Jan. 17, 1956 M. BIRKNER 2,730,999

FURNACE AND BOILER PLANT

Filed Sept. 22, 1950 2 Sheets-Sheet 1

FIG. 1

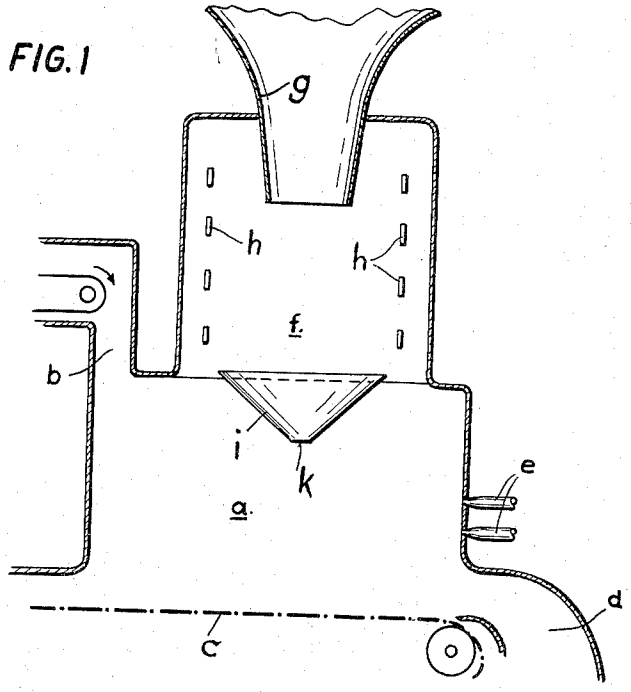
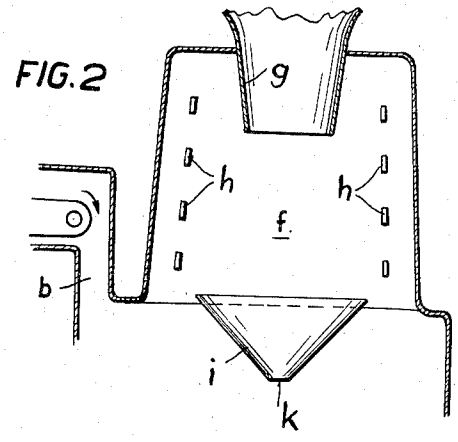


FIG. 2



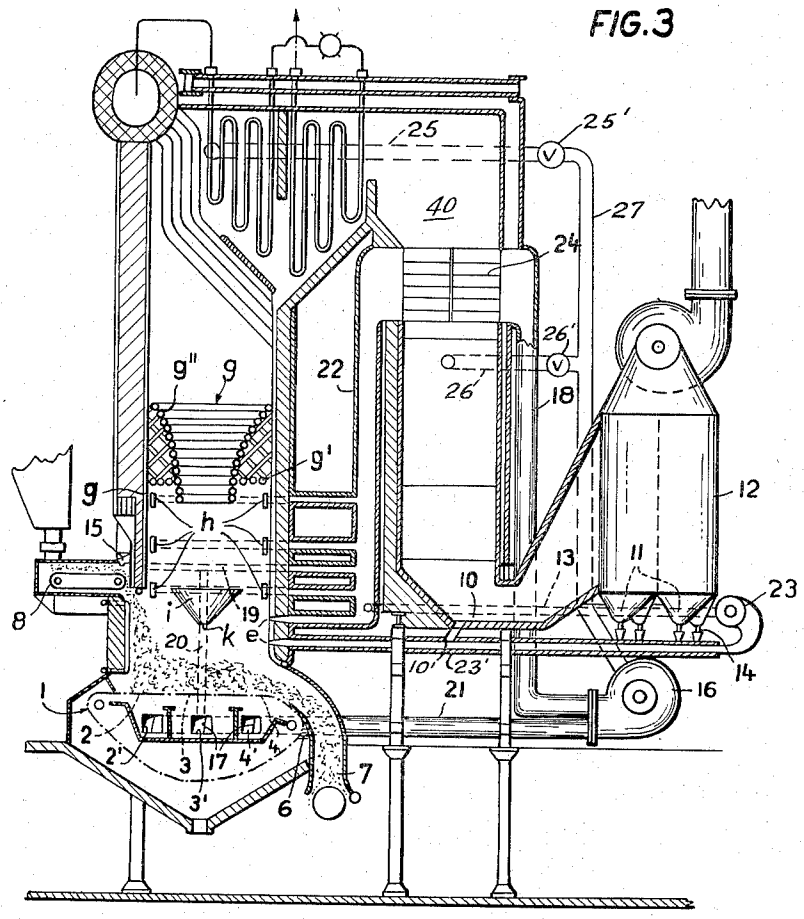
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FIG. 3



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2,730,999

FURNACE AND BOILER PLANT

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Application September 22, 1950, Serial No. 186,284

Claims priority, application Germany September 30, 1949

11 Claims. (Cl. 122—4)

The present invention relates to improvements in a furnace for burning solid fuel of the type described and claimed in co-pending applications Serial No. 123,515, filed October 25, 1949, entitled "Burning Solid Fuel," and Serial No. 168,925, filed June 19, 1950, entitled "Apparatus for Burning Solid Fuel."

In the first of the above-mentioned co-pending applications there is described a method of burning solid fuel in a vertically extending combustion zone which includes delivering fuel by gravity from substantially midway of the height of the zone in the form of a curtain of fuel falling directly upon only the front portion of a relatively short fire bed that is moving with a travelling grate that travels from front to rear of the combustion zone. The grate includes plural longitudinally aligned portions and a primary supply of oxidizing medium is introduced from beneath the grate and thus beneath the bed under all the portions of the grate with the pressure of the introduced medium being increased successively from front to rear of the grate so that the fuel in the form of coal is fluidized under a middle portion of the grate and under the rearmost portion the pressure of the introduced medium is such that incandescent particles are picked up and flung upwardly from the fire bed. A secondary supply of oxidizing medium is introduced through jets disposed at the rear wall of the furnace, extending across the cross-sectional area of the zone, located above the grate and directed toward the front of the combustion zone. This secondary supply of oxidizing medium projects the incandescent particles that have been lifted up from the fire bed toward the front of the combustion zone so that these incandescent particles intermingle with the incoming curtain of fuel to dry and degasify the same. The combustion zone is constituted by two portions, one extending from the grate upwardly to approximately midway thereof where the fuel inlet is located and a second portion located above the fuel inlet. In the lowermost portion the burning of coarse grain fuel is effected through the primary and secondary oxidizing medium whereas above the fuel inlet tuyeres are arranged through which tertiary oxidizing medium supply is introduced in a whirl about the vertical axis of the combustion zone to complete the combustion.

The second referred to co-pending application improves the construction and operation of the installation by providing a partition means that extends between the walls at a level that delimits the upper portion of the combustion zone so that the space or region above or downstream of the partition means is in effect separated from the combustion zone and constitutes a radiation section downstream of the combustion zone. The partition means includes a central opening through which hot combustion gases are discharged into the radiation section of the boiler. Specifically the partition means includes a sleeve member of circular cross-section that extends downwardly from the partition and part way into the upper portion of the combustion zone and a diffuser constituting an upward extension of the sleeve that extends

above the partition into the radiation section or zone and which extension increases in width upwardly so as to constitute a diffuser and it is through this diffuser that the gases are discharged into the radiation section.

As indicated in the prior referred to application, Serial No. 168,925, the portion comprised between the walls of the installation, that is beneath the partition means and thus beneath the radiation section or zone, comprises two primary combustion zones. In the lowermost zone, that is immediately above the travelling grate or fire bed, the major portion of fuel is consumed in what may be termed coarse combustion which provides for combustion and gasification of the fuel. However, absolute complete combustion does not occur in this lower combustion zone or lower fire box. Complete or fine combustion of the yet unburnt fuel particles occurs in suspension in the upper portion of the combustion zone, that is, beneath the partition and adjacent that wall region through which the tuyeres for introducing the tertiary oxidizing medium supply are located. Thus, any particles elevated into this upper portion of the combustion zone or what might be termed an upper fire box are gasified into the gases coming from the lower portion of the combustion zone. With the furnace operating in this fashion, no regulation or at most only a coarse regulation of combustion is necessary in the lower portion of the combustion zone, that is that region immediately above the travelling grate.

Therefore the present invention has for a primary object to improve the regulation of combustion in the two portions of the combustion zone.

Specifically, this invention has for an object to provide a partial spatial separation between the two portions of the combustion zone.

An additional specific object of this invention is to provide for the regulation of combustion by controllably admixing combustion gases with combustion supporting air and introducing the mixture beneath the grate, above the grate, and in the lower portion of the combustion zone and tangentially into the upper portion of the combustion zone.

This partial spatial separation between the lower and upper portions of the combustion zone can be effected by providing a separating and obstructing body at the lower limits of the upper portion of the combustion zone, the body preferably being of circular section. With the interposing of this separating body, the gases from the lower portion of the combustion zone pass into the upper portion of the combustion zone through an annular marginal passage between the perimeter of the body and the inner periphery of the walls of the installation so that these gases are immediately subjected to a whirl about the vertical axis of the installation by the action of the tangentially directed tertiary oxidizing medium entering into the upper portion of the combustion zone.

Specifically, this separating and obstructing body is constructed in the form of an upwardly diverging cone. In consequence of this shape the speed of gas flow from the lower portion of the combustion zone into the upper portion thereof is increased. Additionally, in order to facilitate the carrying away of ash along the periphery of the upper portion of the combustion zone, the walls bounding this upper portion are conical and widened downwardly from the partition. With this arrangement the centrifugal force produces a downwardly directed component of force which is added to the force of gravity.

Further and more specific objects will be apparent from the accompanying drawings, in which:

Figure 1 is a diagrammatic view illustrating one form of the improvement in accordance with the invention,

Figure 2 is a similar view illustrating a modification of

the walls bounding the upper portion of the combustion zone, and

Figure 3 is a longitudinal view partly in section and partly in elevation illustrating the invention with particular reference to the under grate air supply.

As illustrated diagrammatically in Figure 1, the invention provides a furnace installation or structure which includes wall means defining a combustion zone. This combustion zone is constituted by two portions, *a* being a lower combustion zone or lower fire box and *f* being an upper combustion zone or upper fire box. A travelling grate *c* for supporting a fire bed is disposed at the bottom of the lower fire box or lower combustion zone *a* and travels from front to rear, that is from the front wall toward the rear wall. The front wall has an opening *b* therein substantially midway of the height of the entire combustion zone and which opening extends substantially coextensive in width with the zone. An endless conveyor that is adjacent the opening and substantially coextensive in width therewith forwards fuel to fall by gravity in the form of a downwardly flowing curtain of fuel extending substantially coextensive in width with the combustion zone and which fuel by its free fall is deposited in a restricted region of narrow extent with relation to the grate travel subjacent the fuel opening and closely adjacent the front wall. A shaft *d* is disposed adjacent and extending downwardly from the rear wall for completing combustion of any fuel in the ash particles falling off the rear end of the grate. The tuyeres *e* project through the rear wall in the lower combustion zone or lower fire box *a*, above the grate and beneath the fuel inlet for directing secondary oxidizing medium toward the front wall of the combustion zone for the purposes described in my prior filed applications. Additional means for supplying oxidizing medium beneath the grate *c* and constituting the primary oxidizing medium with the pressure of the introduced medium being increased successively from front to rear of the grate are not shown in this figure but are referred to hereinafter. The introduced medium fluidizes the coal at the middle portion of the grate and the pressure thereof is still greater beneath the rear portion of the grate so that incandescent fuel particles are picked up and flung upwardly from the fire bed and then impinged upon by the oxidizing medium entering particularly through the uppermost tuyeres *e*, so that this supply of oxidizing medium will fling the incandescent particles toward the front of the combustion zone in a flattened parabola so that they intermingle with the incoming curtain of fuel. A diffuser *g*, as described in my co-pending application Serial No. 168,925, separates the upper fire box *f* from a radiation section that is downstream of the fire box. Tertiary oxidizing medium nozzles or tuyeres *h* are arranged in spaced banks and so directed that the tertiary supply of oxidizing medium enters tangentially about a common circle as indicated in the above referred to applications. The means partially spatially separating the lower combustion zone portion from the upper combustion zone portion is constituted by a truncated conical obstructing and deflecting body *i*. As illustrated, this body is supported within the combustion zone with its upper edge substantially level with the lower end of the front wall section defining the upper portion of the combustion zone and is located centrally of the combustion zone with its axis coinciding with the axis of the combustion zone. The transverse dimensions of the obstructing body *i* are less than that of the combustion zone so as to leave a space between the marginal edges of the body *i* and the adjacent walls defining the lower limits of the upper portion of the combustion zone or upper fire box. This space provides an annular marginal passage through which gases pass from the lower combustion zone portion or fire box *a* up into the upper fire box *f*. The obstructing body is wider at its top than at the bottom and is provided with an aperture *k* in the lowermost end through which ash and slag particles that are separated from the combustion gases in the upper fire box *f* can pass and fall back into the lower fire box *a*.

It is believed clear that this structure provides a partial spatial separation of the combustion zone into upper and lower combustion zone portions and which in the upper portion or upper fire box there is existing a cyclone effect that prevents ash and slag from passing upwardly through the diffuser *g* and into the radiation section beyond or downstream thereof. It is clear therefore that coarse combustion occurs in the lower fire box *a* below the obstructing body and fine combustion or completion of the combustion occurs in the upper fire box zone *f*. The structural arrangement described prevents the heating surfaces and tube walls from being clogged with dirt and ash. Basically, therefore, the obstructing body separates the combustion zone into two discrete portions, a lower and an upper portion, each of which has its own primary function as regards combustion of the fuel.

The modified form of Figure 2 is a similar to the arrangement of Figure 1 with the exception that the wall structure defining the upper portion of the combustion zone or upper fire box *f* is in the form of a body of revolution widening conically downwardly to facilitate the removal of ash from along the periphery of the upper portion of the combustion zone. Due to this structure, the downwardly increasing centrifugal force existing in the upper portion of the combustion zone imparts a downwardly directed component of force that is in addition to the force of gravity upon slag or ash particles so as to facilitate the movement thereof downwardly into the lower portion of the combustion zone *a* and thence and ultimately through the ash discharge chute *d*.

The foregoing description comprehends the invention from its broadest aspect, namely the partial physical spatial separation of the combustion zone into an upper portion and a lower portion. As regards Figure 3, there is illustrated diagrammatically and in longitudinal view a complete furnace installation, including wall means which define a vertically extending portion which is subdivided into a lower fire box or lower combustion zone, an upper fire box or upper combustion zone and a radiation zone or section downstream of the upper fire box. The furnace further includes combustion gas confining flue means having a downwardly extending portion **40**. At the bottom of the lower fire box or lower combustion zone is a travelling grate **1** which includes plural longitudinally aligned portions or zones denoted at **2**, **3** and **4**. The grate delivers to a slag shaft **7** at the rear of the furnace and a conventional doctor arrangement **6** cooperates with this shaft.

The fuel is fed from a suitable hopper to a conveyor **8** from which it falls by gravity as a curtain of fuel that extends throughout the transverse dimensions of the combustion zone and is narrow in relation to the direction of travel of the grate which moves from front to rear. The wall of the furnace structure is provided with cooling tubes **9** closely adjacent the fuel inlet and a diffuser *g* as described in my co-pending application Serial No. 168,925 provides separation between the upper fire box or upper portion of the combustion zone and a radiation section downstream thereof This diffuser includes a horizontal portion *g'* and the flaring portion *g''*. Beneath the horizontal portion *g'* are disposed the superposed banks of tuyeres *h* which, as described in prior application Serial No. 123,515, provide for the introduction in a tangential fashion of tertiary supply of oxidizing medium. It is clear that the total combustion zone extends from the upper grate surface to the under surface of the horizontal portion *g'* of the diffuser. As set forth in prior application Serial No. 123,515, superposed banks of nozzles *e* extend through the rear wall of the furnace between the upper surface of the grate and the fuel inlet and are directed toward the fuel inlet. Above these nozzles *e* is disposed the stationary conical separating body *i* which is dish-shaped as indicated with reference to Figures 1

and 2. The bottom of this body *i* has an opening *k* at its narrow portion which is also the lowermost portion of the body. Beneath the zones **2**, **3** and **4** of the grate are provided inlets **2'**, **3'** and **4'** through which oxidizing medium is introduced under pressure to flow upwardly through the grate. These inlets are, as set forth in prior application Serial No. 123,515, controlled by conventional means such as dampers so that the supply of medium introduced beneath the grate to flow upwardly therethrough is such that the under grate pressure increases toward the rear of the grate with the greatest pressure conditions existing beneath the rear portion of the grate. Pressure conditions are such that the medium supplied beneath the middle portion **3** is sufficient to fluidize fuel upon the grate and to elevate fine incandescent particles therefrom. The pressure of the medium supplied beneath the rear portion **4** of the grate is greater than that pressure required for fluidization so that larger incandescent particles are elevated upwardly from the rear portion of the grate. The under grate supply of medium constitutes the supply of primary oxidizing means. In order to regulate combustion in the various portions in the furnace the supplies of combustion supporting medium can be air or a mixture of air and combustion gases. Fan or air pump **16** delivers through conduit **21** to the under grate inlets **2'**, **3'**, **4'** where the pressure conditions existing beneath the grate are regulated, as set forth above.

The pump further delivers to another conduit **18** which extends up to an air heater **24** of conventional construction that is mounted in the downwardly extended portion **40** of the flue. The air after passing the air heater enters a downwardly extending conduit **22** from which it is delivered through suitable conduits to the tuyeres *h* in the upper portion of the combustion zone and to the uppermost bank of tuyeres *e* that is in the lowermost portion of the combustion zone. A conduit **19** communicates with the conduit **22** and delivers medium to nozzle means **15** that are directed downwardly so that the medium flows past the discharge end of the conveyor **8**.

A further conduit **20** communicates between conduit **21** and conduit **19** so that the medium discharged through nozzle **15**, a fourth medium supply, is a mixture of mediums of different temperatures. Fume-borne coke or ash particles coming down the stack with the products of combustion either drop through opening **10'** into an elongated conduit **23'** or are separated in filters **12** collected in the separating portions **11** and introduced through nozzles **14** into conduit **23'**. Conduit **23'** provides communication between a fan **23** and the lowermost bank of tuyeres *e*.

A further conduit **13** communicating with the lower portion of the downwardly extending conduit **22** draws medium from this last-mentioned conduit so that the fan **23** forces a hot stream of medium to flow past the nozzles **14** and pick up particles injector fashion and convey the same to the lowermost bank of tuyeres *e*. The length of the conduit between the nozzles **14** and these tuyeres *e* is such that any large particles of coke are degasified in passing therethrough.

The arrangement just described supplies cold medium to the under grate area and the medium constituting the secondary supply through tuyeres *e* and the tertiary supply though tuyeres *h* is hot, having passed through the air heater **24**. In order to regulate combustion in the various zones the invention provides for admixing combustion gases with the medium introduced so that all streams of medium consist of either air or air admixed with a regulated proportion of combustion gases. Thus, means are provided for drawing off combustion gases from the flue, the drawing off means including a first conduit **25** and a second conduit **26** communicating with the flue on opposite sides of the air heater **24** and thus at points of substantially different temperatures. The conduits **25** and **26** include valves **25'** and **26'** which are operative to control the amount of combustion gases from

the points of different temperature in the flue that communicate with conduit **27** which, in turn, communicates with the pump or fan **16**. Thus, the valves **25'** and **26'** can be operated to regulate the proportions in which the gas drawn off at the point of different temperatures is admixed with the air in the streams of oxidizing medium so that the temperature of the streams of oxidizing medium can be regulated.

Thus the invention provides an arrangement wherein with the valves **25'** and **26'** closed all streams of medium consist of air, with those supplied beneath the grate being cold and the other streams being hot. By suitable manipulation of these valves **25'** and **26'** combustion gases of different temperatures and in different amounts can be admixed with the air in all streams.

With regard to the operation of the present furnace structure, the travelling grate is charged with suitable igniting material or if desired, gas or oil burners, not shown, which can constitute igniting devices, are lit. By these means the fuel delivered in the falling curtain throughout the width of the furnace is ignited at the front end of the grate so that when the grate is moved from front to rear the first two sections are soon charged with a burning body of coal. The under grate blast at section 3 through the underlying opening or at **3'**, Figure 3, has its pressure increased beyond the pressure existing at section **2** so that fluidization or pneumatic stirring of the fuel on the grate commences. As soon as the fuel bed has reached the rearmost section **4** the air pressure beneath this section is increased to a considerable extent way beyond the pressure required for fluidization and subsequently the secondary air supply and coke return through the lowermost nozzles *e*, Figure 3, is initiated. In Figure 3 additional secondary oxidizing medium is supplied through the lowermost nozzles *e* which communicate with the lower portion of conduit **22**. The additional oxidizing medium supply through the nozzles or tuyeres *h*, Figure 3, is then started.

The various air or oxidizing medium supplies have definite and important functions and are located in a particular relationship within the furnace. It is important that the fuel that falls upon the grate be dried and degasified. Accordingly the generation of a circular motion or turning over of the fuel in the lower portion of the combustion zone or fire box involves a portion of the falling path of fuel, a part of its movement with the grate and an upward motion due to the under grate blasts and additionally a projection of incandescent coke particles upwardly from the rearmost section of the grate and then forward toward the falling curtain of fuel. In Figure 3 the superposed nozzles *e* have this projecting function, particularly the uppermost ones. During the time the fresh fuel is falling upon the forward end of the grate the same is dried and freed from gas prior to striking the grate and during its free fall it is so mixed with incandescent particles that as soon as the fuel reaches the front portion of the grate and oxidizing medium enters thereunder there is initiated an immediate vigorous combustion. Under these conditions with the drying and degasifying of the fuel in its vertical drop the present arrangement permits elimination of a considerable area of grate length as embodied in conventional travelling grate furnaces. In such conventional arrangements the first third of the travelling grate is used to dry and degasify the coal. With the present structural relationship this initial grate area can be eliminated and the overall depth of the furnace correspondingly diminished.

With the under grate blast increased from the front to the rear in such fashion, that a high degree of pressure exists in the rearmost zone, incandescent large coke grains not consumed on the bed are hurled upwardly so that only slag remains to deposit through the shaft **7**. In the initial zone **2**, of the grate the incandescent fuel mixture rests on the grate. When the under grate

blast hits it it is immediately ignited. The relative velocity between the fuel and the combustion air is at its highest since the component of movement of the air in the direction of the air blast is lowest. Therefore the relative velocity is equal to the air velocity. In the second zone of the grate the under grate pressure is increased so that the pneumatic stirring or fluidization occurs resulting in a sieving action or stirring of fine grain fuel, the finest grains of which are elevated from the fuel bed and into the horizontal air stream and enter the falling curtain of fresh fuel. This is due to the comparatively high relative motion between fuel particles and under grate oxidizing medium supply and the influence of the constant change in the direction of motion of the fuel since it is being stirred. Only fuel particles of increasing size remain on the bed at the zone 3. At the third or rearmost zone the remaining large grain incandescent remnants are lifted up from the heavy slag which occupies the grate and projected upwardly above the grate and into the path of the horizontal streams of oxidizing medium whereby they are hurled into the falling curtain of fresh fuel. In effect the horizontal streams of medium indirectly help separate the lower fire box from the upper fire box. Above the bed of the flame of the furnace, separator *i* is arranged which forces all the gases and unburnt particles to flow in an annular path adjacent the furnace walls and into the influence of the tuyeres which impart a whirling motion on a vertical axis. In connection with the circulating motion of the fuel adjacent the grate, in other words the circulating movement of the fuel about a generally transverse horizontal axis including the downward component from the conveyor to the grate, the horizontal movement along the grate and the upward movement effected by the under grate blasts and the return horizontal movement forward toward the falling curtain of fuel effected by the nozzles *e* the smaller incandescent fuel particles have a shorter distance to travel to reach the falling curtain of fuel since they are lifted from the fuel bed sooner. In other words the incandescent particles are blown into the falling curtain of fresh fuel in accordance with grain size, so to speak. The heavier particles have a longer distance to travel since they are not raised from the bed until the same is above the inlet 4'.

The movement of the fuel in the manner heretofore described in combination with the under grate blasts and the return blasts effected through the nozzles *e* is highly effective not only to dry and degasify the incoming fuel but also to provide more complete combustion. In other words it is extremely effective for elimination or fuel ashes. A great quantity of the ash, approximately 90%, is separated in the lower combustion zone portion so that with the rising gases moving upwardly into the sphere of influence of the tuyeres *h* only about 10% of the ash remains. In the upper combustion zone portion exists a cyclone effect in that the ash particles are hurled against the sides of the furnace by centrifugal force and fall back down to the grate. The central stream of ascending gases passing through diffuser *g* contain only approximately 1% of the fuel ash. The falling ash by falling back on the grate pass out of the furnace with the slag in the slag shaft.

In connection with the modification of Figure 2 in which the intermediate section of the furnace is circular and of increasing diameter downwardly toward the grate, such arrangement provides an increased force extending downwardly to accelerate the downward flow of the ashes separated by the cyclone effect. In connection with the deflector, the shape of this body constituting an upwardly open core with its smallest diameter at the bottom and flaring outwardly and upwardly to a considerable extent defines in cooperation with the adjacent furnace walls a venturi type annular throat to accelerate the flow of gases from the lower fire box into the upper fire box and thus into the sphere of action of the tuyeres.

What I claim is:

1. In a furnace the combination of wall means defining a vertically extending combustion zone including upper and lower portions, means providing a superposed radiation section above and downstream of said combustion zone, water tubes bounding the radiation section, flue means extending downstream of the radiation section, a travelling grate including front, middle and rear portions at the bottom of said combustion zone and movable from front to rear thereof, feeding means substantially midway of the height of said combustion zone for feeding a curtain of solid fuel substantially coextensive in width with the width of the zone into the zone so that the fuel falls freely upon only the front portion of said grate, means for supplying a stream of primary oxidizing medium beneath and upwardly through all portions of said grate under pressure conditions such that the pressure of said medium successively increases beneath all portions of the grate from front to rear thereof with the highest pressure existing beneath and upwardly through the rear portion of the grate so as to lift upwardly incandescent particles of fuel from the grate, means for directing a stream of secondary oxidizing medium consisting at least in part of heated air from rear to front, over and above said grate in the lower portion of said combustion zone and at a level beneath said feeding means so as to project incandescent particles toward the front of the combustion zone so that they mingle with the incoming falling curtain of fuel, means for directing horizontal streams of tertiary oxidizing medium consisting at least in part of heated air tangentially into the upper portion of said combustion zone so as to provide a whirl of combustion supporting medium about the vertical axis of the upper portion of the combustion zone, and deflecting means located in the combustion zone in spaced relation with the wall means and at a level between said secondary and tertiary oxidizing medium directing means to partially physically spatially separate the lower portion of the combustion zone from the upper portion of the combustion zone so as to facilitate regulation of combustion in each portion of the combustion zone.

2. A furnace as defined in and by claim 1, wherein all of said streams of oxidizing medium consist of air admixed with a regulated proportion of combustion gases and said furnace including means for selectively and controllably supplying either air or air admixed with combustion gases beneath the grate, above the grate and in the upper portion of the combustion zone.

3. A furnace as defined in and by claim 1, in which the means for selectively and controllably supplying air admixed with combustion gases includes means for drawing off combustion gases from the flue means, said drawing off means communicating with the flue means at points of substantially different temperatures and means for regulating the proportions in which the gas drawn off at the points of different temperatures is admixed with the said air streams so as to regulate the temperature of the streams of oxidizing medium.

4. A furnace as defined in and by claim 1, and heat exchange means in the flue means downstream of the radiation section for heating air by heat exchange with the combustion gases.

5. A furnace as defined in and by claim 1, in which the deflecting means spacing the upper portion of the combustion zone from the lower portion of the combustion zone is an upwardly open body of substantially conical form and apertured at its apex and the space between the body and the wall means constitutes a marginal passage through which gases flow from the lower portion of the combustion zone to the upper portion of the combustion zone and said upwardly open body having its widest portion uppermost so as to increase the speed of travel of the gases pass-

ing from the lower portion of the combustion zone to the upper portion thereof.

6. A furnace as defined in and by claim 1, in which said body is apertured at its apex and in which the upper portion of the combustion zone increases in width from top to bottom.

7. In a furnace structure, the combination of wall means defining a vertically disposed combustion zone, means providing a radiation section above and downstream of the combustion zone, horizontal partition means extending between the wall means and having a single central opening therein constituting a central outlet from the combustion zone into the radiation section, horizontally disposed tuyeres communicating with said combustion zone beneath said outlet and directed as to produce a whirling action about a vertical axis in the zone, said combustion zone extending vertically downwardly beneath said tuyeres, means providing a partial partition separating the combustion zone into an upper combustion zone portion into which said tuyeres project and a lower combustion zone portion, said last mentioned means constituting a separating and deflecting member having marginal edges spaced from said wall means so that the passage of gases from the lower portion of the combustion zone to the upper portion of the combustion zone is confined to the region between the marginal edges and the adjacent wall means, a travelling grate at the bottom of the combustion zone and movable from front to rear thereof, means for feeding fuel to fall freely upon the front portion of the travelling grate, means for introducing combustion supporting oxidizing medium into the lower portion of the combustion zone including means for supplying a stream of primary supply of oxidizing medium directed beneath and upwardly through said travelling grate under pressure conditions such that the pressure of the medium flowing upwardly through the grate is highest beneath the rear portion of the grate to lift incandescent particles above the grate, and means for supplying a stream of secondary oxidizing medium into the lower portion of the combustion zone including directing means for directing said last mentioned stream in a horizontal plane beneath the partition means and disposed above the rear portion of the grate and directed toward the incoming curtain of fuel so as to project incandescent particles into the said incoming curtain of fuel so that substantially complete combustion of coarse fuel particles occurs in the lower combustion zone, and means for supplying oxidizing medium to the tuyeres so as to complete combustion in the upper portion of the combustion zone and the said partial partition facilitating regulation of combustion in the respective upper and lower portions of the zone.

8. In a furnace structure as defined in and by claim 7, and the said wall means at least from beneath the upper central outlet to the deflecting member having circular cross-section, and the deflecting member having a conical cross-section with the widest portion at the top, its axis vertical and including a lower portion having an aperture therein.

9. In a furnace structure as defined in and by claim 7, and in which the wall means defining the upper combustion zone widens downwardly.

10. In a boiler furnace, the combination of wall means defining a vertically disposed combustion zone and a superposed vertically disposed radiation section downstream of the combustion zone, a travelling grate at the lower portion of the combustion zone and movable from front to rear of said zone, means substantially midway of the height of the combustion zone for forwarding fuel to fall by gravity as a curtain of falling fuel upon only the portion of the grate at the front portion of the combustion zone, said combustion zone including a first portion providing a lower fire box above said grate and a second portion providing an upper fire box downstream thereof, water tubes bounding the radiation section downstream of the

upper fire box, horizontally disposed tuyeres communicating with the upper fire box above the means for forwarding fuel for injecting a supply of tertiary oxidizing medium into the upper fire box, said tuyeres being so directed as to provide whirling action about the vertical axis of the upper fire box, partition means extending between the wall means above the tuyeres and separating the upper fire box from the radiation section, said partition means having a central opening therein, a short cylindrical sleeve extending downwardly from the edge of the opening part way into the upper fire box, said sleeve extending above the partition into the radiation section and increasing in width upwardly to define a diffusing means through which hot gases are discharged into the radiation section, and a conical deflecting member having its axis vertical and its widest portion at the top and including a lower portion having an aperture therein and said deflecting member partially spatially separating the lower fire box from the upper fire box and having marginal edges spaced from the adjacent wall means to provide an annular passage through which combustion gases and fine fuel particles pass from the lower fire box into the upper fire box for further combustion therein and separation of ash from the gases so that only substantially ash free gases pass from the upper fire box into the radiation section.

11. In a furnace structure, the combination of wall means defining a vertically extending combustion zone and a superposed radiation section downstream of the combustion zone, horizontal partition means extending between the wall means and having a single opening therein and separating the combustion zone from the radiation section, said wall means including front and rear walls, said front wall having a fuel feed opening extending thereacross substantially midway of the height of and substantially coextensive in width with said combustion zone, a travelling grate disposed at the bottom of the combustion zone and movable from front to rear therethrough, a hollow conical deflecting member having a vertical axis and its widest base uppermost disposed substantially midway of the height of the combustion zone and in spaced relation to the wall means so as to partially spatially separate the combustion zone into an upper fine combustion zone and a lower coarse combustion zone, means for feeding fuel through said feed opening in a falling curtain of fuel extending substantially coextensive in width with the width of the combustion zone so that the fuel falls by gravity upon the front portion only of the travelling grate, means for introducing a primary supply of oxidizing medium from beneath and upwardly through the grate under pressure conditions such that the pressure increases successively from front to rear of the grate with the greatest pressure existing at the rearmost portion thereof to lift incandescent fuel particles upwardly from the grate, supply means for introducing secondary oxidizing medium including plural horizontally disposed nozzles extending through the rear wall of the furnace, directed toward the falling curtain of fuel and located beneath said deflecting member so as to project the lifted particles into the falling curtain of fuel so that substantially complete combustion of coarse fuel is effected in the lower portion of the combustion zone beneath the deflecting member and combustion gases and ashes are constrained to flow in a path upwardly past said deflecting member into the upper combustion zone, and supply means for tertiary oxidizing medium including horizontally disposed tuyeres directed into said upper combustion zone tangentially about a common circle so as to provide a combustion supporting gas whirl about the vertical axis in the upper portion of the combustion zone to effect completion of combustion of fuel in said upper portion of the combustion zone and to separate ashes from the whirl of combustion gases so that only substantially ash free gases pass through said partition means into said radiation section.

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