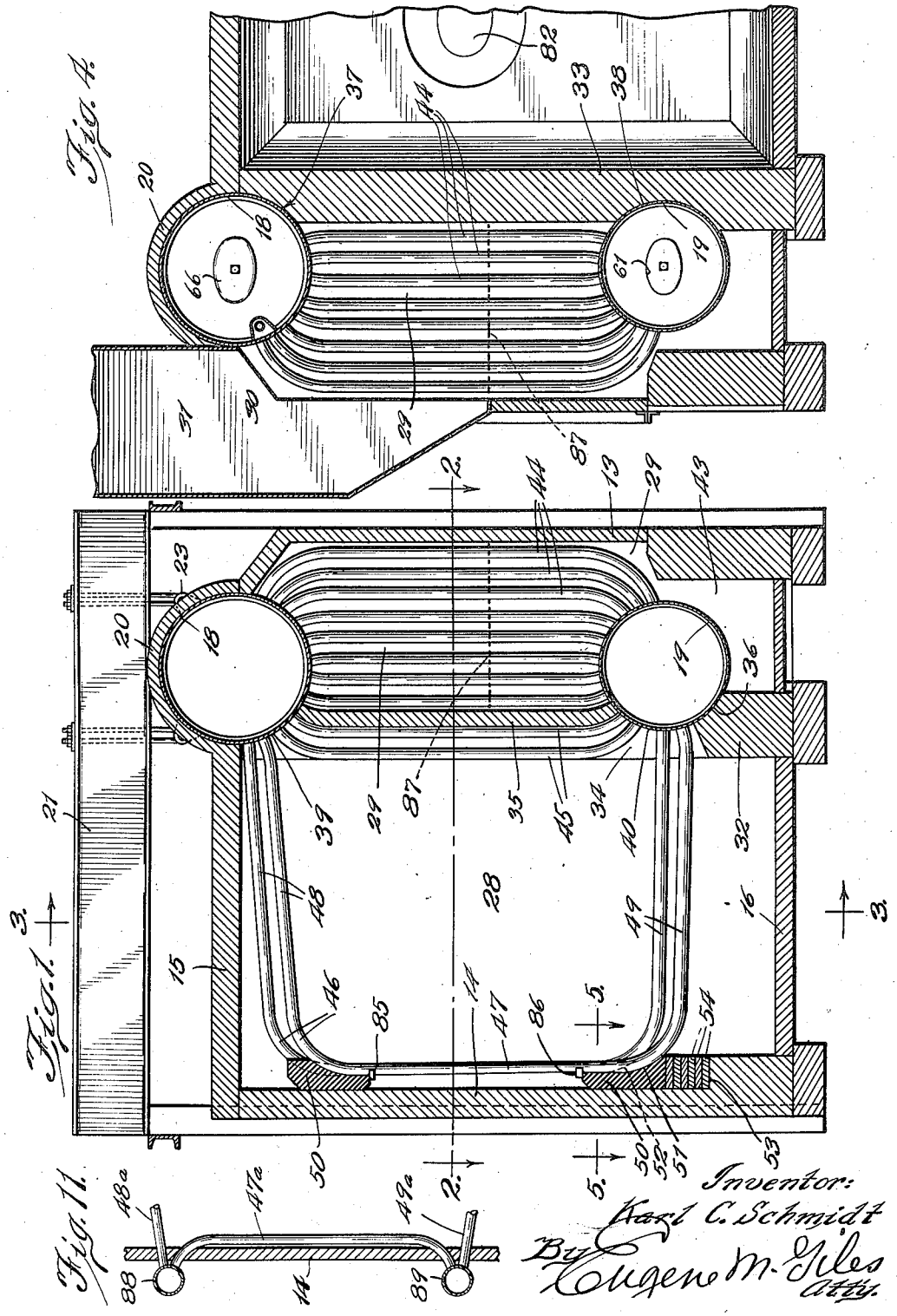
April 30, 1935. K. C. SCHMIDT 1,999,982

BOILER

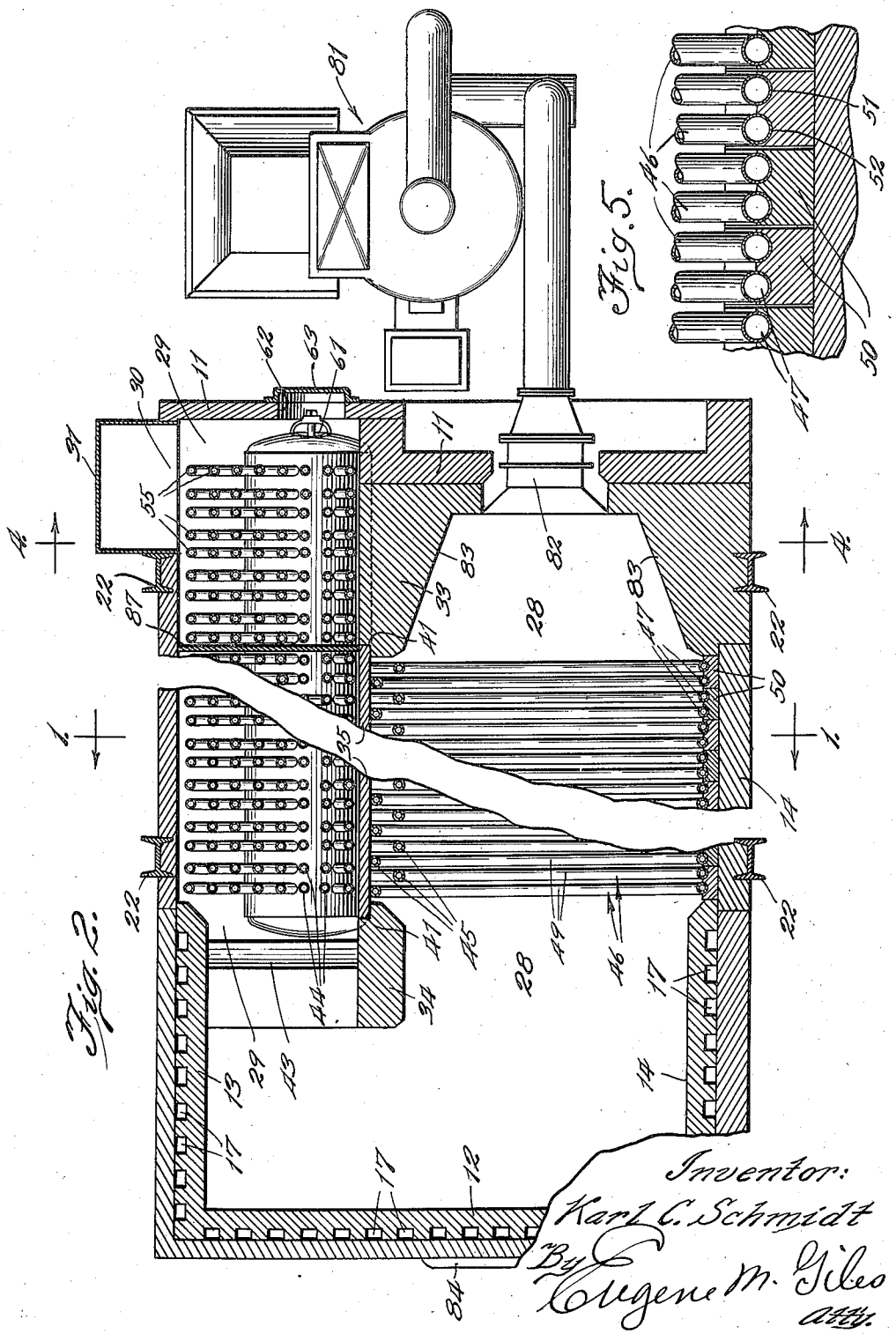
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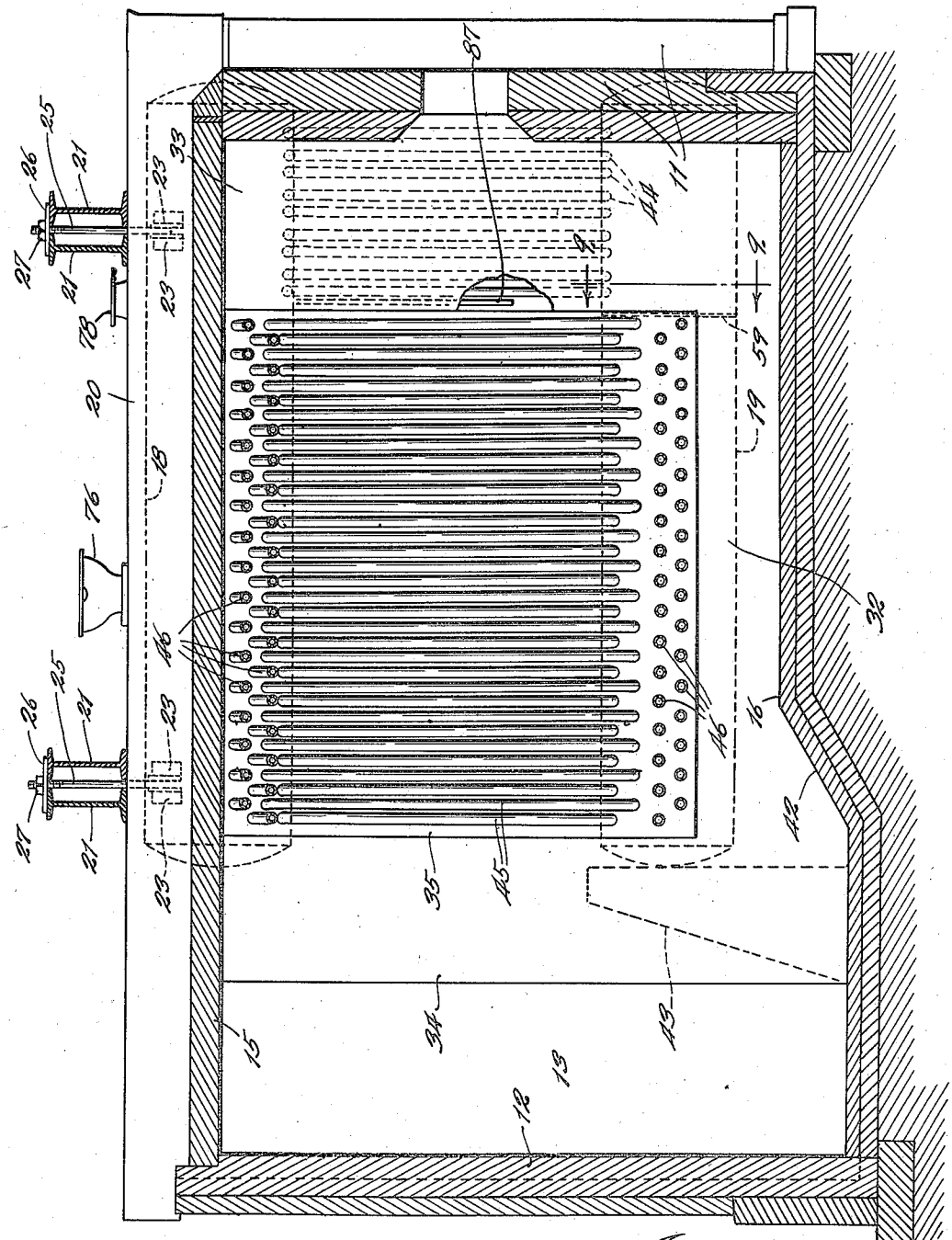


Fig. 3.

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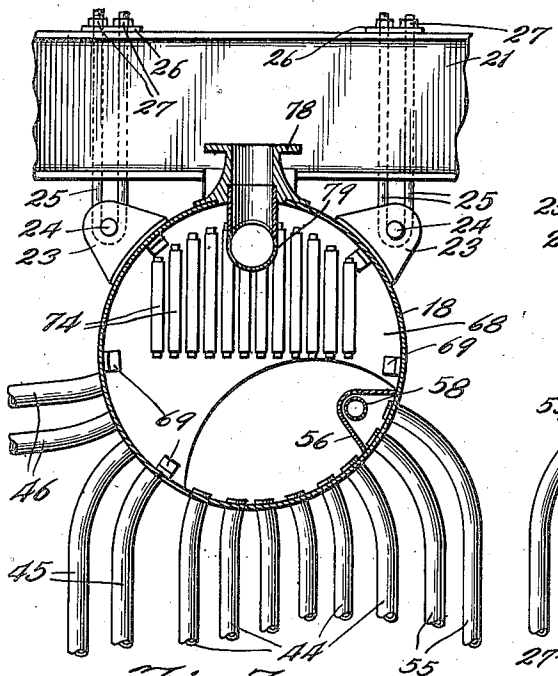


Fig. 7.

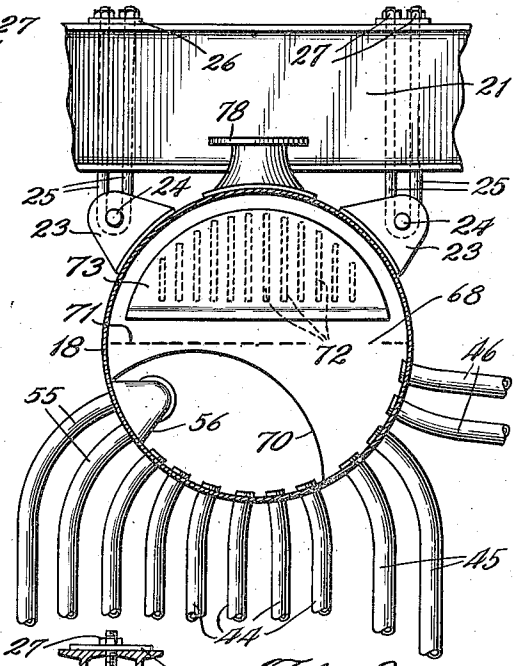


Fig. 8.

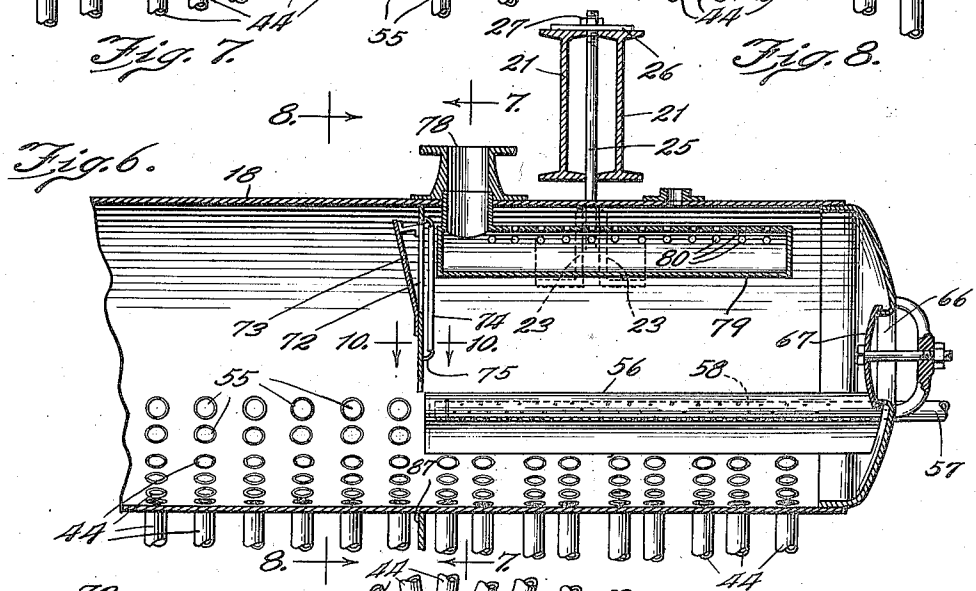


Fig. 6.

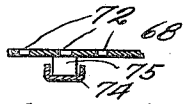


Fig. 10.

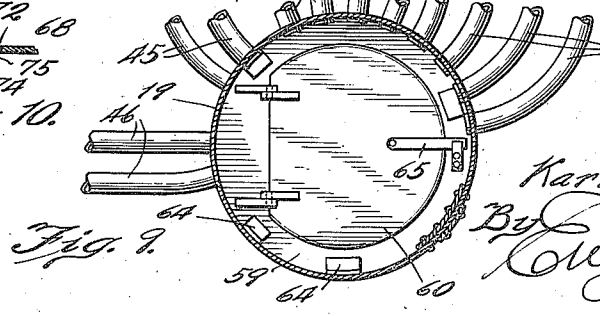


Fig. 9.

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UNITED STATES PATENT OFFICE

1,999,982

BOILER

Karl C. Schmidt, Western Springs, Ill., assignor to The Babcock & Wilcox Company, Newark, N. J., a corporation of New Jersey

Application January 25, 1932, Serial No. 588,511

24 Claims. (Cl. 122—336)

My invention relates to boilers or steam generators of the water tube type and has reference more particularly to a structure wherein the combustion and heating zone comprises adjoining consecutively communicating lanes with a separate group of tubes in each lane connecting the upper and lower drums of the boiler; my invention also including improved facilities for heating the feed water and for removing moisture from the steam to insure supply of same from the boiler in a dry condition.

The principal objects of my invention are to provide an improved boiler or steam generator of the water tube type; to minimize the space required for the installation of such boilers; to provide an ample combustion chamber and a length of lane for combustion and heating which insures complete combustion of the fuel and efficient utilization of the heat; to construct said lane in adjoining consecutively communicating sections with separate groups of boiler tubes therein; to arrange said tubes so as to obtain maximum efficiency; to provide an improved feed water heating or economizer section; to locate the feed water heater where it will minimize wastage of heat; to provide improved means for drying the steam; and in general to provide an improved water tube boiler of maximum efficiency in a compact form as well as improved feed water heating and steam drying facilities all of which are of simple construction, dependable in operation, convenient to manufacture, and assemble, readily accessible for repairs and which may be readily incorporated in boiler structures and advantageously combined in unitary assembly without necessitating unusual or special parts.

On the drawings:

Fig. 1 is a vertical transverse sectional view of the entire boiler structure taken on the line 1—1 of Fig. 2;

Fig. 2 is a horizontal sectional view taken on the line 2—2 of Fig. 1 and with an intermediate portion broken away;

Fig. 3 is a vertical longitudinal sectional view on the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary vertical sectional view on the line 4—4 of Fig. 2;

Fig. 5 is an enlarged detail sectional view on the line 5—5 of Fig. 1;

Fig. 6 is an enlarged vertical longitudinal sectional view of the forward part of the upper drum;

Fig. 7 is a transverse sectional view of the upper drum on the line 7—7 of Fig. 6;

Fig. 8 is a similar view on the line 8—8 of Fig. 6;

Fig. 9 is an enlarged transverse sectional view of the lower drum on the line 9—9 of Fig. 3;

Fig. 10 is an enlarged fragmentary sectional view on the line 10—10 of Fig. 6, and

Fig. 11 is a fragmentary view showing a modification of the looped tube structure.

Referring to the drawings in which I have shown my invention in a preferred form, the reference numeral 11 indicates the front wall, 12 the back wall, 13 and 14 the right and left side walls, 15 the top wall, which is usually referred to as the roof or arch, and 16 the bottom wall or floor of the boiler enclosure or setting, said walls being provided in accordance with the usual practice with air circulation channels 17 where desired for air cooling the walls, roof and/or floor and for pre-heating air for combustion purposes.

Mounted within this boiler enclosure or setting, which is referred to hereinafter as the boiler housing, are upper and lower drums 18 and 19, respectively, the former being known as the steam and water drum and the latter as the water drum and both of which extend from the front wall 11 rearwardly preferably a corresponding distance and they may have their rear ends spaced a substantial distance from the rear wall 12 of the boiler housing, as shown or otherwise as desired, the top wall 15 of the boiler housing in the particular embodiment disclosed being arched over the upper drum as indicated at 20 in Figs. 1, 3 and 4. These drums 18 and 19 are connected substantially throughout their entire length by a large number of tubes which afford communication between the drums and serve also to support the lower drum 19 from the upper drum 18, the latter with the attached tubes and lower drum being suspended from two sets of girders 21 which extend transversely over the top of the boiler housing and are securely mounted in any convenient manner as for example on uprights such as I-beams 22 which are of course mounted on a solid base and held firmly in the upright position in any convenient manner as for example by attachment to or building into the side walls of the boiler housing.

One set of girders 21 is located near the rear end and the other set near the forward end of the drum 18, each set of girders preferably consisting of two heavy I-beams or channels set up on edge in slightly spaced parallel relation. The upper drum is provided at each side and directly below the girders with a pair of lugs 23 having

a pin 24 extending therebetween which engages the lower looped end of a U-bolt 25, the arms of which extend upwardly between the respective pair of I-beams or channels 21 and through a plate 26 on the top of the I-beams or channels and have the nuts 27 threaded thereon against the faces of the respective plates 26.

The drums 18 and 19, which are positioned one directly above the other, are located at one side of the boiler housing, being shown herein as near the right side wall 13, and a partition or baffle is provided along the sides of the drums remote from the wall 13 which said partition extends rearwardly from the front wall 11 of the housing but terminates a substantial distance from the back wall 12 so as to divide the interior of the boiler housing into two laterally adjoining chambers or reverse passageways 28 and 29 respectively which communicate with one another at the rear of the housing. The chamber or passageway 28, which is referred to hereinafter as the combustion lane, is much wider than the other and arranged to have fuel supplied thereto at the front end so that combustion takes place principally in this chamber or passageway, while the other narrower chamber or passageway 29, which is referred to hereinafter as the heating lane has an outlet opening 30 leading therefrom at the front end through the top and side walls of the boiler housing into the breeching 31 which communicates with the stack, so that the flame and hot gases which result from the combustion in the chamber 28 are swept rearwardly in the chamber or combustion lane 28 to the rear of the boiler housing where they enter the open rear end of the chamber or heating lane 29 and pass forwardly therethrough to the outlet 30 into the stack, this reverse and return through the lane 29 insuring complete combustion and a sufficient length of gas travel to permit efficient utilization of the heat before exhaust through the said outlet 30.

The partition or baffle above referred to which divides the interior of the boiler casing into the two lanes for combustion and/or gas travel is made of a curb like portion 32 which extends along the floor 16 at the inner side of and under the lower drum 19 and terminates in upwardly extending ends 33 and 34 between which is an intermediate panel like member 35 which fits between upper and lower drums 18 and 19 leaving portions of said drums exposed to the combustion lane where tubes in the latter are connected therewith.

The curb 32 is formed with a curved seat 36 along the upper edge at the side next to the return lane 29 to conform to the peripheral surface of the lower drum and the portions 33 and 34, which extend upwardly from the front and rear ends respectively of the curb to the top wall of the boiler housing, are recessed at the sides next to the heating lane 29 to accommodate the end portions of the upper and lower drums, the recesses in the front portion 33 for the upper and lower drums being indicated respectively at 37 and 38 in Fig. 4 while the recesses in the rear portion 34 for the upper and lower drums are indicated respectively at 39 and 40 in Fig. 1. These upwardly extending portions 33 and 34 of the lane separating partition are also preferably formed along the edges at the heating lane side with seats 41 for the ends of the panel 35 which, as shown in Fig. 1, is curved along the upper and lower edges to correspond to the bends at the upper and lower ends of the adjoining tubes between which said partition is located.

The floor 16 of the boiler housing is preferably sloped downwardly as indicated at 42 in Fig. 3 to a lower level at the rear to form an ash pit when coal is used as fuel, which said ash pit construction of course is not required when gas or oil are used for fuel, and on this lower level portion of the floor is an abutment or bridge wall 43 which extends across the entrance to the heating lane 29 at the rear end thereof between the partition wall portion 34 and the casing side wall 13 and projects upwardly to a point substantially at or slightly above the top of the lower drum as shown in Fig. 3 so that the flame and heated gases as they enter the heating lane are directed into the space between the upper and lower drums.

Referring now to the tube arrangement of this boiler there are two separate groups of tubes connecting the drums 18 and 19, namely a group of tubes in the heating lane 29 and a group of tubes in the combustion lane 28.

The tubes in the heating lane 29, which are indicated at 44, are arranged vertically and in quite closely adjoining relation throughout substantially the entire length of the drums and throughout substantially the entire width of the heating lane, as shown respectively in Fig. 2 and in Figs. 1 and 4, being preferably arranged in longitudinal rows which are suitably spaced from one another and from the side walls of the heating lane to insure adequate circulation throughout the lane and substantially uniform exposure of the tubes. The tubes in the combustion lane 28 however are not distributed throughout the transverse area of the combustion lane but are arranged around the zone of combustion and comprise the tubes 45 preferably in a double row as shown in Fig. 1 along the partition panel 35 and the tubes 46 which connect with the upper and lower drums 18 and 19 respectively above and below the tubes 45, the tubes 46 being offset laterally as shown in Fig. 1 in a U form so that the middle portions 47 of these U shaped tubes are adjacent the side wall 14 of the boiler casing at the opposite side of the combustion lane 28, from the tubes 45, while the top arms 48 of these U shaped tubes extend across the top of the combustion lane and the bottom arms 49 thereof extend across the bottom of the combustion lane, said tubes 46 being preferably arranged in vertically staggered relation, that is alternately at higher and lower levels, so that the cross arms 48 and 49 thereof form double rows at the top and bottom of the combustion lane while the middle portions 47 of these tubes are preferably in line or form a single row along the wall 14 as shown in Figs. 1 and 2.

For supporting the outer extremities of the laterally offset or U-shaped tubes 46 and to prevent displacement thereof, upper and lower series of blocks 50 are provided along the outer wall 14 of the boiler casing which said blocks engage the tubes 46 at the bends. Each of these blocks is preferably of a width to accommodate two adjoining tubes 46 as shown in Fig. 5 and has two channels 51 and 52 on the inner face which are shaped to provide seats which conform to two adjoining tubes 46 at the bends and which said seats are at different elevations to correspond to the different elevation of the bends of said adjoining tubes. The lower blocks 50 are mounted on a ledge 53 which is provided along

the wall 14 at the inner side, said lower blocks being shimmed up to the proper elevation to support the tubes by filler blocks 54 which are laid on the ledge 53 under the lower tube holding blocks 50, while the upper blocks 50, which are preferably installed after the lower blocks 50 have been placed in position, are merely slipped downwardly at the proper place, the tube 47 being preferably provided with lugs 85 welded thereon which engage the lower ends of the upper blocks 50 to prevent an undesirable wedging action that might be occasioned by said blocks in the expansion and contraction of the tubes. Similar lugs 86 may also be provided to engage the upper ends of the lower blocks 50.

It is to be noted that while the drums 18 and 19 are provided with connecting tubes 44 substantially throughout their entire length in the heating lane 29, the tubes 45 and 46 are discontinued at a distance from the front ends of the drum as shown in Figs. 2 and 3, leaving a substantial length of the drums 18 and 19 at the forward ends that is not provided with connecting tubes 45 and 46 in the combustion chamber, these tubes being omitted at this place not only to facilitate ignition of the fuel but also because the fuel entering at the front of the combustion lane does not reach an effective stage of combustion until it reaches approximately the location of the first tubes 45 and 46. Furthermore the omission of the tubes 45 and 46 at the front ends of the drums 18 and 19 serves, as hereafter pointed out, to permit convenient incorporation in the boiler structure of improved feed water heating and steam drying facilities.

For heating the feed water as it is introduced into the boiler a number of heating lane tubes 44 at the front ends of the drums 18 and 19, namely the tubes of the two outer rows which connect the portions of the drums 18 and 19 where the tubes 45 and 46 of the combustion lane are omitted (the tubes in question being next to the flue outlet 30 and indicated particularly by the reference numeral 55) have their upper ends boxed in by an elongated cap 56 located in the upper drum 18 and which extends back nearly to the front tubes 45 and 46 of the combustion lane 28, and a water feed pipe 57 connects through the header or front end wall of the upper drum 18 with a perforated pipe 58 within the box or cap 56 for supplying and distributing the feed water to the tubes 55 at their upper ends so that the feed water as it enters the boiler is forced downwardly through the selected tubes 55 into the forward end of the lower drum 19.

From the forward end of the lower drum the water is then caused to flow upwardly through the other tubes 44 that connect the front end portions of the drums beyond the tubes 45 and 46, this being accomplished by providing a partition 59 in the lower drum just in front of the first tubes 45 and 46 of the main combustion lane, said partition preferably having a large opening therethrough closed by a door 60 whereby access may be had to the portion of the drum at the rear of the partition from the manhole opening 61 at the front end of the drum. This manhole opening 61 is closed by an internal cover in the usual manner and the front wall 11 of the boiler housing has a corresponding opening 62 closed by a door 63 through which access is had to the manhole opening 61 of the drum 18.

The partition 59 may be secured in place in any convenient manner as for example by providing a plurality of angular clips or brackets 64 at intervals around the partition which are attached to the peripheral wall of the drum and the door 60 may be held closed in any convenient manner as for example by an ordinary latch 65 it being unnecessary that the partition and door effect a thoroughly tight closure but merely confine the water in the forward part of the lower drum sufficiently so that substantially all of the water which is fed through the tubes 55 into the forward end of the lower drum 19 is caused to flow upwardly through the other tubes 44 at the front of the partition 59 so as to insure heating of the water substantially to boiler temperature before it is supplied into the main parts of the boiler.

The upper drum 18, like the lower drum, has a manhole opening 66 in the forward end closed by an internal cover 67 in the usual manner and located at an opening in the front wall which is closed by a door, and this upper drum 18 is also provided with a partition 68 secured by clips 69 to the shell of the drum immediately in front of the first tubes 45 and 46 of the main combustion lane and which not only serves to remove moisture from the steam and assure a dry steam supply but also to provide in the forward end of the upper drum a non-turbulent zone through which the steam passes as it is supplied from the boiler.

This partition 68 is cut away as indicated at 70 to provide a large opening therethrough below the water level to permit free communication of water between the portions of the drum at opposite sides of said partition 68, the level of the water in the drum being indicated by the dotted line 71 in Fig. 8, and the opening formed by cutting away the plate 68 at 70 is of sufficient size to permit passage therethrough of a workman entering the drum 18 through the manhole 66. The upper portion of the partition above the water line is provided with a plurality of vertical slits 72 for passage of steam from the rear portion of the drum to the non-turbulent zone or dry steam compartment in front of the partition 68, and at the rear side of the partition 68 an inclined baffle plate 73 is secured along its lower edge to the partition below the slits 72 and extends upwardly and rearwardly as shown in Fig. 6. At the forward side of the partition 68 a vertical channel iron 74 is mounted in front of each slit 72 with the channeled side thereof facing the slit as shown in Fig. 10, said channel irons being mounted on the partition 68 in any convenient manner, preferably by cutting away the side flanges at the ends and bending the intermediate portion at each end inwardly as at 75 to form brackets which are secured to the partition 18 and hold the channel irons a slight distance away from the front of the partition.

The upper drum 18 is provided with a safety valve outlet at the rear of the partition 68 as indicated at 76 while the normal outlet, through which the steam is supplied from the boiler, leads from the dry steam compartment at the front of the partition 68, said latter outlet being indicated at 78 and communicating through the drum shell with the closed rear end of the tube 79 which extends forwardly in the top of the drum, is closed at the forward end and provided with perforations 80 along the top.

With the above described construction, the steam which is generated in the main portion of the boiler at the rear of the partition, passes over the baffle plate 73 and through the slits 72 in said partition to the outlet tube 79 in the front portion of the drum 18, and in passing through these

slits 72 the steam strikes against the channel irons 74 which serve to remove the moisture therefrom so that dry steam is supplied to the non-turbulent compartment of the drum 18 at the front of the partition 68 and from the compartment through the tube 79 to the outlet 78.

The fuel used in connection with this boiler is preferably gas, oil, pulverized coal or the like, a pulverized fuel installation being shown somewhat diagrammatically at 81 in Fig. 2, the fuel being discharged into the forward end of the main combustion lane 28 through an opening 82 in the front wall which said opening is located substantially centrally of the lane or passageway defined by the tubes 45 and 46 so that said tubes are subjected substantially uniformly to the radiant heat of the burning fuel, and the walls within the main combustion lane at each side of the opening being preferably flared as shown at 83 in Fig. 2 so that any heat reflected therefrom is directed back into the zone of the tubes 45 and 46. A door 84 at the rear of the boiler casing affords access for removal of ash that accumulates in the ash pit where the floor 16 is depressed at the rear end of the boiler casing.

To avoid concentration of flow and escape of the heated gases in the heating lane at the top of the lane with a resultant short circuiting of the tube surface in the lower part of the lane, a baffle 87 is provided in this lane near the outlet 30 and closing off the top of the lane from the upper drum 18 down approximately half way to the lower drum 19 as for example to the level of the dotted line 87 in Figs. 1 and 4, the exact lower extent of this baffle being determined according to the volume of gas to be passed and the available draft. This baffle, which in the present structure is preferably located approximately in the plane of the partitions 68 and 59 of the upper and lower drums respectively, or immediately in front of the foremost tubes 45 and 46 of the main combustion chamber or lane 28, also serves to insure removal from the lane 29 of the coldest gases since only the coldest gases will descend and pass under this baffle.

Instead of forming the tubes 46 of the main combustion chamber or lane 28 of continuous lengths bent into U shapes to provide the intermediate portions 47 with integral top and bottom arms 48 and 49 respectively, a construction such as shown in Fig. 11 may be employed, if desired. In this construction upper and lower headers indicated at 88 and 89 respectively extend along the side wall 14 of the boiler housing and are connected throughout their length by a series of tubes 47^a which correspond to the portions 47 of the looped tubes 46 and the upper header 88 is connected throughout its length to the upper drum 18 by a series of tubes 48^a which correspond to the upper arms 48 of the looped tubes 46 while the lower header 89 is likewise connected with the lower drum 19 by a series of tubes 49^a corresponding to the lower arms 49 of the looped tubes 46.

With this boiler construction there is not only an unusually large area of radiant tube exposure in a minimum amount of space but by separating the interior of the boiler housing into adjoining parallel lanes for combustion and gas travel, a sufficient length of travel is provided for the flame and heated gases to insure complete combustion and effective use of the generated heat. Moreover the location of the feed water tubes at the outlet to the stack results in a zone of relatively cool water at the outlet end of the lane 29 and since the heated gases pass through this zone as they are finally discharged from the boiler casing, a large part of the remaining heat is readily absorbed owing to the relatively low temperature of these tubes and there is accordingly a minimum wastage of heat through the stack. Furthermore it is to be particularly noted that all the tubes of the boiler are arranged substantially at right angles to the direction of travel of the flame and heated gases so that the greatest heating efficiency is assured.

While I have shown and described my invention in a preferred form I am aware that various changes and modifications may be made therein without departing from the principles of my invention, the scope of which is to be determined by the appended claims.

I claim as my invention:

1. In a water tube boiler the combination of an upper drum and a lower drum and a plurality of tubes extending between and connecting said drums, an upper header and a lower header spaced laterally from the drums and a series of tubes extending between and connecting the headers, a series of tubes extending laterally between and connecting the upper drum and upper header a series of tubes extending laterally between and connecting the lower drum and lower header, said three aforesaid series of tubes forming a wide longitudinal lane of combustion at the side of the aforesaid plurality of tubes, and means for burning fuel in said combustion lane and effecting a substantially horizontal flow of gases longitudinally through said combustion lane and reversely in contact with said first mentioned tubes.

2. In a water tube boiler the combination of a housing, upper and lower drums in the housing, a plurality of tubes connecting the drums, and means connected with the upper drum whereby the drums and tubes are suspended, said tubes including a longitudinal series having their middle portions offset laterally from the other tubes and located adjacent a remote side wall of the housing, and removable blocks engaged between the said side wall of the housing and the said laterally offset portions of the tubes for holding the latter against displacement.

3. In a water tube boiler the combination of a housing having a combustion lane and a return heating lane through which the combustion lane discharges, upper and lower drums, a plurality of drum connecting tubes in the combustion lane arranged at intervals along a portion of the length of the drums, tubes in the return heating lane connecting end portions of the drums beyond the location of the first mentioned drum connecting tubes, partitions in the drums separating said end portions of the drums from the portions of the drums to which the tubes of the combustion lane are connected, and a water feed leading to the upper ends of a selected number of said tubes in the return heating lane.

4. In a water tube boiler the combination of upper and lower drums each having a partition correspondingly located therein and dividing the interior of the drums into corresponding large and small compartments, said partition of the upper drum having an opening for water circulation between the bottom portions of the compartments of said drum and having a steam passageway through the top portion thereof, a steam outlet from the small compartment of the upper drum, a plurality of tubes connecting and confined to the large compartments of the drums and a plurality of tubes connecting and confined to

the small compartments of the drums, and a water feed leading to the upper ends of a selected number of the latter mentioned tubes.

5. In a water tube boiler the combination of a housing having the interior thereof divided into adjoining longitudinally extending combustion and heating lanes, the combustion lane discharging at its rear end forwardly through the heating lane, and the heating lane having a stack outlet at its forward end, means for supplying fuel to the forward end of the combustion lane, upper and lower drums extending longitudinally in the housing, correspondingly located partitions in said drums forming a corresponding separate compartment at the forward end of each drum, the partition of the upper drum having the top portion thereof provided with a steam passage leading therethrough and the forward end compartment of said drum having a steam outlet leading therefrom, separate groups of tubes located respectively in the combustion and heating lanes and connecting the portions of the drums at the rear of the partitions, tubes in the heating lane only connecting the portions of the drums at the front of the partitions, and a water feed leading to the upper ends of a selected number of the last mentioned tubes and said selected number of said tubes being located adjacent to the aforesaid stack outlet from the heating lane.

6. A steam boiler having an upper steam and water drum, a lower water drum, a heating lane including a vertically disposed convection heated bank of steam generating tubes extending between and connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, means forming a combustion lane laterally adjoining said heating lane and communicating therewith at its rear end including a row of water tubes connected to said drums and laterally spaced from said tube bank and extending along the opposite side of the rear portion of said combustion lane, the front portion of said combustion lane being formed by a refractory faced ignition section, means at the front end of said combustion lane for burning fuel therein and effecting a substantially horizontal flow of heating gases rearwardly through said combustion lane and forwardly through said heating lane and in thermal contact with the tubes therein, and a gas exit from said heating lane.

7. A steam boiler having an upper steam and water drum, a lower water drum, a heating lane including a vertically disposed convection heated bank of steam generating tubes extending between and connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, means forming a combustion lane laterally adjoining said heating lane and communicating therewith at its rear end including a row of water tubes connected to said drums and laterally spaced from said tube bank and extending along the opposite side of the rear portion of said combustion lane, the front portion of said combustion lane being formed by a refractory faced ignition section, means at the front end of said combustion lane for burning fuel therein and effecting a substantially horizontal flow of heating gases rearwardly through said combustion lane and forwardly through said heating lane and mainly transversely of the tubes therein, a gas exit at the front end of said heating lane, and means for supplying feed water to the tubes in said bank laterally adjoining said ignition section.

8. A steam boiler having an upper steam and water drum, a lower water drum, a heating lane including a vertically disposed convection heated bank of steam generating tubes extending between and connected to said drums along the length thereof, means forming a combustion lane laterally adjoining said drums and heating lane and communicating with said heating lane at its rear end including a plurality of rows of U-shaped water tubes connected to said drums and laterally spaced from said tube bank and extending along the outer, top and bottom sides of said combustion lane, the bottom legs of said U-shaped tubes being staggered vertically, means at the front end of said combustion lane for burning fuel therein and effecting a substantially horizontal flow of heating gases longitudinally through said combustion lane and reversely through said heating lane and in thermal contact with the tubes therein, and a gas exit from said heating lane.

9. A steam boiler having an upper steam and water drum, a substantially parallel lower water drum, a tube chamber containing a vertically disposed bank of substantially straight steam generating tubes extending between and having bent end portions connected to said drums substantially throughout the length thereof, means forming a partition extending between said drums and defining one side of a combustion chamber laterally adjoining said tube chamber and communicating therewith at only one end, means defining the remaining sides of said combustion and tube chambers, said combustion chamber being arranged substantially wholly at one side of the plane including the longitudinal axes of said drums, a row of tubes extending along the opposite side of said combustion chamber and having their upper ends connected to said steam and water drum, a longitudinally extending header connected to the lower ends of said opposite wall tubes, a row of tubes connecting said header to said lower water drum, means for burning fuel in said combustion chamber and effecting a flow of heating gases longitudinally through said combustion chamber and serially through said tube chamber and in thermal contact with the tubes therein, and a heating gas outlet from said tube chamber at the side of said axial plane opposite said combustion chamber.

10. A steam boiler having an upper steam and water drum, a substantially parallel lower water drum, a tube chamber containing a vertically disposed bank of substantially straight steam generating tubes extending between and having bent end portions radially connected to said drums substantially throughout the length thereof, means forming a partition extending between said drums and defining the inner side of a combustion chamber laterally adjoining said tube chamber and communicating therewith at only one end, means defining the remaining sides of said combustion and tube chambers, said combustion chamber being arranged substantially wholly at one side of the plane including the longitudinal axes of said drums, a row of water tubes extending along the outer side of said combustion chamber and having their upper ends connected to said steam and water drum, a longitudinally extending header connected to the lower ends of said outer wall tubes, a row of water tubes connecting said header to said lower water drum, means for burning a fluid fuel in said combus-

tion chamber and effecting a substantially horizontal flow of heating gases longitudinally through said combustion chamber and reversely through said tube chamber and in thermal contact with the tubes therein, and a heating gas outlet from said tube chamber at the side of said partition opposite said combustion chamber.

11. A steam boiler having an upper steam and water drum, a substantially parallel lower water drum, a tube chamber containing a vertically disposed bank of steam generating tubes extending between and having end portions radially connected to said drums substantially throughout the length thereof, refractory means associated with a row of tubes and forming a partition extending between said drums and defining the inner side of a combustion chamber laterally adjoining said tube chamber and communicating therewith at only one end, means defining the remaining sides of said combustion and tube chambers, said combustion chamber being arranged substantially wholly at one side of the plane including the longitudinal axes of said drums, a row of tubes extending along the outer side of said combustion chamber and having their upper ends connected to said steam and water drum below the normal water level therein, a longitudinally extending header connected to the lower ends of said outer wall tubes, a row of outwardly extending inclined tubes connecting said header to said lower water drum, means for burning a fluid fuel in said combustion chamber and effecting a substantially horizontal flow of heating gases longitudinally through said combustion chamber and reversely through said tube chamber and mainly transversely of the tubes therein, and a heating gas outlet from said tube chamber at the side of said axial plane opposite said combustion chamber.

12. A steam boiler having an upper steam and water drum, a lower water drum, a vertically disposed convection heated bank of steam generating tubes extending between and connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, a partition forming one side of a combustion lane substantially wholly at one side of the said axial plane and separating the same from a laterally adjoining heating lane communicating therewith at only one end and containing said tube bank, means defining the remaining sides of said combustion and heating lanes, a row of water tubes connected to said drums and laterally spaced from said partition and extending along the opposite side of said combustion lane, means at the other end of said combustion lane for burning fuel and effecting a substantially horizontal flow of heating gases longitudinally through said combustion lane and reversely through said heating lane and in thermal contact with the tubes therein, and a heating gas outlet from said heating lane on the side of said partition opposite said combustion lane.

13. A steam boiler having an upper steam and water drum, a lower water drum, a vertically disposed convection heated bank of substantially straight steam generating tubes extending between and having bent end portions connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, a partition forming one side of a combustion lane substantially wholly at one side of the said axial plane and separating the same from a laterally adjoining heating lane communicating therewith at only one end and containing said tube bank, means defining the remaining sides of said combustion and heating lanes, a row of water tubes connected to said drums and having substantially straight vertical portions of substantial length laterally spaced from said partition and extending along the opposite side of said combustion lane, means at the other end of said combustion lane for burning fuel and effecting a substantially horizontal flow of heating gases longitudinally through said combustion lane and reversely through said heating lane and in thermal contact with the tubes therein, and a gas exit from said heating lane on the side of said partition opposite said combustion lane.

14. A steam boiler having an upper steam and water drum, a lower water drum, a heating lane including a vertically disposed convection heated bank of steam generating tubes extending between and connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, means forming a combustion lane laterally adjoining said heating lane and communicating therewith at only one end including a plurality of rows of water tubes connected to said drums at one side of said axial plane and having laterally spaced substantially vertical portions extending along opposite sides of said combustion lane, said combustion lane being located substantially wholly at one side of the said axial plane, means at the other end of said combustion lane for burning fuel and effecting a substantially horizontal flow of heating gases longitudinally through said combustion lane and reversely through said heating lane and in thermal contact with the tubes therein, and a gas exit from said heating lane on the side of said axial plane opposite said combustion lane.

15. A steam boiler having an upper steam and water drum, a lower water drum, a heating lane including a vertically disposed convection heated bank of steam generating tubes extending between and connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, means forming a combustion lane substantially wholly at one side of the said axial plane and laterally adjoining said heating lane and communicating with said heating lane at its rear end and including a vertically disposed partition forming one side of said combustion lane and a row of U-shaped water tubes connected to said drums and laterally spaced from said tube bank and extending along the remaining longitudinally extending sides of said combustion lane, means at the front end of said combustion lane for burning fuel therein and effecting a substantially horizontal flow of heating gases rearwardly through said combustion lane and forwardly through said heating lane and in thermal contact with the tubes therein, and a gas exit from said heating lane on the side of said partition opposite said combustion lane.

16. A steam boiler having an upper steam and water drum, a substantially parallel lower water drum, a tube chamber containing a vertically disposed bank of substantially straight steam generating tubes extending between and having bent end portions connected to said drums substantially throughout the length thereof and arranged to support one of said drums, means forming a partition extending between said drums and defining one side of a combustion chamber

laterally adjoining said tube chamber and communicating therewith at only one end, means defining the remaining sides of said combustion and tube chambers, said combustion chamber being separated from said tube chamber by said partition and arranged substantially wholly at one side of the plane including the longitudinal axes of said drums, a row of tubes laterally spaced from said partition and extending along the opposite side of said combustion chamber and having their ends connected to said upper and lower drums, means at the other end of said combustion chamber for burning fuel and effecting a flow of heating gases longitudinally through said combustion chamber and reversely through said tube chamber and in thermal contact with the tubes therein, and a heating gas outlet from said tube chamber on the side of said axial plane opposite said combustion chamber.

17. A steam boiler having an upper steam and water drum, a substantially parallel lower water drum, a tube chamber containing a vertically disposed bank of substantially straight steam generating tubes extending directly between and having bent end portions radially connected to said drums substantially throughout the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, means forming a partition extending between said drums and defining one side of said tube chamber and of a combustion chamber laterally adjoining said tube chamber and communicating therewith at only one end, means defining the remaining sides of said combustion and tube chambers, said combustion chamber being arranged substantially wholly at one side of said axial plane and said tube chamber receiving heating gases solely from said combustion chamber, a row of water tubes spaced longitudinally of said combustion chamber and laterally spaced from said partition and extending along the remaining longitudinally extending sides of said combustion chamber and having their ends connected to said upper and lower drums, means at the other end of said combustion chamber for burning a fluid fuel and effecting a substantially horizontal flow of heating gases longitudinally through said combustion chamber and reversely through said tube chamber and in thermal contact with the tubes therein, and a heating gas outlet from said tube chamber on the side of said partition opposite said combustion chamber.

18. A steam boiler having an upper steam and water drum, a substantially parallel lower water drum, a tube chamber containing a vertically disposed bank of substantially straight steam generating tubes extending directly between and having bent end portions connected to said drums substantially throughout the length thereof and arranged to support one of said drums from the other, means forming a partition extending between said drums and defining one side of a combustion chamber laterally adjoining said tube chamber and communicating therewith at only one end, said combustion chamber being arranged substantially wholly at one side of the plane including the longitudinal axes of said drums, a row of U-shaped water tubes having substantially vertical intermediate portions defining the opposite side of said combustion chamber and having upper and lower oppositely inclined leg portions connected to said upper and lower drums respectively, means at the other end of said combustion chamber for burning a fluid fuel and effecting a substantially horizontal flow of heating gases longitudinally through said combustion chamber and reversely through said tube chamber and in thermal contact with the tubes therein, and a heating gas outlet from said tube chamber on the side of said axial plane opposite said combustion chamber.

19. A steam boiler having upright side and end walls forming a setting, a vertically disposed partition dividing the enclosed space into laterally adjoining combustion and heating lanes connected at one end, upper and lower drums extending longitudinally of said heating lane, a bank of vertically disposed water tubes in said heating lane extending between and connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, a series of water tubes having their upper and lower ends connected to said upper and lower drums respectively and surrounding said combustion lane, means at the opposite end of said combustion lane for burning fuel therein and directing the products of combustion longitudinally through said combustion lane and reversely through said heating lane in thermal contact with the water tubes therein, and a heating gas outlet from said heating lane.

20. A steam boiler having a pair of substantially parallel horizontally disposed upper and lower drums, a single transversely undivided bank of substantially straight vertically disposed water tubes extending between and connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, means forming a longitudinally extending combustion lane arranged substantially wholly at one side of said axial plane and a heating lane laterally adjoining said combustion lane and containing said tube bank, said heating lane receiving heating gases solely from and communicating with said combustion lane only at one end thereof, said means including a vertically disposed longitudinally extending partition separating and forming one side of said combustion and heating lanes, water tubes connected to both of said drums and extending transversely of said combustion lane along the remaining longitudinally extending sides thereof, and means for burning fuel in said combustion lane and generating heating gases flowing longitudinally of said combustion lane, and a heating gas outlet from said heating lane.

21. A steam boiler having side and end walls forming a setting, a vertically disposed partition dividing the entire space within said setting into a single elongated combustion lane and a single laterally adjoining heating lane connected only at one end to and receiving heating gases solely from said combustion lane, upper and lower drums extending longitudinally of said heating lane, a bank of substantially straight vertically disposed water tubes in said heating lane extending between and connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, a series of water tubes having their upper and lower ends connected to said upper and lower drums respectively and extending transversely of said combustion lane along the remaining longitudinally extending sides thereof, means for burning fuel in said combustion lane and generating heating gases flowing longitudinally of said combustion lane, and a heating gas outlet from said heating lane.

22. A steam boiler having side and end walls

forming a setting, a vertically disposed partition dividing the entire space within said setting into a single elongated combustion lane and a single laterally adjoining heating lane connected at its rear end to and receiving heating gases solely from said combustion lane, upper and lower drums extending longitudinally of said heating lane, a vertically disposed bank of substantially straight water tubes in said heating lane extending between and connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, a row of water tubes extending along the side of the combustion lane opposite said partition and having their upper ends connected to said upper drum, a header extending longitudinally of said combustion lane and connected to the lower ends of said wall tubes, a row of water tubes connecting said header to said lower drum and extending along the bottom of said combustion lane, means at the front end of said combustion lane for burning fuel therein and generating heating gases flowing rearwardly through said combustion lane, and a heating gas outlet from said heating lane.

23. A steam boiler having side and end walls forming a setting, a vertically disposed partition terminating short of the rear wall of said setting and arranged to divide the space within said setting into laterally adjoining combustion and heating lanes communicating at the rear end thereof, upper and lower drums extending longitudinally of said heating lane, a vertically disposed bank of water tubes extending between and connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, said tube bank being positioned in said heating lane with the rear end of said tube bank terminating short of the rear end of said partition, a row of water tubes connected to both of said drums and extending transversely of said combustion lane along the side wall thereof opposite said partition, means at the front end of said combustion lane for burning fuel therein and generating heating gases flowing rearwardly through said combustion lane and forwardly through said heating lane, and a heating gas outlet from said heating lane.

24. A steam boiler having a pair of substantially parallel horizontally disposed upper and lower drums, a vertically disposed bank of water tubes extending between and connected to said drums along the length thereof and disposed at both sides of the plane including the longitudinal axes of said drums, means forming a heating lane extending longitudinally of said drums and containing said tube bank and a combustion lane laterally adjoining said heating lane, said combustion lane being arranged substantially wholly at one side of said axial plane and communicating with said heating lane at the rear end thereof, said means including a vertically disposed partition separating said combustion and heating lanes, means at the front end of said combustion lane for burning pulverized fuel in suspension therein, a heating gas outlet from said heating lane, a row of water tubes connected to both of said drums and surrounding said combustion lane, and an ash pit extending across the rear end of said combustion lane.

KARL C. SCHMIDT.

CERTIFICATE OF CORRECTION.

Patent No. 1,999,982. April 30, 1935.

KARL C. SCHMIDT.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 62, second column, line 22, and page 4, first column, lines 12, 18, 41 and 46, strike out the word "main"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 9th day of July, A. D. 1935.

Bryan M. Battey

(Seal) Acting Commissioner of Patents.