.

While I have described this particular embodiment of my invention in this particular type of boiler, I contemplate that many changes may be made therein without departing from the spirit or scope of my invention.

I claim:—

1. The combination with a cylindrical boiler having a multiplicity of longitudinal fire tubes, of means dividing the tubes vertically into right and left groups and sending the combustion gases therethrough in series, and a baffle in the water compartment and between the groups of fire tubes for giving the watery a rotary circulation upwardly through one group and downwardly through the other.

2. The combination with a horizontal boiler having a multiplicity of longitudinal fire tubes, of means for dividing the tubes vertically into right and left groups and sending the combustion gases therethrough in series, whereby there will be temperature difference between the groups, and a baffle in the water compartment and between the groups of tubes for confining the water, set in motion by temperature difference between the gases, to a rotary circulation.

3. The combination with a boiler having a multiplicity of longitudinal fire tubes divided vertically into a right and a left group, of passage means for the combustion gases directing them through the respective groups of fire tubes in series, and a vertical baffle plate positioned longitudinally of the boiler and between the two groups of fire tubes but permitting the flow of water across the bottom and top of the boiler.

4. The combination with a boiler having longitudinal fire tubes therethrough divided vertically into groups and connected in series as regards the passage of combustion gases, of means for pulling the combustion gases down into the lower tubes of the posterior group comprising a discharge opening connecting with the stack end of the posterior group, the upper margin of said opening being below the upper tubes of the posterior group but above the lower tubes thereof.

5. The combination with a boiler having longitudinal fire tubes therethrough divided vertically into groups and connected in series as regards the passage of combustion gases, of means for pulling the combustion gases down into the lower tubes of the posterior group comprising a discharge opening connecting with the stack end of the posterior group, the upper margin of said opening being below the upper tubes of the posterior group, comprising a rear smoke box having a discharge opening offset downwardly relatively to the tubes of the posterior group.

6. The method of effecting an improved circulation in a boiler having horizontal tubes, which consists in heating the fire tubes on one side of the boiler to a higher temperature than those on the other side, and confining the cross flow intermediate the ends of the boiler to paths above and below the fire tubes.

7. The combination with a cylindrical boiler having horizontal fire tubes, of a vertical baffle extending longiutdinally of the boiler and dividing the tubes into two groups but permitting water flow beyond the upper and lower edges of the baffle, and means for heating the fire tubes of one group to a higher temperature than those of the other group whereby water will flow upwardly over the hotter tubes across the upper edge of the baffle downwardly across the lower tubes and beneath the lower edge of the baffle.

8. The combination with a circular boiler of a vertical baffle plate extending longitudinally thereof and providing room above and below its edges for the circulation of the water, of a first group of longitudinal fire tubes disposed on one side of the baffle and a second group of longitudinal fire tubes disposed on the other side of the baffle, and means for conducting the combustion gases through the two groups of fire tubes in series, first through the said first group of fire tubes and then through the said second group of fire tubes, the fire tubes of the first group being larger in diameter than those of the second group but fewer in number so that the proportion of the aggregate cross sectional areas to the aggregate circumferences of the posterior tubes is greater than that in the anterior tubes.

9. The combination with a boiler having a multiplicity of fire tubes arranged in two groups, of means for passing the combustion gases through the two groups of fire tubes in series, the fire tubes of the anterior group being fewer in number than those of the posterior group but larger in diameter, whereby the ratio of the aggregate cross-sectional areas of the fire tubes of the anterior group to that of the posterior group is considerably greater than the ratio of the aggregate perimeters of the fire tubes of the anterior group to that of the posterior group, the arrangement of said groups being such as to produce a thermo siphon circulation of water up through one group of tubes and down through the other.

In witness whereof, I hereunto subscribe my name this 25th day of August, 1926.

PAUL G. KAISER.