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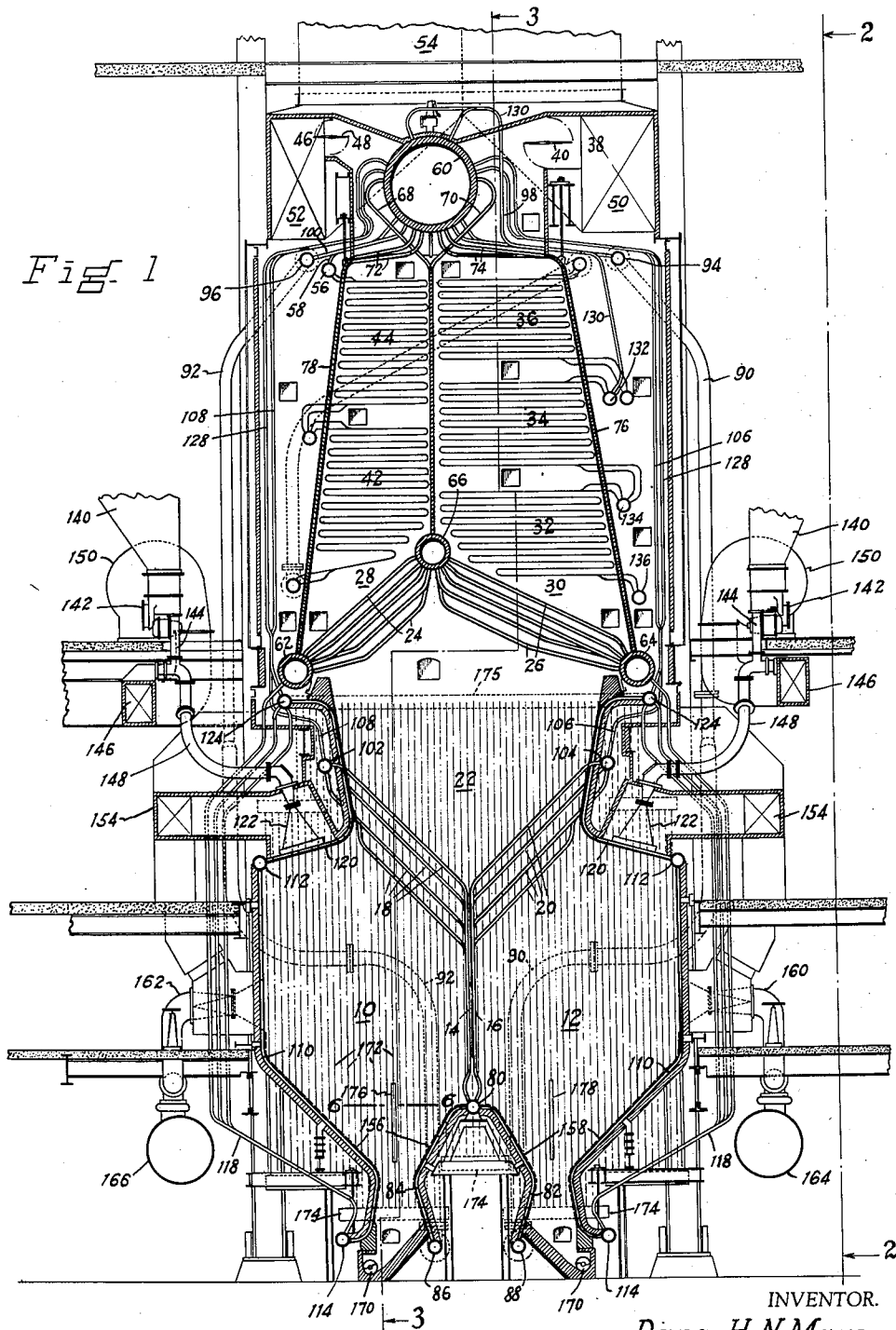
D. H. N. MAYO

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FLUID HEAT EXCHANGE APPARATUS

Filed Jan. 31, 1936

4 Sheets-Sheet 1



INVENTOR.

Dana H.N. Mayo

BY

Ben R. Kewen
ATTORNEY.

June 10, 1941.

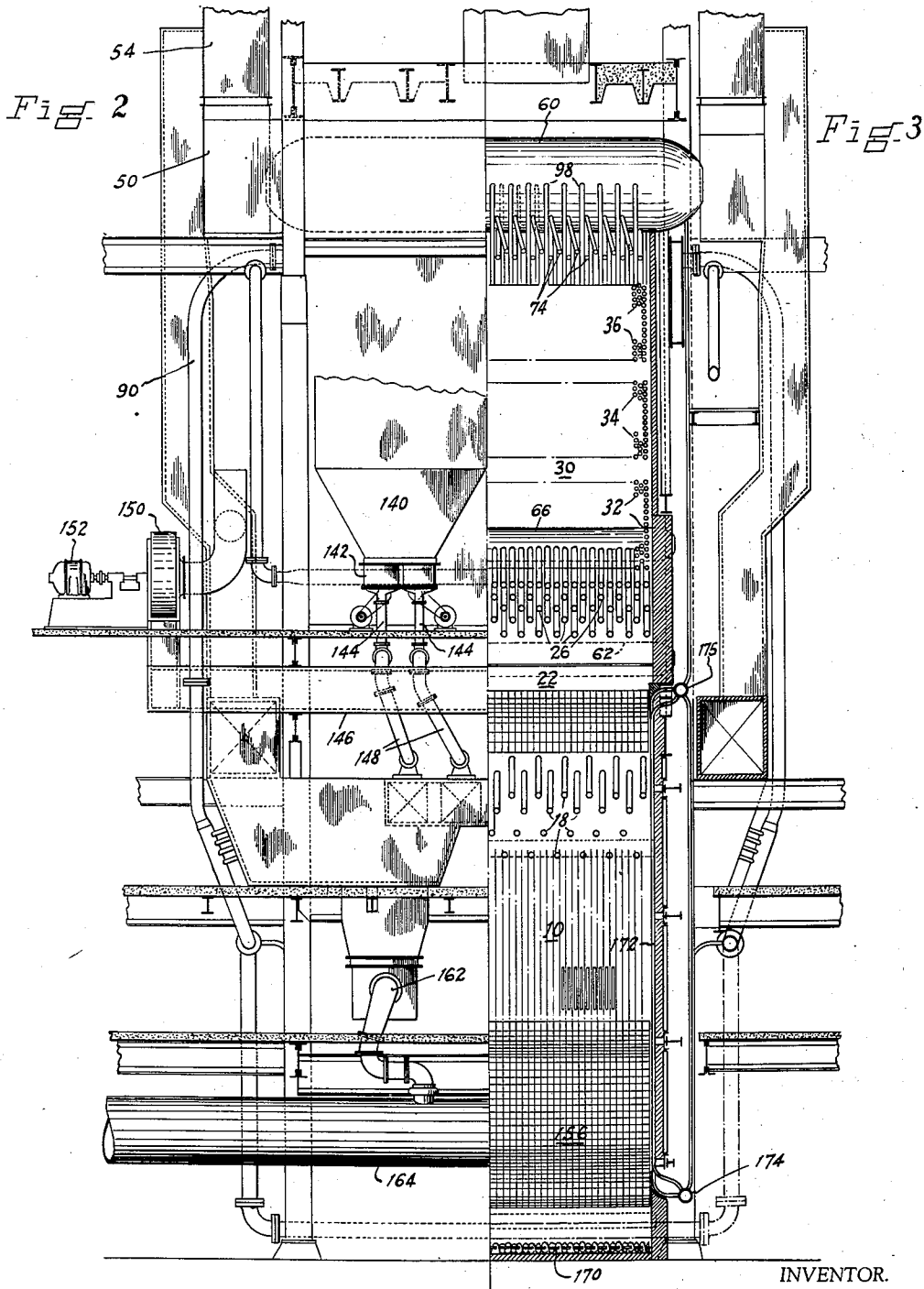
D. H. N. MAYO

2,245,209

FLUID HEAT EXCHANGE APPARATUS

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4 Sheets-Sheet 2



INVENTOR.

Dana H. N. Mayo

BY *Paul R. Navroth*
ATTORNEY.

June 10, 1941.

D. H. N. MAYO

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FLUID HEAT EXCHANGE APPARATUS

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Fig. 5

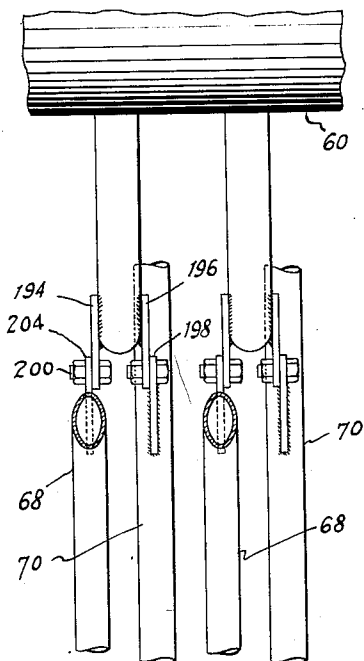


Fig. 4

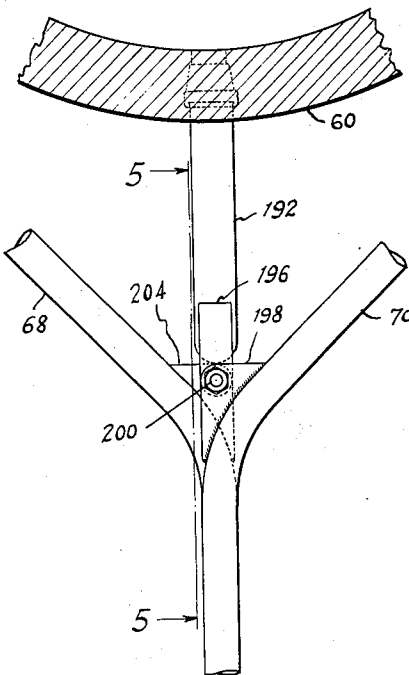


Fig. 6

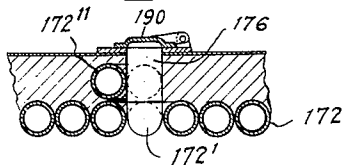
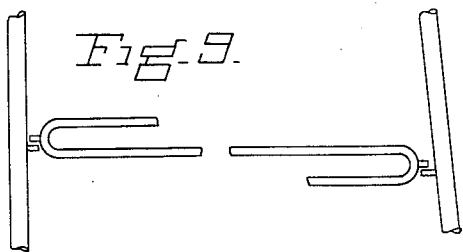


Fig. 8



Fig. 9



INVENTOR.

Dana H. N. Mayo

BY *Barry R. Newcomb*
ATTORNEY.

June 10, 1941.

D. H. N. MAYO

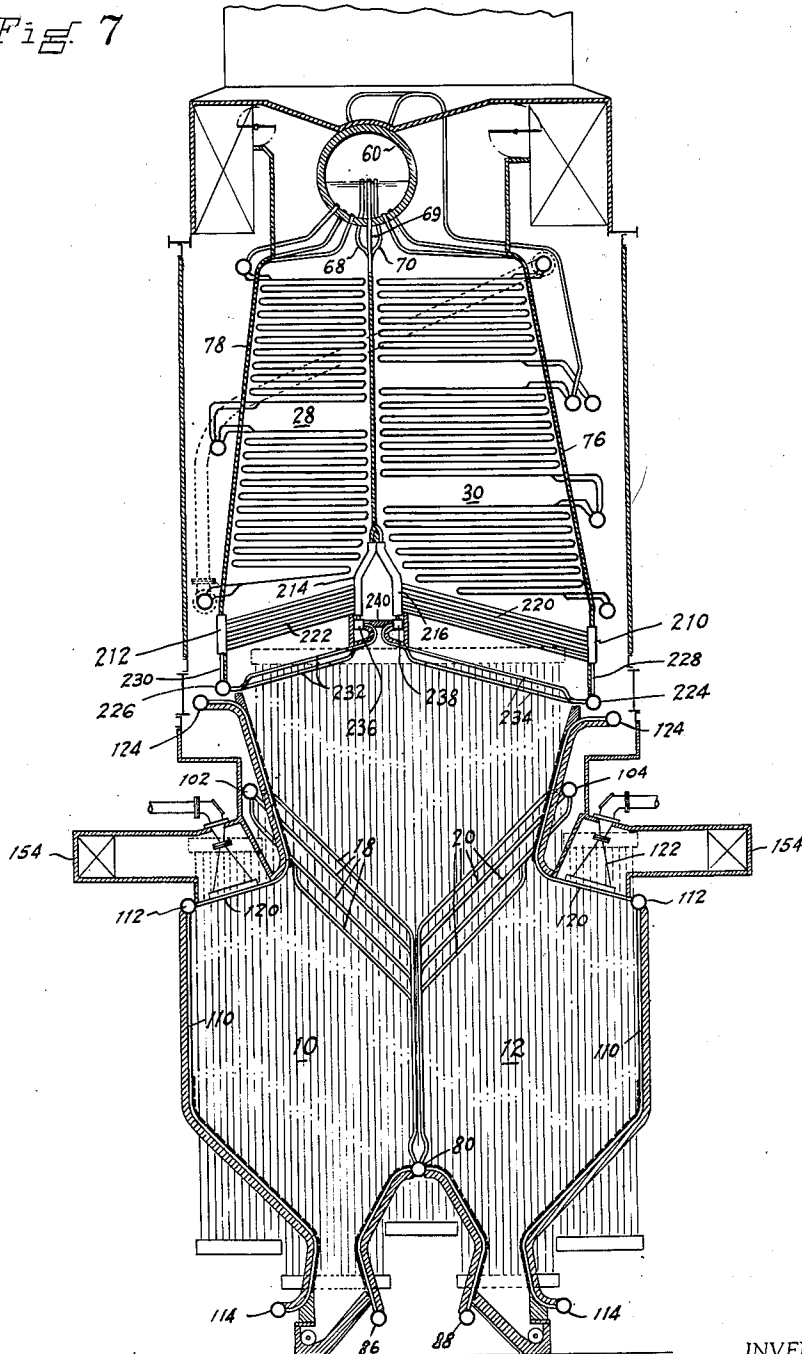
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FLUID HEAT EXCHANGE APPARATUS

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4 Sheets-Sheet 4

Fig 7



INVENTOR.

Dana H. N. Mayo

BY *Benj. K. Newcomb*
ATTORNEY.

UNITED STATES PATENT OFFICE

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FLUID HEAT EXCHANGE APPARATUS

Dana H. N. Mayo, Ridgewood, N. J., assignor to
The Babcock & Wilcox Company, Newark, N. J.,
a corporation of New Jersey

Application January 31, 1936, Serial No. 61,704

21 Claims. (Cl. 122—235)

This invention is concerned with fluid heat exchange apparatus and is here exemplified in a water tube steam boiler associated with a superheater.

It is a matter of prime importance in the operation of modern power plants that superheat temperatures be kept within a limited range. This is especially true when superheats in excess of 800° F. exist. Excessive variations above such temperatures not only involve uneconomical utilization of fuels but also endanger turbines or other prime movers utilizing the superheated vapor. It is an object of this invention to provide a vapor generator so associated with a superheater that such excessive superheat temperatures may be prevented and a predetermined superheat maintained.

Among its other objects the invention seeks to provide an effective superheater boiler having fluid cooled walls so constructed that multi-loop superheater coils may be removed or replaced by moving them through one of those walls and without disconnecting any of the tubes which cool the walls.

Another object of the invention is to provide a superheater boiler in which high capacity and a high degree of superheat control may be attained even though a pulverized coal fired furnace be utilized. The invention comprehends a double slag screen preventing excessive slagging of the superheater tubes.

Other objects will appear as the accompanying description proceeds.

The invention will be described with reference to the accompanying drawings, in which:

Fig. 1 is a view in the nature of a vertical section through a steam generating installation embodying the invention.

Fig. 2 is a view in the nature of a side elevation showing a part of one side of the installation indicated in Fig. 1. It is taken from the position indicated at 2—2 of Fig. 1 and looking in the direction of the arrows.

Fig. 3 is a view in the nature of a vertical section taken on the line 3—3 of Fig. 1 and showing a part of the installation.

Fig. 4 is a detail view showing the manner in which the intermediate gas pass baffle tubes are arranged with reference to the steam and water drum.

Fig. 5 is an upright view taken on the line 5—5 of Fig. 4 and showing some of the parts in vertical section.

Fig. 6 is a detail horizontal section showing the arrangement of wall tubes at those parts of the

furnace walls which are provided with openings through which the superheater and economizer tubes may be removed and replaced. This view is taken on the line 6—6 of Fig. 1.

Fig. 7 is a vertical section of a modified form of the Fig. 1 boiler.

Fig. 8 is a horizontal section of a stud tube wall including the wall tubes 68 and 70 of Fig. 5.

Fig. 9 is a diagrammatic detail view in the nature of a vertical section illustrating the manner in which the coils of the superheater or the economizer may be supported by the wall tubes at opposite sides of the gas passes 28 and 30.

Fig. 1 of the drawings discloses a furnace in which there are two combustion chambers 10 and 12. They are separated by the fluid cooled tubes 14 and 16, the upper parts of which diverge upwardly and are spaced vertically so as to form the slag screens 18 and 20. The tubes of the slag screen 18 extend across the gas outlet of the combustion chamber 10 and the tubes of the slag screen 20 bear a similar relation to the combustion chamber 12.

The furnace gases from the combustion chambers 10 and 12 pass across the tubes of the slag screens 18 and 20 into a secondary combustion chamber 22, and thereafter contact with the fluid cooled tubes of the slag screens 24 and 26, and are divided so as to proceed in parallel through two gas passes 28 and 30.

In the gas pass 30 the gases first contact with the superheaters 32 and 34, and then pass over the tubes of the first economizer section 36. Thence they pass to the flue 38 where the flow is controlled by a regulator 40.

In the gas pass 28 the gases contact with the second and third economizers 42 and 44, and afterwards pass to the flue 46 where the gas flow is controlled by the regulator 48. Beyond the regulators 40 and 48 the gases pass through outlets 50 and 52 to an air heater which may be located at 54.

Water delivered under pressure to the economizers passes through them and the header 56 and the tubes 58 to a steam and water drum 60 which is in circulatory connection with the slag screen tubes and the wall tubes to be described. Steam generated in these tubes passes to the drum, preferably above its water level, and downcomer connections complete the circulatory connection between the drum and the steam generating tubes.

A substantial part of the total steam is generated in the tubes of the slag screens 24 and 26. They converge upwardly from the lateral water drums 62 and 64 to an intermediate submerged

drum 66 which may be protected against overheating by refractory disposed between it and the oncoming furnace gases.

Steam, or a mixture of steam and water is delivered from the submerged drum 66 to the steam and water drum 60 through the baffle tubes 68 and 70 which preferably communicate with the drum 60 slightly above its water level. Between the gas passes 28 and 30 the tubes 68 and 70 may be in row alignment and the spaces between the tubes closed by refractory material. This may be installed as a plastic around metallic studs which are in good heat exchange relation with the tubes.

The water drums 62 and 64 communicate with the water space of the drum 60 through wall tubes 72 and 74, the latter being preferably arranged in row formation so as to delineate the gas pass wall 76 which is so related to the similar opposite wall 78 as to form a total gas passage which tapers upwardly as shown.

The downcomer connections supplying the tubes 14 and 16 with water include the header 80, the hopper tubes 82 and 84 and the headers 86 and 88. The latter communicate with large diameter downcomers 90 and 92 which are connected at their upper ends to headers 94 and 96. The water space of the drum 60 is connected to the header 94 by a plurality of tubes 98 and, similarly arranged tubes 100 establish communication between the header 96 and the drum 60.

Steam generated in the tubes 14 and 16 and the slag screens 18 and 20 passes to the headers 102 and 104 and thence through upcomers 106 and 108 directly to the water space of the drum 60.

The walls of the combustion chambers 10 and 12 opposite the dividing tubes 14 and 16 include wall tubes 110 bent at their lower ends to form hopper bottoms for the combustion chambers and connected to upper and lower headers 112 and 114. The latter preferably communicate with the water space of the drum 60 through downcomer tubes 118, the drums 62 and 64, and the tubes 72 and 74.

From the upper headers 112, wall tubes 120 extend in row formation in front of the pulverized coal burners 122 and thence upwardly past the headers 102 and 104 to positions wherein they are connected to the uppermost water wall headers 124. The latter deliver steam through the uptake tubes 128 directly to the steam space of the drum 60.

In the installation indicated in Fig. 1, steam passes from the top of the steam space of the drum 60 through tubes 130 to the inlet header 132 of the superheater 34. From this superheater it passes to the header 134 and then through to tubes of the superheater 132 to an outlet header 136 from which it may be directed to a point of use.

When pulverized coal is used as a fuel the burners 122 are supplied with fuel from the bunkers 140 by means of the feeders 142. The latter deliver the pulverized fuel to the outlets of the ducts 144 where it is entrained in the primary air passing from the ducts 146 into the burner tubes 148. Movement of air through the ducts 146 is caused by the fans 150 which may be driven by motors 152. The burners 122 are preferably down-shot burners supplied with secondary air through the boxes 154. The burners preferably direct the flame in a U-shaped course, first downwardly towards the hoppers 156 and 158 and then upwardly alongside the wall tubes 14 and 16.

Besides the independently operable sets of burners 122, the separate combustion chambers

10 and 12 are shown as supplied with independently operable gas burners 160 and 162. They are indicated as situated along the upright sides of the furnace, and connected with the gas means 164 and 166.

The burners are arranged in rows extending from front to back along each of two opposite side walls. Consequently, the furnace gases rising to the banks of tubes which extend from front to back have the same temperature of approach to each tube equally from front to back, especially the banks of superheater tubes. Also, the Fig. 1 boiler has, beyond the furnace, two gas passes into either of which the gases from all of the burners may be directed. The superheater being in one of these passes, all of the superheater tubes from front to back receive gases of the same temperature, but the amount of gases is controllable to regulate superheat. Such regulation is also effected by varying the temperature of the gas stream rising on the side of one gas pass.

With the illustrative apparatus, superheat may be closely controlled, and a substantially constant superheat maintained while the boiler load varies over a wide range.

The control of the superheat is exercised through the variation of temperature and quantity of the gases passing over the superheater, the gases leaving the furnace being substantially divided into two streams, one of which sweeps the superheater and the other sweeps boiler heating surface carrying fluid at or below the saturation temperature. The sets of burners for the combustion chambers 10 and 12 may be independently operated to accomplish a part of these results, and the arrangement of the slag screens 18 and 20 and the wall tubes 14 and 16 is such that the two streams of gases coming from the different combustion chambers never thoroughly mix. On the contrary, they will remain largely separated. The total efflux of gases from the furnace may be considered as stratified or laminated so as to constitute three streams flowing in parallel. The middle stream will be more or less of a mixture of the other two and the other two will consist of the products of the independently operable sets of burners for the different combustion chambers. The stream on the superheater side of the furnace can be made hotter or colder than the other stream by the control of these burners, to effect superheat control.

In addition to the superheat control caused by the independent operation of the different sets of burners the proportion of the total gases passing over the superheaters 32 and 34 may be controlled by the operation of the regulators 40 and 48. The boiler thus has a dual control of superheat. The control devices may be operated cooperatively, the two sets of burners varying the gas exit temperature on the superheater side with reference to that on the other side of the furnace while the regulators 40 and 48 vary the quantity of hot gases permitted to sweep the superheater.

The banks of tubes 18, 20, 24 and 26 cooperate to form a composite slag screen in which there are two pairs of oppositely diverging banks of tubes. The banks of tubes constituting the lower part of the slag screen converge downwardly toward a central position in the furnace while the banks of tubes 24 and 26 constituting the upper part of the slag screen converge upwardly toward a position somewhat toward the

economizer side of the upper part of the installation. With this arrangement there is a tendency for the furnace gases to be first turned convergently toward the opposite sides of the furnace, and thereafter be oppositely turned to a central position, this multiplicity of turns promoting effective deposition of solid particles from the gases. This arrangement of the component parts of the composite slag screen also provides a central path of gas travel which is longer than the paths at either side thereof, and, as shown, it provides an undivided space above the furnace dividing wall consisting of the tubes 14 and 16. In this space, combustion may be carried further toward completion, and rapid absorption of gas radiated heat is promoted.

Each of the hoppers 156 and 158 is shown as provided with ash removal means 170 and, preferably adjacent the hopper bottoms, some of the wall tubes 172, connected to the headers 174 and 175, are bent out of their row formation so as to provide elongated openings 176 and 178 through which the coils of a superheater or an economizer may be removed and replaced.

The specific arrangement of the tubes to provide the opening 176 is illustrated in Fig. 6. Below the opening 176 the tube 172' is in row alignment with the adjacent wall tubes. Above this position it is bent outwardly to the position indicated at 172'', and then alongside the opening 176 it is bent laterally. A reversed arrangement exists above the opening 176, and the opening may be normally closed by a cover plate 190. The latter may be latched, or spring pressed to a closed position.

Figs. 4 and 5 illustrate a construction in which the tube sections 68 and 70 are pendently supported from the drum 60. As shown, short tube sections 192, closed at their lower ends, are in communication with the water space of the drum 60, and expanded into the drum, or otherwise secured thereto. Fig. 5 illustrates each of these sections as having lugs 194 and 196 welded to its lower end, and extending beyond the lower end of the tube section. A similar upwardly extending lug 198 is welded to the tube 70 and attached to the lug 196 by any suitable means such as the bolt 200. The opposite tubes 68 have similar lugs 204 welded thereto and secured to the lugs 194 in a similar manner.

The boiler indicated in Fig. 7 of the drawings is, in many respects similar to that shown in Fig. 1. The primary combustion chambers 10 and 12 are the same, and the arrangement of the auxiliary heating surface elements in two parallel gas passes above the steam generating section is similar, but the latter includes upright sectional headers. The downtake headers 210 and 212 are connected with the water space of the drum 60 by the wall tubes of the walls 76 and 78, and the uptake headers 214 and 216, converging at their upper ends, communicate with the steam space of the drum 60 through the partition wall tubes 68, 69, and 70. These tubes pass directly through the drum wall and extend up in the drum to a position above the water level, as shown.

At the entrance of the gas pass 30 the tubes of the bank 220 connect the headers 210 and 216, and a similar bank of tubes 222 extends across the entrance of the gas pass 28 where they connect the headers 212 and 214.

Cross headers 224 and 226 are connected to the headers 210 and 212 by the nipples 228 and 230 and circulation through the boiler slag screen tubes 232 and 234 is thus provided. The latter

are connected at their upper ends to the cross headers 236 and 238, which in turn communicate with the sectional headers 214 and 216 at the lower ends of the latter. Movement of the furnace gases into the space between these sectional headers is prevented by a baffle 240 which preferably is positioned above the outwardly bent ends of the slag screen tubes.

Whereas, the invention has been described with reference to the specific structures indicated in the drawings, it is to be understood that the invention is not limited thereto, but is rather of a scope commensurate with the scope of the subjoined claims.

What is claimed is:

1. In a water tube steam boiler, a furnace fired by two sets of burners positioned on opposite sides thereof and divided between said sets by a row of water tubes, walls forming a plurality of gas passes arranged in parallel and receiving the furnace gases, a superheater in one of said passes at one side of the boiler, and an economizer in another pass, one of said sets of burners being disposed at the superheater side of the furnace and the other set at the economizer side.

2. In a vapor generator, a furnace from which two gas passes lead in parallel, means forming auxiliary fluid heating surface other than vapor generating surface in one of the passes, two sets of burners on opposite sides of the furnace with one set being on the auxiliary heating side of the furnace, a row of fluid cooled tubes positioned between said burner sets so as to divide the furnace, means including tubes defining a combustion chamber common to both gas passes, and vapor generating tubes extending across the entrances of said gas passes and above said common combustion chamber.

3. In the superheating of steam by high temperature furnace gases, a method of controlling superheat which comprises, producing a stream of furnace gases which is of non-uniform temperature in its cross section, dividing the stream of furnace gases into a plurality of parts forwardly of the superheater, using one of the divisions of said gases for superheating, independently controlling the quantity of gases supplied to said divisions and simultaneously controlling the temperature of the gases utilized for superheating, independently controlling the fractional part of the total quantity of gases utilized for superheating while using the remainder of the total quantity of gases for vapor generation only, and coordinating said independent controlling operations with reference to the temperature of the superheated steam.

4. In a water tube steam boiler, a furnace, a steam and water drum, steam generating tubes extending across the path of the furnace gases, circulatory tubes in an upright row connecting the steam space of the drum and the steam generating tubes and extending around a side of the drum toward the furnace gases, means connecting the generating tubes with the water space of the drum, and hangers connected to the drum and the circulatory tubes to suspend the latter in row formation from the drum.

5. In a steam generating installation, a furnace, a drum at each of two opposite positions near the opposite walls of the furnace, steam generating tube sections upwardly inclined from said drums toward a central position relative to gas flow from the furnace, and uptake tube sections receiving fluid from the generating sections and outlining an upright wall separating parallel

gas passes, a superheater in one of the passes, an economizer in the other, and means for proportioning the gas flow through the passes to control superheat.

6. In a water tube steam boiler, a boiler setting, a boiler furnace in the setting, a steam and water drum, fluid heat exchange tubes delineating a wall separating two parallel gas passes leading from the furnace, a fluid chamber communicating with said tubes at the base of the wall, inclined steam generating screen tubes extending from opposite sides of the chamber across the entrances to said gas passes and connected into boiler circulation to and from the drum, an economizer in the first of said passes, a superheater in the second pass, and means to regulate the gas flow over the superheater and thereby control superheat.

7. In combination with a water tube steam boiler, a furnace, means forming parallel gas passes leading from the furnace, oppositely inclined steam generating tubes extending across the entrances of the gas passes, a first economizer section in one of said passes, a superheater in the other pass, and a second economizer section exposed to furnace gases after they have passed over the superheater, said economizer sections being connected to the boiler and a source of feed water supply.

8. In a water tube steam boiler; a furnace fired from opposite sides with a slag forming fuel; a superheater; and a double slag screen; said slag screen comprising lower banks of tubes converging downwardly into the furnace and upper banks of tubes converging upwardly toward an intermediate position, the superheater being positioned beyond the slag screens with reference to gas flow.

9. In a water tube steam boiler; a furnace burning a slag forming fuel; fluid heat exchange tubes contacted by the furnace gases; and a double convex slag screen operating to prevent deposition of slag on said tubes; said screen comprising upper banks of inclined tubes converging upwardly across the path of the furnace gases from opposite sides of the furnace, lower banks of inclined tubes converging downwardly from the same sides of the furnace, and means for connecting said tubes into fluid circulation.

10. In a high head water tube steam boiler, a boiler setting, a steam and water drum at the top of the setting, a furnace at the lower part of the setting, steam generating tubes including wall tubes depending from said drum, downcomer wall tubes at opposite sides of the first mentioned wall tubes and co-operating therewith to form parallel gas passes tapering upwardly, banks of superheater and economizer tubes extending across said passes, and means for supporting said last named tubes from the wall tubes.

11. In combination with a steam boiler, a furnace including a plurality of combustion chambers, a wall including wall cooling tubes separating said chambers and having extensions forming slag screens upwardly diverging from said wall, down shot burners utilizing a slag forming fuel and directing flames against said wall from opposite directions, walls forming parallel gas passes beyond the slag screens relative to gas flow, and a superheater in one of said gas passes.

12. In a water tube steam boiler, a steam and water drum, a first wall including uptake tubes communicating with the drum, rows of downcomers connected with the water space of the drum and extending downwardly therefrom to

delineate walls forming upwardly tapering gas passes separated by said first wall, means forming a fluid pressure chamber between said passes and having the lower ends of the uptake tubes connected thereto, a header or drum connected to each row of downcomers, a bank of inclined steam generating tubes extending from each drum or header to said chamber, and auxiliary fluid heat exchange tubes extending across said gas passes.

13. In a water tube steam boiler, a furnace, a boiler circulation system including tubes delineating a plurality of gas passes extending in parallel from the furnace, a superheater in one pass, an economizer in the other pass and means for proportioning the flow of furnace gases between said passes to the end that superheat is controlled, said means including two sets of fuel burners at opposite sides of the furnace with one of said sets positioned at the superheater side of the furnace.

14. In a water tube steam boiler, a boiler furnace, steam generating tubes over which the furnace gases pass, means forming a plurality of gas passes communicating with the furnace in parallel, a superheater in one of said passes, an economizer in the other pass, and means proportioning the flow of furnace gases over the economizer and the superheater, said last named means including two sets of burners on opposite sides of the furnace with one set being on the side of the superheater gas pass.

15. A steam generator comprising a setting, means providing a combustion chamber, a bank of steam generating tubes disposed above said chamber but at a substantial distance below the top of the setting, a steam and water drum located adjacent to the top of the setting, a plurality of circulating tubes connecting said bank with said steam and water drum, means within the setting for providing a plurality of vertical gas passes above said bank, said passes being arranged in parallel, means providing auxiliary heat absorbing surface in each of said passes, said auxiliary heat absorbing surface including a superheater disposed in one of said passes, an economizer disposed in another of said passes, a drum or header between said passes, and banks of steam generating tubes connected to said drum or header and extending across the entrances to said gas passes.

16. In a steam boiler combination, a boiler setting, two side-by-side hopper bottom furnaces with the inclined sides of the hopper bottoms and the adjacent furnace walls defined by wall cooling tubes connected into the boiler circulation, the division wall between said furnaces including a double row of said wall tubes communicating with a common drum or header to compensate for tendencies to develop different circulation conditions in the wall tubes of the respective furnaces, means for independently firing the furnaces, spaced tubes forming a convection heated section subjected to the heat of the furnace gases, means forming a furnace gas chamber common to the outlets of said furnaces and located forwardly of said section relative to gas flow, said last named means including oppositely inclined banks of furnace screen tubes extending across said furnace outlets and acting to receive the fluid discharged from said division wall tubes, a steam and water drum above said section, and means establishing communication between the discharge ends of said screen tubes and the drum, the division wall tube portions acting as risers for tube portions defining parts of the hopper bottoms.

17. The method of operating a furnace having a superheater and steam generator, the method including dividing the combustion gases passing therethrough; passing some of the gases in contact with a series of economizer surfaces while passing the remainder of the gases in contact with one or more superheaters and economizer surfaces; and regulating the velocity, temperature, and volume of gases passing over the economizer surfaces of each division.

18. A steam generator comprising, in combination, a plurality of combustion chambers, means for independently firing said combustion chambers, a gas radiation chamber receiving furnace gases from the combustion chambers, screen tubes between each combustion chamber and the gas radiation chamber, a pair of parallel chambers each forming a continuation of the gas radiation chamber and providing separate gas passes leading therefrom, screen tubes across the entrances of said passes, a superheater section and an economizer section in one of the gas pass chambers, another economizer section in the other gas pass chamber, a flow regulator for each of the said gas pass chambers, and a steam and water drum to which the superheater and economizer sections are connected.

19. A steam generator comprising, in combination, a plurality of combustion chambers, a partition including baffle tube sections between adjacent combustion chambers, a gas radiation chamber leading from the outlets of said combustion

chambers, and means for directing furnace gases from the radiation chamber in two independent paths over an economizer section in one instance and a superheater section and another economizer section in the other instance.

20. A steam generator comprising, in combination, a plurality of separate combustion chambers, a gas radiation chamber into which each of the combustion chambers open, a pair of chambers each forming an independent continuation of the gas radiation chamber and providing separate gas passes therefrom, wall cooling tubes lining the walls of each gas pass chamber, an economizer section in one gas pass chamber, a superheater section in the other gas pass chamber, and means for controlling the rate of heat transfer in each gas pass chamber.

21. In a water tube steam boiler, laterally adjacent furnaces, means including downshot pulverized fuel burners for independently firing the furnaces, a water cooled wall including wall tubes separating said furnaces, water tubes connected into the boiler circulation and forming a screen across the gas outlet of one of said furnaces, means forming a secondary combustion zone beyond said screen, a plurality of convection heating gas passes arranged in parallel and leading from the secondary combustion zone, a superheater in one of said passes, and an economizer in one of said passes.

DANA H. N. MAYO.