Aug. 16, 1938. D. BUMSTEAD, JR 2,126,730

STEAM BOILER AND FURNACE

Filed April 26, 1935 4 Sheets-Sheet 1

Fig. 1

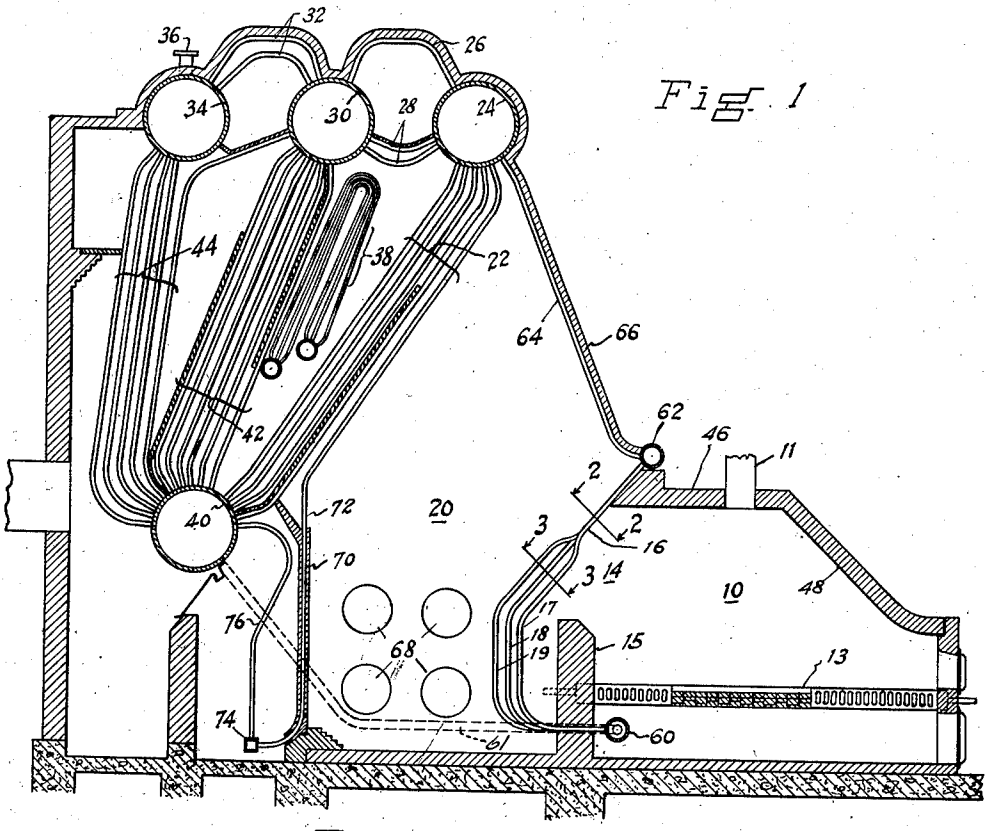


Fig. 2

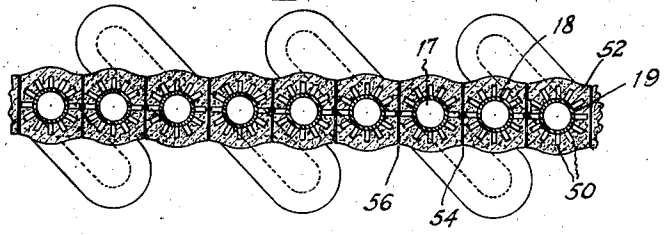
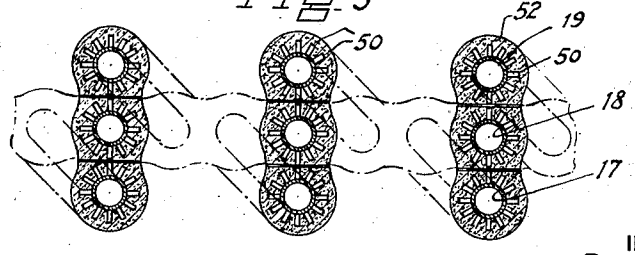


Fig. 3



INVENTOR
Dale Bumstead, Jr.
BY
Benj. R. Newcomb
ATTORNEY

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STEAM BOILER AND FURNACE

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Fig. 4

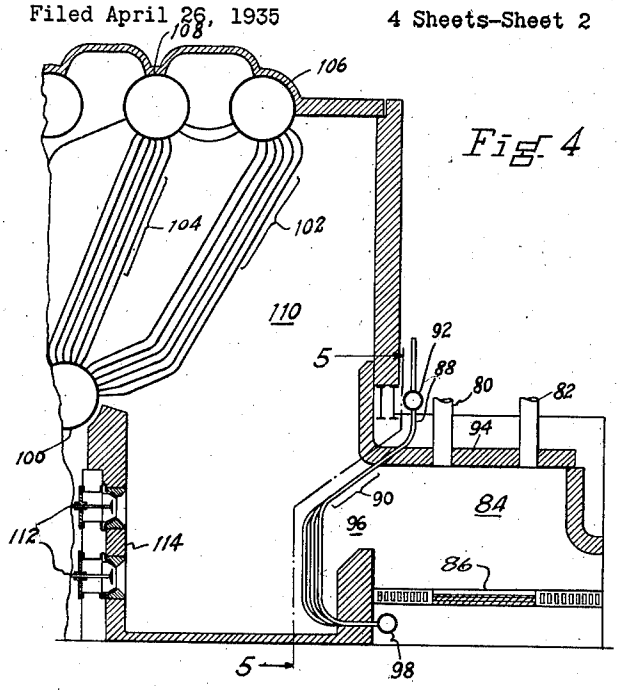


Fig. 5

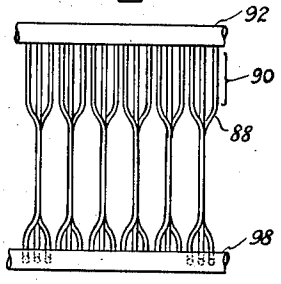
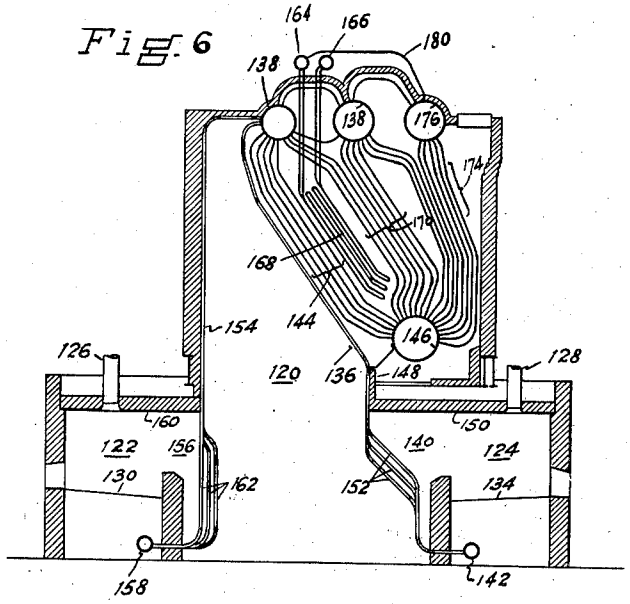


Fig. 6



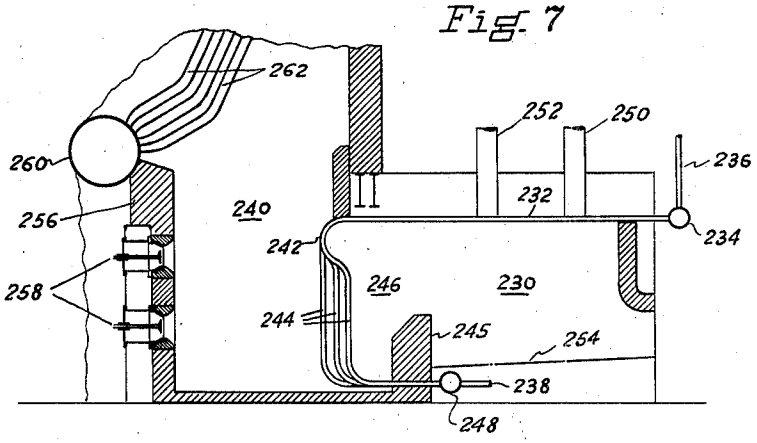
INVENTOR
Dale Bumstead, Jr.
BY
ATTORNEY

Aug. 16, 1938. D. BUMSTEAD, JR 2,126,730

STEAM BOILER AND FURNACE

Filed April 26, 1935 4 Sheets-Sheet 3

Fig. 7



INVENTOR
Dale Bumstead, Jr.
BY
ATTORNEY

Aug. 16, 1938. D. BUMSTEAD, JR 2,126,730

STEAM BOILER AND FURNACE

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Fig. 8

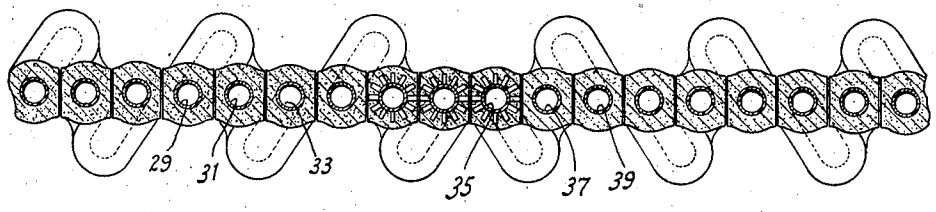


Fig. 9

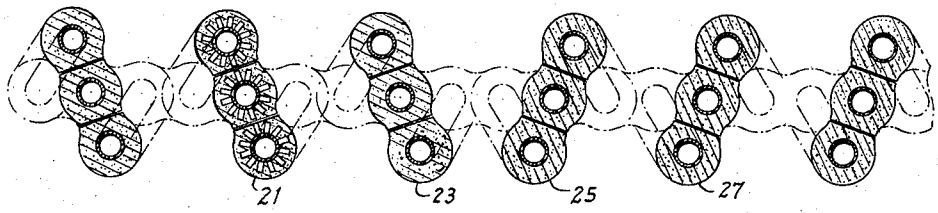
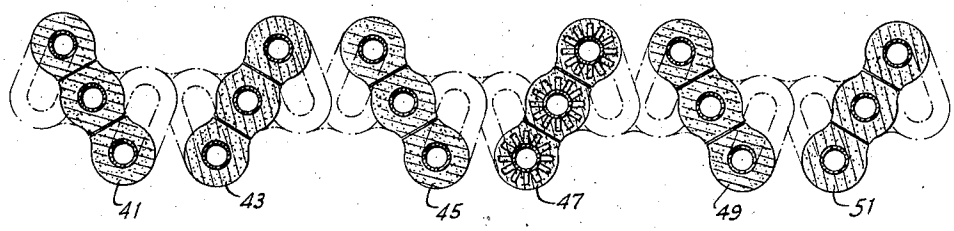


Fig. 10



INVENTOR.
Dale Bumstead, Jr.
BY
ATTORNEY.

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UNITED STATES PATENT OFFICE

2,126,730

STEAM BOILER AND FURNACE

Dale Bumstead, Jr., Portland, Oreg., assignor to The Babcock & Wilcox Company, Newark N. J., a corporation of New Jersey

Application April 26, 1935, Serial No. 18,334

18 Claims. (Cl. 122—235)

This invention relates to multiple furnace installations for fuels of different combustion characteristics. It is exemplified herein as a dual furnace steam boiler.

The invention is concerned with furnaces wherein fuels having different physical properties and different combustion characteristics can be simultaneously or independently burned in a proper manner. The combination furnace of the invention is primarily intended for use in plants where combustible waste material is present in sufficient quantity to provide a material portion of the fuel requirement, and it has special advantages when used as the furnace portion of steam generating apparatus.

One object of the invention is to provide an improved construction of a multiple furnace steam boiler installation characterized by provisions for maintaining a high combustion efficiency and for protecting portions of the furnace structure ordinarily exposed to high furnace temperatures. A further object of the invention is to provide an improved combination furnace particularly adapted for burning of a finely divided fuel in suspension in one furnace combustion chamber, and of a high volatile long flaming fuel in a bed or pile in a second combustion chamber from which the furnace gases discharge into the first.

Recent developments pertaining to power generation have emphasized production economy matters as prime factors. The demand for power at lower rates has particularly effected this result where steam operated electric generating plants are used. Intense competition and an over-supply of generating capacity have also made it increasingly important to decrease production costs.

It has been proposed that fuels of low cost be burned, but it has been appreciated that the actual use of such fuels in generating stations would be beset with many difficulties. For example, the conditions pertaining to burning of the byproducts of saw mill operations will be considered. These operations have resulted in tremendous accumulations of sawdust, shavings, and broken wood particles, known sometimes in the trade as "hogged fuel". Its moisture content is high, not only on account of the fact that it is derived from green timbers but also on account of the fact that it is accumulated in the open where it is effected by rain and snow, or it is the residue of water soaked logs floated to the mill. It is therefore difficult to burn effectively in furnaces of power boilers where high temperatures and high combustion rates are desideratums and where efficiencies must be as high as practicable. Many opposing factors must be considered in the operation of such furnaces. For instance, furnace temperatures must be higher than ignition temperatures as much as possible. Otherwise the fuel cannot be completely burned at an effectively high rate. The high moisture content makes it imperative that heat absorbed during combustion by cold boiler surfaces be limited. Consequently such surfaces must not be in sight of the furnace. Ceramic refractory walls are alsq demanded to keep the furnace temperature high enough. However, if the wall temperatures of the furnace become too high the wood ash in suspension accumulates on the refractory and causes a flexing reaction which, on account of the composition of the fused ash, is particularly destructive to the walls. The furnace walls will be destroyed and considerable time is lost while the furnace is rebuilt. When this results in boiler "outage", i. e. shutting down the boiler, effective power generation is imposible. Consequently, the furnace must be kept within a relatively narrow temperature range. This limits furnace capacity and renders such fuels unsuitable for power plant use, when used alone, by reason of the very large size of furnace required and its poor adaptability to operation at both very low and very high combustion rates corresponding to load changes.

Electric power generating stations are particularly subject to "peak load" conditions. That is, for example, there are one or two hours of each day when there is a maximum or near maximum load. At other times the load will vary but will be relatively low. Consequently, steam operated plants require high capacity furnaces which can respond to a wide range of load variation. A furnace burning waste wood fuel cannot effectively meet such peak load requirements and still operate well at very low loads, but it is highly advantageous to use it for the lower load ranges or for a more or less steady base load requirement. As a solution of this problem, this invention comprehends the combining of such a waste fuel furnace in a particular way with a furnace of the high heat release type of flexible range as to rates. The latter burns a high grade fuel such as oil or pulverized coal and is capable of high combustion rates and is also suitable for low rate operation. High furnace temperatures are attained and high capacities, capable of meeting peak load conditions, characterize this furnace which may have cold absorbing surface in sight without impairment of its performance.

The waste wood furnace is a furnace with a low

heat release rate, and certain of its combustion characteristics must be taken into consideration in co-relating it with the other furnace. Also, these characteristics must be considered along with the properties of the different fuels used.

In plotting temperatures against furnace heat release rates, for a given fuel there will be a theoretical flame temperature which the actual temperature may approach without ever reaching. This is the temperature for combustion with no moisture, no excess air, and no absorption of radiantly (or otherwise) transmitted heat during combustion. When the same fuel is burned with moisture present, with an excess of air, and with no absorption of heat during combustion, there is another limit, the adiabatic temperature, lower than the theoretical flame temperature, and the actual furnace temperature approaches it as the heat release rate increases. Absorption of heat during combustion, still further limits the possible furnace temperature. The actual flame temperature does not, however, actually reach the adiabatic limit. Even with no absorption, and still less when there is absorption, actual flame temperatures increase as heat release rates increase under these combustion conditions, but there is always a limit beyond which the temperature can not go. This limit is relatively low for wet wood and other waste fuels. Consequently furnaces burning such fuels are classed as cold furnaces, and, to prevent them from being too cold, absorption of heat must be limited until after combustion is completed.

When a good fuel, such as oil or pulverized coal is burned there is a relatively rapid increase in furnace temperature as the heat release rate increases because the adiabatic value is very high due to absence of moisture and low excess air requirements. The temperature will relatively quickly exceed the ignition point and will approach, at a relatively small fraction of the possible heat liberation rate, the temperature at which furnace wall damage will occur in the event that the walls are of ceramic refractory material. The problem then, in such furnaces for good fuel is wall protection by absorbing heat during combustion, to keep temperatures below the value at which wall damages will take place. There is never any difficulty in keeping them above the ignition point.

In the poor fuel furnace, the problem is to keep the temperature above the ignition point so that effective combustion may be maintained, but not too much above, in the interest of wall protection, and absorption of heat during combustion must be limited or prevented.

The present invention presents a multiple furnace boiler in which both types of furnaces are combined and arranged with reference to the above conditions so that they may be effectively operated separately or simultaneously with the furnace gases from the furnace of low heat release rate always passing through the furnace of the other type before contacting with the steam generating surfaces of the boiler.

In addition to the objects indicated above, it is an object of the invention to so combine a furnace burning waste wood fuels, known in the art as "hogged fuel", with other furnaces burning a fuel in suspension that the walls of the hogged fuel furnace will be maintained in a heated condition while the fuel is burned in suspension in the other furnace. Another object of the invention is, in this combination, to limit the radiation from the hogged fuel furnace and simultaneously prevent excessive damage by ash impact fluxing action against the gas deflector which cooperates in limiting radiation from the furnace.

A further object of the invention is to so combine a hogged fuel furnace with a second furnace burning fuel in suspension that the excessive costs of maintaining refractory drop nose arches at the outlets of the hogged fuel furnace are greatly reduced. To this end it is an object of the invention to provide a wall consisting of refractory covered studded tubes connected into boiler circulation and positioned at the outlet of the hogged fuel furnace in such a way that it is subject to flame impact from the hogged fuel furnace and directs the products of combustion downwardly to the outlet of that furnace and into the furnace burning the finely divided fuel in suspension.

Other objects of the invention 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 showing a 4-drum Stirling boiler which is associated with a primary furnace burning waste wood fuel, and a secondary furnace burning fuel in suspension.

Fig. 2 is a section taken on the line 2—2 of Fig. 1, indicating the construction of the deflector wall between the two furnaces.

Fig. 3 is a section taken on the line 3—3 of Fig. 1, indicating the furnace screen construction formed by the tubes which also form a support for the walls shown in Fig. 2.

Fig. 4 is a vertical section showing a modification of the fluid cooled wall between the two furnaces.

Fig. 5 is a detail view in the nature of a side elevation taken on the position indicated by 5—5 in Fig. 4, and looking in the direction of the arrows.

Fig. 6 is a vertical section of a further embodiment of the invention in which two hogged fuel furnaces are arranged at either side of the first furnace which burns fuel in suspension.

Fig. 7 is a partial sectional view of an additional embodiment of the invention.

Fig. 8 is an extended sectional view of a wall between the combustion chambers 84 and 110.

Fig. 9 is a horizontal section through the furnace screen separating the combustion chambers 10 and 20, showing converging screen walls directing the furnace gases toward the center of the main combustion chamber.

Fig. 10 is a horizontal section showing a modification of the tubular screen with alternate screen walls oppositely angled.

The steam generating installation illustrated in Fig. 1 of the drawings includes the refractory wall furnace 10. A long flaming fuel such as the wood by-products from saw mill operations may be burned in this furnace. It is delivered thereto by the conveyor 11, and is burned on a grate 13. The products of this combustion pass from the furnace through the outlet 14, which is shown as located between the refractory bridge wall 15 and the fluid cooled arch wall 16. After passing between the fluid cooled furnace screen tubes 17, 18 and 19 further combustion takes place in the combustion chamber 20. Thereafter the furnace gases pass across the front bank 22 of steam generating tubes of a Stirling boiler.

The pressure parts of the boiler include a front

steam and water drum 24 directly connected by steam circulators 26 and water circulators 28 to the drum 30 from which steam passes to the offtake drum 34 and through the offtake connections 36 to the superheater 38 and thence to a point of use, or directly from the drum 34 to such point of use. The drum 30 is connected to the drum 34 by steam circulators 32. The lower drum 40 is directly connected to the upper drums by separate banks of tubes. Rearwardly of the bank of tubes 22 there is a middle bank of tubes 42 and a rear bank of tubes 44. The by-products from saw-mill operation include saw dust, shavings, bits of bark, and miscellaneous refuse, which are accumulated in large quantities and allowed to stand in exposed positions. The moisture content of such fuel is normally high. This renders the fuel difficult to burn unless means are provided to keep the furnace as hot as possible, and this construction is directed to this end. The furnace 10 therefore, has a roof 46 and walls 48 and 16 extending downwardly from the roof, faced with ceramic refractory material which, when heated to incandescence, reflects intense radiant heat upon the fuel in the center of the furnace. The bridge wall 15 is combined with the refractory faced wall 16 to limit heat radiation losses from this primary furnace.

It has been proposed to use solid refractory drop nose arches at the position of the wall 16, but the use has not been successful or economical. Such arches are located at a turning point in the furnace gases and are subject to intense flame impact and some erosion, in addition to the refractory fluxing action set up by the tendency of the fused ash suspended in the flame to cause a chemical reaction which is destructive.

The wall 16 of the illustrative furnace organization is protected against such destructive tendencies by reason of the fact that it includes the fluid cooled tubes 17, 18 and 19. These tubes are preferably arranged in a row as indicated in Fig. 2, and have welded thereto metallic studs 50. These studs, when they are surrounded by the refractory material 52, act to control furnace temperatures and the wall fluxing action caused by the impact of flame and fused ash.

The refractory material 52 may be installed as a plastic between combustible partition members 54 and 56. When the wall is installed and the furnace is in operation these partition members will leave each tube covered with its own individual body of refractory material. This will prevent such breakage of the wall as might be caused by expansion and contraction stresses if the wall were a monolith. The fluxing away of any of the refractory results in flame and ash impact upon refractory material which is nearer the studs 52, and hence subject to greater cooling action originating in the fluid circulating through the tubes 17, 18, and 19.

Below the wall 16 the wall tubes are indicated as forming a screen through which furnace gases pass from the furnace 10. Figs. 2 and 3 indicate the manner in which the tubes are bent and arranged so as to form this screen, Fig. 3 particularly indicating the arrangement of the tubes in the screen. For instance, the tube 19 is bent to the left from its wall forming position indicated in Fig. 2 so that it is positioned directly behind the tube 18, as indicated in Fig. 3. The tube 17, on the other side of the tube 18 in the wall formation is bent so that it is positioned forwardly of the tube 18, as also indicated in Fig. 3. This arrangement promotes good combustion and affords considerable resistance to the flow of gases. The tubes, at their screen positions may also be covered with studs and refractory material as described with reference to the wall 16.

In the present case the tubes 17 and 18 are connected into the boiler circulation. At their lower ends they are preferably connected with a header 60 which may have a circulatory connection 61 with the drum 40 or 24. A similar header 62 is connected to the tubes at their upper ends. Fluid passing from the drum 40 through the header 60 and thence through the tubes 17, 18 and 19 continues its upward course through the header 62 and the wall tubes 64 which are shown as directly connecting the drum 24 to the header 62. These latter wall tubes act as wall protection for the refractory layer 66 with which they combine to form a furnace wall for the combustion chamber 20.

When the fuel burners 68 are used, the combustion chamber 20 forms a part of a secondary furnace which may be operated independently or, simultaneously with the furnace 10. The fuel burned in this secondary furnace may be oil, gas, or pulverized coal. When such fuels are burned the bridge wall 15 is protected by the screen tubes and the wall 70 is kept within an economical temperature range by the wall tubes 72. These tubes extend upwardly from the header 74 which is connected to the drum 40 by circulators 76. As shown, the tubes 70 extend upwardly to the drum 24 at positions in front of the steam generating tubes of the bank 22 which directly connect the drums 24 and 40. They may thus constitute a slag screen for the boiler.

The wood by-products delivered through the conveyors 80 and 82 to the primary furnace 84 of the Fig. 4 embodiment may be supported upon a water cooled grate at the position 86. This grate has tubes constituting grate bars and connected into the fluid circulation of the boiler. In this embodiment the tubes 88 forming the wall 90 extend downwardly from the header 92 through the roof 94 of the furnace. After forming a screen opposite the gas outlet 96 they extend downwardly to a header 98 which may be connected to the drum 100 of a steam boiler similar to that shown in Fig. 1. Front and middle banks of tubes 102 and 104 connect this lower drum to upper drums 106 and 108.

The secondary furnace 110 of the Fig. 4 embodiment may have burners 112 positioned in the wall 114. These burners are preferably provided for a short flaming fuel such as the fuel mentioned in connection with the description of the Fig. 1 modification.

Fig. 5 illustrates the manner in which the tubes 88 are arranged when connected to the headers 98 and 92. In this case the tubes are viewed in vertical elevation so as to indicate the gas passages below the refractory covered wall 90 which includes the upper parts of the tubes.

The Fig. 6 modification shows the steam boiler installation including the furnace 120 interposed with reference to the by-product furnaces 122 and 124. The latter are located on opposite sides of the installation and are of the same general type as the by-product furnaces of the Fig. 1 and Fig. 4 modification. They include the fuel delivery means 126 and 128 and may have water cooled grates at positions indicated at 130 and 134.

Tubes 136 extend downwardly from the boiler drum 138 past the outlet 140 of the furnace 124 to a header 142 which may be connected into

the fluid circulation of the boiler by any suitable means. These tubes form a slag screen in front of the tubes of the first bank of steam generating tubes of the boiler, and below the drum 146 they are positioned as wall tubes in front of the refractory wall 148. From this position they may extend downwardly in wall formation past the roof 150 of the furnace 124 and have studs welded thereto to maintain such refractory material as that illustrated in Fig. 2 of the drawings. Below this wall the tubes are arranged to form the furnace screen 152.

Opposite the furnace 124 the combustion chamber of the furnace 122 has wall tubes 154 preferably leading downwardly from and connecting to the drum 138, extending across the outlet 156 of the furnace 122 and communicating with the header 158 connected into boiler circulation.

Tubes 154 may extend below the roof 160 in wall formation, and below that roof be arranged in screen formation to provide the screen 162. Studs and refractory may be provided as a covering for these tubes.

The boiler shown in the Fig. 6 modification includes a superheater having upper headers 164 and 166 supporting a pendant superheater 168. This superheater is interposed with reference to the bank of tubes 144 and the middle bank 170, the latter being composed of some tubes which lead directly from the drum 138 to the drum 146 and other tubes which lead from the drum 138 to the lower drum 146. The rear bank of tubes 174 include some tubes directly connecting the steam offtake drum 176 to the drum 146 and other tubes which directly connect the drums 138 and 146. Saturated steam passes from the offtake drum 176 through the line 180 to the superheater header 164.

In the steam generating installation indicated in Fig. 7 of the drawings the by-product furnace 230 has a roof protected by the cooling effect of roof tubes 232 and these may be connected into fluid circulation by the header 234 and circulatory connections 236 and 238.

At the end of the by-product furnace 230 adjacent the furnace 240, the roof tubes are bent downwardly to form the curved arch 242. At this position the tubes may have studs welded thereto, and the tubes and studs covered with refractory in the manner indicated in Fig. 2 of the drawings. The roof portions of the tubes may also be similarly covered so as to form a ceramic refractory roof for the furnace.

Below the refractory covered arch 242 the tubes are bent out of their wall formation to form a screen 244 across the furnace outlet 246. Below this screen the tubes extend through the bridge wall 245 and are connected to a header 248. The by-product fuel is supplied to the furnace 230 by conveyors 250 and 252 which may deposit the fuel in constantly burning piles upon a water cooled grate located at the position indicated by the layer 254.

The furnace 240 of the installation indicated in Fig. 7 has an upright wall 256 through which burners 258 may extend. A fuel of high B. t. u. value such as gas, oil or pulverized coal may be burned in the furnace 240. Above the furnace 240 may be located a steam boiler similar to that shown in Figs. 1, 4 and 6. It seems unnecessary to show in this view anything more than the drum 260 and a part of the bank of steam generating tubes 262.

While the invention has been described with reference to the particular embodiments shown in the drawings, it is to be appreciated that it is not limited to all of the structural details thereof. For example, attention is invited to the disclosures of Figs. 1, 2 and 3 of the drawings. The latter two figures illustrate the relation of the wall 16 formed by the upper parts of the studded tubes to the walls formed by the lower portions of the studded tubes, the tube portions 17, 18 and 19. While the walls formed by these lower tube portions are shown substantially normal to the wall 16 the invention comprehends an arrangement of these tubes so that the gases will be deflected to one side or the other of the combustion chamber 20. The walls formed by these lower portions of the studded tubes may, in such additional modifications, be arranged obliquely with reference to the wall 16 so as to direct the furnace gases alternately to the right and to the left in a manner generally corresponding to vanes of oil burners. Again, some of the walls formed by the tube portions 17, 18 and 19 may at one part of the furnace direct the furnace gases toward the right and at another part direct them toward the left. The turbulence secured in such manners increases the rate of combustion and reduces the necessary size of the secondary combustion chamber. Again, the walls such as those shown in Fig. 3 of the drawings may be arranged so as to direct the furnace gases away from the side wall of the combustion chamber 20, thereby minimizing wall erosion and protecting the walls in a zone where they may be particularly subject to damage.

Fig. 8 of the drawings shows an extended arrangement of the upper portions of the tubes which divide the main and auxiliary furnace and Fig. 9 shows an embodiment of a furnace screen in which the gases flowing from the furnace 10 are directed toward the center of the combustion chamber 20.

Fig. 9 shows sets of converging walls, the wall 21 being formed by parts of the tubes 29, 31, 33, and the wall 25 being delineated and supported by the tubes 35, 37, and 39. The remaining walls 23 and 27 are similarly formed.

In the Fig. 10 embodiment the adjacent screen walls, such as the walls 45 and 47, are oppositely angled. Fig. 10 shows the additional walls 41 and 43, 49 and 51 which are similarly arranged.

What is claimed is:

1. In a dual furnace steam boiler installation, a first combustion chamber, means for burning fuel in suspension in said chamber, a second combustion chamber at one side of said first chamber, means for burning a long flaming fuel in said second combustion chamber, and refractory covered tubes connected into boiler circulation and forming a wall deflecting the gases from the second combustion chamber downwardly into the first, parts of said refractory covered tubes extending downwardly relative to the top of the second combustion chamber.

2. In a dual furnace steam boiler installation, a first combustion chamber, means for burning fuel in suspension in said chamber, a second combustion chamber at one side of said first chamber, means for burning a poor grade of fuel in said combustion chamber, and refractory covered tubes connected into boiler circulation and having parts extending downwardly relative to the top of the second combustion chamber and forming a wall deflecting the gases from the second combustion chamber downwardly into the first, said tubes having separate refractory coverings so that the wall formed thereby will not be ex-

cessively broken by expansion and contraction stresses.

3. In a dual furnace steam boiler installation, a first combustion chamber, means for burning fuel in suspension in said chamber, a second combustion chamber disposed at one side of said first chamber and having an outlet communicating with the first combustion chamber, means for burning a poor grade of fuel in said combustion chamber, and refractory covered tubes connected into boiler circulation and having parts extending downwardly relative to the top of the second combustion chamber and forming a wall deflecting the gases from the second combustion chamber downwardly into the first, said tubes being bent out of their wall formation to form a furnace screen extending across the outlet of the second combustion chamber.

4. In a steam boiler installation, a bank of steam generating tubes constituting pressure parts of the boiler, a "hogged fuel" boiler furnace having ceramic refractory walls extending downwardly from a roof of similar material, a second furnace burning other fuel and forming a combustion space for the "hogged fuel" furnace, said furnaces being connected by a gas passage or opening, and refractory covered studded tubes connected into the boiler circulation and having parts forming a wall deflecting combustion elements of the "hogged fuel" furnace downwardly into the second furnace, said studded tubes having other parts extending downwardly from said wall as a furnace screen in which the gas passages between adjacent groups of the tubes are wider than one of said groups, said studded tubes constituting in effect a fluid cooled drop nose arch for the hogged fuel furnace.

5. In a steam boiler installation, a bank of steam generating tubes constituting pressure parts of the boiler, a "hogged fuel" boiler furnace having ceramic refractory walls, a second furnace burning other fuel and forming a combustion space for the "hogged fuel" furnace, said furnaces being connected by a gas passage or opening, and refractory covered studded tubes connected into the boiler circulation and having parts forming a wall deflecting combustion elements of the "hogged fuel" furnace downwardly into the second furnace, said studded tubes also having other parts extending downwardly from said wall as a furnace screen in which the gas passages between adjacent groups of the tubes are wider than one of said groups, said studded tubes constituting in effect a fluid cooled drop nose arch for the hogged fuel furnace.

6. In a multiple furnace steam boiler installation, a main combustion chamber having fluid cooled walls, means for buring fuel in suspension in said chamber, a second combustion chamber at one side of said main combustion chamber, a grate located in the lower part of the second chamber, a vertically extending bridge wall between said grate and the main combustion chamber, and a plurality of refractory covered studded tubes connected into fluid circulation and having parts extending downwardly to form a gas deflecting wall above the bridge wall.

7. In a steam boiler installation, a bank of steam generating tubes constituting pressure parts of the boiler, a "hogged fuel" boiler furnace having ceramic refractory walls, a second furnace burning a poor grade of fuel in suspension and forming a combustion space for the "hogged fuel" furnace, said furnaces being connected by a passage or opening, and refractory covered studded tubes connected into the boiler circulation and having parts forming a wall deflecting combustion elements of the "hogged fuel" furnace downwardly into the second furnace, said studded tubes having other parts constituting in effect a fluid cooled flame impact wall for the hogged fuel furnace, and extending downwardly from said wall as a furnace screen in which the gas passages between adjacent groups of the tubes are wider than one of said groups.

8. In a multiple furnace steam boiler installation, a main combustion chamber having fluid cooled walls, means for burning fuel in suspension in said chamber, a second combustion chamber at one side of said main combustion chamber, a water cooled grate located in the lower part of the second chamber, a vertically extending bridge wall between said grate and the main combustion chamber, and a plurality of refractory covered studded tubes connected into fluid circulation and having downwardly extending parts forming a gas deflecting wall above said bridge wall, said tubes each having separate bodies of refractory which have such a close spacing near the roof of the second combustion chamber that they form a substantially complete gas deflecting wall.

9. In a water tube steam boiler installation, steam generating tubes, a primary furnace having refractory walls and otherwise adapted for burning fuels such as the waste wood resulting from saw mill operations, said walls forming a furnace gas outlet, a second furnace between the steam generating tubes and the primary furnace, refractory covered stud tubes connected into the boiler circulation and positioned between the furnaces so as to form a refractory faced gas deflecting wall extending downwardly from the roof of the primary furnace, said tubes being bent out of their wall forming positions below said wall to form a screen of spaced groups of tubes affording relatively small resistance to gas flow across the outlet of the primary furnace, means for delivering waste wood fuel to the primary furnace, and fuel burning means extending through a wall of the second furnace, said deflecting wall including separate bodies of refractory material covering and supported by separate tubes.

10. In a water tube steam boiler installation, steam generating tubes constituting pressure parts of the boiler, a primary furnace having refractory walls and otherwise adapted for burning fuels such as the waste wood resulting from saw mill operations, said walls forming a furnace gas outlet for the primary furnace, a second furnace between the steam generating tubes and the primary furnace, refractory covered stud tubes connected into the boiler circulation and positioned between the furnaces so as to form a refractory faced gas deflecting wall extending downwardly from the roof of the primary furnace, said tubes being bent out of their wall forming positions below said wall to form a screen of spaced groups of tubes affording relatively small resistance to gas flow across the outlet of the primary furnace, means for delivering waste wood fuel to the primary furnace, and fuel burning means extending through a wall of the second furnace.

11. In a dual furnace steam boiler installation, a first furnace having a vertically elongated combustion chamber of substantial volume having wall sections which are fluid cooled, means for

burning fuel in suspension in said chamber, a second furnace having a combustion chamber at one side of said first combustion chamber, a water cooled grate located in the lower part of the second chamber, a vertically extending bridge wall between said grate and the main combustion chamber arranged to protect said second furnace from radiant heat losses, and a plurality of refractory separately covered studded tubes connected into fluid circulation and having downwardly extending parts forming a gas deflecting wall above said bridge wall, said tubes being covered at their wall forming positions with refractory installed as a plastic.

12. In a multiple furnace steam boiler installation, fluid circulation devices including a bank of steam generating tubes, a furnace, means for burning a fuel of high B. t. u. value in said furnace, a second furnace discharging its furnace gases into the first, means for burning a high moisture content long flaming fuel of low B. t. u. value in the second furnace, spaced refractory covered tubes connected into fluid circulation and forming a wall common to both furnaces, said common wall having parts defining an outlet for the second furnace the first furnace constituting a combustion chamber for the gaseous and solid products passing from the second furnace.

13. In a dual furnace steam boiler installation, a by-product furnace adapted for burning high moisture content fuels, tubes extending along the roof of the furnace and covered with refractory material on their furnace sides so as to promote the maintenance of furnace temperatures well above the ignition point of the by-product fuel, a refractory arch nose provided by refractory covered studded tubes near the outlet of said furnace, a furnace screen extended across said outlet and formed by continuations of the tubes forming the arch nose, means for connecting said tubes into fluid circulation, means providing a grate in said furnace, means for supplying fuel to said furnace, a second furnace including a combustion chamber into which the products of combustion of the first furnace are delivered, and fluid heat exchange tubular elements contacted by the furnace gases after they have passed from the second furnace.

14. In a steam boiler installation, drums and connecting tubes forming pressure parts of the boiler, a combustion chamber from which furnace gases pass across said tube, by-product wood burning furnaces on opposite sides of said combustion chamber, walls forming furnace gas outlets through which furnace gases pass into the combustion chamber from the by-product furnaces, wall tubes connected into the boiler circulation and extending along opposite walls of the combustion chamber and thence across the gas outlets of the by-product furnaces in screen formation, means providing grates in said by-product furnaces and means for supplying saw mill by-products as fuel for said furnaces, said wall tubes being provided with a refractory covering across the upper parts of the outlets for said furnaces.

15. In a dual furnace steam boiler installation, a by-product furnace, tubes extending along the roof of the furnace and covered with refractory material so as to promote the maintenance of furnace temperatures well above the ignition point of the by-product fuel, walls forming sides of a furnace gas outlet of the by-product furnace, a refractory arch nose provided by refractory covered studded tubes near the outlet of said furnace, a furnace screen extended across said outlet and formed by continuations of the tubes forming the arch nose, means for connecting said tubes into fluid circulation, means for providing a water cooled grate in said furnace, means for supplying fuel to said furnace, a second furnace including a combustion chamber into which the products of combustion of the first furnace are delivered, and fluid heat exchange tubular elements contacted by the furnace gasses after they have passed from the second furnace.

16. In a steam boiler installation, drums and connecting tubes forming pressure parts of the boiler, a combustion chamber from which furnace gases pass across said tubes, by-product wood burning furnaces on opposite sides of said combustion chamber, walls forming sides of a furnace gas outlet for each by-product furnace, wall tubes connected into the boiler circulation and extending along opposite walls of the combustion chamber and thence across the gas outlets of the by-product furnaces in screen formation, means providing fluid cooled tubular grates in said by-product furnaces and means for supplying saw mill by-products as fuel for said furnaces, said wall tubes being provided with studs and a refractory covering across the upper parts of the outlets for said furnaces.

17. In fluid heat exchange apparatus, a furnace including furnace gas chambers, operating at different temperatures, and fluid heat exchange tubes positioned between the chambers, said tubes being subjected on both sides to the heating effect of furnace gases but at higher temperatures on one side, said tubes having separate coverings of ceramic refractory material at their upper portions to act as a gas-deflecting baffle, said refractory material being maintained on the tubes by metallic extensions welded to the tubes, the coverings being separated by temporary partition members positioned during installation of the apparatus.

18. In fluid heat exchange apparatus, a furnace combustion chamber, a second furnace gas chamber into which the furnace gases pass from an outlet of the combustion chamber, and fluid heat exchange tubes having parts in alignment at a position between said chambers so as to define a baffle deflecting the furnace gases toward said outlet, said tubes also having other parts which define a plurality of screen walls obliquely related to the plane of the baffle.

DALE BUMSTEAD, JR.