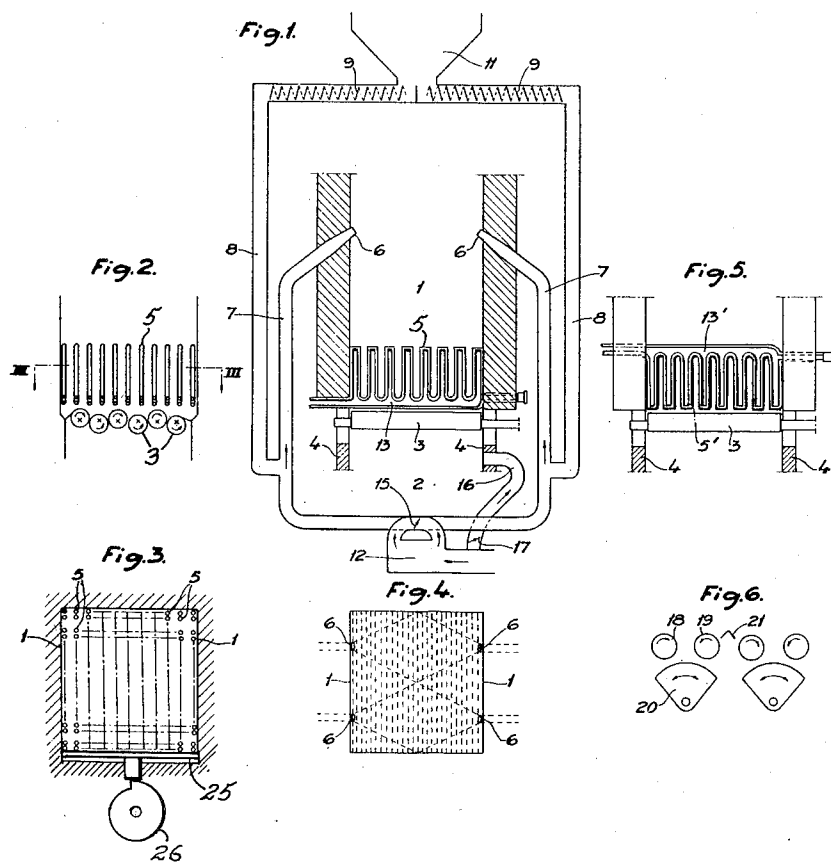


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D. DALIN ET AL
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Inventors
David Dalin
Tore Johannes Hedbäck
By *Substant Jones*
Charles Jones

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METHOD AND APPARATUS FOR COMBUSTING FINELY DIVIDED LOW SINTERING TEMPERATURE FUEL

David Dalin, Ronninge, and Tore Johannes
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The present invention relates to the combustion of granular solid fuels and refers more particularly to a method and apparatus for combusting relatively finely divided fuels in particles ranging in size from powder to coarsely crushed or waste fuel granules such as screenings of the type ordinarily known as "slack."

Heretofore the usual practice in combusting finely divided solid fuels has been either to grind or crush the fuel to a fine powder and combust it in suspension or to use it in relatively coarser form and combust it on a grate of special construction. These two methods have sometimes been used in combination in the combustion of ash-rich fuels having a high sintering temperature, where the principal problem was disposal of the ash, and where the combustion temperature seldom or never exceeded the sintering temperature of the fuel. Heretofore, however, there has been no feasible way of combusting ash-rich fuels having low sintering temperatures when such fuels were presented to the combustion apparatus in the form of granules having a wide range of sizes. Such fuels might be crushed to a powder and burned wholly in suspension, as shown for example by the patent to Coutant, No. 1,703,814, issued February 26, 1929, but this necessitated the expense of pulverizing the fuel, which was obviously objectionable. Nor was it possible to employ with such fuels the device which had proven relatively successful with ash-rich granular fuels having higher sintering temperatures, namely the use of a grate constructed in such a way that the fuel bed was kept in constant motion in an attempt to prevent ash and slag particles from sticking together to form large cakes which prevented combustion and were difficult to discharge. Such moving grates were usually made as inclined grates, e. g., the Martin grate or Pluto stoker, and the grates were arranged as a sort of conveyor, fuel being introduced or fed to one end of the grate and ash being discharged at the other end, the combustion occurring as the fuel was substantially horizontally carried across the interval. However, even with such moving grates sintering could not always be avoided, and even when they were successful their employment entailed certain serious disadvantages, the most obvious of which resided in the fact that their first cost was high and it was virtually impossible to prevent small ash particles from creeping into all of the slide faces of the grate parts and causing serious wear and damage, necessitating the further expenses of frequent repair and replacement.

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It is, therefore, an object of the present invention to provide a method for combusting ash-rich granular fuels having a relatively low sintering temperature whereby such granular fuels, varying in size from fine powder to coarse granules, may be combusted at a high rate and with inexpensive apparatus.

A further and very important object of this invention resides in the provision of a method and means for combusting fuel particles of a wide range of sizes without requiring sizing or crushing, which method and apparatus will permit particles of such fuel to be simultaneously combusted in suspension and in a fuel bed, to thereby attain utmost combustion efficiency despite the wide differences in particle sizes.

Another important object of this invention resides in the provision of a method and apparatus for combusting fuel of the character described in the manner described in a furnace having a relatively small bottom area.

In furtherance of the foregoing object, it is another object of this invention to provide vertical travel of fuel particles in the fuel bed of apparatus of the character described instead of the horizontal fuel particle travel which has heretofore characterized such apparatus.

With the above and other objects in view which will appear as the description proceeds, this invention resides in the novel method as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the herein disclosed invention may be made as come within the scope of the claims.

The accompanying drawing illustrates one complete example of the physical embodiment of the invention constructed in accordance with the best mode so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a vertical sectional view diagrammatically illustrating a furnace embodying this invention;

Figure 2 is a diagrammatic sectional view through the lower part of the interior of the furnace chamber viewed from the left in Figure 1;

Figure 3 is a horizontal sectional view taken on the plane of the line 3—3 in Figure 2;

Figure 4 is a top plan view of the furnace chamber shown in Figure 1;

Figure 5 is a vertical sectional view of the lower portion of a furnace showing a modified embodiment of the invention; and

Figure 6 is a fragmentary view illustrating a

specific grate structure which may be employed in the furnace of this invention.

Referring now more particularly to the accompanying drawing, the furnace chamber is indicated by 1, the ashpit by 2, rotatable grate bars for the ash by 3 and their bearing support by 4. Ducts for cooling medium are indicated by 5. These ducts are arranged in such a way that they become embedded in the fuel charge as it settles onto the grate to form a fuel bed. The fairly fine-crushed or more or less fine-grained fuel is introduced into the furnace pneumatically through e. g. four nozzles 6 which are fed through pipe-lines 7, 8 from a mechanically driven fuel distributing device, e. g., screws 9, preferably one screw for each nozzle pipe-line, said screws issuing from a container 11. The conveying air, which forms part of the required primary air (the other air is supplied from below the grate) is admitted at 12 and entrains the fuel falling down through the respective branch pipe-line 8 and conveys it upwards through the respective pipe-lines 7 to the nozzles 6.

According to the invention the fuel is blown in and spread over the whole furnace bottom. The smallest particles are combusted substantially in suspension, while the coarser particles fall down and are combusted on the furnace bottom to which combustion air (primary air) is admitted and from which the ash is conveyed away practically vertically downwards. In order to prevent sintering in the fuel bed, combustion heat is abstracted from the bed by a fluid heat absorbing medium flowing in the ducts 5 which traverse the bed as shown. These ducts are preferably arranged as substantially vertically disposed finger-like pipe-coils spaced from one another a distance to suit the fuel used and the prevailing combustion conditions. The arrangement of the pipe coils may be seen in Figs. 1 to 3.

Channels for distributing primary air coming from below may be provided below the ducts or "fingers" 5 and preferably these channels extend transversely of the furnace. Thus, the natural falling down of the fuel is not prevented by unnecessary beams on which the fuel might get caught. Alternatively, the channels 13' may be disposed above the pipe coils 5', as shown in Fig. 5. In order to prevent fuel from getting caught the channel systems should be adapted to be vibrated or shaken at uniform intervals. Any conventional means for vibrating or shaking the channel system may be used, as for instance that shown in Figure 3. In this case a shaker bar 25 adapted to be reciprocated at uniform intervals by an eccentric 26 is located adjacent to one end portion of the channel system so that reciprocation of the shaker bar imparts a vibrating motion to the channel system and thereby prevents fuel from becoming lodged therein. As fuel is continuously added at the top of the fuel bed, ash is removed at the bottom thereof, dropping through the rotatable grate bars 3 into the ashpit 2, to maintain the depth of the fuel bed substantially constant, and it will thus be seen that each fuel particle is thus completely combusted in the course of vertical travel from top to bottom of the fuel bed.

The grate by means of which the ash is thus removed may have any suitable form, although it is desirable that it should provide for agitating motion of the fuel bed in installations intended for the combustion of fuel having a very high ash content. One suggested device is illustrated by Figures 1 and 2, employing a series of eccentric-

ly mounted cylindrical grate bars, the axes of rotation of all of which are disposed in a single plane. Adjacent pairs of grate bars are operated simultaneously, the two grate bars of each pair being moved in opposite directions, as indicated by the arrows (see Figure 2), to provide a shearing movement of the fuel bed; and the individual pairs of grate bars are preferably arranged to have separately controllable rotation mechanisms to thereby regulate their discharge capacities in order to compensate for irregularities in the fuel bed.

The discharge device shown in Figure 6 is suggested for use with more finely divided fuels. In this device rotatable grate bars 18 and 19 are disposed at spaced intervals, likewise arranged to be actuated in pairs but mounted to rotate on their geometric axes. A segmental element 20 is oscillatably mounted beneath each pair of grate bars and is moved whenever the grate bars move, so that a relatively large discharge may be effected when desired, while preventing finely divided particles of combusting fuel from dropping down into the ashpit at times when the grate is not operated. To further control discharge of ashes, a plate 21 is disposed between each pair of grate bars. In order to combust descending fuel particles according to the invention it is desirable that the particles fall down periodically on the furnace bottom so that the largest fuel pieces are ignited before further fuel covers the same and prevents their ignition by radiation. This may be accomplished with immovable nozzles by feeding fuel in equal quantity through two nozzles 6 disposed opposite one another in the furnace walls. If most of the fuel is to be combusted in suspension, the nozzles are directed upwards. On the other hand, if a greater part of the fuel is to be combusted on the grate, the nozzles are directed downwards. The fuel discharged from the nozzles is directed over the whole width of the furnace bed by means of a guide device, for example. When a nozzle directed obliquely upwardly is used the guide device may be dispensed with and the nozzle may be formed as part of a conical surface, the fuel being spread laterally to the desired degree. The fact that part of the furnace bottom—a corner, for example—is situated at a greater distance from the nozzle than the opposite wall, is compensated for by setting the angle of elevation of the nozzle directed toward the corner to that which corresponds to the greatest required length of throw, while the angles of elevation for the nozzles discharging in the other directions are made so that the lengths of throw are decreased proportionally and to the desired degree. If the angle of elevation for the greatest distance is chosen as 42°, the angles for the other directions may be chosen either larger or smaller, all with the result that the length of throw is decreased. The particles flung out from the nozzle fall down on the surface of the furnace bottom in a narrow zone. The distance of the particles from the nozzle is a function of the initial velocity of discharge from the nozzle, i. e. of the conveying-, gas-, air-velocity or -quantity. However, if two or more nozzles are used, the velocity in the nozzles may be varied periodically. The nozzles may receive their air from a common fan working with constant quantity and the distribution between the nozzles regulated by means of positively guided dampers which may be coupled together and guided in such a manner that the fuel rain on the furnace bottom sweeps to and fro within certain given limits. If two oppo-

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site nozzles are used, they are preferably arranged in such a way that each of them sweeps the bottom surface from the opposite wall to the middle. It is true that the consequence of such an arrangement is that the paths of the particles cross one another, but this will not cause any serious difficulty, the density being not too great. Four nozzles, as shown in Fig. 4, may, however, be arranged in such a way that two nozzles located in opposite walls—i. e. those placed diagonally—work at the same time, while the nozzles in the other diagonal are shut off, whereafter a reversal takes place. The reversal is preferably effected by means of the guide mechanism for the distributing dampers, one of which, indicated by 15, is visible at the bottom in Fig. 1.

To enable varying amounts of air to be fed to the pipe lines 7, a by-pass or shunt duct 16, controlled by a damper 17, may be connected in the primary air supply system to bypass excessive or undesired amounts of such air into the ashpit (and thus into the fuel bed) instead of permitting all of it to flow out through the fuel lines and nozzles.

In order to dry the fuel in connection with the feeding of the same preheated air should preferably be used as conveying medium. By preheating the air the ignition of the suspended fuel is also facilitated. From the foregoing description, taken together with the accompanying drawing, it will be readily apparent to those skilled in the art that this invention provides a method and apparatus for combusting relatively finely divided fuel of the type having a high ash content and low sintering temperature when the same is in the form of granules of a wide range of sizes, from powder to coarse screenings, without requiring a horizontally movable grate or the large furnace floor area concomitant thereto, and without requiring pulverization of the coarser granules.

Having now described our invention, what we claim as new and desire to secure by Letters Patent is:

1. A furnace for combusting finely divided particles of high-ash fuel, which particles range in size from powder to relatively coarse screenings, said furnace comprising: means defining a combustion chamber; nozzle means for injecting fuel particles of the character described, entrained in combustion air, into said chamber near the top thereof and in substantially even distribution throughout the horizontal cross-sectional area of the chamber; an ashpit below the combustion chamber and in communication therewith; grate means above the ashpit and below the combustion chamber; means for introducing combustion air into the combustion chamber from below the grate means to enable the smallest fuel particles introduced into the combustion chamber to be combusted in suspension and to provide for complete combustion of the remaining particles on a fuel bed of substantial height on said grate in the course of downward movement of such particles from the top of said fuel bed to the grate; and a plurality of vertical finger-like coils disposed at laterally closely spaced intervals in the portion of the bottom of the combustion chamber adapted to be occupied by the fuel bed and extending vertically substantially throughout the normal fuel bed height of the combustion chamber and through which coolant fluid is adapted to be circulated in indirect heat exchange relation with fuel in all parts of the bed in quantities and at a rate sufficient to maintain the temperature of such fuel below its sintering point.

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2. The method of combusting ash-rich low sintering temperature fuel particles of a relatively wide range of sizes, from powder to coarse screenings, wherein the combustion of the coarser pieces, due to the character of the fuel, entails considerable time, which method comprises: introducing the fuel particles into a combustion chamber over burning fuel at a substantial distance above the bottom thereof with the fuel particles loosely dispersed and substantially evenly distributed over the horizontal area of the chamber so that the individual particles are accessible from all directions whereby the finer particles are burned in suspension and the coarser pieces drop to collect at the bottom of the combustion chamber; confining the coarser pieces which collect at the bottom of the combustion chamber to a bed of substantial depth so that a large volume of fuel may be combusted in a combustion chamber of relatively small horizontal area despite the long time required for combustion of the fuel which forms the bed; removing the ash resulting from combustion of the fuel in the bed; and continuously circulating cooling fluid through the fuel bed in heat exchange relation therewith, but not in contact therewith, with the cooling fluid moving along paths distributed throughout the entire bed and reaching substantially the full depth thereof so that the cooling influence of the cooling fluid reaches all portions of the bed to maintain the temperature of the fuel bed below that at which it sinters.

3. The method of combusting ash-rich low sintering temperature fuel particles of a relatively wide range of sizes, from powder to coarse screenings, wherein the combustion of the coarser pieces, due to the character of the fuel, entails considerable time, which method comprises: introducing the fuel particles into a combustion chamber over burning fuel at a substantial distance above the bottom thereof with the fuel particles loosely dispersed and substantially evenly distributed over the horizontal area of the chamber so that the individual particles are accessible from all directions whereby the finer particles are burned in suspension and the coarser pieces drop to collect at the bottom of the combustion chamber; constraining the burning fuel bed to downward movement in a column of relatively small horizontal area so that to afford sufficient time for combustion of the coarser pieces and enable the combustion of a large volume of fuel per unit of time, a bed of substantial depth must be maintained; removing the ash resulting from combustion of the fuel in the bed from the bottom thereof; and continuously circulating cooling fluid through the fuel bed in heat exchange relation therewith, but not in contact therewith, with the cooling fluid moving along paths distributed throughout the entire bed and reaching substantially the full depth thereof so that the cooling influence of the cooling fluid reaches all portions of the bed to maintain the temperature of the fuel bed below that at which it sinters.

4. A furnace for combusting ash-rich low sintering temperature fuel particles of a relatively wide range of sizes, from powder to coarse screenings, comprising: means defining an upright combustion chamber of relatively small horizontal area; means defining an ash pit below the combustion chamber and communicated therewith; a grate defining the bottom of the combustion chamber; means for introducing combustion air into the combustion chamber; means

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located a substantial distance above the grate for introducing the fuel particles into the combustion chamber; means for effecting loose dispersion and substantially even distribution of the fuel particles over the horizontal area of the combustion chamber so that the individual particles are accessible from all directions whereby the finer particles may be combusted in suspension and the coarser particles collect in a bed on the grate; and ducts for fluid heat exchange medium substantially uniformly distributed throughout the space in the bottom of the combustion chamber and extending a substantial distance above the grate so that the cooling influence of the medium circulated through the ducts reaches a substantial distance above the grate, whereby a fuel bed of substantial depth may be maintained without sintering.

5. In a furnace for combusting ash-rich low sintering temperature finely divided solid fuel of the type in which fuel particles of various sizes are injected into a combustion chamber at a point spaced above the bottom of the chamber to be partially combusted in suspension, the remainder of the combustion occurring in a fuel bed at the bottom of the combustion chamber; a grate means at the bottom of the combustion chamber and upon which fuel injected into the combustion chamber and not combusted in suspension is adapted to lie to be combusted in a fuel bed, the sides of the combustion chamber constraining the fuel bed to downward movement as combustion thereof proceeds; means including fuel injection nozzles for injecting solid fuel particles of a wide range of sizes into the combustion chamber at a substantial distance above the grate means with said particles loosely dispersed and substantially uniformly distributed

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so that the individual particles are accessible from all directions whereby the finer particles may be combusted in suspension and the coarser particles drop to form a fuel bed of substantially uniform thickness on said grate means; and a plurality of substantially vertical heat exchange coils uniformly distributed across the bottom of the combustion chamber and of a height to extend upwardly a substantial distance from the top of said grate means, so that the cooling influence of fluid heat exchange medium conveyed through said coils reaches all portions of the fuel bed to maintain the temperature of the bed below its sintering point despite the fact that the fuel bed is maintained at a substantial depth to provide the time needed for combustion of the coarser particles.

6. The furnace structure of claim 5, further characterized by the fact that said coils are adapted to be agitated.

DAVID DALIN.

TÖRE JOHANNES HEDBÄCK.

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