July 28, 1931. J. JOHNSON 1,816,780

WATER TUBE BOILER

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Fig. 2.

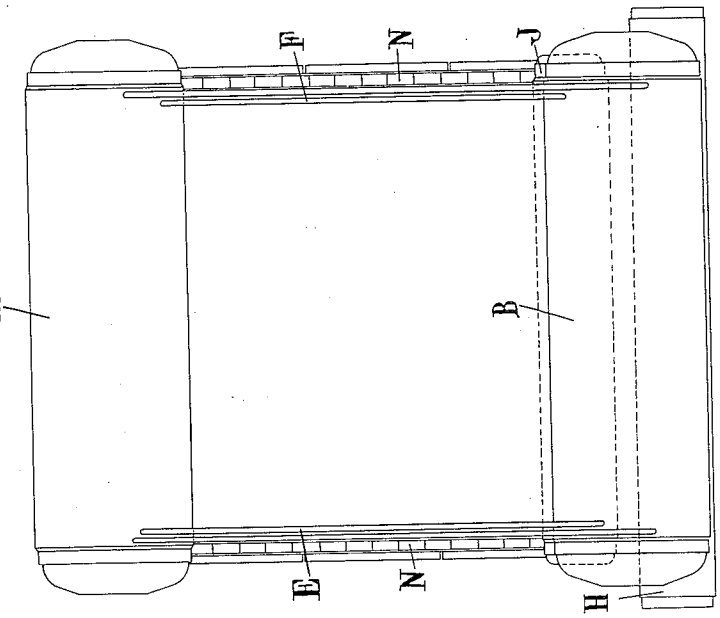
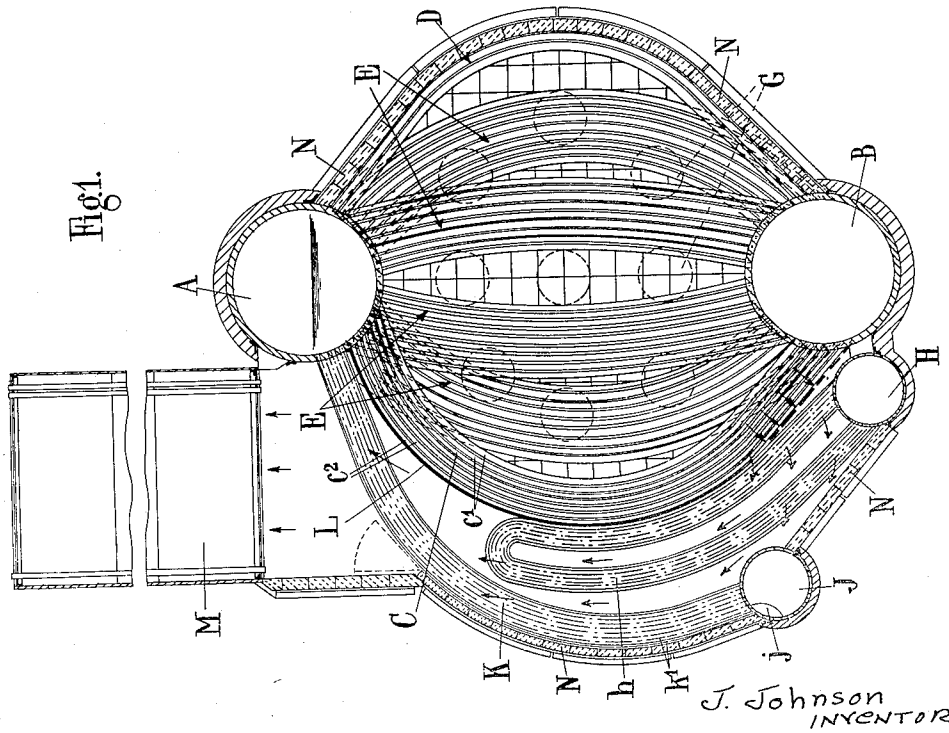


Fig. 1.



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WATER TUBE BOILER

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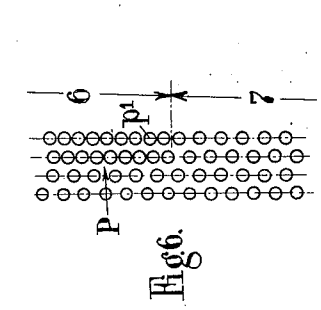


Fig 6.

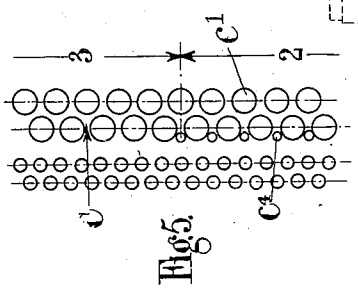


Fig 5.

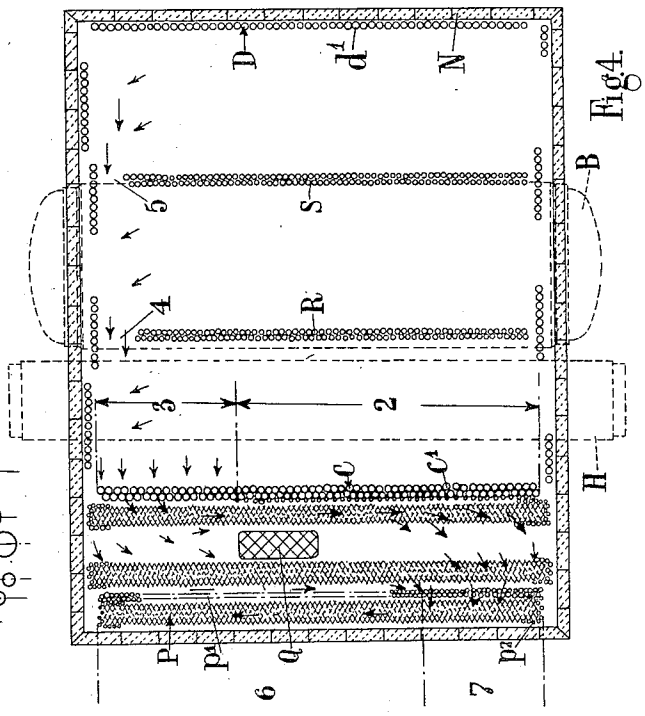


Fig 4.

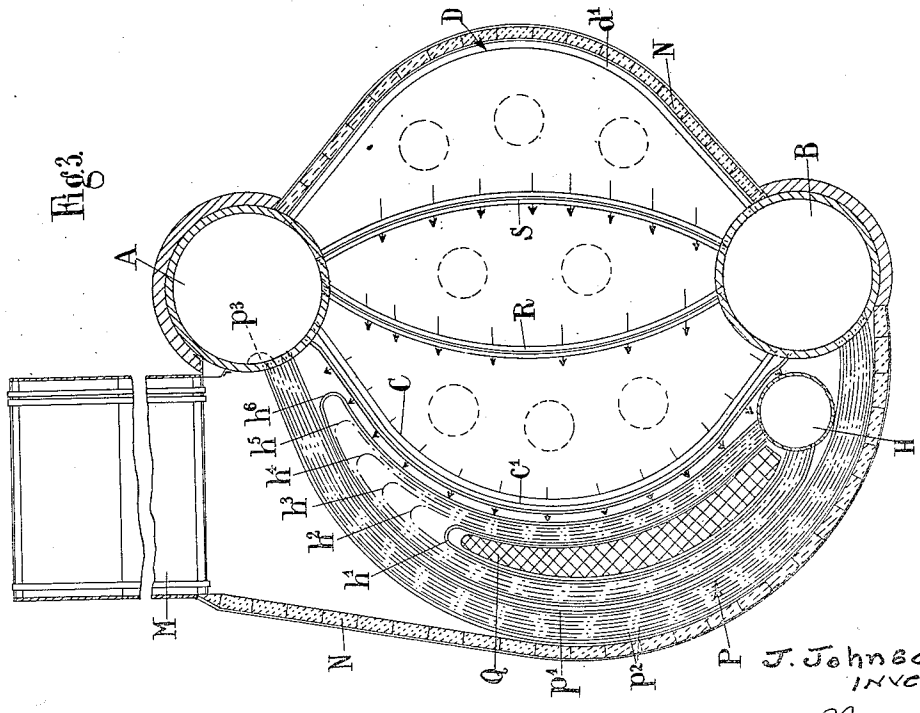


Fig 3.

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WATER TUBE BOILER

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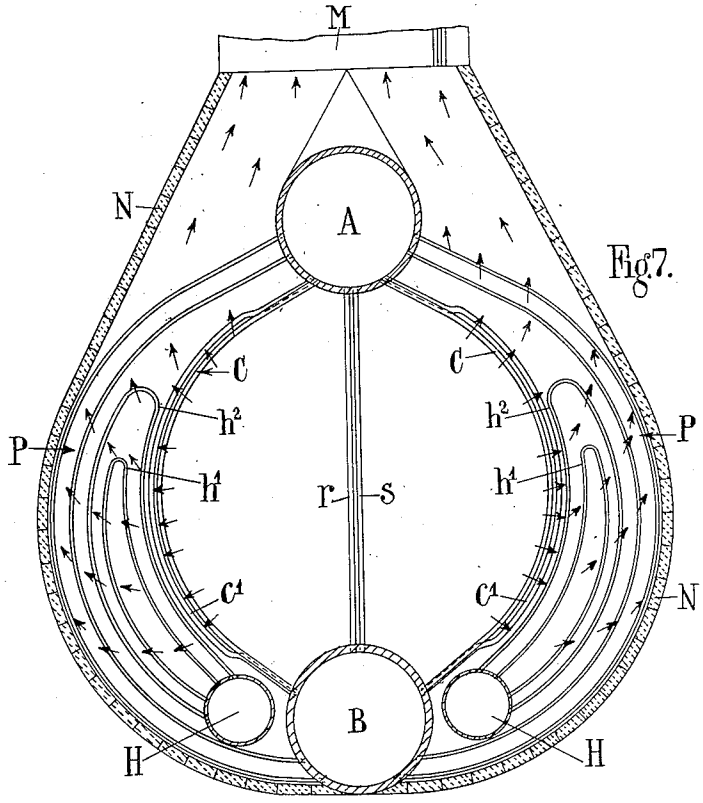


Fig. 7.

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WATER TUBE BOILER

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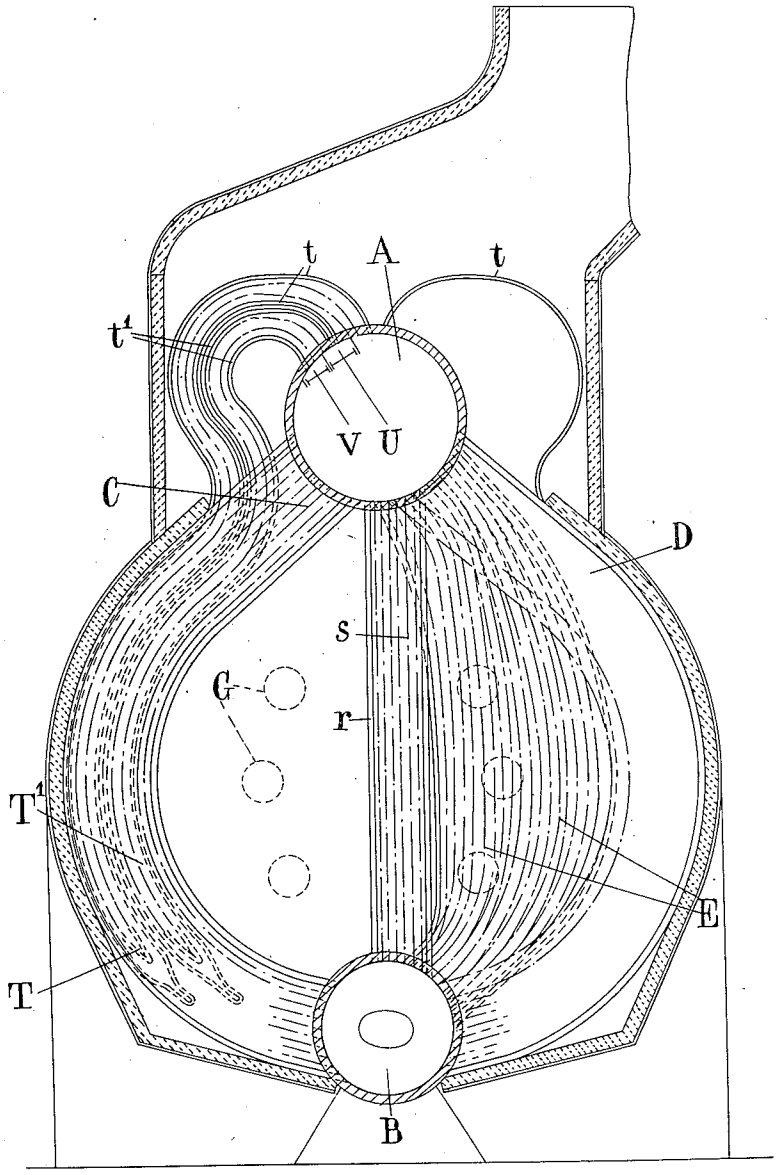


Fig.8.

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Patented July 28, 1931

1,816,780

UNITED STATES PATENT OFFICE

JOHN JOHNSON, OF WIMBLEDON, LONDON, ENGLAND

WATER TUBE BOILER

Application filed August 6, 1928, Serial No. 297,692, and in Great Britain August 15, 1927.

This invention relates to water-tube boilers and especially to those of the high-pressure marine type burning fuel in the gaseous, liquid or pulverized form.

The main object of the invention is to provide a boiler of the kind indicated which will have a higher thermal efficiency and at the same time be smaller, lighter and cheaper than comparable types of boiler which have been applied to marine purposes.

To obtain the object sought, the present invention seeks fundamentally (*a*) To reduce radiation losses and (*b*) To obtain low leaving temperatures of the gases in accordance with the following general principles, modifications being made therein as required to meet particular requirements:—

The volumetric capacity of the combustion chamber for a given duty should be as small as is consistent with the time required to effect complete combustion of the necessary weight of fuel before the gases impinge on relatively cool surfaces; in addition, the form of combustion chamber should be chosen so that the area of its envelope is low in proportion to the volume in order to approximate to the geometrically ideal but practically unattainable spherical form. Due to the relatively small heating surface of such an envelope, a high furnace temperature coupled with efficient heat abstraction from the products of combustion are necessary, these requirements, which are to a certain degree interdependent, being jointly satisfied, in part by highly preheating the combustion air and employing a minimum surplus thereof, in part by passing the gaseous media over the heat-interchange surfaces at a considerable velocity and in part by providing an extended path for the products of combustion.

In order to carry the above principles into effect, the invention consists in a water-tube boiler of the single or divided-flow type for burning fuel in the liquid, gaseous or pulverized form, having an upper and a lower longitudinal drum and tubular side and end walls including banks of outwardly-curved steam-generating tubes connected to the upper and lower drums along their length, the tubular walls, modified as required for the accommodation of the burners, thus serving as a complete or substantially complete envelope for the chamber in which the fuel is burned.

Referring to the accompanying drawings, which are of a diagrammatic nature:—

Figure 1 shows a sectional end view of one form of boiler according to the present invention;

Figure 2 being a corresponding side elevation;

Figure 3 shows a modified form of boiler provided with an outer supplementary bank of water tubes connecting directly the upper and lower drums;

Figure 4 being a corresponding sectional plan;

Figure 5 is a detail of Figure 4 to a larger scale showing a row of small-diameter tubes associated with certain of the main steam-generating tubes to form a baffle, and

Figure 6 a similar detail to show the method of baffling certain of the supplementary water tubes;

Figure 7 shows a sectional end view of a form of the invention of the divided-flow type; while finally

Figure 8 shows a sectional end view of a boiler according to the present invention provided with a modified form of superheater.

The same reference symbols are used in the different figures to denote corresponding parts, while the arrows show the general direction of flow of the hot gases.

In carrying the invention into effect according to the illustrative form shown in Figures 1 and 2, the boiler comprises an upper steam-and-water drum, A, and a lower water drum, B, placed the one above the other with their axes parallel in a vertical plane, the drums being connected along their lengths on the two sides by banks of water tubes, C and D, curved outwardly to a considerable extent, for example, so as roughly to define a cylindrical surface. The drums are further connected at the ends by steam-generating tubes, E, F, curved in a plane transverse to the length of the drums, and in part overlapping, as shown, to complete the combustion space or chamber.

The tubes, D, on one side of the boiler, all

serve as risers, while the bank of tubes, C, on the other side consists of one or more rows or risers, c^1, and adjacent thereto on the side remote from the furnace further rows of tubes, c^2, acting as downcomers for all the water tubes.

On the same side of the main water drum, B, as the downcomer tubes, c^2, and at about the same level, is arranged a superheater drum, H, having reversed U-tubes, h, secured thereto, and following approximately the curve of the downcomer tubes, c^2, to which they are adjacent. Outside, the superheater tubes again is a supplementary water drum, J, connected to the steam-and-water drum, A, by a bank of curved tubes, K, the outer ones, k^1, of which preferably act as a feed-water heater and issue from a longitudinal pocket, j, within the supplementary drum, J.

In addition, a baffle, L, extends downwardly a certain distance from the steam-and-water drum, A, between the downcomer tubes, c^2, and the superheater tubes, h, so that the gases from the furnace pass under this baffle to the superheater tubes, h, and the supplementary bank of water tubes, K, and are thus given a path of considerable length in relation to the tubes over which they pass.

To assist in maintaining the desired high temperature of the furnace, the boiler is encased both at the sides and ends by walls of firebrick, N, N, screened or partly screened by the water tubes above described, so as to prevent overheating.

The air for combustion, which preferably does not exceed by more than about 20 per cent. the amount theoretically required, is heated to say 400° or 500° F. in an air preheater, M.

The principles underlying the methods of securing a positive circulation last described may be extended by omitting the bank of tubes, K, with supplementary drum, J, shown in Figure 1, and substituting therefor the downcomer bank, P, having inner and outer tubes, p^1, p^2 (see Figures 3 and 4) arranged outside the superheater and connecting directly the upper and lower drums, A and B. To ensure that all the tubes of the banks, C and D, serve as risers, only one or two rows of tubes are provided as indicated at c^1 and d^1 respectively. In addition, in the particular example under description, longitudinal banks of tubes, R, S, also serving as risers are arranged in the combustion chamber.

In order to utilize more adequately the space between the bank of tubes, C, and the outer bank, P, the U's of the superheater may be successively elongated as shown at h^1 to h^6, while within the smallest U, h^1, is arranged an obturator body, Q, of fire-clay or the like to serve as a baffle.

Further, in order to give the desired extended path to the hot gases, a row of small-diameter tubes, c^4 (see Figure 5) is arranged outside the steam-generating tubes, c^1, adjacent to the superheater, this row of small tubes extending for a distance, 2, equal say to two-thirds of the length of the boiler from the front end and owing to their proximity to the tubes, c^1, serving as a baffle; the remaining one-third of the length of the bank of tubes, C, denoted by the numeral, 3, thus forms a passage for the hot gases. Similarly, a few rows of closely-pitched tubes, p^1 (see Figure 6), are arranged on the side of the supplementary bank of tubes, P, adjacent to the superheater so as to form in effect a baffle extending a distance, 6, equal to about two-thirds of the length of the boiler from the rear end leaving a passage of length, 7, at the front end. In addition, as shown, the longitudinal banks of tubes, R, S, sub-dividing the furnace, stop short of the rear end of the boiler so that gaps, 4 and 5, respectively are left.

With such an arrangement, the combustion gases pass by ways of the gaps, 5 and 4, at the rear end of the banks of tubes, R, S, continue through the passage, 3, at the rear end of the bank, C, and thence pass forwardly through the superheater, being divided into two streams by the firebrick obturator, Q, to correspond more or less to the two legs of the superheater U's; finally, the gases flow through the passage, 7, in the front end of the inner tubes, p^1, whence they pass rearwardly and upwardly among the remaining tubes, p^2, of the bank to the preheater.

If desired, a longitudinal pocket, p^3, may be arranged in the drum, A, to receive the ends of some or all of the tubes, p^2, the feed water being pumped into this pocket to descend in a direction on the whole opposite to the direction of flow of the hot gases.

All the forms of the invention above described are of the one-sided or single-flow type, i. e., the products of combustion pass to the uptake on only one side of the steam-and-water drum. In Figure 7, however, a boiler in accordance with the present invention is shown of the double-sided or divided-flow type, i. e., products of combustion pass to the uptake on both sides of the steam-and-water drum. In this figure, the outer bank of tubes, P, and the superheater drum, H, and tubes, h^1, h^2, are duplicated and arranged one set on each side of the boiler as shown, the same reference symbols for both the right- and left-hand sides being used as for the left-hand side in Figure 3. In the present form of the invention, two main rows of water tubes, c^1, are provided on each side, individual tubes in the neighbourhood of the drums, A and B, between which they are connected, being set or joggled as shown to form baffles so that the gases are directed over the various heat-interchange surfaces in the manner indicated by the arrows. The

end-wall tubes in this form of the invention may be as shown in Figure 1.

Further, in Figure 7, the combustion chamber is shown divided, by way of example, by two juxtaposed longitudinal walls of tubes, *r*, *s*, the tubes of each wall being disposed in a vertical plane.

Referring now to Figure 8, a modified form of superheater is shown applied to a typical boiler according to the present invention.

According to this form, a pair of tubes, *t*, *t*, forming as it were a superheater element and lying in a plane transverse to the axis of the drum, A, leave the latter into which they are expanded and pass down into the hot gases to form a loop, T, preferably turned inwardly towards the furnace as shown; the tubes then return to the steam-and-water drum, A, into which they are expanded and deliver into a longitudinal internal pocket, U, formed to receive them. The partly superheated steam reverses its direction in this pocket to pass through a second pair of superheater tubes, t^1, downwardly through the hot gases and preferably through a zone thereof nearer to the furnace as shown to form a second loop, T^1, and return to a longitudinal internal pocket, V, in the steam drum serving to collect the superheated steam and provided with a valved outlet of any suitable construction.

It will be seen that the form of superheater just described becomes in effect an integral part of the steam-generating unit, the usual headers and drums in connection with the superheater being eliminated with a consequent gain in space, weight and cost.

In the examples of the invention above described, the fraction of the aggregate water-tube area exposed to radiant heat is larger than usual; further the shape of the combustion chamber is substantially that of a right circular cylinder of comparatively short length thereby giving a small surface in relation to its volume in accordance with the principles set out above, while the tubular side and end walls form a substantially complete envelope of effective heating surface to the combustion chamber; in addition, the preheater ensures a supply of highly-heated air to the furnace while the products of combustion are drawn over the heat-interchange surfaces, e. g., water tubes, superheater tubes, air-preheater tubes and the like, at a considerable velocity by way of an extended path defined by the baffles.

When simplicity or cheapness of manufacture is the dominant consideration, only the fundamental structure of the improved boiler need be retained together with as many, if any, of the high-efficiency adjuncts as are required to meet the conditions of the particular design.

Although specific examples of the invention have been described above, it will be understood that many variations can be made in detail without departure from the general principles outlined above, while structural features shown or described in relation to one form of the invention may be equally applicable to other forms.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:—

1. A water-tube boiler comprising in combination, an upper and a lower longitudinal drum; outwardly-curved oppositely-disposed banks of water tubes connecting said upper and lower drums along their length in wall formation to enclose a combustion chamber laterally; and disposed within said combustion chamber other water tubes in wall formation also connecting said upper and lower drums along their length.

2. A water-tube boiler comprising in combination, an upper and a lower longitudinal drum; outwardly-curved oppositely-disposed banks of water tubes connecting said upper and lower drums along their length in wall formation to enclose a combustion chamber laterally; and disposed within said combustion chamber other water tubes in wall formation also connecting said upper and lower drums along their length, said other water tubes being curved to afford resilience.

3. A water-tube boiler comprising in combination, an upper and a lower longitudinal drum; a plurality of banks of oppositely-disposed outwardly-curved water tubes connecting said upper and lower drums along their length in wall formation to enclose a combustion chamber laterally; together with superheater tubes curved to conform with the curvature of said outwardly-curved tubes, said superheater tubes being disposed between certain of said outwardly-curved banks of tubes.

4. A water-tube boiler comprising in combination, an upper and a lower longitudinal drum; inner and outer banks of outwardly-curved water tubes connecting said upper and lower drums along their length in wall formation, the inner banks enclosing a combustion chamber laterally; and superheater tubes disposed between said inner and outer banks and curved to conform with the curvature of said outwardly-curved tubes, certain tubes of both said inner and said outer banks being closely pitched over a part of the length of the boiler to form a baffle and certain other tubes of both said inner and said outer banks being spaced apart over another part of the length of the boiler to form a duct for the furnace gases, said closely-pitched and said spaced-apart tubes in the two said banks being reversely disposed in relation to the length of the boiler.

5. A water-tube boiler comprising in combination, an upper and a lower longitudinal drum, outwardly-curved oppositely-disposed

water tubes connecting said upper and said lower drums along their length in wall formation to enclose a combustion chamber laterally, said outwardly-curved tubes receiving heat only from said combustion chamber; superheater tubes disposed on the outside of certain of said outwardly-curved tubes and curved to conform with the curvature of said tubes; together with other water tubes connected to at least one of said drums, said other tubes being disposed outside at least some of said superheater tubes and curved to conform with the curvature of said tubes.

In testimony whereof I have signed my name to this specification.

JOHN JOHNSON.