

March 19, 1946.

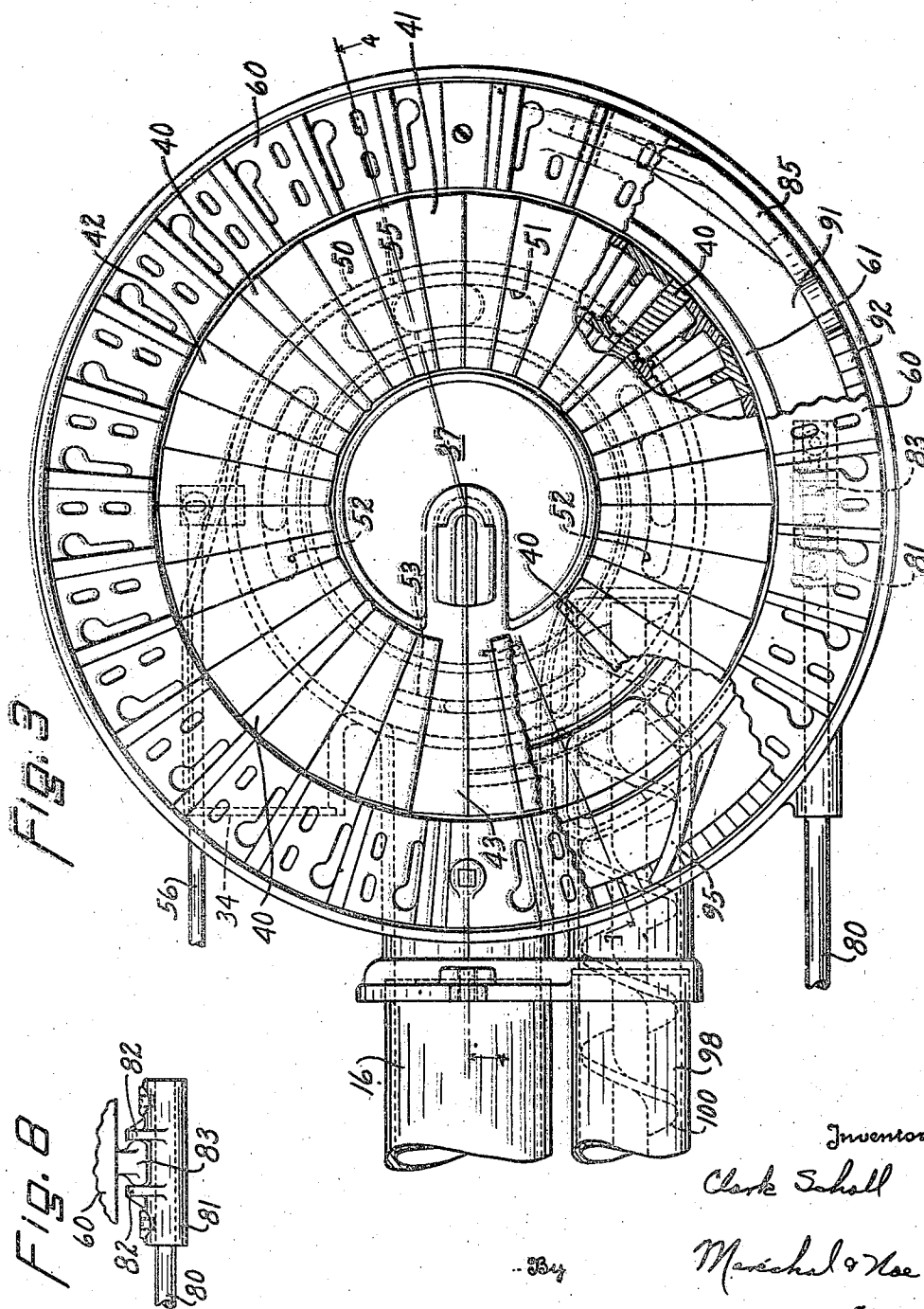
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2,396,888

COMBUSTION APPARATUS

Filed Sept. 30, 1941

4 Sheets-Sheet 2



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4 Sheets-Sheet 3

Fig. 4

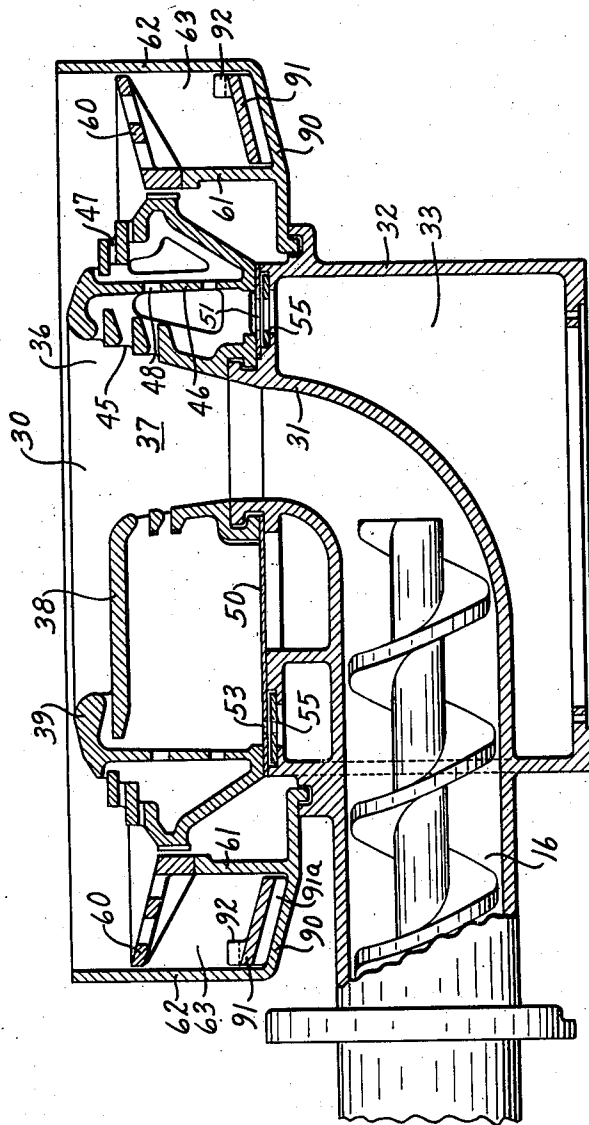
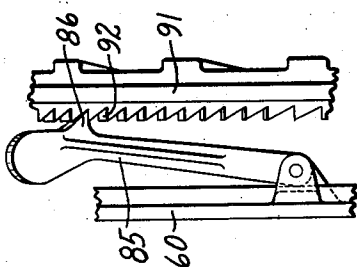
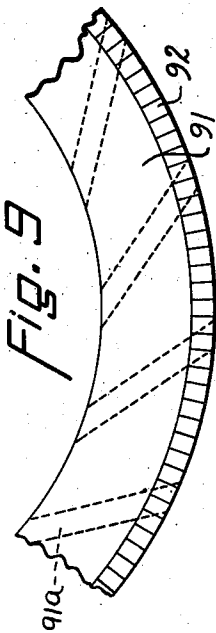


Fig. 6



334

Fig. 9



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4 Sheets-Sheet 4

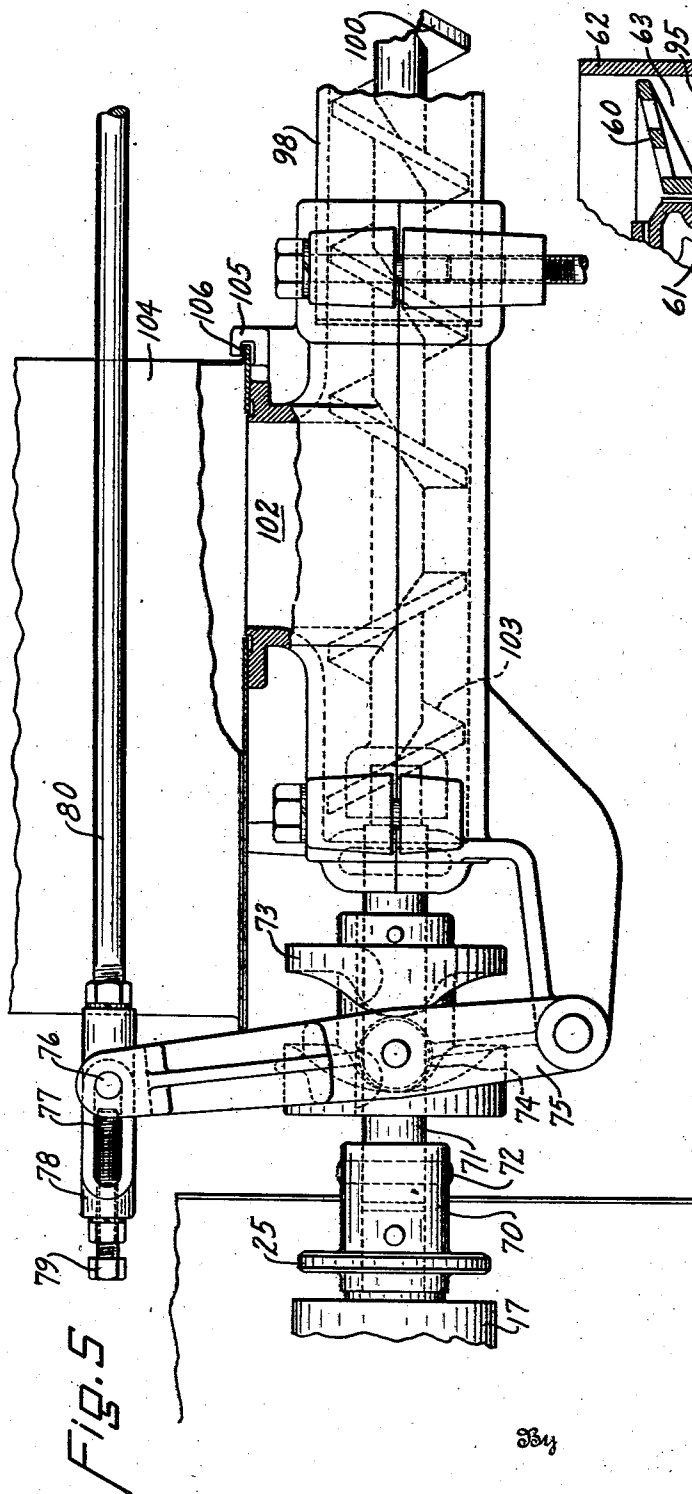
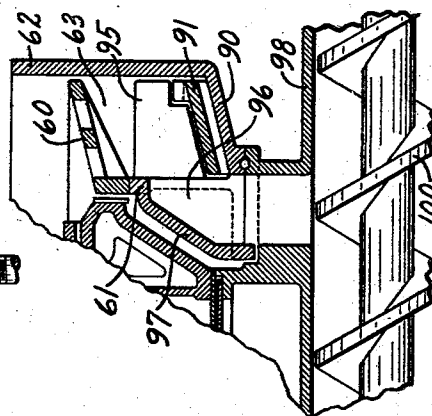


Fig. 7

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UNITED STATES PATENT OFFICE

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COMBUSTION APPARATUS

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13 Claims. (Cl. 110—45)

This invention relates to combustion apparatus and more particularly to stokers.

It is a principal object of the invention to provide a stoker of simple and effective construction providing for the combustion of solid fuel under predetermined conditions such that objectionable coke or clinker formation is reduced or eliminated and the ash is produced in the form of powder or particles of small size in which it can be readily handled and removed.

It is a further object to provide such a stoker device in which there is a predetermined regulation of the quantity of air supplied throughout the combustion zone so as to properly control the combustion and assure complete combustion while avoiding excessive temperatures which would otherwise result in the fusing of the ash in large masses of clinker.

It is a further object to provide an underfeed stoker in which the section of the body of burning fuel is of predetermined shape and depth and in which combustion air is introduced throughout the burning fuel body in correlated relation with respect to the depth of the fuel body to obtain substantially a uniform and complete combustion at all rates of fuel supply.

It is also an object to provide an underfeed retort in which the combustion chamber is zoned around the periphery thereof as to air supply and each zone is separately supplied from a plenum chamber so that proper air supply is maintained throughout the body of burning fuel notwithstanding locally occurring variations in the thickness of the fuel bed.

It is a further object to provide a combustion device of this character in which combustion air is supplied at relatively low velocities and low pressures in predetermined space distribution over and into the body of burning fuel assuring a maintained distributed supply of combustion air at low velocities and pressures to avoid high temperature combustion and the resultant fusing of the ash into large clinkers.

It is a further object to provide a combustion device of this character in which the ash as received in finely divided particles is removed continuously from the combustion zone and deposited in a suitable ash receptacle.

Other objects and advantages will be apparent from the following description, the accompanying drawings, and the appended claims.

In the drawings,

Fig. 1 is a plan view of a stoker installation made in accordance with the present invention;

Fig. 2 is a side elevational view of the same mechanism;

Fig. 3 is a plan view looking down on the retort of the present stoker construction with certain of the parts being broken away to more clearly disclose the construction;

Fig. 4 is a vertical sectional view through the retort on the line 4—4 of Fig. 3;

Fig. 5 is a view partially in elevation and partially in vertical section showing the ash worm and the drive mechanism for effecting actuation thereof;

Fig. 6 is a detail view showing the construction which provides for the drive of the ash conveyor ring;

Fig. 7 is a detail view in section on the line 7—7 of Fig. 3 showing the provision for discharging the collected ash onto the ash conveyor;

Fig. 8 is a detail view showing the drive connection for effecting the oscillatory movement of the ash ring; and

Fig. 9 is a broken plan view of the ash conveyor ring.

In the field of stokers, particularly those for the domestic or household heating system, it has heretofore been proposed to provide a device embodying a retort and an ash removal arrangement for removing the ash to a place where it can be properly received and disposed of. In the past considerable difficulty has been experienced in the actual operation of such devices in part by reason of the failure of the retort to properly burn the fuel under the wide range of load conditions necessarily encountered, and the resulting objectionable formation of coke trees because of incomplete combustion, or the formation of large clinkers by reason of combustion taking place at excessively high temperatures. In some cases it has been proposed to introduce mechanism for breaking or grinding up these formations, but in most cases they have not proven entirely satisfactory in operation since substantial power is required to break or grind up clinkers to a small enough size for handling in the usual conveyor, and the heavy forces involved required correspondingly heavy and expensive constructions.

In accordance with the present invention, a construction of stoker is provided in which the combustion conditions are maintained under predetermined control for all rates of combustion and throughout the entire body of the fuel bed, so that objectionable formation of coke trees or clinkers does not take place. The body of fuel in the retort is of predetermined shape such that combustion air is introduced thereinto from all

sides and under such circumstances that there is practically no portion of the body of burning fuel which is not properly and adequately supplied with combustion air. The fuel bed is limited in cross section and is readily accessible to the combustion air throughout its section.

Where the combustion air is supplied to the fuel bed at a relatively high pressure, a portion of the fuel bed which becomes thin tends to cause a lesser resistance to the flow of air, with the result that it becomes cumulatively thinner, resulting in a tendency to burn through locally with the production of local high temperature combustion forming clinkers and at the expense of complete over-all combustion. In the present construction, the combustion air is supplied to the body of fuel from a plenum chamber in which a substantially constant pressure is maintained, and from that chamber the combustion air is introduced into the body of fuel through the tuyère openings at a plurality of spaced zones or sections. Each such supply is independent of the others and the tuyères are separated into independent sections by solid tuyère members preventing air flow from one section to another. The aggregate of the tuyère openings in each section is greater than the area of the opening from the plenum chamber into that section, and, a pressure drop occurs from the plenum chamber to each of such sections, so that even in the event that the fuel bed should burn through in one spot, combustion air will continue to be supplied independently into the body of fuel at each of the remaining sections. Thus the tendency for such condition to become cumulatively worse is effectively overcome, and it is practically impossible for a localized condition of this character to occur to the extent that it will interfere with the continued supply of combustion air to the entire body of burning fuel.

Being supplied at relatively low pressure and limited velocity, the combustion takes place more uniformly throughout the retort, with the substantial elimination of objectionable coke trees resulting from incomplete combustion, and with similar substantial elimination of such high temperature combustion as to result in the production of objectionable clinkers. The ash is formed primarily as a powder, or in particles of relatively small size, the ash remaining primarily in an unfused condition, or if some fusing does occur, it is limited in extent, and the resulting fused particles are small in size and capable of being handled by an ordinary screw conveyor. Similarly as a result of the introduction of the air under predetermined conditions of pressure and space distribution, the production of fly ash is limited, and cleaner and more efficient combustion conditions are maintained. While suitable for the combustion of different types of solid fuel, the present invention has been particularly developed for the burning of bituminous coal, and for purposes of illustration, will be described more particularly in that relation.

Referring to the drawings which disclose a preferred embodiment of the invention, a bin 10 is shown which is adapted to receive a quantity of the solid fuel to be burned. It will be understood that the invention is equally suitable for use with a hopper type stoker, and that the showing of the bin feed type is merely illustrative. Extending into the bin and suitably supported upon brackets 11 from the bottom thereof is the bin end of the feed worm 12. It is suitably supported, preferably in an open slotted conveyor

tube 13 which is open along its entire upper extent as shown so that fuel can pass thereinto along the entire length of the bin and be conveyed forwardly and into the closed conveyor section 14 located exteriorly of the bin wall. The construction of this bin feed portion of the conveyor is preferably as disclosed in applicant's copending application Serial No. 354,599, filed August 28, 1940, now Patent No. 2,369,370, granted on February 13, 1945, and assigned to the same assignee as this application.

The feed worm for supplying the fuel into the retort is shown at 16, and located in non-axial relation with respect to the bin worm 12. The adjacent ends of these worms are received within a transfer chamber shown at 17 to which the fuel is delivered by the bin worm and from which it is withdrawn by the feed worm 16.

Suitable drive mechanism for actuating the worms is provided in the form of motor 20 suitably mounted above the transfer chamber and directly belt connected to a blower 21 and through the same shaft connected to a speed reducing mechanism indicated at 22. From this mechanism drive shafts extend on opposite sides and carry sprocket wheels 23 and 24 suitably connected as by means of sprocket chains to driven pulleys 25 and 26, provided respectively for the drive of the bin worm 12 and the feed worm 16. Further details of such drive and construction of transfer chamber are as shown in applicant's copending application Serial No. 297,247, filed September 30, 1939, now Patent No. 2,364,166, and assigned to the same assignee as this application.

The feed worm 16 extends into the lower portion of a retort 30 which has an upwardly curved wall 31 to supply the fuel delivered by the worm upwardly into the combustion zone. The wall 31 is completely closed and is preferably formed integrally with the casing 32 to provide a plenum chamber 33 into which the blower 21 discharges through the air supply conduit 34.

The tuyères 36 are positioned above the casing section 31 and as shown are preferably arranged to provide a combustion space 37 substantially C-shaped in cross section. The tuyères 38 immediately overlying the end of feed worm 16 and the upwardly inclined supply passage extend inwardly so as to break up the circular section of the combustion space, and to form it as an arcuate space with means for introducing combustion air into both the outer and inner portions of such space. Preferably as shown projecting or nose portions of tuyères 38 do not extend upwardly as far as the tuyères 36, but at their rearward or outward portions 39 they do extend to substantially the same level as the remaining body of tuyères.

It has been found that with this construction because of the varying depth of the body of fuel and its resistance to the passage of air thereto, the greatest quantity of combustion air should be introduced into the combustion space in that portion immediately opposite tuyères 38 or at the exterior surface of the body of burning fuel, that lesser quantities of air should be introduced into the combustion space at either side of tuyères 38, and that the smallest quantity of air should be introduced through tuyères 38 themselves to be supplied to the interior surface of the fuel body. In this way, proper quantities of air are supplied to the various sections of the fuel bed to effectively complete combustion therein at predetermined and regulated rates of burning.

For the purpose of establishing a plurality of

air sections from which air may be supplied at proper predetermined pressures, solid tuyère sections 40 are introduced at the boundary of each of the sections. In the arrangement shown, four such solid tuyère sections are provided, establishing a front zone 41 into which air is introduced at the highest pressure, two side zones 42 into which air is introduced at an intermediate pressure, and the single rear zone 43 into which air is introduced at the lowest pressure.

Each of the tuyères is arranged with a series of vertically stepped air introducing apertures 45 on its inner portion, providing for introducing air into the main combustion space, and likewise is provided with a vertically extending rib 46 separating the inner air apertures from an outer series of apertures 47. These outer apertures extend in similarly and reversely stepped relation at the outer periphery of the tuyères, and are preferably substantially smaller in their total cross sectional area of outlet than the openings 45. Likewise, the total area of the outlet apertures 47 is in excess of the area of the apertures 45 through the partition wall 46 so that a pressure differential will be maintained at all times between the air discharged from the two series of openings.

In order to provide for the independent control and regulation of the combustion air, each of the plurality of sections 41, 42, and 43, is independently connected with plenum chamber 33. An adequate supply of combustion air is maintained in the plenum chamber by the blower, and thus an assured supply of combustion air to each of the plurality of sections is maintained, so that even in the event of the resistance of the fuel bed dropping down materially in one of those zones, the resistance afforded to the flow of air into that zone is such that it does not exhaust the pressure of the plenum chamber, and a proper and substantially uniform supply of pressure air continues to be maintained into each of the remaining zones.

In order to provide for the regulated introduction of the combustion air into the several zones, a bottom plate 50 is provided on which the tuyères are adapted to rest, and this plate is provided with a series of arcuate slots, indicated at 51, 52 and 53. Slot 51 is the largest in cross section, and is located in that portion of the plate within zone 41. The two slots 52 are of intermediate cross section and are located in the combustion zones 42, respectively. Slot 53 is the smallest in section and is located in section 43 of the combustion zone.

In order to provide for regulation in the quantity of air supplied from the plenum chamber, an adjustable plate 55 is provided and received within the casing 31 in position immediately below plate 50. This movable plate 55 has a similar series of apertures therein of the same corresponding size and shape as apertures 51, 52 and 53, and adapted to register respectively therewith. An adjusting rod 56 extends through the wall of the chamber 31 and is arranged to be moved by the operator to rotate plate 55 and to thus vary the degree of registration between corresponding apertures. As will be obvious, such adjustment thus regulates, in a similar and corresponding manner, the total effective opening into the several air zones, and thus provides for regulating the pressure in the tuyère sections with respect to the pressure existing in the plenum chamber. Preferably the maximum degree of opening possible is sufficiently limited with re-

spect to the capacity of the plenum chamber and of the blower that even in the event of a marked reduction in the resistance of the fuel bed occurring in any one section, the pressure in the plenum chamber is not materially reduced, and consequently combustion air continues to be supplied substantially uniformly to the remaining portions of the fuel bed. In actual operations, this arrangement has been found to be productive of highly satisfactory results, substantially eliminating the uneven combustion conditions resulting from changes in the air resistance of the fuel bed, and providing for complete combustion taking place under regulated temperature conditions such as to avoid objectionable formation of either coke trees or clinkers. As a specific example of pressure conditions which have been found to give highly satisfactory results, a pressure of .90 inch of water was provided in the plenum chamber 33, .65 inch in section 41, .55 inch in sections 42, .40 inch in section 43 and .15 inch in the space beyond partitions 46 which supply combustion air to the air apertures 47. It will be understood that these figures are illustrative only and may be varied with changes in the shape of the combustion space, the depth of the fuel bed at each section, etc.

Combustion continues with the air being supplied through air apertures 45, and after the fuel passes over the top of the tuyères, with the air introduced, at lower pressures, through air apertures 47. By the time the fuel has travelled over the tuyères, its combustion at the desired controlled rate has been substantially completed, and only the ash, in a condition of relatively finely divided particles or powder remains. Such ash is discharged upon the ash ring 60, which is arranged in the form of a grating having a series of apertures of predetermined limited size therein. The ash ring is suitably supported for movement upon an upstanding flange 61, spaced from and parallel with the outer wall portion 62. The space 63 between these walls 61 and 62 constitutes an ash chamber into which the particles of ash small enough to drop through the apertures in the ash ring may fall and as shown is of limited vertical extent so that the entire ash space is located above the level of the feed worm 16. If any excessively large clinker formation does take place, such clinkers are not permitted to drop into the ash space, but are held on top of the ash ring where they can be removed through the furnace door.

In order to provide for movement of ash ring 60 and the continuous removal of the collected ash from the ash space 63, suitable drive and conveyor mechanism is provided. As shown, a drive socket 70 is provided at the end of the bin worm 12, and extending from the opposite side of the transfer chamber 17. An ash conveyor shaft 71 is suitably connected to this socket by a universal connection 72, and carries thereon a barrel cam 73. A cam follower 74 is carried on a pivoted lever arm 75 which extends upwardly and is provided with an operating pin 76 extending into an elongated slot 77 formed in a link member 78. An adjustable bolt 79 is threaded in the link at one end thereof and extends into the slot, being adjustable to vary the effective length of the slot. The pin 76 is adapted to bear against one end of the slot in one direction of movement and against the end of the bolt 79 in the other, the adjustment of the bolt thus providing for an adjustable clearance and a regulation of the extent of re-

reciprocating movement of the link under the action of the lever.

The link 78 is attached to a connecting rod 80 which extends into the retort, and which carries at its inner end an operating shoe 81 formed with opposed flanges 82. The ash ring 60 is provided with a depending lug portion 83 adapted to be freely received between flanges 82 so that upon reciprocation of shaft 80 under the action of the drive described immediately above, the ash ring will be given an oscillatory movement. Since this drive is actuated from the reduced speed worm construction as described, it will be clear that the cycles of operation of the ash ring take place relatively slowly, and that the extent of the oscillatory movement thereof will vary in accordance with the adjustment of the threaded bolt 79.

Pivotaly attached to the lower side of the ash ring 60 is a pivoted and weighted lever 85, such lever being formed with a downwardly extending pawl 86. As shown in Fig. 3, such lever is suitably shaped to conform generally to the arcuate shape of the ash ring, and such as to be received within the casing wall 62.

Rotatably mounted upon the bottom wall 90 of the ash space 63 is an ash conveyor ring 91. The ring 91 is shaped generally similarly to the bottom wall portion 90, that is, both sections are dish-shaped to tend to work the collected ash material radially inwardly toward inner wall 61, the provision of lower scraper surfaces 91a facilitating such action. The ash conveyor ring 91 carries ratchet teeth 92 on its upper outer surface, these teeth being located in the line of action of pawl 86. The teeth are inclined in one direction and extend substantially vertically in the other, so that in response to oscillatory movement of ash ring 60, the pawl will engage the teeth to cause concurrent movement of the ash conveyor ring in response to one direction of movement of the ring 60 but will be lifted out of engagement and not cause return movement of the conveyor ring 91, in response to reverse movement of ring 60. Thus by this means the oscillatory movement of ring 60 is converted into a corresponding intermittent but unidirectional rotational movement of ring 91.

As the ash falls into the ash space 63, it is gradually conveyed around through the space by means of ring 91, to the point of discharge from such space. As shown in Figs. 3 and 7, a stationary scraper blade 95 is mounted in the ash space and is inclined with respect to the direction of movement of the ash ring so as to tend to scrape the ash thereon radially inwardly and toward the discharge outlet 96. The inner wall portion 61 is depressed as shown at 97, to form this opening, which leads downward and into ash conveyor tube 98, located parallel with and in substantially the same horizontal plane as the feed worm 16.

The ash conveyor worm is shown at 100, extending through the tube 98, comprising a forward feeding flight portion for the removal of the ash from the discharge space 96. The worm is actuated by the shaft 71, being located in proximity thereto and preferably being formed as a part thereof, and hence is driven through the speed reducing mechanism as described above and at the same speed as the feed worm and in correlated feed relation with respect to the drive mechanism for operating the ash ring.

The ash is fed forwardly through the tube 98 to a discharge opening 102, beneath which a reverse

flight portion 103 is provided for preventing continued forward feeding of the ash. The combined action of flights 100 and 103 causes the lifting of the ash upwardly through the discharge opening, the ash being suitably received within a container shown at 104. This container preferably is of suitable size for receiving and retaining a proper accumulation of ash, and is provided with an inlet opening in one corner of its bottom wall, in alignment with the discharge opening 102. Preferably a suitable bracket 105 is provided for receiving the flanged edge 106 of the container in operative position, providing for ready removal thereof. Likewise an adjustable gate 107 is located above the bottom opening of the receptacle and arranged to be closed by a manually operable handle 108 extending above the receptacle so that when it is desired to remove and dump the receptacle, the gate can be closed with the receptacle still in position, thus preventing any undesired loss or dropping of the ashes during removal.

The invention thus provides a highly satisfactory and yet simple construction of stoker device providing for the controlled introduction of combustion air in predetermined space distribution and under predetermined conditions of regulated and maintained pressure. Such air is introduced substantially uniformly into the entire section of the combustion zone and under such conditions that it is not possible for locally occurring changes in the air resistance of the fuel bed to affect materially the supply of combustion air to the remainder of the fuel bed. As a result, the combustion air is supplied under relatively low pressure, and with complete combustion being assured so as to avoid the formation of coke trees, the avoidance of high temperature combustion is likewise assured with resulting freedom from clinker formation. It is thus possible to provide for the simple and effective removal of the ash in essentially the form of powder or small particles and without the necessity of grinding or reducing large size clinkers to a form suitable for handling.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. Combustion apparatus of the character described which comprises a generally circular retort for the burning of solid fuel, means located around the periphery of the retort for introducing air into the burning fuel at relatively low velocity and in predetermined maintained distribution around the periphery of the body of burning fuel to avoid formation of clinkers and leaving the ash in a finely divided form including a plurality of tuyères for introducing combustion air into the body of burning fuel, means for dividing said tuyères into a plurality of independent sections forming separate air introducing zones spaced around the periphery of said body of fuel, a plenum chamber, means for separately introducing air from said plenum chamber to each of said air zones, said independent air supplies providing a plurality of maintained supplies of combustion air spaced around the combustion zone independently of locally occurring variations in the air resistance of the fuel bed.

2. Combustion apparatus of the character de-

scribed which comprises a generally circular retort for the burning of solid fuel, means for introducing air into the burning fuel at relatively low velocity and in predetermined maintained distribution around the periphery of the body of burning fuel to avoid formation of clinkers and leaving the ash in a finely divided form including a plurality of tuyères located around the periphery of the body of fuel for introducing combustion air into the body of burning fuel, means for dividing the air passages of said tuyères into a plurality of independent sections forming separate air introducing zones spaced around the periphery of said body of fuel, a plenum chamber, means for separately introducing air from said plenum chamber to each of said air zones, means for separately regulating the quantity of air introduced into each of said air zones and providing a pressure drop between said plenum chamber and each of said air zones, said independent air supplies providing a plurality of maintained supplies of combustion air spaced around the combustion zone independently of locally occurring variations in the air resistance of the fuel bed.

3. Combustion apparatus of the character described comprising a retort for the burning of solid fuel, a feed worm for supplying fuel upwardly into said retort, a plurality of tuyères for introducing combustion air to the burning fuel, means for dividing the air spaces of said tuyères into a plurality of independent sections around the periphery of the fuel bed, a plenum chamber for supplying air into each of said sections, and restricting means for effecting a pressure drop from said plenum chamber into each of said sections to assure continued supply of air from said chamber into all of said sections notwithstanding the occurrence of variations in the fuel bed resistance in any of said sections.

4. Combustion apparatus of the character described comprising a retort for the burning of solid fuel, a feed worm for supplying fuel upwardly into said retort, a plurality of tuyères for introducing combustion air to the burning fuel, means for dividing the air spaces of said tuyères into a plurality of independent sections around the periphery of the fuel bed, a plenum chamber for supplying air into each of said sections, restricting means for effecting a pressure drop from said plenum chamber into each of said sections to assure continued supply of air from said chamber into all of said sections notwithstanding the occurrence of variations in the fuel bed resistance in any of said sections, and means for controlling the pressure drop into each of said chambers.

5. Combustion apparatus of the character described comprising a retort for the burning of solid fuel, a feed worm for supplying fuel upwardly into said retort, a plurality of tuyères for introducing combustion air to the burning fuel, means for dividing the air spaces of said tuyères into a plurality of independent sections around the periphery of the fuel bed, a plenum chamber for supplying air into each of said sections, restricting means for effecting a pressure drop from said plenum chamber into each of said sections to assure continued supply of air from said chamber into all of said sections notwithstanding the occurrence of variations in the fuel bed resistance in any of said sections, and means for causing a different pressure drop into said sections in predetermined relation to the thickness of the fuel bed upon said respective sections.

6. Combustion apparatus of the character de-

scribed comprising a generally circular retort for the burning of solid fuel, a plurality of tuyères arranged to form a combustion zone substantially C-shaped in cross section, means for supplying fuel to said retort in the direction toward the open end of said C-shaped combustion zone, means for dividing the tuyères into a plurality of separate air introducing sections around the periphery of said combustion space, a plenum chamber, means for supplying air from said plenum chamber to each of said sections independently of the others, means for regulating the quantity of combustion air supplied into the several sections of said tuyères to provide a greater air supply to the exterior and a lesser air supply to the interior of said body of fuel in accordance with the thickness of the fuel bed upon said sections, and means for causing a pressure drop in the pressure supplied to all of said sections from said plenum chamber to assure continued supply to each section notwithstanding the occurrence of pressure variations in any of said sections.

7. Combustion apparatus of the character described comprising a generally circular retort for the burning of solid fuel, means for introducing fuel into said retort for burning therein an arcuate shaped fuel body, means for supplying fuel to said retort, a plurality of tuyères arranged to supply combustion air into the interior and exterior of said arcuate shaped body of fuel, means for dividing the tuyères into a plurality of separate air introducing sections around the periphery of said combustion space, a plenum chamber, means for supplying air from said plenum chamber to each of said sections independently of the others, means for regulating the quantity of combustion air supplied into the several sections of said tuyères to provide a greater air supply to the exterior and a lesser air supply to the interior of said body of fuel in accordance with the thickness of the fuel bed upon said sections, and means for causing a pressure drop in the pressure supplied to all of said sections from said plenum chamber to assure continued supply to each section notwithstanding the occurrence of pressure variations in any one of said sections.

8. Combustion apparatus of the character described comprising a generally circular retort for the burning of solid fuel, a plurality of tuyères arranged to form a combustion zone substantially C-shaped in cross section, means for supplying fuel to said retort toward the open side of said combustion zone, means for dividing the tuyères into a plurality of air introducing sections around the periphery of said combustion space, a plenum chamber, means for supplying air from said plenum chamber to each of said sections independently of the others, means for regulating the quantity of combustion air supplied into the several sections of said tuyères in accordance with the thickness of the fuel bed upon said sections, means for causing a pressure drop in the pressure supplied to all of said sections from said plenum chamber to assure continued supply to each section notwithstanding the occurrence of pressure variations in any of said sections, and means for regulating the pressure supplied to each of said pressure sections.

9. Combustion apparatus of the character described comprising a generally circular retort for the burning of solid fuel, means for supplying fuel to said retort, a plurality of tuyères for introducing combustion air into the combustion

space, said tuyères having both inner and outer air introducing apertures, means for dividing said tuyères into a plurality of separate air introducing sections spaced around the periphery of said combustion space, a plenum chamber, means for separately supplying air from said chamber into each of said tuyère sections, means for separately regulating the pressure in each of said sections to supply the proper quantity of combustion air in accordance with the depth of fuel bed upon each section, and means for additionally regulating the supply of combustion air to said outer series of air apertures, respectively, to provide for air introduction therethrough at lower pressures than through said inner series of apertures.

10. Combustion apparatus of the character described comprising a generally circular retort, a plurality of tuyères arranged to form a substantially C-shaped combustion space, means for supplying solid fuel to said retort toward the open side of said combustion space, means for dividing said tuyères into a plurality of separate air introducing sections for introducing combustion air into both the exterior and the interior surface of the body of fuel in said space, a plenum chamber, means for supplying air from said plenum chamber separately into each of said tuyère sections, means for regulating the air pressure supplied to said sections to introduce the highest pressure into the exterior portion of said C-shaped space, an intermediate pressure into the sections at either side of said exterior portion, and the lowest pressure into said interior portion of said space.

11. Combustion apparatus of the character described comprising a generally circular retort, a plurality of tuyères arranged to form a substantially C-shaped combustion space, means for supplying solid fuel to said retort toward the open side of said combustion space, means for dividing said tuyères into a plurality of separate air introducing sections for introducing combustion air into both the exterior and the interior surface of the body of fuel in said space, a plenum chamber, means for supplying air from said plenum chamber separately into each of said tuyère sections, means for regulating the air of said pressure supplied to said sections to introduce the highest pressure into the exterior portion of said C-shaped space, an intermediate pressure into the sections at either side of said exterior portion, and the lowest pressure into said interior portion of said space, and control means for increasing or decreasing the supply of combustion air to all of said sections.

12. Combustion apparatus for the burning of solid fuel and for removing the ash by means of a feed worm to which the ash substantially free of clinkers is supplied in substantially the condition in which it is formed during combustion and through which the ash is transferred to a point of delivery outside of said apparatus, said apparatus comprising a retort for the burning of the solid fuel, a feed worm for supplying fuel into said retort, a plurality of tuyères for introducing combustion air to the burning fuel, means for dividing the air spaces of said tuyères into a plurality of independent sections around the periphery of the fuel bed, a plenum chamber, means for separately introducing air from said plenum chamber to each of said sections, said separate air supplies providing a plurality of maintained supplies of combustion air spaced around the combustion zone independently of locally occurring variations in the air resistance of the fuel bed to provide for combustion of said fuel under conditions controlled to produce the ash in finely divided form and substantially free of large clinkers such that it is capable of being handled directly by said ash feed worm.

13. Combustion apparatus for the burning of solid fuel and for removing the ash by means of a feed worm operating in a closed conveyor tube to which the ash substantially free of clinkers is supplied in substantially the condition in which it is formed during combustion and through which the ash is transferred to a point of delivery outside of said apparatus, said apparatus comprising a retort for the burning of the solid fuel, a feed worm for supplying fuel into said retort, a plurality of tuyères for introducing combustion air to the burning fuel, means for dividing the air spaces of said tuyères into a plurality of independent sections around the periphery of the fuel bed, a plenum chamber, means for separately introducing air from said plenum chamber to each of said sections, said separate air supplies providing a plurality of maintained supplies of combustion air spaced around the combustion zone independently of locally occurring variations in the air resistance of the fuel bed to provide for combustion of said fuel under conditions controlled to produce the ash in finely divided form and substantially free of large clinkers such that it is capable of being handled directly by said ash feed worm, and means for delivering said ash substantially in its originally formed condition from said combustion zone to said ash worm to be removed thereby.

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