Nov. 2, 1954 C. L. MARQUEZ, JR 2,693,173

SPREADER STOKER FIRED FURNACE

Filed Aug. 27, 1949 2 Sheets-Sheet 1

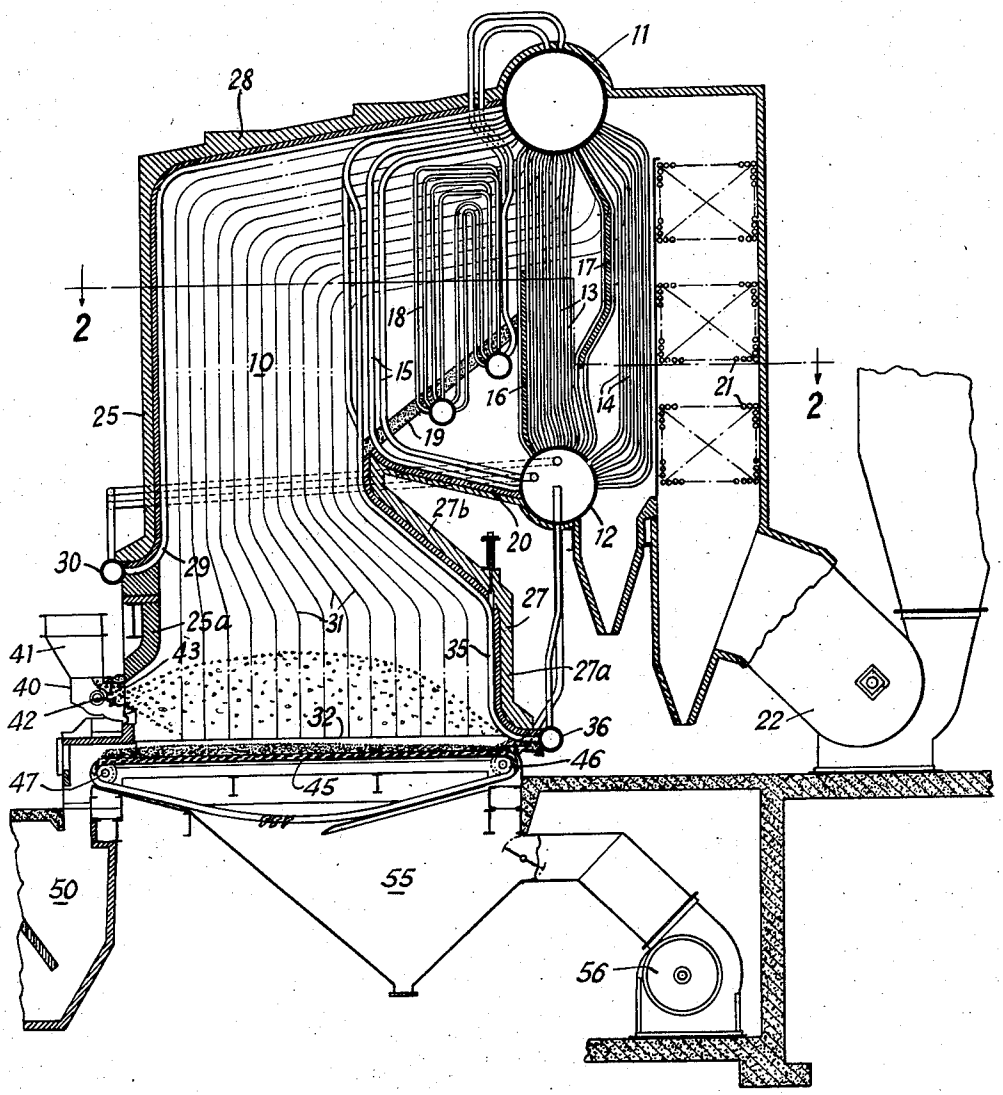

FIG. 1

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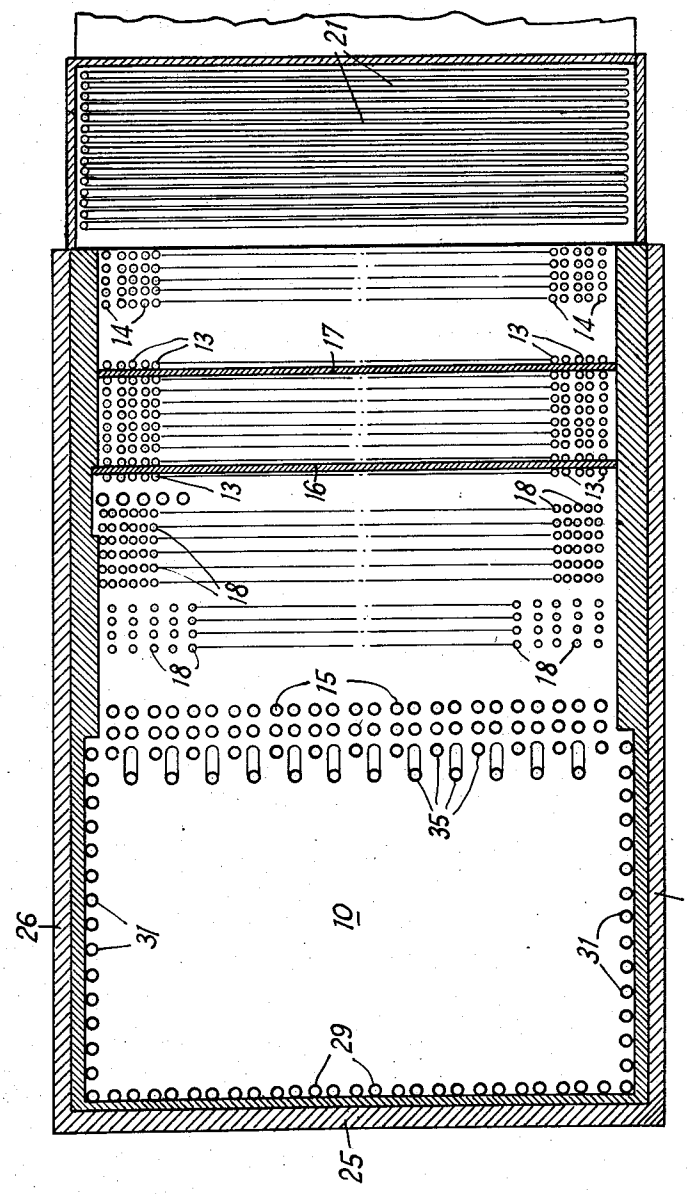

FIG. 2

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SPREADER STOKER FIRED FURNACE

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5 Claims. (Cl. 122—4)

This invention relates in general to the construction and operation of furnaces fired by solid fuel introduced by means of a spreader type stoker, and more particularly to the construction and operation of spreader stoker fired furnaces having a forwardly moving continuous grate and adapted for use in a vapor generating unit.

Spreader stokers have come into use for firing a wide range of solid fuels, ranging from lignites to the high grades of bituminous coals, with little or no fuel preparation, screenings and crushed run-of-mine coal being usable without pulverization. The fuel is mechanically thrown rearwardly from a fuel hopper arranged along the front furnace wall by one or more bladed rotors. In the usual projected stream of fuel, a substantial portion, e. g. 30%, burns as fine particles held in suspension above the grate, while the coarser particles deposit on the grate at separated points and are burned thereon. Small openings in the grate elements permit the passage of air for combustion at relatively low pressure over the entire grate area from an air box below the grate. The portion of the furnace above the grate must be left unrestricted to afford sufficient furnace volume and height to accommodate the desired fuel trajectories and combustion space for the fines and volatiles. The heat release rate of the fuel burned in suspension is quite high and heat reflecting or reradiating arches of the type heretofore used with moving grate fuel beds are neither necessary nor desirable. When the grate has a multiplicity of linked sectional elements defining an endless chain, the grate elements normally move forwardly very slowly and continuously discharge the residual ash below the front wall into a suitable ash hopper.

With the described construction and arrangement of the fuel burning parts, the zone of most intense combustion is normally located in the rear portion of the furnace opposite the wall of fuel introduction. In commercial practice, it has been found difficult to operate furnaces of the type described under smokeless combustion conditions throughout the desired load range, and particularly at low operating loads. The smoke conditions are mainly due to the presence in the gaseous products of combustion of unconsumed volatiles released by the fines wholly or partly burned in suspension, particularly in the zone of most intense combustion, and carried out in the gases under relatively stratified flow conditions. Under such flow conditions, the further mixing required between the volatiles and the air for complete combustion is difficult to attain. For this reason it is customary to increase the air-fuel ratio by providing a greater percentage of excess air in the upper portion of the furnace, to thereby complete combustion of the unburned fuel particles and volatiles. An alternative method is to so dilute the stack gases with air that the unconsumed carbon constituents of the gases are not so evident. In addition, to improve combustion conditions, "overfire" air has been introduced through ports in the furnace walls. When such ports are also used for the return of fines, such as cinders and fly ash from other portions of the unit, to the furnace, part of the fines so suspended in the air jets will be picked up and added to the relatively large amount of solids carryover in the stack gases which is characteristic of spreader stoker fired furnaces.

While a forwardly moving endless grate has special advantages when used with a spreader type stoker, a controlled distribution of the combustion air supply from the air box is difficult unless the air box can be correspondingly subdivided, a structural arrangement difficult with an endless chain grate construction. Accordingly, it has been found that a substantial portion of the combustion air passing upwardly, particularly through the forward portion of the grate, is ineffective in the combustion process in that it tends to flow upwardly without any substantial mixing with the products of combustion of the fuel on the grate and the fuel particles burned in suspension. Also, the lack of any localized air flow control results in the volatiles released in the zone of intense combustion receiving insufficient air to complete their combustion.

In accordance with my invention, a furnace designed for use with a spreader type stoker arranged along its front wall and delivering solid fuel to a forwardly traveling grate, is provided with a special fluid cooled rear wall construction consisting of a lower vertical section and an upper inclined wall portion projecting forwardly and upwardly to a substantial extent above the rear or high combustion section of the grate and at a level a substantial height above the grate fuel bed. For the purposes of the invention, this rear wall should project inwardly at least twenty-five per cent (25%) of the furnace chamber length at the grate level. The furnace arch or roof section so formed effects a progressive and substantial reduction in the furnace cross-sectional flow area at a level intermediate the height of the furnace and has been found to materially assist in promoting mixing and turbulence in the adjacent part of the furnace, by diverting the products of combustion and the included incompletely burned volatiles and carbon rising from the zone of intense combustion at the rear section of the grate forwardly into the restricted cross-sectional area of the furnace. This lateral flow of hot gases not only improves the internal mixing of the deflected gas stream, but also substantially increases the mixing of the deflected gas stream with the hot gases passing upwardly through the forward section of the grate, to complete the combustion of any unburned volatiles and carbon in the mixed gas streams before the gases reach the convection heated tubular heat transfer surface. Due to the increased mixing and turbulence of the gases effected, spreader stoker fired furnaces with this construction can be operated with lower excess air values and more complete combustion conditions, whereby the smoke density will be considerably reduced, or a wider range of operation can be attained with the present smoke conditions. The desired combustion conditions are thus attainable without recourse to overfire air jets located in the furnace side walls. This arch construction substantially increases the heating gas flow in and through the upper portion of the furnace, and a more efficient utilization of the heat transfer surface in the section thus results. The lower carryover of solids in the gases correspondingly decreases the carbon loss, as well as tube abrasion and fouling.

In the drawings:

Fig. 1 is a sectional elevation of a spreader stoker fired steam generating unit embodying the invention; and

Fig. 2 is an enlarged horizontal section taken on the line 2—2 of Fig. 1.

The invention is illustrated as incorporated in a steam generating unit in which the setting encloses a vertically elongated furnace chamber **10** along the front side of a generating and superheating section comprising an upper steam and water drum **11**, a lower water drum **12**, and spaced groups of water tubes **13**, **14** and **15** connecting the drums, the tubes **13** constituting a vertical bank of generating tubes, the tubes **14** constituting a bank of downcomer tubes spaced rearwardly of the tube bank **13**, and the tubes **15** constituting two rows of screen tubes of U-formation extending forwardly of the tube bank. Baffles **16** and **17** are arranged to provide a gas downflow over the tube bank **13** and upflow over the tubes **14**. An inverted U-tube steam superheater **18** is positioned in the space between the screen tubes **15** and tube bank **13**, with the headers thereof positioned below an inclined baffle **19** extending downwardly and forwardly from the baffle **16** to define a rearwardly tapering gas pass containing the vertical portions of the screen tubes **15** and superheater **18**. The heating gases leaving the

upper end of the tube bank 14 pass downwardly over economizer sections 21 to an induced draft fan 22 from which they are discharged to the stack.

The furnace 10 of the unit is of rectangular horizontal cross-section and defined by a water cooled front wall 25, side walls 26, rear wall 27, and roof 28. The front wall 25 and roof 28 are lined with water tubes 29 extending between the header 30 and steam and water drum 11. The side walls 26 are lined with water tubes 31 extending from a bottom header 32 vertically and then laterally into a circumferential row in the drum 11. The rear furnace wall 27 is lined with a row of water tubes 35 extending from a bottom header 36 upwardly to the drum 11, as hereinafter described.

The fuel burning equipment for the steam generating unit illustrated consists of a spreader stoker 40, in combination with a forwardly moving endless chain grate 45. The spreader stoker 40 is of any suitable type for feeding solid fuel from the hopper 41 to side-by-side bladed rotors 42 which distribute the fuel substantially uniformly over the width and length of the grate, through ports 43 located in the front wall 25 below the refractory wall section 25a. The chain grate is formed in a series of side-by-side endless chain sections, each having driving sprockets 46 at its rear end connected to any suitable drive mechanism (not shown), and idler sprockets 47 at its forward end, the forward end of the grate being arranged to discharge into an ash hopper 50 below the front wall of the furnace chamber. The chain comprises link elements carrying a series of perforated grate bars for supporting the fuel bed and permitting the flow of air therethrough. The lower part of the grate is enclosed in an air box 55 arranged to receive a controllable supply of air from a forced draft fan 56.

With this fuel burning equipment the solid fuel particles are mechanically discharged by the stoker over the length and width of the grate area in the furnace chamber along the trajectories indicated in Fig. 1. In normal operation, the chain grate is moved slowly forward, continuously receiving fresh fuel from the stoker which burns during the subsequent grate movement with the ash being discharged at the forward end of the grate. The fine fuel particles discharged by the spreader stoker are wholly or partly burned in suspension and facilitate rapid burning of the fuel particles depositing on the grate. With the grate construction shown, the combustion air from the air box will be discharged at a relatively low pressure throughout the length and width of the grate area. With such an arrangement the zone of most intense combustion will be on and over the rear section of the grate, and usually with a deficiency in the amount of air required for complete combustion of the carbon and the volatiles driven off from the fuel bed and fuel burned in suspension. Substantially all of the fuel in the fuel bed will be consumed by the time the corresponding grate section reaches the forward end of the grate, and normally there will be a surplus amount of combustion air passing upwardly through this section.

In accordance with my invention the rear wall of the furnace has a special configuration and construction for improving combustion conditions in the furnace and reducing solids carryover in the furnace gases. For this purpose the rear wall 27 has a lower vertical section 27a extending to a height above the normal maximum fuel trajectory and an upper forwardly inclined arch section 27b at an angle of approximately 45° to the horizontal. In the embodiment illustrated, the arch 27b extends inwardly a distance equal to approximately 40% of the furnace chamber length at the grate level. The inner and upper end of the arch section 27b is connected with the lower end of the inclined baffle 19 and also to a horizontally arranged baffle 20 formed by tile associated with the screen tubes 15. The wall sections 27a and 27b are lined with bare water tubes 35 on their inner sides, the tubes 35 having the same configuration as the wall sections, and extend upwardly therealong to the juncture of the wall section 27b and baffle 19. Above that level alternate tubes 35 are bent out of alignment to form two rows of widely spaced slag screen tubes in front of the screen tubes 15. The upper ends of the tubes 35 are bent into alignment and connected to the drum 11. It will thus be noted that the longitudinal dimension of the furnace chamber 10 is progressively reduced a substantial extent from the upper end of the vertical wall section 27a to approximately the level of the lower water drum 12. The inclined water tube lined rear arch thus formed by the wall section 27b is spaced sufficiently above the fuel bed to allow ample height for the fuel trajectories and combustion space for the fines and volatiles burning in suspension. The water cooled construction employed makes the arch a heat absorbing surface relative to the fuel bed rather than a heat reradiating surface intended to reflect heat to the fuel bed on the grate.

As previously described, the inclined arch 27b deflects the combustion gases and suspended fuel and ash particles towards the front furnace wall 25, promoting turbulence and mixing of the gases in all restricted furnace area. Complete combustion of the volatiles and carbon content of the suspended particles is thus effected before the mixed gas stream turns laterally into contact with the screen tubes 35 and 15 and remaining convection heated surface. The resulting increased gas flow through the upper section of the furnace substantially increases the heat absorption rate of the furnace wall tubes in that section with a consequent increase in thermal efficiency.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. In a fluid heater, vertical front and side walls partly defining a vertically elongated furnace chamber having a heating gas outlet in the upper rear portion thereof, a spreader stoker at the lower end of said front furnace wall having means for mechanically projecting solid fuel in rearwardly directed trajectories in said furnace chamber, a continuous grate extending across the bottom of said furnace chamber and having substantially horizontal forwardly moving upper grate portions arranged to receive on rear portions of said grate the fuel particles projected by said stoker, said fuel projecting means being upwardly spaced from said upper grate portions, a combustion air box below said grate and opening thereto throughout the grate area, means for supplying air to said air box, a rear wall for said furnace chamber comprising a lower vertical section extending from adjacent the grate level to an elevation above said fuel projecting means of said stoker, said lower rear wall section being positioned directly over a portion of said grate rearwardly of said fuel receiving portions, and an inclined arch section confined to a lower portion of said chamber and extending forwardly and upwardly over said rear portions of said grate and arranged to deflect the gases rising from said rear grate portions forwardly in said furnace chamber, said lower vertical rear wall section extending to an elevation higher than the summit of the maximum trajectory of fuel projected by said stoker.

2. In a fluid heater, vertical front and side walls partly defining a vertically elongated furnace chamber having a heating gas outlet in an upper portion thereof, a spreader stoker at the lower end of said front furnace wall having means for mechanically projecting solid fuel in rearwardly directed trajectories in said furnace chamber, a continuous traveling grate extending across the bottom of said furnace chamber and having substantially horizontal upper run portions arranged to receive on rear portions of said grate the fuel particles projected by said stoker, said upper run portions being downwardly spaced throughout from said fuel projecting means, means for continuously moving the fuel receiving portions of said grate forwardly in said furnace chamber, a combustion air box below said grate and opening thereto throughout the area of said fuel receiving portions, means for supplying air to said air box, a rear wall for said furnace chamber comprising a lower vertical section extending from adjacent the grate level to an elevation above said fuel projecting means of said stoker, said lower rear wall section being positioned directly over a portion of said grate rearwardly of said fuel receiving portions, and an inclined arch section confined to a lower portion of said chamber and extending forwardly over the rear section of said grate and arranged to deflect the gases rising from said rear grate section forwardly in said furnace chamber, said lower vertical rear wall section extending to an elevation sufficiently above said fuel projecting means so as to position said arch

section at an elevation higher than the summit of the maximum trajectory of fuel projected by said stoker.

3. In a fluid heater, vertical front and side walls partly defining a vertically elongated furnace chamber having a heating gas outlet in an upper rear portion thereof, a spreader stoker at the lower end of said front furnace wall having means for mechanically projecting solid fuel in rearwardly directed trajectories in said furnace chamber, a continuous traveling grate extending across the bottom of said furnace chamber and having substantially horizontal upper run portions arranged to receive on rear portions of said grate the fuel particles projected by said stoker, means for continuously moving the fuel receiving portions of said grate forwardly in said furnace chamber, said upper run portions being downwardly spaced throughout from said fuel projecting means, a combustion air box below said grate and admitting air thereto at a common pressure throughout the area of said fuel receiving portions, means for supplying air to said air box, a rear wall for said furnace chamber comprising a lower vertical section extending from adjacent the grate level to an elevation above said fuel projecting means of said stoker, said lower rear wall section being positioned directly over a portion of said grate rearwardly of said fuel receiving portions, an inclined fluid cooled arch section confined to a lower portion of said chamber and extending forwardly over the rear section of said grate and arranged to deflect the gases rising from said rear grate section forwardly in said furnace chamber, said lower vertical rear wall section extending to an elevation sufficiently above said fuel projecting means so as to position said arch section at an elevation higher than the summit of the maximum trajectory of fuel projected by said stoker.

4. In a fluid heater, upright front, rear and side walls partly defining a vertically elongated furnace chamber having a heating gas outlet in an upper rear portion thereof, a spreader stoker at the lower end of said front furnace wall having means for mechanically projecting solid fuel in rearwardly directed trajectories in said furnace chamber, a continuous traveling grate extending across the bottom of said furnace chamber and arranged to receive on rear portions of said grate the fuel particles projected by said stoker, means for continuously moving the fuel receiving portions of said grate forwardly in said furnace chamber, a combustion air box below said grate and admitting air thereto at a common pressure throughout the area of said fuel receiving portions, means for supplying air to said air box, said grate being arranged to discharge from front portions thereof the ash resulting from combustion of said particles, said rear wall for said furnace chamber comprising a lower vertical section extending from adjacent the grate level to an elevation above said fuel projecting means of said stoker, an upper inclined arch section confined to a lower portion of said chamber and extending forwardly and upwardly over said rear portions of said grate for a distance at least 25% of the furnace length at the grate level and arranged to

deflect the gases rising from said rear grate portions forwardly in said furnace chamber, said lower vertical rear wall section extending to an elevation sufficiently above said fuel projecting means so as to position said upper arch section at an elevation higher than the summit of the maximum trajectory of fuel projected by said stoker, said lower rear wall section having its lower end portion positioned directly over a portion of said grate rearwardly of said fuel receiving portions.

5. In a stoker fired furnace in which fuel is burned in a forwardly and horizontally movable bed, the method of operating said furnace which comprises, supplying fuel to the bed in rearwardly directed trajectories originating at a point upwardly spaced from the front end of the bed, directing air upwardly through the bed throughout the entire area thereof so as to cause the fine fuel particles to be at least partially burned in suspension and thus facilitate rapid combustion of fuel particles depositing on the bed whereby the zone of most intense combustion is created in and above the rear portion of the fuel bed while the deposited fuel particles are progressively consumed during the forward movement of the bed and ash is continuously discharged from the front end thereof, the progressive combustion of fuel as the bed moves forwardly rendering the forward portion of the bed more permeable to air flow therethrough than the rearward portion and resulting in a flow of excess air through the forward portion and in a flow of air through the rearward portion less than is required to support complete combustion of unconsumed volatiles in the zone of most intense combustion; and, in a lower part of said chamber, superjacent the summit of the maximum trajectory of the rearwardly projected fuel particles, deflecting the gases rising from said rearward portion of the bed together with gases resulting from the combustion of fuel particles in suspension so as to direct such gases forwardly and upwardly into the stream of gases and excess air rising from the forward portion of the bed.

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