July 31, 1962 L. D. SCHMIDT 3,047,473

DRYING, PREHEATING, TRANSFERRING AND CARBONIZING COAL

Filed Sept. 10, 1956 4 Sheets-Sheet 1

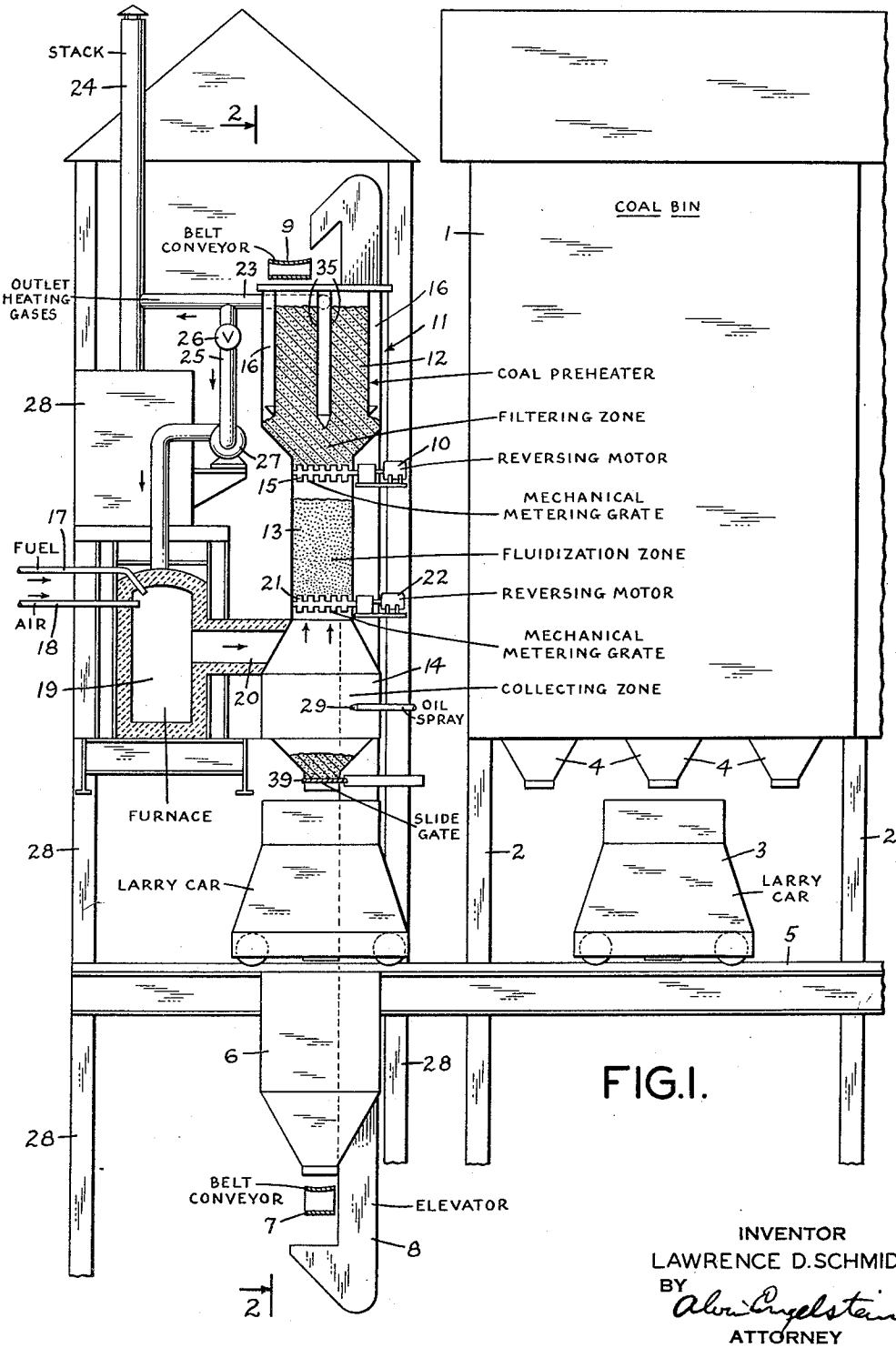


FIG.1.

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Filed Sept. 10, 1956 4 Sheets-Sheet 2

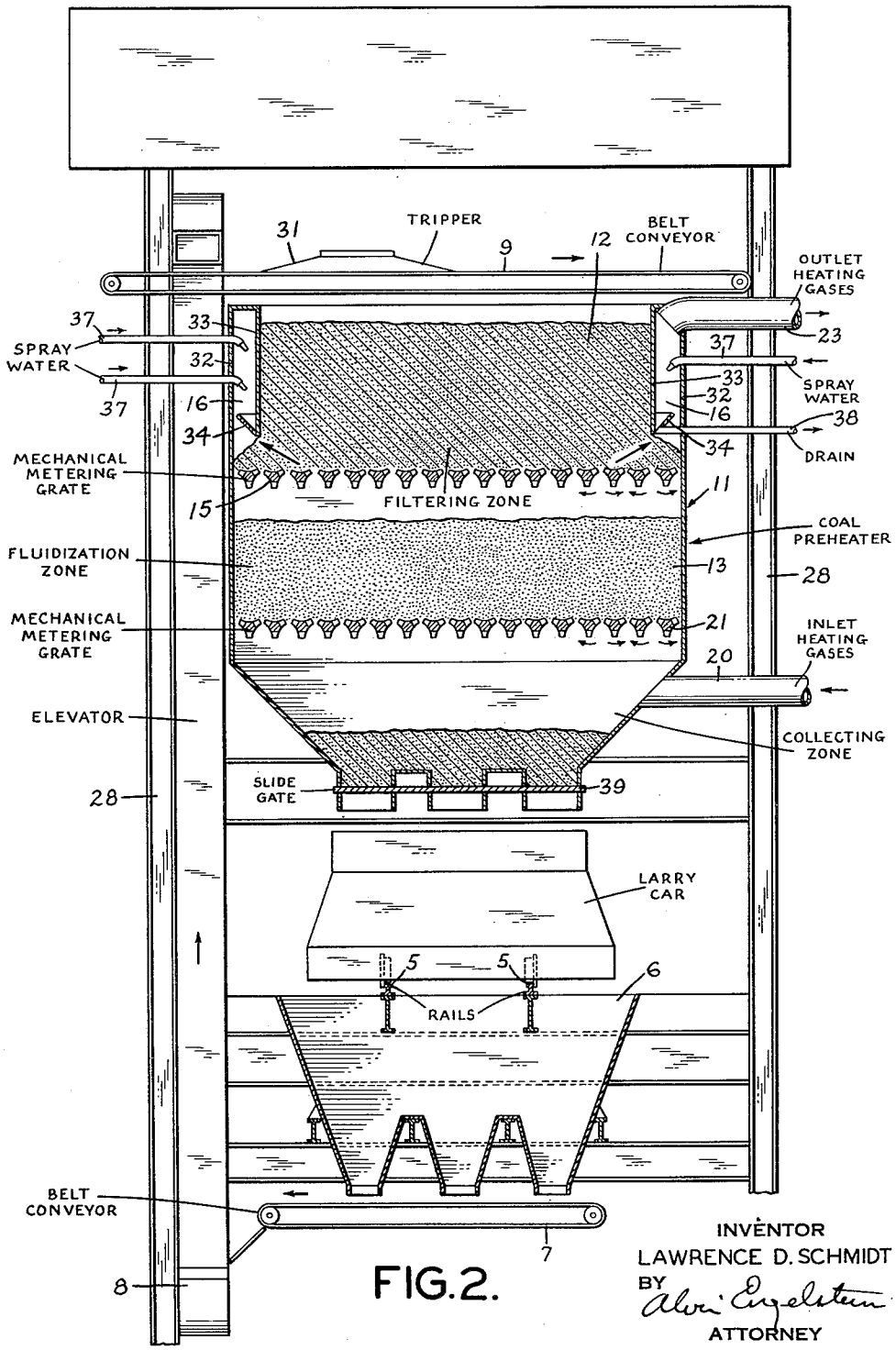


FIG.2.

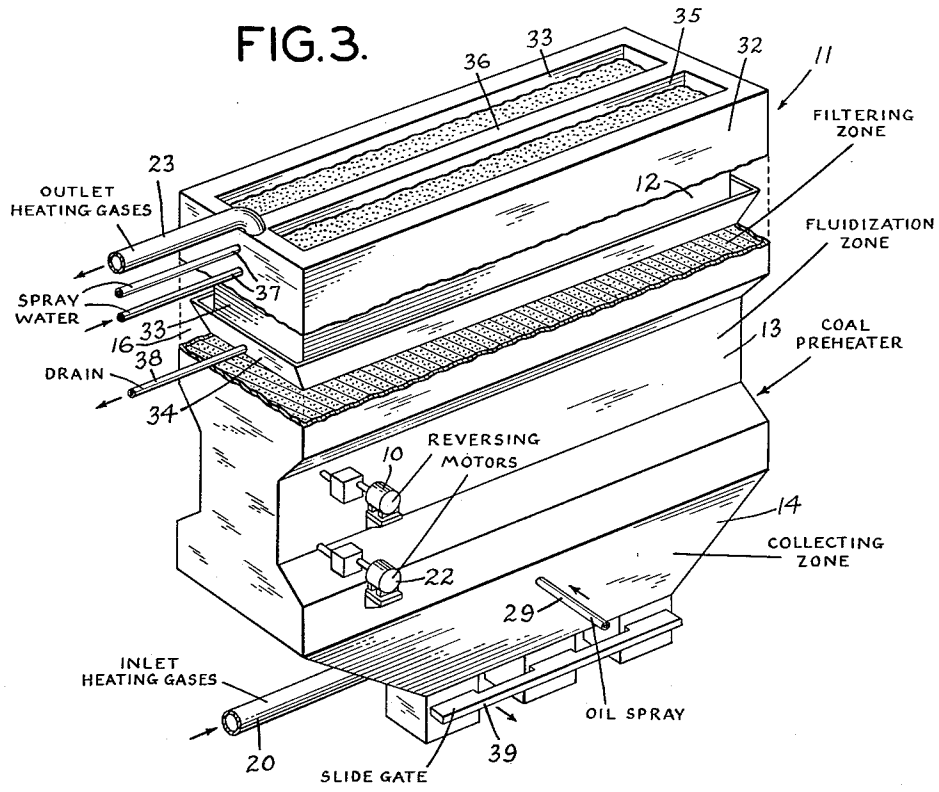
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DRYING, PREHEATING, TRANSFERRING AND CARBONIZING COAL

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FIG.3.



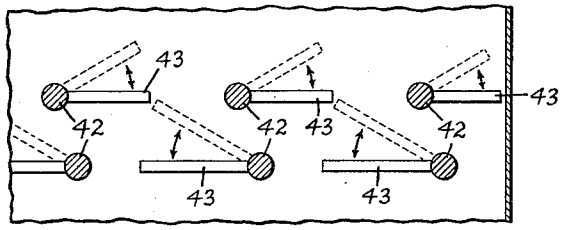


FIG.5.

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DRYING, PREHEATING, TRANSFERRING AND CARBONIZING COAL

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FIG.6.

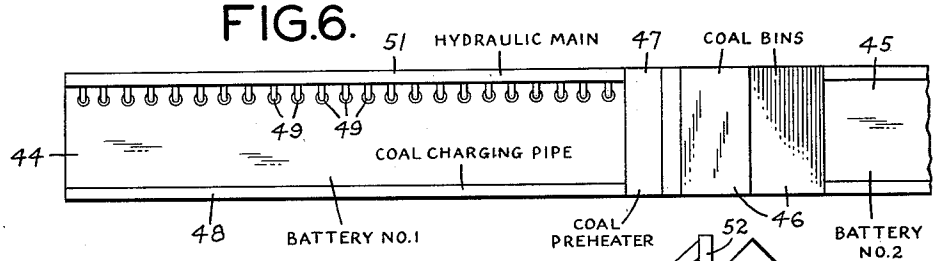


FIG.7.

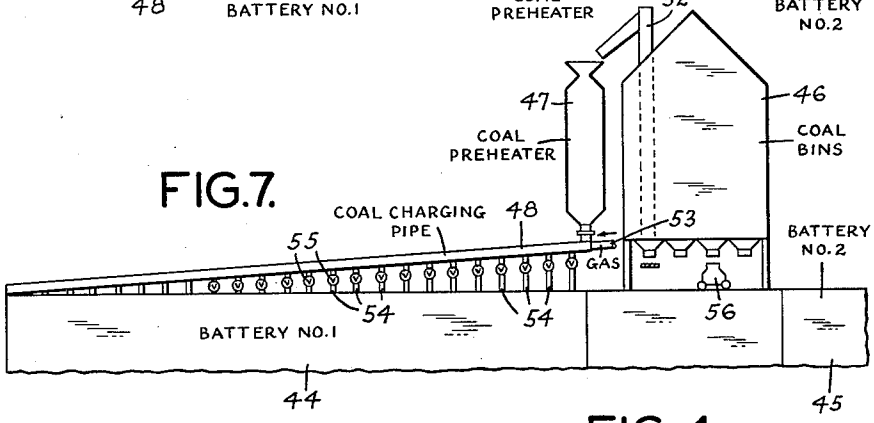


FIG.4.

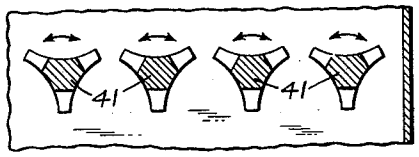


FIG.8.

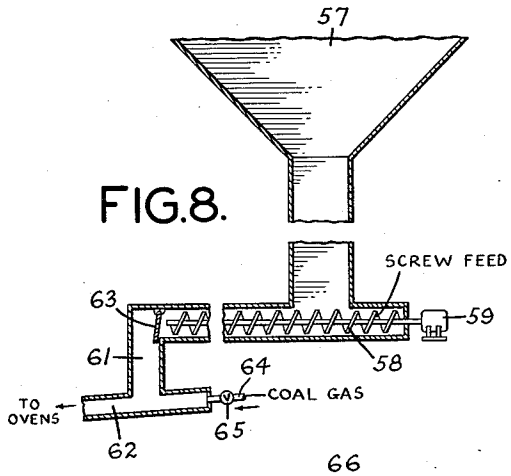


FIG.9.

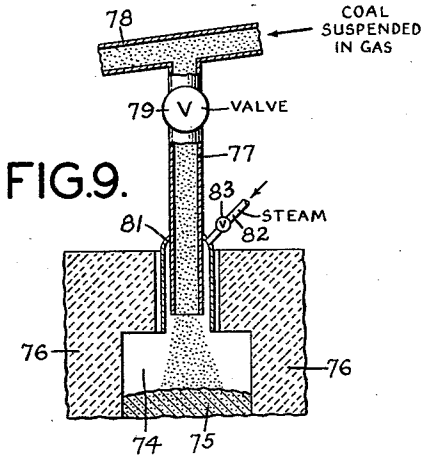
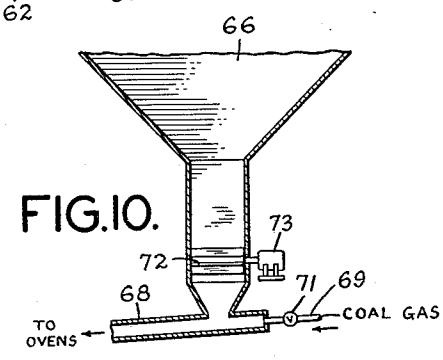


FIG.10.



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United States Patent Office

3,047,473

Patented July 31, 1962

3,047,473

DRYING, PREHEATING, TRANSFERRING AND CARBONIZING COAL

Lawrence D. Schmidt, New York, N.Y., assignor to Allied Chemical Corporation, a corporation of New York

Filed Sept. 10, 1956, Ser. No. 608,990
23 Claims. (Cl. 202—27)

This invention relates to the carbonization of coal and more particularly refers to new and improved methods and apparatus for drying and preheating wet coal, transferring the dried, preheated coal to coke ovens and carbonizing the dried, preheated coal in coke ovens.

The most common commercial method of carbonizing coal, particularly for the production of blast-furnace and foundry coke, as well as coal gas, is in the well-known by-product coke ovens generally constructed in the form of a row of ovens termed a battery in which each oven is approximately about 40' long, 13' high and 18" wide with heating flues between ovens in which fuel gas is burned to generate heat for the carbonization of coal. A charge of about 17 tons of crushed coal is introduced through the top of the oven, the oven heated for a period of about 16–40 hours to carbonize the coal, during which time gaseous and vaporous coal products are released from the top of the oven, and after carbonization, doors at the ends of the oven are removed and the coke pushed out of the oven by means of a ram. A complete cycle of operation takes only a few minutes more than the actual coking time. Illustrative examples of the construction of byproduct coke ovens may be found in U.S. Patents 2,098,013; 2,235,970, and 2,488,952.

Byproduct coke oven batteries are massive structures of high-temperature masonry, built with expensive refractories, so that just one battery represents a construction cost of millions of dollars. Coke oven batteries have almost complete lack of flexibility with respect to varying the throughput of coal to produce satisfactory coke in that each oven cannot be pushed much beyond its rated capacity of about 22 tons per 24 hours, and individual ovens cannot be shut down for periods to reduce the capacity of a battery without serious danger of damage to the oven.

The suggestion was made more than 20 years ago and indeed tests were carried out to preheat coal in a vessel externally of the byproduct coke oven, thereby effecting a reduction of coking time in the expensive byproduct coke ovens and imparting throughput flexibility. Despite these many past efforts, preheating coal prior to carbonization in byproduct coke ovens was not adopted commercially because of the inherent difficulties in preheating and charging of dry, hot coal to the coke ovens.

One object of the present invention is to provide an efficient method and apparatus for drying and preheating coal for feeding coke ovens.

Another object of the present invention is to provide an improved system for feeding hot, dry, crushed coal to byproduct coke ovens.

A further object is to provide a method for decreasing fire hazard in charging hot, dry coal to the byproduct coke oven.

A still further object of the present invention is to provide an improved pneumatic system for charging preheated coal to coke ovens.

Another object of the present invention is to provide a method of preheating and carbonizing preheated coal in byproduct coke ovens with material increase in throughput of coal and increased production of foundry and blast furnace coke. Other objects and advantages will be apparent from the following descriptions and accompanying drawings.

FIGURE 1 is an elevation in partial section of one embodiment of the present invention.

FIGURE 2 is an elevation in partial section of the apparatus taken on line 2—2 of FIGURE 1.

FIGURE 3 is a perspective of the coal preheater in FIGURES 1 and 2.

FIGURE 4 is an enlarged section of the mechanical metering grate in FIGURE 1.

FIGURE 5 is an alternative form of mechanical metering grate.

FIGURE 6 is a plan view of a coke oven battery with coal preheater and pneumatic system for feeding preheated coal to the coke ovens.

FIGURE 7 is an elevation of FIGURE 6.

FIGURE 8 is an enlarged sectional view of apparatus for feeding dry, preheated coal from the bottom of the dryer to the coke oven.

FIGURE 9 is an enlarged sectional view of an alternative method for feeding dry, preheated coal from the bottom of the dryer to the coke oven.

FIGURE 10 is an enlarged sectional view of the charging port of a coke oven and the charging line for feeding preheated coal into the oven.

Apparatus for drying and preheating coal in accordance with the present invention comprises an outer vertical casing, preferably rectangular in shape, an upper mechanically operated grate adapted to support a compact column of wet, cold coal fed into the top of the casing, said compact column of coal being of sufficient height to prevent the flow of gas through the column of coal and in or out of the top of the casing into the atmosphere, said upper grate being spaced to provide passageways for the free flow of gas up through the grate but said passageways being sufficiently small to prevent the flow of coal down therethrough when the grate is in static condition, said grate being further mechanically operated to permit controlled amounts of coal to fall down through the grate into the zone beneath said upper grate, a sleeve projecting downwardly from about the top of the casing into said casing terminating a short distance above the upper grate and spaced from the casing wall to form therewith an annular gas outlet header, said gas outlet header being sealed at its top to prevent the escape of gas into the atmosphere, said inner zone bounded by the inside walls of said sleeve being adapted to receive and maintain a column of wet coal introduced into the top of the open casing, an outlet in the gas outlet header for the discharge of gas passing up through the upper grate into the gas outlet header, water inlets spaced around the casing for washing down the walls of the sleeve to keep the heat transfer surfaces clean, a trough for receiving and collecting liquid at the bottom of the sleeve, a conduit for the discharge of liquid extending from the trough out through the casing, a second lower mechanically operated metering grate disposed across the cross-section of the casing and adapted to support a fluidized bed of coal fed by the coal dropping down through the upper grate, a gas inlet entering the casing at a point below the second lower grate for the introduction of hot gases at a sufficient velocity to maintain the bed of coal above the second lower grate in the fluidized state and to dry and preheat said coal, means for mechanically moving said second lower grate to cause dried, preheated coal to fall therethrough at a controlled rate, said dried, preheated coal collecting in the bottom of said casing and valve means at the bottom of said casing to regulate the discharge of the dried, preheated coal from the casing.

In accordance with the present invention, wet, cold coal may be dried and preheated preliminary to carbonizing the coal by passing hot inert gases up through a fluidized

bed of coal supported on a mechanically operated metering grate at a sufficient velocity to maintain the bed of coal in a fluidized state and to dry and preheat said coal, mechanically operating said metering grate to discharge dried, preheated coal at a controlled rate down through said grate, passing the inert gases leaving the top of the fluidized bed and containing suspended fine particles of coal elutriated from the fluidized bed upwardly through a second mechanically operated metering grate supporting a compact column of wet coal, said gases penetrating the lowermost portion of the compact column of coal thereby transferring sensible heat of the gases to the coal and filtering suspended finely divided particles of coal from the gases, discharging the cool filtered inert gases from the coal at a point well below the top of the column of coal, said compact column of coal being of sufficient height to prevent the flow of gas up through the entire column of coal, mechanically operating said upper grate supporting the compact column of wet, cold coal to permit controlled amounts of coal to fall down through the grate into the fluidized bed of coal beneath it, and feeding wet, cold coal into the top of the compact column of coal.

The preheated, dry coal produced as above, if charged in a conventional manner by dropping into the coke oven would result in smoke, fire and explosions. I have found that byproduct coke ovens may be fed with hot, dry, crushed coal with a material decrease in fire hazard by the addition of a small amount, about 0.5% to 5%, of residual fuel oil of Baumé gravity of 6° to 25°, preferably 10° to 20° Baumé, or by the addition of hydrocarbon pitch in the amount of 0.5–5%, preferably 0.5–2%, having a melting point within the range of 120° C. to 240° C., preferably 150° C. to 180° C., and preferably a mixture of residual fuel oil and hydrocarbon pitch to the coal prior to introduction into the byproduct coke oven.

In an alternative method of feeding hot, dry, crushed coal to the ovens of a battery of a byproduct coke oven after completion of the coking cycle and discharge of coke therefrom, an inert gas such as steam or coke-oven gas at an appreciably lower temperature than the hot coke oven is introduced into the coal feed inlet of the hot, empty coke oven to effect a drop in temperature of the coal inlet of several hundred degrees Fahrenheit and thereafter hot, preheated, crushed coal pneumatically conveyed from the preheater by forcing the finely divided coal in a dispersed condition with an inert gas under pressure through a conduit into the cooled coal inlet in the top of the coke oven wherein the finely divided coal settles to the bottom of the coke oven and the inert gas separates from the settled coal and discharges through another port in the top of the coke oven.

Apparatus for charging hot, dried, crushed coal to a by-product coke oven battery comprises a byproduct coke oven battery with each oven having an inlet port into which coal is charged and a discharge port for the release of gases from the coke oven, a coal charging conduit above the inlet ports of the coke oven battery with valved branch conduits extending from the coal charging conduit into each coke oven, inlet lines for the introduction of cooling gas in the inlet ports of the coke ovens for cooling the inlet ports prior to the introduction of hot coal, a coal preheater for drying and preheating cold, wet coal, means for transferring the hot, dry coal from the coal preheater to the inlet of the coal charging conduit and a gas inlet at the inlet side of the coal charging conduit for pneumatically conveying the coal through the coal charging conduit into the coke oven.

In the commercial practice of carbonizing coal in byproduct coke ovens for the production of metallurgical coke, particularly foundry coke, the coal charged is generally a blend of low-volatile and high-volatile coking coals containing volatile matter, about 25–36%, with a smaller amount, about 5–10% of an antifracturant material such as anthracite coal fines, petroleum coke fines, or pulverized coke breeze which are low in volatile matter below 25%, preferably below 20%, and are essentially non-coking in character. The antifracturant material is blended with the coal mix to improve the quality of the coke when throughput is high and also to reduce any tendency for dangerous expansion pressures to develop during coking. Excessive expansion pressures could cause extensive damage to the coke oven structure. Another factor bearing on the coke production and quality of coke produced by carbonization in byproduct coke ovens is the temperature of carbonization. To speed the rate of carbonization, it is desirable in some cases to operate at the highest possible temperature without destruction of the coke oven walls, usually this temperature, as measured by the flue temperature between the oven walls is not permitted to exceed 2650° F. However, experience has shown that when carbonizing coal at the maximum permissible flue temperature, the coke produced is not of a quality satisfactory for foundry coke. In general, the higher the flue temperature, the smaller and more highly fissured is the coke produced. In fact, in order to obtain good-quality foundry coke of adequate size and size stability, when cold, wet charges are used, the flue temperatures must be held from 700 to 1000° F. below the temperature considered dangerous to the oven brickwork. I have discovered that I could carbonize the coal at 50–250° F. higher flue temperature and produce good quality foundry coke provided the percentage of antifracturant material in the blend is increased by about 20–100% and further that the coal charge is dried and preheated prior to introduction into the coke oven. Merely by way of illustration, a coal mix which tolerated 5–10% antifracturant material by weight of the mix would in accordance with the invention be increased to 10–20% antifracturant material by weight of the mix. The over-all effect of drying, preheating coal charge and operating at a higher flue temperature is to increase the coke producing capacity of a byproduct coke oven by about 50–75%. It is impossible to separate the effects of preheat and higher antifracturants and higher oven temperatures because, in a plant operating at maximum capacity on cold, wet charges, the mix already contains the maximum tolerable amount of antifracturants and oven temperatures also are at a maximum to give coke of acceptable commercial quality. The preheating of the charge raises the toleration limit on antifracturant content and thus the tolerable oven temperature for manufacture of commercial coke. This increased tolerance for antifracturants was a surprising and important discovery in my experimental work.

The conventional practice for feeding coal to regenerative byproduct coke ovens is to dispose a coal bin atop the coke oven with the bottom of the coal bin spaced a distance above the top of the coke oven to permit a coal larry to pass beneath the coal bin for charging with coal. The coal larry usually has three ports at its bottom which are spaced to coincide with the three inlet ports for the introduction of coal to each oven. The larry car rides on tracks placed on top of the coke oven and running the length of the oven. In FIGURE 1 is shown the usual coal storage bin **1** situated generally between two batteries of coke ovens supported by usual structural members **2** at an elevation above the top of the battery of coke ovens. Beneath coal bin **1** is larry car **3** adapted to receive a charge of coal from one of the spouts **4** of coal bin **1**. In accordance with the present process after being filled with cold, wet coal, larry car **3** moves to the left along rail **5** until it stands over bin **6** whereupon a bottom gate of car **3** is opened and the wet coal dumped into bin **6**. Wet coal is discharged at a regulated rate from the bottom of bin **6** onto a belt conveyor **7** which carries the wet coal to a vertical conveyor **8**, which may be any suitable conventional type of conveyor such as a bucket conveyor, and the wet coal discharged onto belt conveyor

9 which carries it into the top of coal preheater, designated generally by numeral 11.

The apparatus and method of preheating coal are important features of the present invention. The coal preheater should be capable of removing the moisture from the wet coal and preheating it to a temperature of up to 650–700° F. and in addition must be adequate to continuously supply such dried and preheated coal to at least one battery and preferably two batteries of coke ovens. Uniform heating of the coal to a precise maximum temperature in relatively small equipment with high thermal efficiency are important considerations for good commercial operation. If during the heating operation, which ordinarily takes the coal up to maximum permissible temperatures, any of the coal should exceed this temperature, damage to coking power would result. Accurate temperature control such as permitted by this apparatus is essential. Also coal fines must be conserved, i.e. prevented from being carried out with the combustion gases and polution of the atmosphere with such coal fines avoided. In the preferred form of dryer and preheater, as illustrated in the drawing, the coal preheater is generally rectangular in shape, about 30 ft. long, 7 ft. wide and 30 ft. high. Coal preheater 11 may be divided into an upper filtering, metering and separation zone, designated by number 12, an intermediate fluidization zone 13 for drying and preheating and a bottom collecting zone 14. The cold, wet coal fed into the top of coal preheater 11 moves down by gravity as a compact mass supported on mechanical metering grate 15 activated by reversing motor 10 by which the rate of feed of wet coal into fluidization zone 13 is controlled. Hot gases carrying finely divided particles of coal in suspension elutriated from fluidization zone 13 pass up through metering grate 15 into the body of wet coal 12, which acts as a filtering medium and strips the gases of most of the finaly divided particles carried in suspension. Because of the compactness of the body of coal 12 and its height, usually about 8–10 ft., the gases are impeded from traveling up through coal body 12 and discharging from the top of preheater 11, and instead are diverted into open passageways 16, as more fully illustrated in FIGURES 2 and 3 and thence discharged from the preheater. During passage of the gases in contact with the wet coal in the bottom of zone 12, the gases give up sensible heat thus accomplishing high thermal efficiency. Hot gases for drying and preheating coal may be derived from any source and conveniently are generated by burning a fuel such as a combustible gas or oil entering through line 17 with air entering through line 18 in furnace 19, and the hot combustion gases pass through transfer line 20 upwardly through mechanical metering grate 21, operated by reversing motor 22, and through the coal in zone 13, at a velocity, about 4–10 ft. per second, sufficient to maintain particles of coal in the fluidized state in zone 13. The height of the fluidized bed, ordinarily 5–10 ft. high, and also residence time may be varied by controlling the rate of rotation of mechanical metering grates 15 and 21. Coal may be heated in coal preheater 11 to a temperature of 660° F. in a matter of minutes—a residence time of less than 5 minutes, usually 2 to 3 minutes. Preheated coal, at a rate controlled by metering grate 21, discharges downwardly into the bottom of collecting zone 14. Spent combustion gases, after being filtered in zone 12, enter passageway 16 discharging through conduit 23 and then into stack 24 to the atmosphere. If desired, a suction blower or other device may be interposed in line 23 to facilitate the withdrawal of gases from the filtering zone. Also, a portion of the spent combustion gases may be recirculated through line 25 and valve 26 by means of blower 27 to furnace 19 and thence returned to coal preheater 11. Oil and pitch may be added through line 29 to the dry, preheated coal in collecting zone 14. Of course, pitch may also be added in solid form to the wet coal before entering the coal preheater. The usual structural members for supporting coal preheater 11, furnace 17 and stack 21 are designated by the numeral 28.

In FIGURE 2 may be seen coal preheater 11 supported on structural members 28. Beneath coal preheater 11 is larry car 3 riding on rails 5 and in turn underneath larry car 3 is bin 6 into which drops wet coal from larry car 3. Belt conveyor 7 carries wet coal to elevator 8 which discharges it onto belt conveyor 9 and carries it to plow-type tripper 31 which forces the coal off belt conveyor 9 into the top of coal preheater 11. The construction of the upper zone 12 of coal preheater 11 is shown with greater clarity in FIGURE 2 and consists of outer rectangular walls 32 and spaced parallel rectangular inner walls 33 which resemble a box within a box. The annular space between outer walls 32 and inner walls 33 is designated by numeral 16. Extending from the bottom of walls 33 at an acute angle are bases 34 which form a trough onto which liquid may collect or a trough may be formed at the bottom of annulus 16 in any other suitable manner as for example by curving the bottom portion of walls 33. If desired, zone 12 may be further subdivided by means of a pair of spaced parallel members 35 (FIGS. 1 and 3) providing a gas collection channel or space extending the length of coal preheater 11 and sealed at its top by plate 36. Gases passing up into the space bounded by members 35 discharge from both ends into annular space 16. Hot gases leaving the top of fluidization zone 13 contain an appreciable amount of sensible heat and also carry finely divided particles of coal suspended in the gas. As these hot coal dust laden gases rise, they are forced to pass up through mechanical metering grate 21 and thence into and through the lower portion of the compact mass of wet coal in zone 12. These gases give up a considerable part of their sensible heat and most of the finaly divided particles as they flow through the bottom portion of the coal in zone 12 into annulus 16, which is the path of least resistance. Although the spent combustion gases entering annulus 16 contain a relatively small amount of coal dust, nevertheless, to reduce pollution of the air and to keep heat transfer surfaces surrounding zone 12 clean, it is desirable to scrub the gases prior to discharge through outlet 23 with water entering line 37 having spray nozzles at their terminal ends. The water, after scrubbing gas and surfaces, collects in trough formed by plates 33 and 34 and is drained through line 38. If desired, the trough may be inclined slightly from the horizontal to provide for collecting a pool of liquid near the point of discharge. The spacing between the elements of grate 21, as well as grate 15, is such as to permit the free passage of gas upwardly therethrough but prevent flow of coal down through the grates unless activated by mechanical action, as for example motors 10 and 22, which regulate the quantity of coal which may pass through the grates depending upon the speed of the motors. In this manner, uniform controlled drying to the desired temperature may be accomplished with the avoidance of local hot or cold spots and without overheating or underheating the coal. It should be noted that coal improperly preheated, as for example by exposing the coal or substantial portions of it to a temperature in excess of 650–700° F. for prolonged periods of time, results in deterioration of the coking properties of the coal and degeneration in the properties of the resultant coke.

Hot combustion gases entering coal preheater 11 through transfer line 20 flow upwardly through mechanical metering grate 21 at a velocity sufficiently high to maintain the coal in the fluidized state above grate 21 thence upwardly through grate 15 into annulus 16 and out through outlet conduit 23. Mechanical metering grate 21 serves to function in a manner different from the usual perforated plates for supporting fluidized beds of solid materials. Coal fed to coke ovens varies in size from very fine coal dust of 14 microns to irregular pieces of coal of about ¼ inch in diameter with the bulk of the coal, about 70%, being larger than 60 mesh and smaller than

6 mesh. Because the coal feed mixture contains the extremes in coal particle size at both ends, i.e. coal dust of 14 microns and coal pieces of ¼ inch diameter, it is difficult, if not impossible, to obtain proper preheating of such coal mixture in a conventional fluidization bed. Furthermore, there is very poor control, if any, of the rate of flow of coal through the fluidized bed and consequently poor control of the preheating of the coal. As a practical matter, I have experimented with the conventional type fluidized beds for preheating coal and found them inadequate. However, the use of a mechanical grate, which supports the fluidized bed of coal under normal fluidization gas velocities without excessive elutriation of coal fines and without passage through the support unless the grate is mechanically operated, and with an upper compact mass of coal for filtering the coal particles from the gases leaving the fluidized bed results in highly efficient uniform controlled preheating of coal which could not be accomplished in a conventional fluidization system. When operating with the grate system shown in FIGURES 2 and 4 with contiguous grates rotating in opposite directions and all changing direction after a few revolutions, I discovered that a new type of flow through the fluidized bed resulted. There was a down flow of coal between the grates rotating  and the gas passed up between the grates rotating . The resultant controlled gas channeling up through the bed gives startlingly effective gas-solid contact.

The dried, preheated coal dropping down through grate 21 collects in the bottom of collecting zone 14. The preheated coal is fed into larry car 3 beneath it by opening a suitable valve at the bottom of zone 14, as for example a slide gate 39. The larry car 3 containing the preheated coal then moves over rails 5 on top of the oven of the battery required to be filled and discharges the preheated coal directly into the oven. The same larry car which is employed for carrying the wet coal from coal bin 1 and dumping that coal into bin 6 may also be utilized for conveying the preheated, dry coal to the coke oven or different larry cars may be employed.

In trails with preheating coal prior to charging it to coke ovens, the hot, dry, crushed coal splashed into the coke oven when dropped from the larry cars and evolved combustible gases immediately so that frequently fires started at points of egress. I found that the addition of from about 0.5% to 5% of residual fuel oil of Baumé gravity higher than 6°, preferably 10°–20° Baumé, to preheat dry coal materially reduced the number and volume of spasmodic shooting flames during the period of charging coal to the coke ovens. This effect is surprising and contrary to normal expectation since it would be assumed that a liquid combustible material susceptible of ready volatilization under the conditions would induce and increase explosions rather than reduce explosions.

The reason for the marked decrease in fire hazard is not fully understood. Apparently the oil, by surface tension effects, causes agglomeration and thus decreases the exposed surface area per unit weight of coal charged. It can be reasoned that the decrease in surface area results in a lower initial rate of heat transfer to the coal, minimizing heat transfer by radiation and by convection since both of these modes of heat transfer are directly dependent upon the amount of surface area available to receive heat and the only remaining mode of heat transfer, i.e. conduction, is relatively slow. Apparently the agglomerative effect of the oil is much more important than is the small increase in volatile matter content of the charge as far as fire hazard and ignitibility are concerned.

In further investigation, I found that the addition of 0.5–5%, preferably 0.5–2%, of hydrocarbon pitch, such as coal tar pitch or petroleum pitch, having a melting point within the range of 120° C. to 240° C., preferably 150° C. to 180° C., to the coal also had the effect of materially reducing the smoke and flame during the charging of the coal to the coke ovens. As a matter of fact, the addition of residual oil to the coal was particularly beneficial in decreasing the flame during the first part of the charging period but had a lesser effect on spasmodic shooting flames during the latter part of the charging period, whereas the addition of pitch to the coal appeared most effective in reducing smoke and flames during the latter part of the charging period. Accordingly, I tried and found the combination of pitch and oil addition to the charging of coal practically eliminated the fire hazard when the hot, dry coal was charged to the coke ovens.

In the perspective view shown in FIGURE 3 is illustrated the coal preheater with the upper filtering zone 12, the intermediate fluidization zone 13 and the bottom collecting zone 14. The upper zone is bounded by outer walls 32 which together with inner walls 33 form an annular space 16 into which gases from filter zone 12 enter. These gases discharge through line 23. Water is introduced into line 37 for washing the walls and gases to aid in removal of particles of coal. A trough for the collection of the wash water is formed by plates 34 and 33 and the wash water drained through line 38. Into the space bounded by walls 33 is fed the wet, cold coal and the compact mass of wet, cold coal moves downwardly. This area may be further subdivided as illustrated by means of parallel spaced walls 35 to form additional passageway which is closed at its top by wall ceiling 36. Also as illustrated, the annular space 16 is sealed at its top to prevent the escape of the gases into the atmosphere and to force them to discharge through line 23 and thence out through stack 24. Ordinarily substantially all the solid particles in the gas are removed by scrubbing with water entering through line 37, but if it is desired to effect further removal of the solid particles, the gases leaving line 23 may be passed through a cyclone separator or any other suitable precipitator for removal of dust and the dust-free gases then discharge into the atmosphere through stack 24. Motor 10 operates grate 15 and regulates the rate of discharge of coal from filtering zone 12. Motor 22 operates grate 21 which supports the fluidized bed of coal. Both motors reverse periodically. Hot combustion gases are introduced through transfer line 20 beneath grate 21 and passed upwardly through the fluidized bed in zone 13. Oil may be injected through line 29 into the preheated coal collecting at the bottom of zone 14. Slide gate 39 regulates the discharge of coal from the preheater.

FIGURE 4 illustrates one form in partial section of mechanically operated metering grate. As seen from the drawing, the grate is constructed of a series of shafts 41 with each shaft curved to form the general shape of a triangle as illustrated in the drawing. While the width of each shaft and the spacing between shafts may be varied dependent upon the size of the crushed coal and other conditions of operation, shafts having a width of 2 to 3 inches from the center to one apex and being spaced 4 to 6 inches between center lines of shafts will generally be found satisfactory. For most satisfactory operation, it is best to rotate the shafts first in one direction and then in the other as shown by the arrows in FIGURE 4 with neighboring shafts rotating in opposite directions, and for this purpose reversing motors may be employed.

In FIGURE 5, as illustrated, is another form of mechanically operated metering grate constructed of a series of spaced rotatable shafts 42 with a plate 43 extending from each shaft 42. Here again rotation of the shafts, as shown by the arrows, will cause coal to drop down through the grate at a rate dependent upon the rate and extent of rotation of the shafts of the grate.

A pneumatic system of feeding preheated coal to by-product coke ovens is diagrammatically illustrated in plan view in FIGURE 6. On the left-hand side of FIGURE 6 is illustrated a typical battery of byproduct coke ovens designated battery number 1 and to the right is indicated a second battery 45 of coke ovens designated battery number 2. Between the two batteries are coal bins 46

disposed at an elevation above the top of batteries numbers 1 and 2. Adjacent the coal bins is coal preheater 47. Leading from the bottom of coal preheater 47 is coal charging pipe 48 for conveying the preheated coal to the coke ovens. On the other side of battery number 1 are riser pipes 49, one for each oven for the release of gaseous and vaporous materials resulting from the carbonization of coal which then pass into hydraulic main 51. The riser pipes and hydraulic main may also be utilized for the discharge of gas employed for pneumatically conveying preheated coals to the coke ovens through line 48.

FIGURE 7, which is an elevation of FIGURE 6, shows the coal bins 46 disposed between and above the two batteries 44 and 45. Coal from the bottom of bin 46 is carried by elevator 52 and fed into the top of coal preheater 47. Dried, preheated coal from the bottom of coal preheater 47 enters coal charging pipe 48 and is pneumatically forced through pipe 48 by the introduction of gas, such as coal gas, under pressure through line 53. A surprisingly small amount of gas relative to the amount of coal to be moved is necessary for conveying the coal through pipe 48 into the coke ovens. Usually a pound of gas under 10–30 p.s.i.g. pressure is adequate to move 200–400 pounds of preheated coal into the coke ovens. When operating in this manner employing inert gas as a fluid for pneumatically charging coke ovens with coal, it is unnecessary to employ oil or pitch as a medium for reducing fire and explosion hazard, since in a pneumatic system, the coke oven, as well as a coke feeding system, is not open to the air and, of course under these conditions, combustion cannot occur. Any combustible gas, smoke, dust and fumes which are such a nuisance in ordinary operation, as they are formed during the charging period and also the inert gas introduced through line 53 as a vehicle for conveying the coal are released through risers 49 and discharged through hydraulic main 51. Since it is the practice when operating the battery coke ovens to stagger the charging of the coke ovens in the battery, there is provided a series of branch lines 54 extending from coal charging pipe 48 with a branch line entering each oven. Branch lines 54 are each equipped with a valve 55 to control the flow of coal into the individual coke ovens of the battery. FIGURE 7 illustrates one method of modifying existing coke oven equipment, and as shown in the drawing, battery 1 is equipped with the preheater and pneumatic system of feeding hot, dried coal. Adjoining battery 2 may continue to be operated in the conventional manner with cold, wet coal dropping from coal bin 46 into larry car 56 which moves on rails over battery number 2 to discharge the coal charge into the coke oven.

FIGURE 8 illustrates one method of transferring the hot coal from the coal preheater to the coal charging pipe. Hot, dried coal collects in the bottom of coil preheater as illustrated by numeral 57. This hot coal is forced at a regulated rate dependent upon the speed of screw 58 turned by motor 59 into channed 61 and then dropping down into coal charging pipe 62. Backflow is prevented by means of check valve 63. The coal then is pneumatically conveyed down through coal charging pipe 62 to the coke ovens by the introduction of coal gas entering under pressure through line 64 and valve 65. This systm permits the removal of coal from a preheater operating at subatmospheric pressure and the feeding of the coal into a coke at nearly atmospheric pressure. Operation of the preheater at slight vacuum or subatmospheric pressure makes simple the introduction of wet coal and combustion air into the preheater.

FIGURE 10 illustrates another method of controlling the rate of feed of hot, dried coal from the bottom of the coal preheater to the coal charging pipe. As in FIGURE 8, there is illustrated at the bottom of coal preheater 66 coal charging pipe 68, coal gas inlet 69 and valve 71. The rate of flow of coal into coal charging line 68 is regulated by the speed of rotation of valve 72 operated by motor 73 which valve consists basically of a shaft with plates extending from the shaft to form a cylinder divided in sections by the plates. The coal trapped in the upper section of the cylinder when rotated drops down into pipe 68, and when rotated still further to its original position, fills with additional coal. Such vane type valves are known in the industry as star feeders.

FIG. 9 is an enlargement of the coal feed inlet port of a coke oven. The coke oven 74 containing coal 75 is bounded by oven walls 76. At the top of the coke oven is an opening into which extends branch pipe 77 connected to coal charging pipe 78. Coal suspended in coal gas pneumatically flows down through coal charging pipe 78, thence down through branch pipe 77, controlled by valve 79 into coke oven 74. The opening at the top of the coke oven may be permanently sealed from the atmosphere by means of a sealing member 81. Preliminary to introducing coal, it is desirable to cool the inlet port of the coke oven to prevent the coal from carbonizing and caking up at the inlet port and thus impeding the introduction of coal into the coke oven. For this purpose, an inlet line 82 and valve 83 are provided through which a cooling medium, such as steam or other cool inert gas, may be introduced. Ordinarily a drop of 500–600° F. will be sufficient to prevent caking of the inlet line. The inert gases escape through riser pipes and hydraulic main, as illustrated in FIGURE 6.

Other advantages, in addition to the gain in throughput, result from the use of dried, preheated coal charges to byproduct coke ovens. Drying and preheating of coal results in all coal charges having substantially equal heat requirements which give heatermen better control of "heats" or true coking rate and result in improved uniformity of coke. As is recognized in industry, the wet, cold coal charges have a wide variation in heat requirements for coking. This variation is caused partly by variations in bulk desnisty due to changing moisture content and partly to poor flowing qualities due to moisture.

Cold-wet charges are not free flowing and require leveling to obtain uniformity of charge in the coke oven. Charging and leveling time is materially reduced by the free flowing nature of the preheated coal and its tendency to be self-levelling.

Thermal efficiency would be improved by the use of preheated coal, since on a per ton of coal carbonized basis, heat lost by radiation from the coke ovens and to the stack would be decreased in proportion to the decrease in coking time.

The heat required in conventional operations to raise water vapor amounting to about 7% of charge weight from slightly above its boiling point, say 300° F., to exit gas temperature, say 1200° F., would not be required. Gas cooling requirements would be lowered a like amount. More concentrated liquors are recovered.

The higher rates of coking resulting from pre-heated charges minimize the effects of unavoidable oxidation of stocked coal. Coals presently unusable because of inadequate coking power, but having desirable attributes such as low cost, low ash or low sulfur content, may be upgraded sufficiently by preheated charging to make their use both practical and desirable.

The following example illustrates the present invention: The coal preheater is similar in construction to that illustrated in FIGURES 1, 2 and 3 being rectangular in shape, having the over-all dimensions of 30 feet long, 7 feet wide and 30 feet high, with a mechanical metering grate disposed 11 feet from the top of the coal preheater and a second mechanical metering grate disposed 21 feet from the top of the coal preheater, a rectangular inner sleeve extending downwardly from the top of the coal preheater being 29 feet long, 6 feet wide and 8 feet high with a plate at the bottom of the sleeve to form a trough, a gas outlet pipe from the annular space formed by the

sleeve in the outer casing of the coal preheater equipped with water spray heads extending into the annular space and a water drain from the bottom of the trough, an inlet for the introduction of heating gases beneath the lowermost mechanical metering grate and a slide valve at the bottom of the coal preheater. The wet, cold charge to the preheater is a blend of 40% low-volatile coal and 45% high-volatile coal and 15% anthracite fines. The three coals have the following properties:

Proximate Analyses

	Low-Volatile Coal	High Volatile Coal	Anthracite
Moisture, Percent	7.5	6.1	13.00
Volatile Matter [1], Percent	17.4	36.1	6.4
Fixed Carbon [1], Percent	77.0	58.7	82.8
Ash [1], Percent	5.6	5.2	10.8
Sulphur [1], Percent	0.6	0.6	0.5

[1] Dry basis.

The mixture of coal has the following screen analysis:

Screen Analyses

[United States Standard Screens]

	Low Volatile and High Volatile Coal	Anthracite	Mixture
Cumulative Percent Retained on:			
3 mesh	3.0	0.0	2.6
6 mesh	14.0	0.0	11.9
8 mesh	22.0	0.6	18.8
16 mesh	41.0	6.8	35.9
30 mesh	68.0	48.8	75.1
60 mesh	85.0	91.2	85.9
100 mesh	90.0	97.2	91.1
200 mesh	95.0	98.8	95.6

Cold, wet coal is fed into the top of the coal preheater and dry, preheated coal discharged from the bottom of the preheater. Hot combustion gases are introduced beneath the lowermost mechanical metering grate and passed upwardly through the coal preheater. When equilibrium conditions are obtained in the preheater, a compact column of wet coal 10 feet high is supported on the upper grate and a fluidized bed of coal of 5–10 feet high is supported on the lower grate. Wet, cold coal feed is fed into the top of the coal preheater at the rate of 60 tons per hour, and after a residence time of 5 to 10 minutes in the fluidized bed, discharges from the preheater in a dry condition at a temperature of 660° F. Combustion gases, generated by burning fuel gas with air, pass upwardly through the fluidized bed at a linear velocity of 10 feet per second, thence pass up through the grate supporting the compact mass of cold, wet coal into the annular space surrounding the compact mass of coal wherein they are scrubbed with 120 gallons of water per hour and then discharge from the system. The spent combustion gases are at a temperature of 210° F. and are substantially free of coal dust. Water, after scrubbing the gases, collects in the trough at the bottom of the annular zone and is continuously drained therefrom. Reversing motors operating the mechanical metering grates are run at a speed and time between reversals sufficient to maintain good solids-to-gas contact in the fluidized bed.

To dry, preheated coal is added 1% by weight residual fuel oil having a Baumé gravity of 16° and 1% of pitch having a melting point of 170° C., and conveyed by larry cars into a coke oven. The coking time, as compared to conventional coking without preheating with one-third less antifracturant content (anthracite fines) and 160° F. lower flue temperature, is reduced from 30 hours to 20 hours. The coke produced is of good quality and in all respects eminently suitable as foundry coke. Actual trial showed that the beneficial effect of preheat, permitting a 50% increase in antifracturant content and 160° F. higher flue temperature without impairment of coke quality, resulted in a 75% increase in rate of production of +3½" size shattered foundry coke per oven per day. Foundry coke as received at the foundry after handling equivalent to the A.S.T.M. shatter test should have the least possible quantity of −3½" coke, as small coke obstructs the passage of air in the cupola and is a detriment to efficient operation.

In another method of operation, the dried, preheated coal is sent to the inlet side of a coal charging pipe in a manner as illustrated in FIGURES 6, 7 and 8 and the coal conveyed to a coke oven by means of .003 pound of coal gas per pound of coal under a superatmospheric pressure of 20 p.s.i.g. Here again the coal is carbonized in 20 hours and produces foundry coke of excellent quality.

Although certain preferred embodiments of the invention have been disclosed for purpose of illustration, it will be evident that various changes and modifications may be made therein without departing from the scope and spirt of the invention.

I claim:

1. Apparatus for drying and preheating coal comprising in combination an outer vertical casing, an upper grate adapted to support a compact column of wet coal fed into the top of the casing of sufficient height to prevent the flow of gas up through the column of coal and out of the top of the casing, said upper grate being spaced to provide passageways for the free flow of gas up through the grate but said passageways being sufficiently small to prevent the substantial flow of coal down therethrough when the grate is in static condition, said grate being further mechanically operated to permit controlled amounts of coal to fall down through the grate, a sleeve projecting downwardly from about the top of the casing into said casing terminating a short distance above the upper grate and spaced from the casing wall to form therewith an annular gas outlet header, said gas outlet header being sealed at its top to prevent the escape of gas into the atmosphere, an outlet in the gas outlet header for the discharge of gas passing up through the upper grate into the gas outlet header, a second lower grate in the casing adapted to support a fluidized bed of coal fed by the coal dropping down through the upper grate, a gas inlet entering the casing below the second lower grate for the introduction of hot gases at a sufficient velocity to maintain the bed of coal above the second lower grate in a fluidized state and to dry and preheat said coal, and means for mechanically moving said second lower grate to cause dried, preheated coal to fall therethrough at a controlled rate.

2. Apparatus for drying and preheating coal comprising in combination an outer vertical casing, an upper grate adapted to support a compact column of wet coal fed into the top of the casing of sufficient height to prevent the flow of gas up through the column of coal and out of the top of the casing, said upper grate being spaced to provide passageways for the free flow of gas up through the grate but said passageways being sufficiently small to prevent the substantial flow of coal down therethrough when the grate is in static condition, said grate being further mechanically operated to permit controlled amounts of coal to fall down through the grate, a sleeve projecting downwardly from about the top of the casing into said casing terminating a short distance above the upper grate and spaced from the casing wall to form therewith an annular gas outlet header, said gas outlet header being sealed at its top to prevent the escape of gas into the atmosphere, an outlet in the gas outlet header for the discharge of gas passing up through the upper grate into the gas outlet header, a water inlet into the gas outlet header, a trough for receiving and collecting liquid at the bottom of the sleeve, an outlet for the

discharge of liquid collecting in the trough, a second lower grate in the casing adapted to support a fluidized bed of coal fed by the coal dropping down through the upper grate, a gas inlet entering the casing below the second lower grate for the introduction of hot gases at a sufficient velocity to maintain the bed of coal above the second lower grate in the fluidized state and to dry and preheat said coal, and means for mechanically moving said second lower grate to cause dried, preheated coal to fall therethrough at a controlled rate.

3. Apparatus for drying and preheating coal comprising in combination an outer vertical, rectangular casing, an upper grate adapted to support a compact column of wet coal fed into the top of the casing of sufficient height to prevent the flow of gas up through the column of coal and out of the top of the casing, said upper grate being spaced to provide passageways for the free flow of gas up through the grate but said passageways being sufficiently small to prevent the substantial flow of coal down therethrough when the grate is in static condition, said grate being further mechanically operated to permit controlled amounts of coal to fall down through the grate, a sleeve projecting downwardly from about the top of the casing into said casing terminating a short distance above the upper grate and spaced from the casing wall to form therewith an annular gas outlet header, said gas outlet header being sealed at its top to prevent the escape of gas into the atmosphere, said inner wall bounded by the inside walls of said sleeve being further divided by a pair of vertical parallel spaced walls which form an additional gas outlet header in free communication with said annular gas outlet header, an outlet in the gas outlet header for the discharge of gas passing up through the upper grate into the gas outlet header, a water inlet into the gas outlet header, a trough for receiving and collecting liquid at the bottom of the sleeve, an outlet for the discharge of liquid collecting in the trough, a second lower grate in the casing adapted to support a fluidized bed of coal fed by the coal dropping down through the upper grate, a gas inlet entering the casing below the second lower grate for the introduction of hot gases at a sufficient velocity to maintain the bed of coal above the second lower grate in the fluidized state and to dry and preheat said coal, means for mechanically moving said second lower grate to cause dried, preheated coal to fall therethrough at a controlled rate, said dried, preheated coal collecting in the bottom of said casing and valve means at the bottom of said casing to regulate the discharge of the dried, preheated coal from the casing.

4. Apparatus for drying and preheating coal comprising in combination an outer vertical casing, an upper grate adapted to support a compact column of wet coal fed into the top of the casing of sufficient height to prevent the flow of gas up through the column of coal and out of the top of the casing, said upper grate being spaced to provide passageways for the free flow of gas up through the grate but said passageways being sufficiently small to prevent the substantial flow of coal down therethrough when the grate is in static condition, said grate being further mechanically operated to permit controlled amounts of coal to fall down through the grate, a sleeve projecting downwardly from about the top of the casing into said casing terminating a short distance above the upper grate and spaced from the casing wall to form therewith an annular gas outlet header, said gas outlet header being sealed at its top to prevent the escape of gas into the atmosphere, an outlet in the gas outlet header for the discharge of gas passing up through the upper grate into the gas outlet header, a second lower grate in the casing adapted to support a fluidized bed of coal fed by the coal dropping down through the upper grate, a gas inlet entering the casing below the second lower grate for the introduction of hot gases at a sufficient velocity to maintain the bed of coal above the second lower grate in the fluidized state and to dry and preheat said coal, a connecting conduit for recirculating a portion of the gas from the gas outlet header to below the second lower grate, and means for mechanically moving said second lower grate to cause dried, preheated coal to fall therethrough at a controlled rate.

5. Apparatus for drying and preheating coal comprising in combination an outer vertical casing, an upper grate adapted to support a compact column of wet coal fed into the top of the casing, an upper grate constructed of a series of parallel shafts with spaces between the shafts to provide passageways for the free flow of gas up through the grate but said passageways being sufficiently small to prevent the substantial flow of coal down therethrough when the grate is in static condition with contiguous shafts rotating in opposite directions and periodically reversing directions to permit controlled amounts of coal to fall down through the grate, a second lower grate in the casing adapted to support a fluidized bed of coal fed by the coal dropping down through the upper grate, said second lower grate being constructed of a series of spaced parallel shafts with contiguous shafts rotating in opposite directions to permit controlled amounts of dried, preheated coal to fall therethrough, and a gas inlet entering the casing below the second lower grate for the introduction of hot gases at a sufficient velocity to maintain the bed of coal above the second lower grate in the fluidized state and to dry and preheat said coal.

6. Apparatus for effecting contact between finely divided solids of varying particle size and a gas involving a casing, a grate in the casing adapted to support a fluidized bed of said solids, a gas inlet beneath the grate for the passage of gases through spaces in the grate to intimately contact the solids and maintain the solids in the fluidized state supported on said grate, the improvement which comprises constructing said grate of a plurality of parallel shafts spaced to provide passageways for the free flow of gas up through the grate with contiguous shafts rotating in opposite directions and periodically reversing directions to permit controlled amounts of solids to fall through the grate.

7. A process for drying and preheating wet coal preliminary to carbonizing the coal which comprises passing hot gases up through a fluidized bed of coal supported on a mechanically operated grate at a sufficient velocity to maintain the bed of coal in the fluidized state and to dry and preheat said coal, mechanically operating said grate to discharge dried, preheated coal at a controlled rate down through said grate, passing the gases leaving the top of the fluidized bed of coal and containing suspended finely divided particles of coal elutriated from the fluidized bed upwardly through a second mechanically operated grate supporting a compact column of coal, said gases penetrating the lowermost portion of the compact column of coal thereby transferring sensible heat of the gases to the coal and filtering suspended finely divided particles of coal from the gases, discharging the cooler filtered gases from the coal at a point near the bottom of the column of coal, said compact column of coal being of sufficient height to prevent the flow up through the column of coal, mechanically operating said upper grate supporting the compact column of wet, cold coal to permit controlled amounts of coal to fall down through the grate into the fluidized bed of coal beneath it, and feeding wet coal into the top of the compact column of coal.

8. A process for drying and preheating wet, cold coal preliminary to carbonizing the coal which comprises passing hot combustion gases up through a fluidized bed of coal supported on a mechanically operated grate at a velocity of about 4–10 feet per second to maintain the bed of coal in the fluidized state and to dry and preheat said coal to a temperature between 600–700° F., mechanically operating said grate to discharge dried, preheated coal at a controlled rate down through said grate, passing the combustion gases leaving the top of the fluidized bed of coal and containing suspended finely divided

particles of coal elutriated from the fluidized bed upwardly through a second mechanically operated grate supporting a compact column of coal, said combustion gases penetrating the lowermost portion of the compact column of coal thereby transferring sensible heat of the combustion gases to the coal and filtering suspended finely divided particles of coal from the combustion gases, discharging the cooler filtered combustion gases from the coal at a point near the bottom of the column of coal, said compact column of coal being of sufficient height to prevent the flow up through the column of coal, scrubbing said combustion gases with water to remove residual particles of coal suspended in said combustion gases, recirculating a portion of said cooler filtered combustion gases to beneath the fluidized bed of coal for passage up through the fluidized bed of coal, mechanically operating said upper grate supporting the compact column of wet, cold coal to permit controlled amounts of coal to fall down through the grate into the fluidized bed of coal beneath it, and feeding wet, cold coal into the top of the compact column of coal.

9. In a process for contacting finely divided coal of varying particle size with gases involving passing gases up through a fluidized bed of said coal supported on a grate, the improvement which comprises regulating the flow of coal down through said grate constructed of parallel spaced shafts by rotating contiguous shafts in opposite directions and periodically reversing directions.

10. A method of minimizing fire and explosion hazard when feeding hot, dried, preheated coal charge into a byproduct coke oven which comprises adding about 0.5% to 5% of residual fuel oil of about 6°–25° Baumé gravity to the coal charge prior to introduction into the byproduct coke oven.

11. A method of minimizing fire and explosoin hazard when feeding hot dried, preheated coal charge into a byproduct coke oven which comprises adding about 0.5% to 5% of residual fuel oil of about 10°–20° Baumé gravity to the coal charge prior to introduction into the byproduct coke oven.

12. A method of minimizing fire and explosion hazard when feeding hot dried, preheated coal charge into a byproduct coke oven which comprises adding about 0.5% to 5% of hydrocarbon pitch having melting point of 120°–240° C. to the coal charge prior to introduction into the byproduct coke oven.

13. A method of minimizing fire and explosion hazard when feeding hot, dried, preheated coal charge into a byproduct coke oven which comprises adding about 0.5% to 2% of hydrocarbon pitch having melting point of 150°–180° C. to the coal charge prior to introduction into the byproduct coke oven.

14. A method of minimizing fire and explosion hazard when feeding hot, dried, preheated coal charge into a byproduct coke oven which comprises adding about 0.5% to 5% of a mixture of residual fuel oil and hydrocarbon pitch to the coal charge prior to introduction into the byproduct coke oven.

15. A process for drying and preheating wet, cold coal preliminary to carbonizing the coal which comprises passing hot gases up through a fluidized bed of coal supported on a mechanically operated grate at a sufficient velocity to maintain the bed of coal in the fluidized state and to dry and preheat said coal, mechanically operating said grate to discharge dried, preheated coal at a controlled rate down through said grate, adding about 0.5% to 5% of residual fuel oil to said dried, preheated coal, passing the gases leaving the top of the fluidized bed of coal and containing suspended finely divided particles of coal elutriated from the fluidized bed upwardly through a second mechanically operated grate supporting a compact column of coal, said gases penetrating the lowermost portion of the compact column of coal thereby transferring sensible heat of the gases to the coal and filtering suspended finely divided particles of coal from the gases, discharging the cooler filtered gases from the coal at a point near the bottom of the column of coal, said compact column of coal being of sufficient height to prevent the flow up through the column of coal, mechanically operating said upper grate supporting the compact column of coal to permit controlled amounts of coal to fall down through the grate into the fluidized bed of coal beneath it, and feeding coal into the top of the compact column of coal.

16. A process for drying and preheating wet, cold coal preliminary to carbonizing the coal which comprises passing hot gases up through a fluidized bed of coal supported on a mechanically operated grate at a sufficient velocity to maintain the bed of coal in the fluidized state and to dry and preheat said coal, mechanically operating said grate to discharge dried, preheated coal at a controlled rate down through said grate, adding about 0.5% to 5% of hydrocarbon pitch having melting point of 120°–240° C. to said dried, preheated coal, passing the gases leaving the top of the fluidized bed of coal and containing suspended finely divided particles of coal elutriated from the fluidized bed upwardly through a second mechanically operated grate supporting a compact column of wet, cold coal, said gases penetrating the lowermost portion of the compact column of coal thereby transferring sensible heat of the gases to the coal and filtering suspended finely divided particles of coal from the gases, discharging the cooler filtered gases from the coal at a point near the bottom of the column of coal, said compact column of coal being of sufficient height to prevent the flow up through the column of coal, mechanically operating said upper grate supporting the compact column of wet, cold coal to permit controlled amounts of coal to fall down through the grate into the fluidized bed of coal beneath it, and feeding wet, cold coal into the top of the compact column of coal.

17. A process for drying and preheating wet, cold coal preliminary to carbonizing the coal which comprises passing hot gases up through a fluidized bed of coal supported on a mechanically operated grate at a sufficient velocity to maintain the bed of coal in the fluidized state and to dry and preheat said coal, mechanically operating said grate to discharge dried, preheated coal at a controlled rate down through said grate, adding about 0.5% to 5% of a mixture of residual fuel oil and hydrocarbon pitch to said dried, preheated coal, passing the gases leaving the top of the fluidized bed of coal and containing suspended finely divided particles of coal elutriated from the fluidized bed upwardly through a second mechanically operated grate supporting a compact column of coal, said gases penetrating the lowermost portion of the compact column of coal thereby transferring sensible heat of the gases to the coal and filtering suspended finely divided particles of coal from the gases, discharging the cooler filtered gases from the coal at a point near the bottom of the column of coal, said compact column of coal being of sufficient height to prevent the flow up through the column of coal, mechanically operating said upper grate supporting the compact column of wet, cold coal to permit controlled amounts of coal to fall down through the grate into the fluidized bed of coal beneath it, and feeding wet, cold coal into the top of the compact column of coal.

18. A process for drying and preheating coal and feeding the hot, dry coal to the ovens of a battery of a byproduct coke oven which comprises passing hot gases up through a fluidized bed of coal supported on a mechanically operated grate at a sufficient velocity to maintain the bed of coal in the fluidized state and to dry and preheat said coal, mechanically operating said grate to discharge dried, preheated coal at a controlled rate down through said grate, passing the gases leaving the top of the fluidized bed of coal and containing suspended finely divided particles of coal elutriated from the fluidized bed upwardly through a second mechanically operated grate supporting a compact column of coal, said gases penetrating the

lowermost portion of the compact column of coal thereby transferring sensible heat of the gases to the coal and filtering suspended finely divided particles of coal from the gases, discharging the cooler filtered gases from the coal at a point near the bottom of the column of coal, said compact column of coal being of sufficient height to prevent the flow up through the column of coal, mechanically operating said upper grate supporting the compact column of wet, cold coal to permit controlled amounts of coal to fall down through the grate into the fluidized bed of coal beneath it, feeding wet, cold coal into the top of the compact column of coal, introducing an inert gas at an appreciably lower temperature than the hot coke oven into the coal feed inlet of the hot, empty coke oven to effect a drop in temperature of the coke oven at the coal inlet and pneumatically conveying the dried, hot coal from the preheater by forcing the coal in a dispersed condition with an inert gas under pressure through a conduit into the cooled coal inlet in the top of the coke oven wherein the coal settles to the bottom of the coke oven and the inert gas separates from the settled coal and discharging the separated inert gas from the coke oven.

19. A process as claimed in claim 18 wherein the inert gas for cooling the coke oven is steam and wherein the inert gas for pneumatically conveying the coal is coal gas and wherein the coal gas separating from the coal in the coke oven is released from the coke oven through a riser pipe connecting to a hydraulic main.

20. A method of feeding hot, dried, crushed coal to the ovens of a battery of a byproduct coke oven after completion of a coking cycle and discharge of coke therefrom which comprises passing an inert gas at an appreciably lower temperature than the hot coke oven into the coal feed inlet of the hot, empty coke oven until the temperature of the coke oven at the coal inlet drops at least 500° F. and thereafter pneumatically conveying the hot, crushed coal in a dispersed condition with an inert gas under pressure through a conduit into the cooled coal inlet in the top of the coke oven wherein the crushed coal settles to the bottom of the coke oven and the inert gas separates from the settled coal and discharging the separated inert gas through another port in the coke oven.

21. A process as claimed in claim 20 wherein the inert gas for cooling the coke oven is steam and wherein the inert gas for pneumatically conveying the coal is coal gas and wherein the coal gas separating from the coal in the coke oven is released from the coke oven through a riser pipe connecting to a hydraulic main.

22. Apparatus for drying and preheating cold, wet, crushed coal and charging the hot, dried, crushed coal to a byproduct coke oven battery comprising in combination an outer vertical casing, an upper grate adapted to support a compact column of coal fed into the top of the casing of sufficient height to prevent the flow of gas up through the column of coal and out of the top of the casing, said upper grate being spaced to provide passageways for the free flow of gas up through the grate but said passageways being sufficiently small to prevent the substantial flow of coal down therethrough when the grate is in static condition, said grate being further mechanically operated to permit controlled amounts of coal to fall down through the grate, a sleeve projecting downwardly from about the top of the casing into said casing terminating a short distance above the upper grate and spaced from the casing wall to form therewith an annular gas outlet header, said gas outlet header being sealed at its top to prevent the escape of gas into the atmosphere, an outlet in the gas outlet header for the discharge of gas passing up through the upper grate into the gas outlet header, a second lower grate in the casing adapted to support a fluidized bed of coal fed by the coal dropping down through the upper grate, a gas inlet entering the casing below the second lower grate for the introduction of hot gases at a sufficient velocity to maintain the bed of coal above the second lower grate in the fluidized state and to dry and preheat said coal, means for mechanically moving said second lower grate to cause dried, preheated coal to fall therethrough at a controlled rate, a byproduct coke oven battery having a plurality of ovens with each oven having an inlet port into which coal is charged and a discharge port for the release of gases from the coke oven, a coal charging conduit above the inlet ports of the coke oven battery with valved, branched conduits extending from the coal charging conduit into each coke oven, inlet lines for the introduction of cooling gas in the inlet ports of the coke oven for cooling the inlet ports prior to the introduction of hot coal, means for transferring the hot, dry coal dropped from the bottom of the grate supporting the fluidization bed to the inlet of the coal charging conduit and a gas inlet at the inlet side of the coal charging conduit for pneumatically conveying the hot, dried coal through the coal charging conduit and valved, branched conduit into the coke oven.

23. Apparatus for charging hot, dried, crushed coal to a byproduct coke oven battery comprising a byproduct coke oven battery having a plurality of ovens with each oven having an inlet port into which coal is charged and a discharge port for the release of gases from the coke oven, a coal charging conduit above the inlet ports of the coke oven battery with valved, branched conduits extending from the coal charging conduit into each coke oven, inlet lines for the introduction of cooling gas in the inlet ports of the coke oven for cooling the inlet ports prior to introduction of hot coal, a coal preheater for drying and preheating coal, means for transferring the hot, dried coal from the coal preheater to the inlet of the coal charging conduit and a gas inlet at the inlet side of the coal charging conduit for pneumatically conveying the coal through the coal charging conduit into the coke oven.

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