

March 2, 1937.

J. R. A. HOBSON, JR

2,072,450

FURNACE

Filed May 13, 1932

2 Sheets-Sheet 1

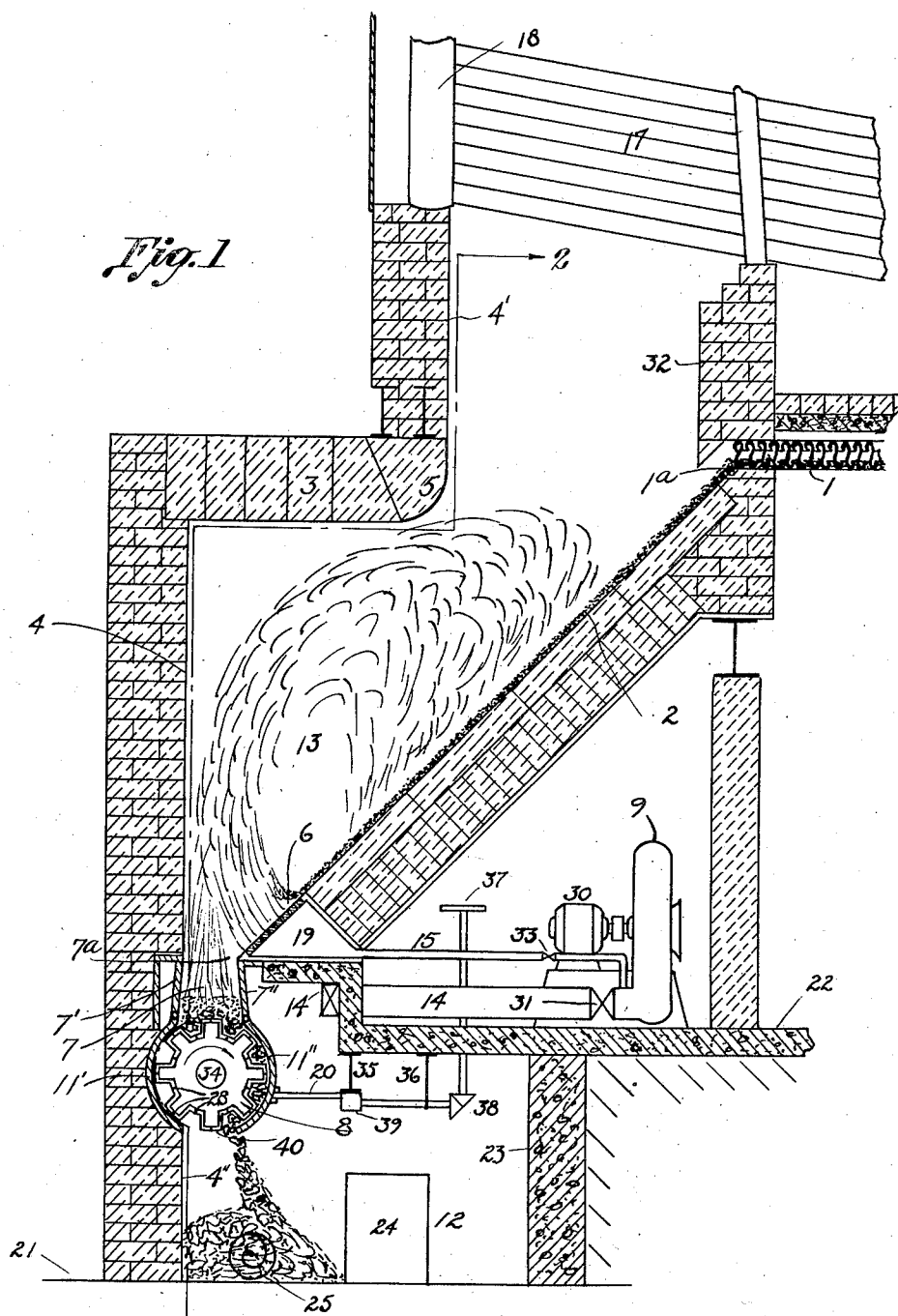


Fig. 1

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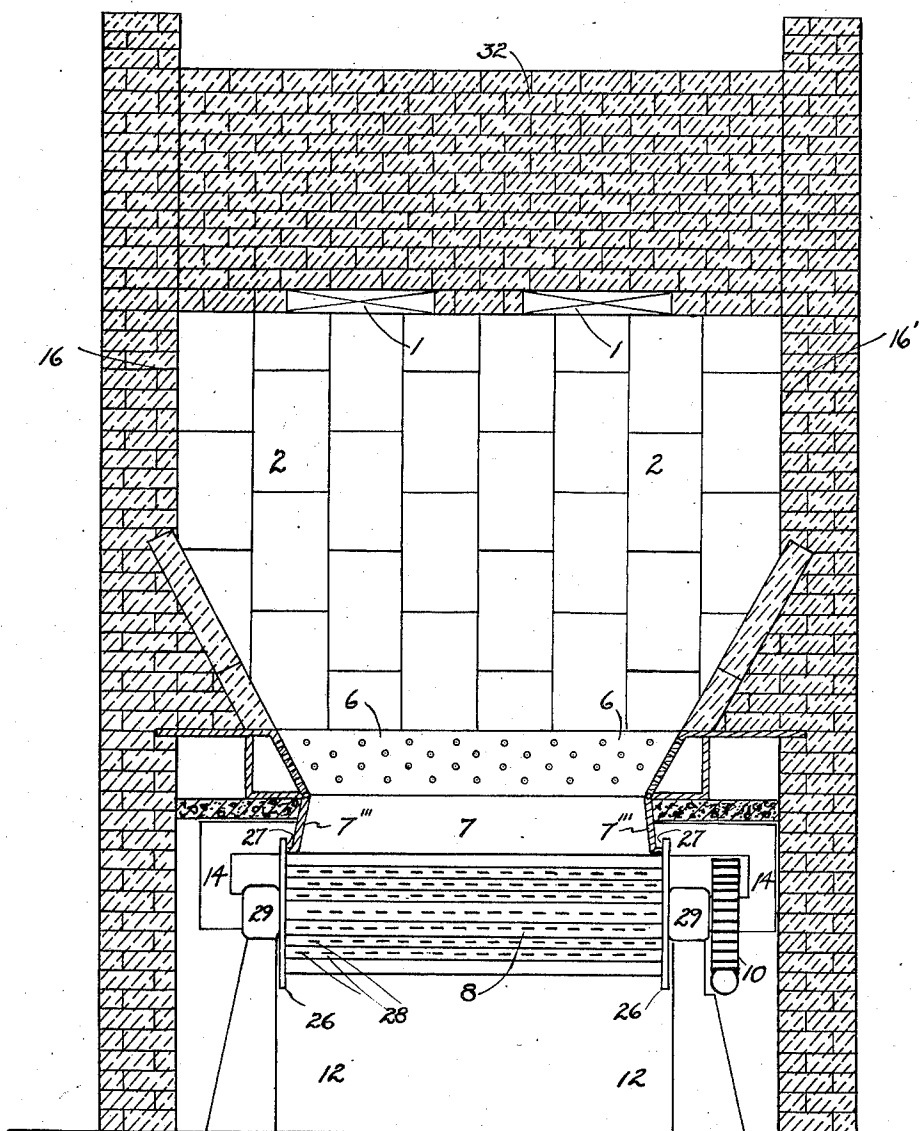
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2 Sheets-Sheet 2

Fig. 2



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FURNACE

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Application May 13, 1932, Serial No. 611,101

9 Claims. (Cl. 110—28)

This invention relates to furnaces, and more particularly to a furnace adapted to burn finely divided, crushed or pulverized fuel having low volatile content such as anthracite fines or coke breeze, but is not limited to the use of these materials. My improved furnace is particularly adapted to fuels which have high ignition temperatures and which are difficult to ignite and utilize in known types of furnaces, as well as to fuels having ash with high fusion temperatures.

A specific object of the invention is the provision of an improved simple, compact and efficient furnace adapted to burn a fuel of relatively small size, the combustion preferably taking place with the fuel largely in suspension in the combustion chamber. In accordance with the invention, I provide means for heating the fuel prior to its injection into the burning zone and means whereby the fuel prior to and during combustion is under the influence of high radiant heat. Another feature of the invention resides in improved means for separating the finer combustible material in the fuel from the heavier particles and ash. Still another feature is a novel grate for burning out substantially all of the combustible from the ash and for removing the ash and clinker from the furnace. The two last-mentioned features preferably include novel means for supplying air through the grate and also thereabove, and for controlling the amount of air supplied.

Through my invention the extent to which fuel is fed, combustion is carried on, and ash is removed, can readily be controlled in accordance with requirements, all without sacrifice of efficiency.

Other objects of my invention are to provide a furnace in which low volatile, small sized fuel can be burned at high rates of combustion and in which the supplies of air and fuel can be regulated either independently or simultaneously so as to produce highly efficient combustion and flexibility of operation. Further objects and advantages of my invention will become apparent as the description proceeds.

My invention can best be explained by a detailed description of one preferred form thereof, reference being had to the accompanying drawings in which:

Fig. 1 shows, partly diagrammatically, a cross section of one embodiment of my invention as applied to a horizontal water tube boiler.

Fig. 2 is a partly diagrammatic view in cross section on the line 2—2 of Fig. 1.

The main body 13 of the furnace where the combustion takes place is confined within the

front walls 4 and 4', the combustion arch 3 and 5, the sloping hearth 2, the bridge wall 32 and the side walls 16 and 16' (see Fig. 2). This space is closed off at the bottom as will be more fully described later. At the top it communicates with the first pass 17 of the boiler 18.

Suitable conveying means such as the screw conveyor 1 are provided to introduce the fuel into the furnace.

The rear wall of the furnace comprises the sloping hearth 2 which is preferably set at an angle to the horizontal somewhat greater than the angle of repose of the fuel to be used, but small enough so that the fuel is enabled to remain on the hearth over desired periods of time. It consists of a solid, preferably smooth surface composed of highly refractory material such as carborundum tile, or similar material capable of withstanding the high temperatures obtained during the operation of the furnace.

At the bottom of the sloping hearth 2 and forming a continuation of the slope is a wind box 19 with its perforated face plate 6 at substantially the same angle as the sloping solid hearth 2. Face plate 6 is provided with perforations or openings which provide communication from the wind box 19 into the combustion chamber 13. Below the combustion chamber 13 is located an air supply duct 7 of frusto-pyramidal shape having its smallest horizontal cross section at its top forming a throat 7a between the main duct 7 and the combustion chamber 13. The main air supply duct is formed by front plate 7', rear plate 7'', and side plates 7'''. A rotatable, cylindrical grate 8 and its housing positioned below the main air supply duct 7 prevents free fall of larger fuel or ash particles to the ash pit.

At the lower end of the plates 7' and 7'' are plates 11' and 11'' preferably substantially in the form of a horizontal cylinder which is open at the top and the bottom, and which conforms closely to and contains a cylindrical rotating grate. Plate 11' is joined to plate 7', and plate 11'' is joined to plate 7'' by suitable connections so that both plates 11' and 11'' are easily removable for repairs or replacements. Furthermore, the connection between plate 7'' and plate 11'' is preferably of hinged character, plate 11'' being held in position by a removable brace 20 for easy adjustment, assembly and disassembly.

The grate 8, the air supply duct 7, and the plates 11' and 11'' are confined within the closed air chamber 12 while the interior of the grate is in direct communication with it through apertures 28. This air chamber 12 forms a sealed ash

pit which is an enclosed compartment substantially bounded by the extension of the side wall 16 of the furnace, front wall 4'' of the furnace, the floors 21 and 22, and the rear wall 23. It is provided with a suitable airtight door 24 so as to allow access to the air chamber 12 for repairs and replacements of the various parts within this space. There is also shown provided in this space suitable means such as a screw conveyor 25 for removing the ashes which will be deposited in chamber 12 upon rotation of the grate.

The grate 8 comprises substantially a hollow ribbed cylinder. This cylinder, as indicated, is provided with a number of openings 28 which communicate from the interior to the exterior of the cylinder. These openings are desirably of such size that the proper volume of air may pass therethrough, but not large enough to allow passage of substantial amounts of fuel. Each end of the cylinder is closed off by a flange 26 (Figure 2), each of which forms a seal 27 with the plates 7''. The projections or ribs 40 on the grate 8, conforming to the plates 11' and 11'', form a suitable seal as will be seen from Figure 1. Connected to each of the flanges 26 is a hollow trunnion 34 mounted in a bearing 29. These trunnions provide means of delivering air under pressure to the interior of grate cylinder 8. Connected to one of the trunnions is a worm gear assembly 10 or other suitable means for transmitting power to rotate the grate cylinder 8. This worm gear assembly is in turn driven by any suitable motive power (not shown) which will provide means for suitable rotation of the cylindrical grate 8, preferably slowly and continuously, though possibly intermittently. The worm gear shaft may be carried through the front wall 4 of the furnace setting, so as to allow for the control and adjustment of rotation from a convenient point outside of the air chamber 12.

The fan 9, operated by the motor 30, furnishes air for combustion through the ducts 14 and 15. Duct 15, controlled by valve 33, delivers air under suitable pressure from the fan 9 to the wind box 19. Duct 14, controlled by valve 31, is bifurcated to deliver air from the fan to each of the hollow trunnions of the cylindrical grate 8 (Figure 2). Suitable stuffing box connections (not shown) may be provided between ducts 14 and trunnions 34, if desired. The pressures in the duct 14, the trunnion 34, the inside of the hollow grate 8, and the air chamber 12, will be substantially the same since all of these parts are in direct communication with one another. When the pressure in these parts is built up sufficiently, the air will flow through openings 28 in the grate and through the bed supported thereon. The pressure and quantity of air through the wind box 19 may be controlled independently of the pressure and quantity of air delivered to air chamber 12 by independent operations of valves 31 and 33.

The movable brace 20 which holds the plate 11'' in position as indicated, is shown supported by the I beam 35 and the hanger 36. By means of suitable mechanism (such as the hand wheel 37, bevel gear 38 and the worm or screw and block 39) the loose end of plate 11'' may be moved in and out with respect to the rotating grate 8, from a convenient operating position outside of the air chamber 12.

A feature of my invention is the construction of arch 3 and front wall 4, and their relation to the sloping hearth and to the combustion chamber 13, so that they form surfaces for reflecting radiant heat back into the combustion zone and

onto the sloping hearth. I further prefer that front wall 4 and arch 3 be so positioned relative to the sloping hearth 2 that the opening between the nose 5 of the arch 3 and the sloping hearth 2 be somewhat restricted in cross-section relative to the general cross-section of the combustion chamber 13. While for convenience of construction a square corner is shown between flat walls 3 and 4, it will be understood these walls may take other shapes and relations not inconsistent with the preferred feature last mentioned. The arch 3 and wall 4 are desirably constructed of refractory material such as high grade fire brick or tile.

The operation and certain advantages of my invention may be described as follows:

Fuel is fed by means of the conveyor onto the solid sloping hearth 2, where it spreads over the face of the hearth and under the action of gravity gradually slides down the slope provided by the hearth surface. During this travel down the solid refractory hearth, the fuel is brought to a high temperature. Under load conditions the fuel reaches incandescence before striking the furnace face 6 of the wind box. This heating of the fuel in its progress down the hearth is accomplished largely through the reflection of heat from the front wall 4 of the furnace and from the suspended arch 3. It is assisted also by means of the restriction between the nose 5 and the hearth 2, a condition which maintains and confines the heat within the combustion space 13 so that reflection onto the sloping hearth is obtained from the combustible particles in suspension. This preheating of the fuel serves two purposes. The first of these is the substantial completion of desired endothermic reactions prior to the introduction of the fuel into the main combustion zone, including the distillation of such volatile ingredients and moisture as may be contained with the fuel. By this method a fuel of more uniform quality is supplied to the main combustion zone than would be the case if the fuel contained its initial moisture and volatile content, as irrespective of the initial conditions of moisture and volatile content the proportion of these two in the fuel as it reaches the perforated face plate 6 of the wind box is at a constant minimum value when using my invention. Furthermore, because substantially all of the volatile content has been eliminated, these endothermic reactions do not limit the temperature of the initial main combustion. The second feature which I mention is the fact that the fuel before reaching the main combustion zone is heated to a high temperature, preferably near the ignition temperature. The necessity of adding sensible heat to the coal particles in the combustion zone is, therefore, reduced to a minimum. These two features are of extreme importance in my invention for the following reason. With low volatile fuel a higher temperature is required to initiate and maintain combustion than is necessary with fuels of high volatility. By the initial heating of the fuel, and incident substantial completion of the endothermic reactions, temperatures are maintained higher than the minimum required for the combustion of the fuels.

On reaching the perforated face plate 6 of the wind box, the fuel meets a number of high velocity blasts of air, advantageously at right angles to the hearth, which force the finer particles of the fuel into suspension and provide an intimate turbulent mixture of the fuel and the air. The finer fuel particles are thus carried in suspension into the combustion chamber 13 and

combustion is maintained preferably throughout this space. Inasmuch as the volume of the combustion chamber, as shown, increases toward the top, as the fuel and air stream are elevated, the velocity or carrying capacity of the stream will decrease, thus allowing particles of the incandescent fuel in the combustion stream to drop out and fall on the sloping hearth 2. There they mingle with the fresh fuel particles delivered by the conveyor preferably in a substantially continuous manner. The construction of my furnace, as shown, is preferably such that the direction of the flow of gases through the furnace facilitates the separation and movement of the particles toward the sloping hearth rather than into the air jets. In this way, thorough commingling is obtained of the fresh fuel fed by the conveyor with the partially combusted fuel returned from the air stream. This further provides for uniform and high temperatures in the initial combustion zone.

Depending on the size of comminuted fuel being used, the rate of fuel feed and the pressure and volume of air being supplied through the perforated wind box face plate 6, a certain percentage of the coarser fuel particles or agglomerated particles of fuel, or ash, or both, passes over the perforated wind box face plate 6 and discharges into the main air supply stream entering the bottom of the combustion chamber through the throat 7a. Particles of sufficient size and weight to overcome the lifting effect of the main air stream through throat 7a fall into the main air supply duct 7 and onto the rotatable grate 8 where any remaining combustible is consumed. Particles not sufficiently heavy to overcome the lifting effect of the main air supply stream through the throat 7a are projected vertically upward into the combustion space 13 commingling with the ignited finer fuel projected from the perforated wind box face plate 6. Such fuel as passes the perforated wind box face plate 6 will, in general, comprise the larger particles, and will be composed largely of agglomerated ash particles which consist of a number of small ash particles fused together with such small amounts of combustible as they may contain. A bed of these particles will be maintained within the main air supply duct 7 on top of the rotating grate and will be subject to a current of air which passes through the duct 14, the trunnion 34, and through the face openings 23 of the rotating grate 8 when these openings are in a position directly below the duct 7. This stream of air will be initially heated through its contact with the rotating grate 8. This provides means of burning out of such combustible as may be left in the bed which lies on top of the grate. As the stream of air passes through this bed, (the temperature of which may be near the fusion point of the ash) it is heated to a high degree. On the other hand, the air entering the grate cools the same somewhat.

It will be understood from the preceding description that two streams of air are preferably employed, one entering the combustion chamber 13 through the grate 8 and throat 7a (this stream being designated as primary), and the other entering through the perforations in the face plate 6 of wind box 19 (this latter stream being termed secondary). The size of the holes in face plate 6 will be suitable for the purposes indicated and may vary somewhat depending on the size of fuel employed, as will be understood by those skilled in the art. As shown in Fig. 1, these streams

preferably enter the combustion chamber adjacent the front wall 4 of the furnace and advantageously converge a short distance above the throat 7a, with the result that desired turbulent flow of the gases is increased. In other words, the construction is preferably such that a secondary air stream impinges upon a generally vertical primary stream close to the wall 4, and intimately intermingles therewith, carrying hot particles of coal generally in the path indicated.

By admitting the fuel at a point 1a, at the opposite side of the furnace from the air admission, and permitting the fuel to slide down the hearth 2 a considerable distance before it reaches the entering air, and by employing a wall 3-5 which converges toward the upper end of the hearth, the gas outlet port between the point 1a and the opposite portion of the wall 3-5 lies adjacent the portion of the hearth upon which relatively cold coal lies, so that the hot combustion gases are concentrated upon and act to preheat the entering coal by what may be termed a counter-current heat exchange, the relatively cool air which enters at the lower end of the hearth meeting fuel which has been preheated on the hearth. That is to say, the hot gases have to pass substantially entirely over the hearth to reach the outlet port of the combustion chamber, being admitted at the opposite side of the furnace from outlet port and being directed toward the hearth by wall 3-5.

A large portion of the air for combustion is thus highly heated prior to its introduction into the main combustion zone 13 and this greatly assists in maintaining the high temperatures which are necessary for the combustion of the low volatile fuel to which this invention is principally directed.

The velocity of the main air supply stream through the throat 7a effects a classification of the material which has passed over the perforated wind box face plate 6 into particles sufficiently light to be lifted by the main air supply stream and blown upward into the combustion chamber 13 and particles heavy enough to fall through the main air supply stream and deposit on the rotatable grate 8. This is advantageous because it limits the amount of combustible which must be burned out on the rotatable grate 8.

As the particles of agglomerated clinker descend to the grate 8, they are caught between the ribs on the grate 8. By the rotation of the grate, the particles are carried in the pockets formed by the ribs and the plate 11' and are finally discharged into the ash pit 12. From there they may be removed by any suitable means such as the screw conveyor 25. The projecting rib of the rotating grate 8 entering the zone of the duct 7, has an upward movement which tends to loosen the bed of material lying above the grate. The projecting rib of the rotating grate 8 leaving the zone of the duct 7, exerts in combination with element 11' a shearing action on the particles thus tending to break up any large accumulations which may lodge in the bed next to plate 11'. This provides a positive action for the removal of clinker. By the action of the pockets rotating within the plate 11', a substantially definite quantity of ash and clinker is removed at each revolution of the rotating grate 8. Thus, by proper regulation of the speed of the rotating grate, a positive control of the height of material on the grate is maintained. The rate of ash production will be governed substantially by two factors, the rate of fuel feed and the quan-

tity of ash contained in a unit of fuel. The speed of the grate is in turn coordinated with these two factors. Since, prior to the dumping of the ash, a bed containing this material may be maintained over the rotating grate at any reasonable height desired, the quantity of combustible in the ash discharge from the furnace can be finally reduced to a minimum. The maintenance of such a bed over the grate is especially desirable with fuel containing ash of high fusion point as without such a bed great difficulty is encountered in securing an ash which is reasonably free from unburned combustible.

My invention provides an easy and economical way of controlling this condition and further, it provides means of furnishing a large amount of highly preheated air to the combustion zone without the use of expensive preheating equipment.

Under certain conditions of load, clinkers might be produced and be imperfectly comminuted by the action of the ribs against the fixed plates. Should this occur, plate 11' may be moved by operation of the hand wheel 37. In this way, any undue pressure may be relieved by increasing the space at the point of shear. This is necessary only on the side towards which the ash rotates as indicated on the drawings.

Great flexibility of operation is readily available with my invention. That is to say, the furnace may be rapidly converted from a condition where it is banked to one of maximum heat generation per unit of time, by simple changes in the rates of feed of air and fuel, and possibly of rotation of the grate. The furnace may be banked by simply reducing or stopping the feed of fuel, and reducing or preferably cutting off the flow of air through the wind box 19, though the speed of rotation of the grate and the air stream there-through may also be varied, if desired, for this same purpose. During banking, fuel will burn on the rotating grate 3 in a manner substantially the same as an ordinary hand fired pin hole hearth and will be confined to the limited space of duct 7, provided, as contemplated, that the holes in the wind box are sufficiently small to prevent any substantial amount of fuel from passing therethrough. In this way, only a small amount of fuel will be consumed during the banking period, and at the same time, sufficient hot combustible will be available at all times to start operations under load without delay. In addition to providing for preheating of the fuel as it descends slowly along the inclined solid hearth 2, before it is brought into contact with air blasts supplied through the perforated wind box face plate 6 and the main air supply throat 7a and is blown into suspension, I provide for a selective classification and stage combustion of the fuel in first blowing out and projecting into the combustion chamber 13, the finest portion of the fuel, by means of the air supplied through the perforated sloping face plate 6 and second in separating coarser fuel and agglomerated ash or particles of agglomerated ash containing some combustible, projecting the lighter particles upward into the combustion chamber 13 for combustion and dropping the heavier particles to the rotatable grate for final combustion and discharge as ash. This stage combustion has distinct advantages as it brings coarser fuel into contact with fresh air supply in the main air stream before it is projected upward into the combustion zone of the burning finer coal projected from the perforated wind box face plate 6.

By controlling the pressure in the wind box and

the air pressure chamber, as well as the flow of fuel and the speed of the rotating grate, the operations of the furnace can easily be adjusted to conform to the load and to give high efficiency at all loads.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described, or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What I claim is:

1. A furnace adapted to burn comminuted fuel, said furnace including walls forming a combustion chamber, a solid hearth therein sloping at an angle to the horizontal slightly greater than the angle of repose of fuel used, means for supplying fuel to the hearth adjacent the upper end thereof, means adjacent the lower end thereof for receiving fuel therefrom and for projecting part of the fuel into suspension in said combustion chamber, means adjacent to and below said last mentioned means for receiving fuel overflowing said last mentioned means and projecting it upward and into suspension in said combustion chamber and means for collecting and discharging residues from the bottom of said combustion chamber.

2. A furnace adapted to burn comminuted fuel comprising walls forming a combustion chamber, a solid hearth therein sloping at an angle to the horizontal slightly greater than the angle of repose of the fuel used, means for supplying fuel to the hearth adjacent the top thereof, a sloping perforated plate adjacent to the lower end thereof and adapted to receive fuel therefrom, means for supplying air under pressure through said perforated plate, a substantially vertical air supply duct adjacent the lower end of said perforated plate and positioned to receive fuel therefrom, a grate below said air duct and means for supplying air under pressure through said grate and said air duct for projecting fuel into suspension in said combustion chamber.

3. A furnace according to claim 2 in which the grate is a hollow, rotatable grate.

4. A furnace according to claim 2 in which the perforated plate is disposed at an angle adapted to direct air discharged therefrom toward and into the stream discharged from the air supply duct.

5. The method of burning comminuted fuel which comprises, preheating the fuel supported out of suspension in a combustion chamber; blowing a stream of the finer size particles of the preheated fuel into suspension by an air blast and burning them, and then flowing the coarser size particles of preheated fuel into a second air blast and blowing a stream of said coarser fuel particles into suspension by said second air blast and burning them in the combustion chamber; separating heavy residue from lighter fuel in the second air blast and withdrawing the heavy residues from the furnace.

6. The method of burning comminuted fuel according to claim 5 in which the burning stream of finer size fuel particles impinges on the stream of coarser size fuel particles.

7. The method of burning comminuted fuel according to claim 5 in which incompletely burned particles of the suspended fuel are dropped out and commingled with the fuel being preheated and are again subjected to the action of the two air blasts.

8. A furnace adapted to burn comminuted fuel, said furnace including walls forming a combustion chamber, a solid hearth therein sloping at an angle to the horizontal slightly greater than the angle of repose of fuel used, means for supplying fuel to the hearth adjacent the upper end thereof, means adjacent the lower end thereof for receiving fuel therefrom and for projecting part of the fuel into suspension in said combustion chamber, means adjacent to and below said last mentioned means for receiving fuel overflowing said last mentioned means and projecting it upward and into suspension in said combustion chamber, means adjacent to the upper end of said hearth and to said fuel supplying means for venting products of combustion from said chamber, and

means for collecting and discharging residues from the bottom of said combustion chamber.

9. A furnace adapted to burn finely divided fuel comprising walls forming a combustion chamber having a gas outlet at its top, a stationary hearth therein sloping at an angle to the horizontal slightly greater than the angle of repose of the fuel to be used, means for supplying fuel to the hearth adjacent the top thereof, means forming a substantially vertical air supply duct adjacent the lower end thereof, a grate below said hearth and adjacent lower portion of said air duct and a perforated wind box between said hearth and said air duct for blowing fuel into suspension.

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