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METHOD OF AND APPARATUS FOR BURNING SOLID FUELS

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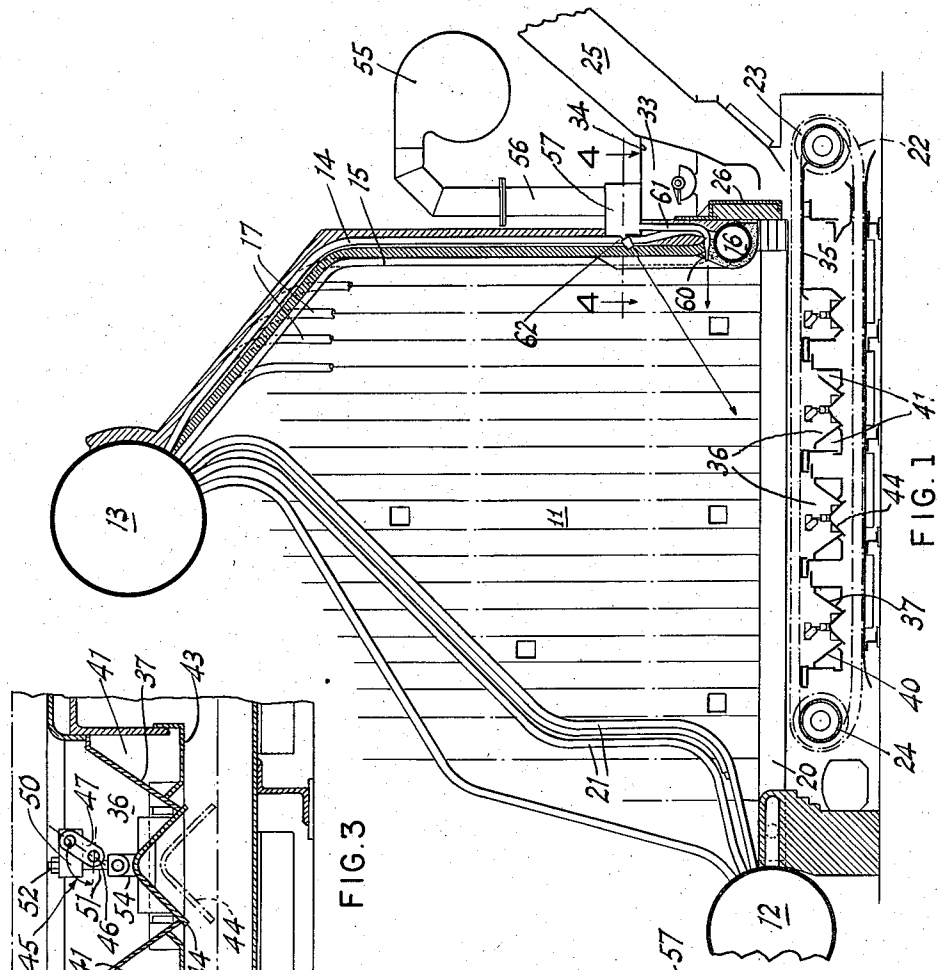

FIG. 1

FIG. 3

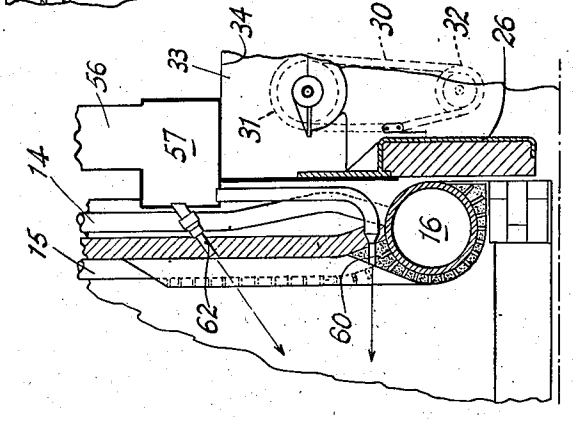

FIG. 2

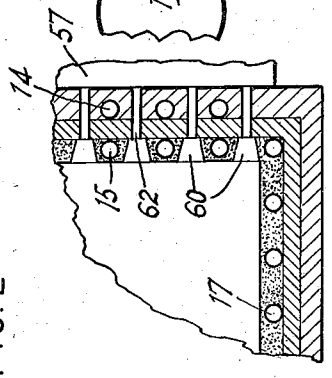

FIG. 4

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METHOD OF AND APPARATUS FOR BURNING SOLID FUELS

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4 Claims. (Cl. 110—40)

The present invention relates to the combustion of solid fuels, and more particularly to an improved construction and arrangement of furnace and moving grate stoker for the combustion of solid fuels.

Heretofore, moving grate stokers have commonly been unable to maintain ignition and to satisfactorily burn solid fuel during rapid changes in the firing rate. The lack of flexibility in stoker operations has been particularly detrimental in steam generating applications where rapid load swings are encountered. Moving grate stokers have also been limited in their ability to burn coking coals under either continuous firing conditions or under rapid changes in firing rates.

In accordance with the present invention, I provide an improved furnace and stoker construction with air inlet provisions whereby the flow of combustion air through the stoker to the furnace may be closely regulated, and in addition, I provide a novel combination of overfire air jets discharging to the furnace combustion zone. More specifically, the overfire air is supplied through jet nozzles positioned in the front wall of the furnace with the air directed in directions to adequately mix the combustible gases above the moving fuel bed. As a result of the novel combination of air introduction, the moving bed stoker of the present invention is capable of burning solid fuels, including coking coal, under conditions of rapid changes in firing rates with a minimum of carbon loss and without loss of ignition.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of my invention.

Of the drawings:

Fig. 1 is a side elevation of a stoker and furnace combination constructed in accordance with the invention;

Fig. 2 is an enlarged elevation view, in section, of a portion of the apparatus shown in Fig. 1;

Fig. 3 is an enlarged elevation, in section, of a portion of the stoker shown in Fig. 1; and

Fig. 4 is a section view taken on the line 4—4 of Fig. 1.

As shown in the drawings, the present invention is illustrated as applied to a fluid-cooled furnace wherein the walls of the furnace are provided with steam generating tubes connected in the circulatory system of a steam generator. The stoker illustrated is of the traveling grate type primarily intended for the combustion of bituminous coal, although the stoker can also be used for the combustion of anthracite coal and other solid fuels.

Referring to Fig. 1, the water-cooled refractory walls of the furnace 11 are formed of tubes inter-connecting a lower drum 12, sidewall and front wall headers, and an upper steam and water drum 13. The front wall of the furnace includes two rows of tubes, downcomer and riser tubes 14 and 15 respectively, spaced longitudinally

of a lower front wall header 16 and extending from the header in an upward direction to a spaced position, and are thereafter upwardly and rearwardly inclined to open into the steam and water drum 13. The sidewalls of the furnace 11 are also each cooled by a row 17 of upright tubes extending from a lower sidewall header 20 positioned on each side of the furnace, to the upper steam and water drum 13. Rows of tubes 21 extend between the lower drum 12 and the upper steam and water drum 13, defining a slag screen extending across the rearward portion of the furnace 11.

The traveling grate stoker illustrated in Fig. 1 consists of an endless chain 22 projecting through the front wall of the furnace 11 and having a driving sprocket 23 positioned outwardly of the furnace and an idler drum or sprocket 24 disposed laterally of the furnace at a spaced position forwardly of the lower drum 12.

The driving sprocket 23 is driven at a controlled rate in any convenient manner, such as by an electric motor (not shown). Solid fuel is deposited upon the stoker exteriorly of the furnace by the spout 25 which is connected with and receives fuel from an overhead bin (not shown), and directs the movement of fuel to the stoker and furnace in a quantity dependent upon the speed of the stoker chain and the clearance between the chain and a positively driven seal gate 26. The gate 26 is adjustable vertically and not only regulates the depth of fuel deposited upon the stoker, but also serves to restrict leakage of air to or gases outwardly from the furnace 11. As shown in Figs. 1 and 2, the seal gate 26 is formed by an open channel metallic member which is provided with refractory material facing the furnace side of the front wall. The gate 26 is vertically adjustable by means of an endless chain 30 attached to the gate and operable by the sprockets 31 and 32. The upper sprocket 31 is rotatably adjusted by a crank or the like (not shown) projecting beyond the side of a housing 33 which encloses the gate 26. As shown in Figs. 1 and 2 the housing 33 is provided with a removable top 34 so as to provide means of access to the gate 26 and its operating mechanism. With the construction shown and described, the depth of solid fuel upon the stoker is regulated by the position of the gate 26, and movement of air into the front of the furnace over the fuel bed is largely avoided.

The raw fuel receiving end of the stoker is provided with a dead-plate 35 extending beneath the upper run of the endless chain 22 from a position adjacent the drive sprocket 23 to a position within the furnace. Between the furnace end of the dead plate and the idler sprocket 24 the air flow to the stoker is compartmentalized. Each stoker compartment 36, as shown particularly in Fig. 3, is provided with laterally extending converging plates 37 and 40 forming, in section, an inverted truncated cone. The plates 37 and 40 are perforated for the admission of combustion air therethrough from the transverse air passageways 41 defined by plates 37, 40, 42, and 43. The air passageways 41 open to a distributing manifold (not shown) positioned on one side of the furnace. Preferably, the air flow to each of the stoker compartments 36 is individually controlled by dampers or the like, so that the amount of air delivered to each longitudinal portion of the fuel bed maintained on the stoker can be closely regulated.

The air flow to the compartments 36 is ordinarily regulated to cause approximately 70 to 75 percent of the total combustion air to pass upwardly through the front half of the stoker grate. The actual proportion of the total combustion air passed through the front half of the grate will vary somewhat depending upon the type of fuel burned, for example, high volatile fuels should receive a greater proportion of the combustion air im-

mediately after entering the furnace than low volatile fuels.

The lower portion of the inverted truncated cone formed by the perforated plates 37 and 40 is provided with a closure member 44. This member is formed as an inverted trough with the apex thereof attached to a support and movement linkage 45. The linkage is operable from and supported by a transverse rod 46 whereby the trough member 44 can be lowered to the position shown by the dot-dash lines in Fig. 3 for the discharge of any "siftings" which may be deposited in the compartment by droppage of fine fuel through the stoker chains supporting the fuel bed. The linkage mechanism 45 is constructed to lock the trough member 44 in a closed position abutting the ends of the plates 37 and 40. As shown in Fig. 3, the mechanism includes a link 47 keyed at one end to the rod 46 and pivotably connected to a horizontally disposed arm 50. The arm is slideably connected with a bolt 51 having a threaded upper end engaging a nut 52, and a lower end attached to a clevis. The clevis is pivotably connected with an upstanding flange 54 welded to the member 44. With the construction described, the vertical distance between the fixed position of the rotatable rod 46 and the trough member 44 can be adjusted as circumstances require by rotation of the nut 52 on the bolt 51. The pivotal connection between the clevis and flange 54 permits the trough to engage the ends of the plates 37 and 40 regardless of any slight unevenness in the vertical relationship thereof.

In accordance with the invention, overfire air is supplied to the fuel bed adjacent the front wall of the furnace to provide sufficient oxygen to promote a thorough and substantially complete combustion of the combustible gases distilled from the fuel bed. This air is supplied through vertically-spaced rows of jet nozzles projected through the front wall of the furnace between the tubes 14 and 15. All of the nozzles receive air from an individually controlled blower 55 which discharges through a conduit 56 into a distributing manifold 57. As shown in Figs. 1 and 2, one row of jet nozzles 60 is positioned immediately above the front wall header 16, each of which receives air from the manifold 57 through a duct 61 and discharges in a generally horizontal direction. A second row of jet nozzles 62 is positioned upwardly adjacent the nozzles 60 and is provided with a downward inclination to project the streams of air therefrom toward the fuel bed.

The row of nozzles 60 extends through the intertube space between adjacent tubes 15 and discharge jets of air in a direction generally parallel to or slightly inclined downwardly toward the bed of fuel maintained upon the moving grate. The downward angle of inclination of the nozzle may be as much as 10° with respect to the horizontal, but ordinarily the inclination will be less than this and approach the horizontal. It is desirable to install a plurality of the nozzles in a row across the furnace closely adjacent the fuel bed surface to obtain good air distribution in the front portion of the furnace. The jet nozzles 60 are of small internal diameter to obtain tip air velocities of the order or 15,000 to 18,000 feet per minute to attain intimate mixing of air with the volatile combustible matter distilled from the fuel bed and to obtain rapid ignition.

The upper row of nozzles 62 extends through the front wall of the furnace, terminating in the intertube space between adjacent tubes 15. The angle of inclination of the nozzles 62, with respect to the horizontal, may be between 0 and 60°, although I prefer that the nozzles should be inclined downwardly with an extension of the nozzle centerlines intersecting the fuel bed within the furnace space. The tip velocity of the air leaving the nozzles 62 may be considerably less than that leaving the nozzles 60, i. e. for example, of the order of 5000 to 7000 feet per minute.

In the embodiment of the invention shown in the drawings the length of the stoker within the furnace is approximately ten feet with a width of approximately 9 feet 6 inches. The riser tubes 15 of the front wall are placed on 7½ inch centers with the centerline spacing reduced to 5¾ inch and 6½ inch adjacent the front corners of the furnace. A total of 17 nozzles 60 are installed, with a nozzle associated with the intertube space of each pair of upright tubes 15. The nozzles 60 are ⅜ inch internal diameter and are each spaced between 16 and 30 inches upwardly of the stoker surface. As shown, the nozzles 62 are downwardly inclined at an angle of approximately 35° with respect to the horizontal, and are spaced from 3 to 5 feet above the surface of the stoker. The nozzles 62 have an internal diameter of 1 inch and are positioned to discharge overfire air through alternate intertube spaces, with a total of nine of the nozzles 62 installed in the front wall of the furnace. The relationship of the nozzles 60 and 62, and the tubes 15 is shown in Fig. 4. Approximately 10 percent or less of the total combustion air delivered to the furnace is introduced through the overfire jet nozzles 60 and 62.

In the operation of the apparatus, the fuel entering the furnace 11 on the stoker chain 22 is subjected to the heating effects of combustion within the furnace. The combination of heat, and air passed upwardly through the stoker compartments 36 adjacent the dead plate 35 causes distillation of volatile combustible matter from the fuel. As the volatiles rise from the fuel bed they are impacted by the jets of overfire combustion air discharged from the jet nozzles 60. The air intimately mixes the volatile combustible matter with oxygen, promoting the early combustion thereof. The jets of overfire air discharged from the nozzles 62 intersect the expanding stratum of air projected by the jets 60 and tend to cause the movement of burning gases forwardly of the furnace from the intermediate and discharge end of the stoker and to mix with any volatiles which may have passed through the air streams discharged from the nozzles 60. This further promotes the creation and maintenance of a very hot combustion zone upwardly of the fuel bed adjacent the front wall of the furnace.

The hot zone in the furnace immediately above the incoming solid fuel bed not only permits rapid swings in the operating load range with unusually quick response, but also permits the use of coking coals in the stoker and furnace combination. A typical example of a rapid response to an increase in the steam load on a boiler and stoker installation similar to the illustrated embodiment of the invention is as follows:

Steaming rate, pounds per hour	B. t. u. feed rate, square ft. of stoker grate	Time, minutes
9,000–10,000	120,000	0
18,000	500,000	7
27,000	500,000	12

Under these conditions ignition remained steady and good combustion with low carbon loss was maintained throughout the steaming capacity increase.

When burning coking coals with a Free Swelling Index of above 9 (tested in accordance with the ASTM test D–720), the hot zone of burning hydrocarbons directly above the incoming coal bed induces rapid combustion of the raw coal with the individual particles of coal quickly passing through the sticky stage without adhering to adjoining particles. The ability to burn coking coal without causing the formation of a swollen mass of material on the grate, and thereby restricting the flow of air upwardly through the fuel bed, is novel and attributed to the creation of the hot zone of combustion in the furnace by the directed streams of overfire air and minimizing leakage of air with the fuel entering the furance. The solid fuels used in the stoker can contain large quantities of particles ⅛ inch or less in cross-section

without adversely affecting the successful operation of the boiler and stoker combination.

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 covered by the 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. Apparatus for burning solid fuel including walls defining a furnace chamber, means for maintaining a bed of solid fuel moving across the lower portion of said furnace from a fuel entry end to an ash discharge pit, means for passing combustion air upwardly through said moving bed of solid fuel, and means for maintaining a hot zone of burning gases upwardly adjacent said moving bed of solid fuel in the vicinity of the fuel entry end of said furnace including nozzles disposed in a furnace wall above and adjacent the fuel entry end of said moving bed and arranged to inject jets of combustion air generally horizontally into said furnace in the direction of said fuel bed movement, other nozzles disposed in said furnace wall and spaced above said first named nozzles, said other nozzles injecting combustion air jets into said furnace in the direction of said fuel bed movement and with a downward component of movement to intersect said horizontally projected jets of combustion air at an acute angle above said moving fuel bed to swirl a mixture of air and burning gases in said hot zone.

2. Apparatus for burning solid fuel including walls defining a furnace chamber having an upright front wall, means for maintaining a bed of solid fuel moving across the lower portion of said furnace from said front wall, means for passing combustion air upwardly through said moving bed of solid fuel, and means for maintaining a hot combustion zone above and adjacent said moving bed of solid fuel in the vicinity of said front wall including a plurality of nozzles disposed in said front wall upwardly adjacent said moving fuel bed and arranged to inject high velocity jets of combustion air generally horizontally into said furnace in the direction of fuel bed movement, other nozzles disposed in said front wall and spaced above said first named nozzles, said other nozzles injecting high velocity jets of combustion air into said furnace with a downward component of motion to intersect said horizontally projected jets of combustion air at a spaced position from said front wall.

3. The method of burning solid fuel containing volatile matter on a horizontal travelling grate stoker in a furnace formed by walls including a vertical front wall terminating at its lower end above the stoker level which comprises continuously supplying the fuel in controlled amounts to the front end of the stoker to form a fuel bed of maximum thickness below said front wall and of decreasing thickness towards the ash discharge end of the stoker, and supplying the air for combustion of the fuel mainly by the admission of air upwardly through the fuel carrying portion of the stoker within the furnace in varying amounts along the lengths of the stoker and the remainder by rows of high velocity jets discharging through the furnace side of the front wall partly in a lower row of horizontally spaced jets directed substantially horizontally above and adjacent the upper level of the fuel bed and parallel to the moving fuel bed and partly in an upper row of horizontally spaced jets directed downwardly at an acute angle in planes parallel to the moving fuel bed, the lower jets being maintained at a velocity of 15,000–18,000 feet per minute and the upper jets at a velocity of 5000–7000 feet per minute, whereby the volatiles distilled off from the fuel are blasted with high velocity air jets to produce a swirling turbulent mass of burning gas along the front wall radiating heat to the subjacent portion of the fuel bed.

4. Apparatus for burning solid fuel containing volatile matter comprising stoker means providing a substantially horizontally moving bed of solid fuel, a furnace formed by walls including a vertical front wall terminating at its lower end above the stoker level, means for continuously supplying the fuel in controlled amounts to the front end of the stoker to form a fuel bed of maximum thickness below said front wall and of decreasing thickness towards the ash discharge end of the stoker, means for supplying the air for combustion of the fuel mainly by the admission of air upwardly through the fuel carrying portion of the stoker within the furnace in varying amounts along the length of the stoker, and means for supplying the remainder of the combustion air including vertically spaced rows of high velocity jet nozzles arranged to discharge through the furnace side of the front wall including a lower row of horizontally spaced jet nozzles directed substantially horizontally above and adjacent the upper level of the fuel bed and substantially normal to the front wall and an upper row of horizontally spaced jet nozzles directed downwardly at an acute angle in planes normal to the front wall, whereby the volatiles distilled off from the fuel are blasted with high velocity air jets to produce a swirling turbulent mass of burning gas along the front wall radiating heat to the subjacent portion of the fuel bed.

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