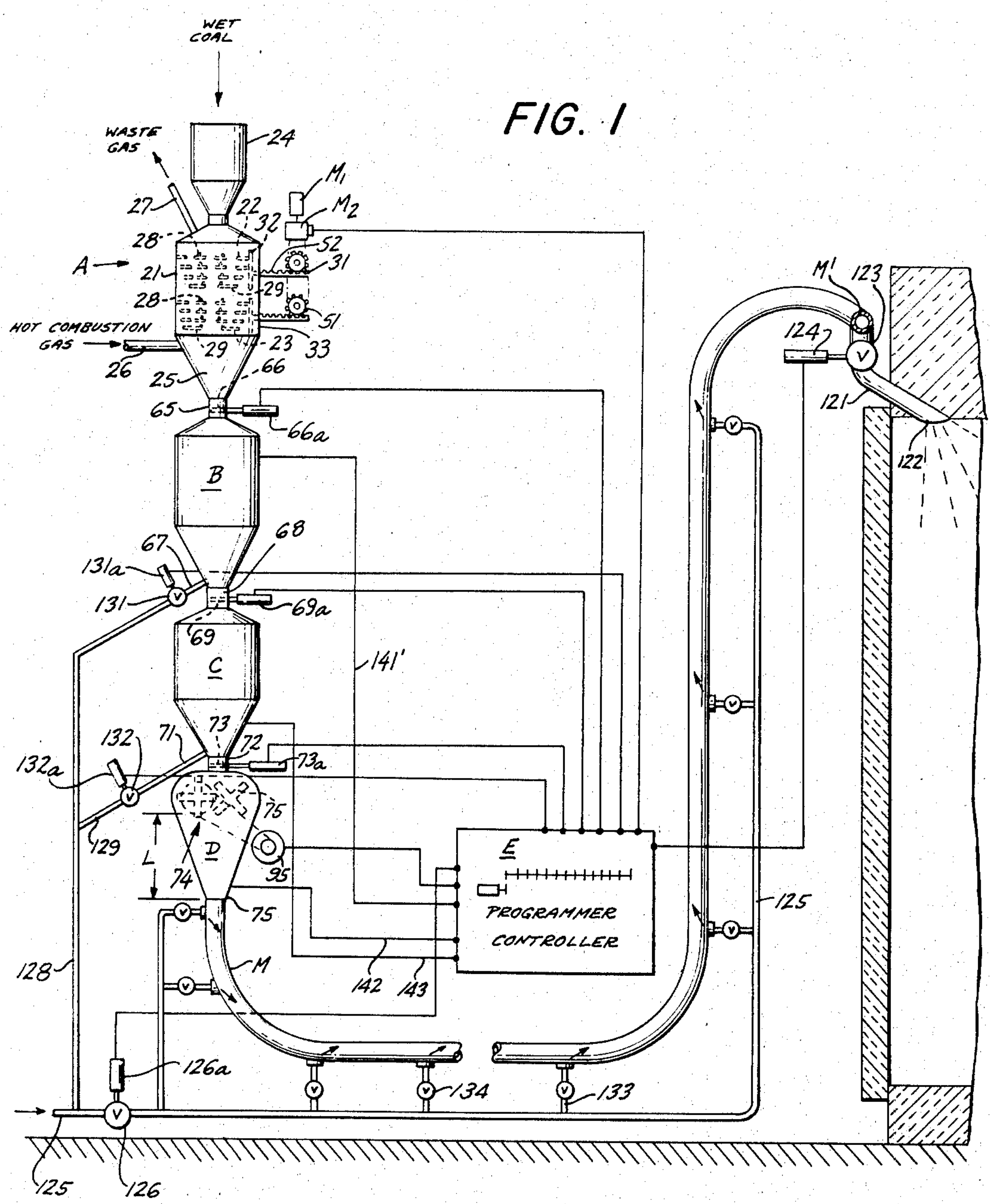
March 19, 1968 L. D. SCHMIDT 3,374,151

METHOD AND APPARATUS FOR AUTOMATICALLY CHARGING THE COKING CHAMBERS OF COKE OVEN BATTERIES

Original Filed May 22, 1963 5 Sheets-Sheet 1

FIG. 1



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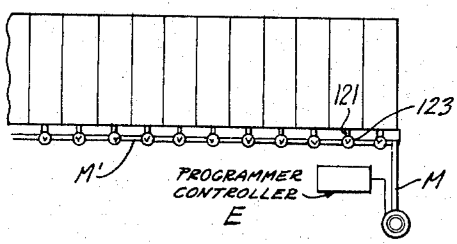


FIG. 2

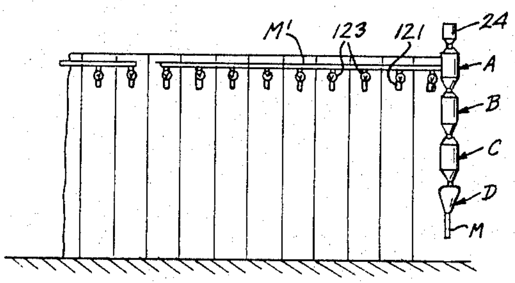


FIG. 3

FIG. 4

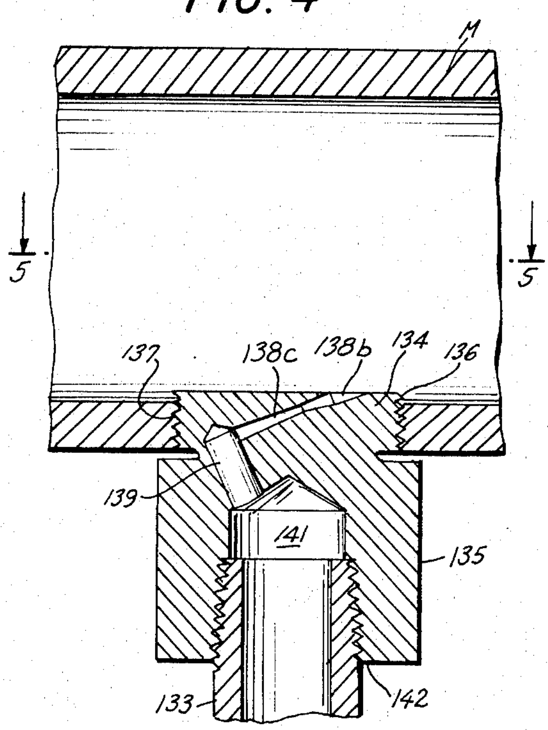
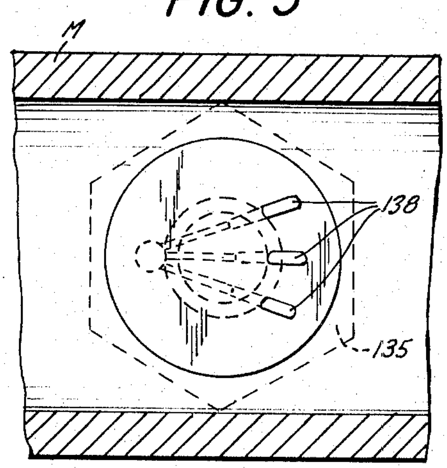


FIG. 5



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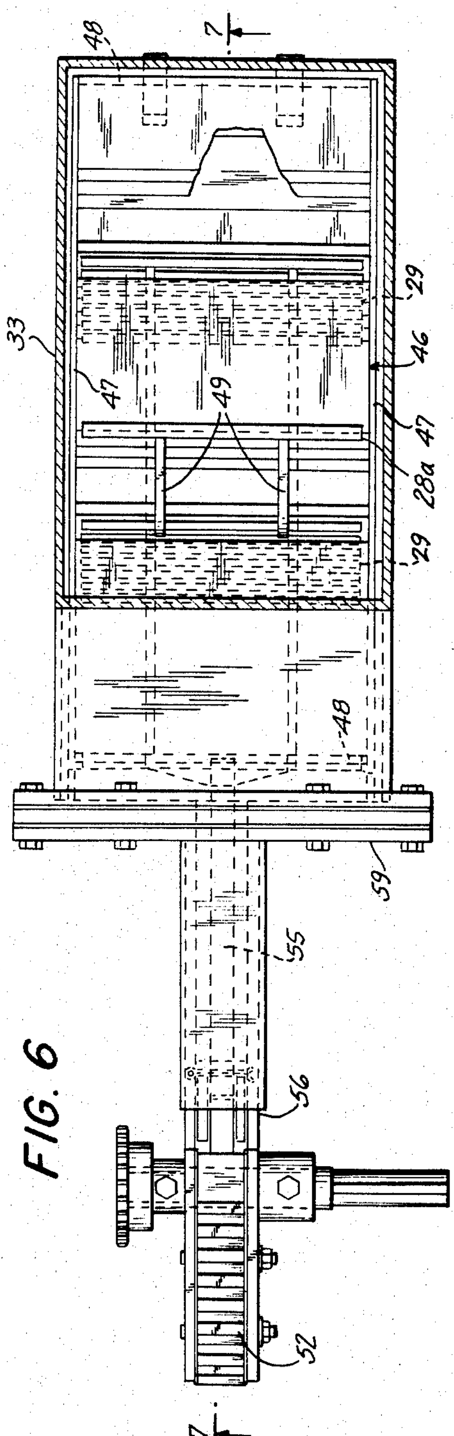

FIG. 6

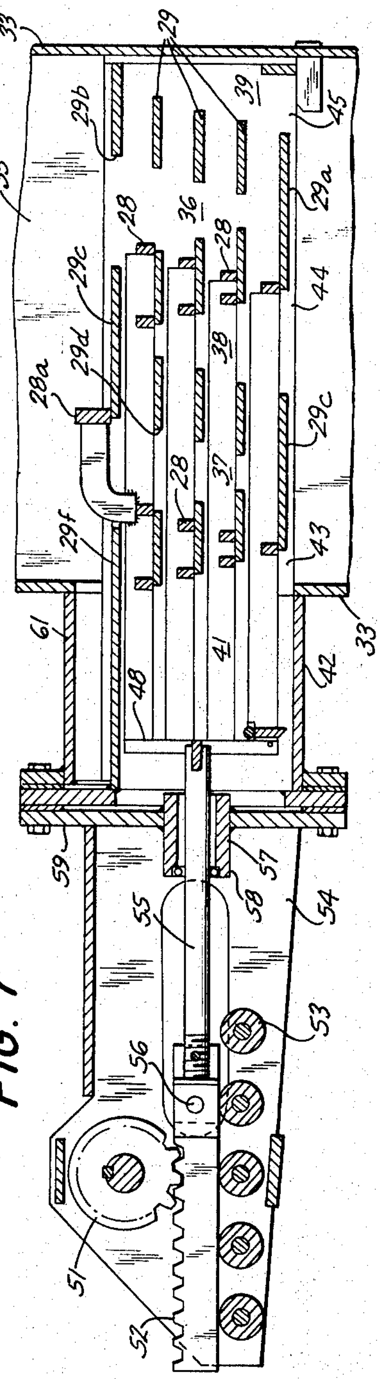

FIG. 7

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FIG. 8

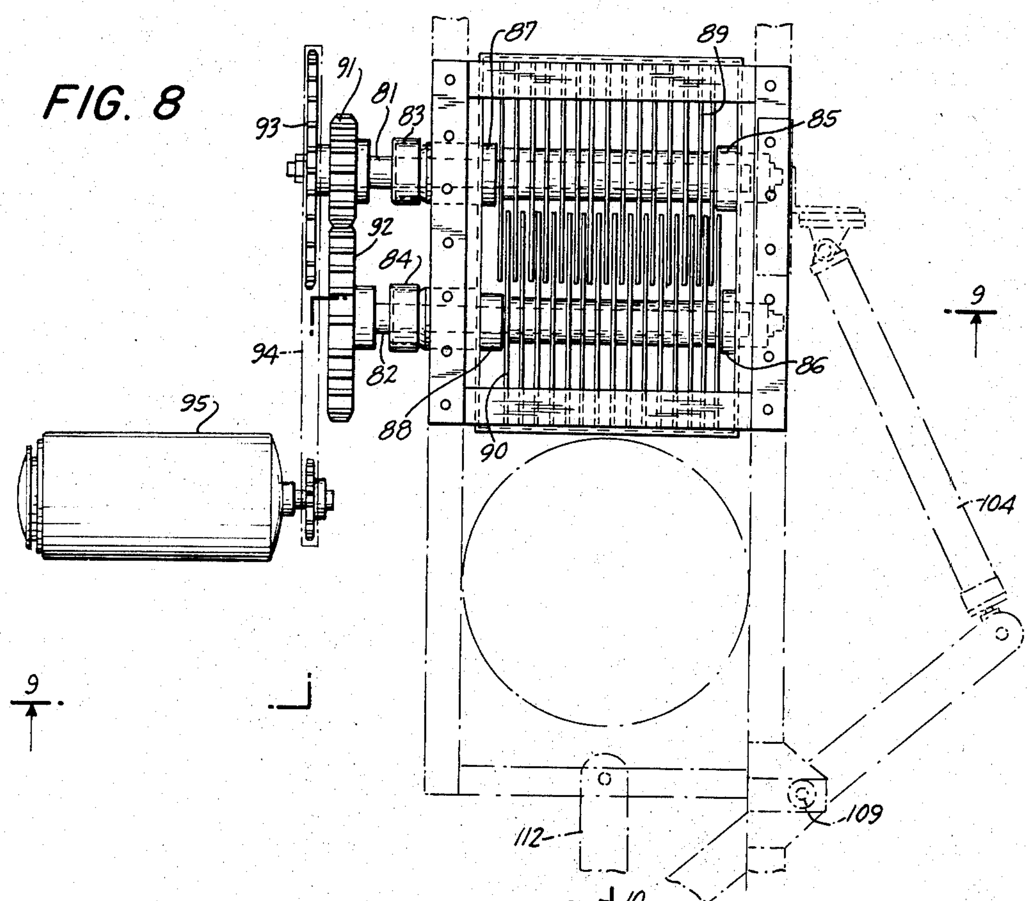

FIG. 9

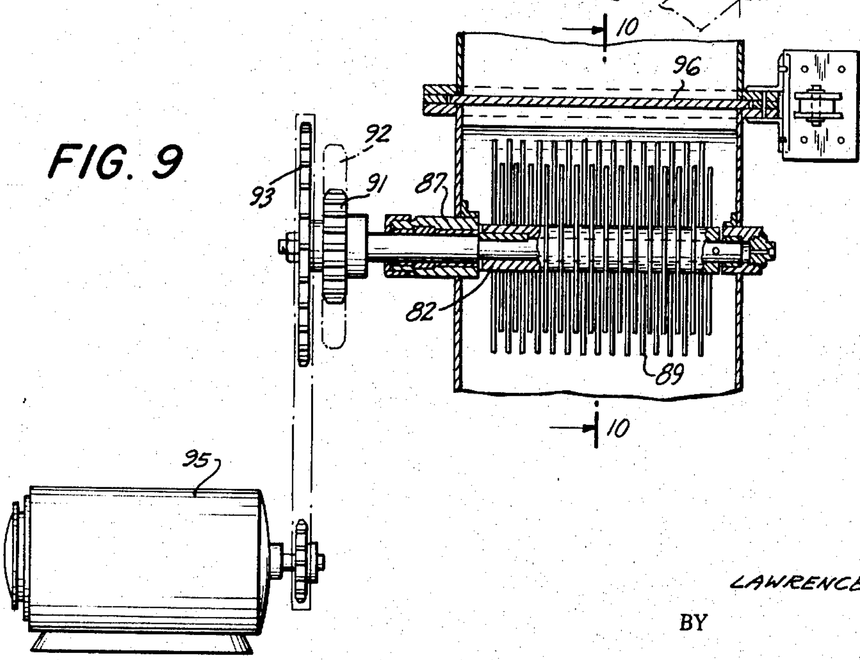

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FIG. 10

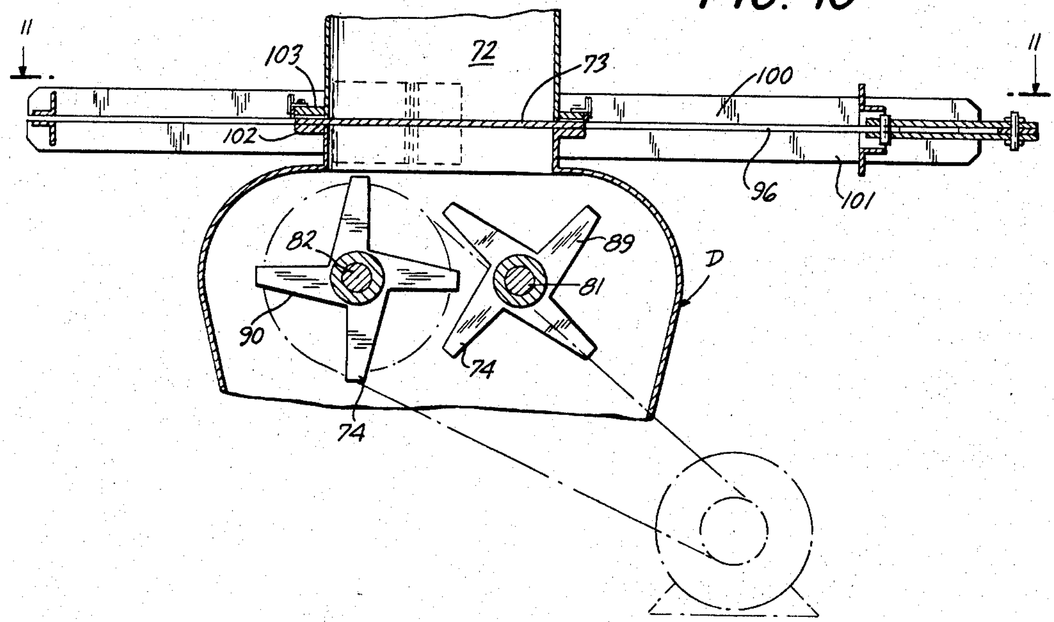
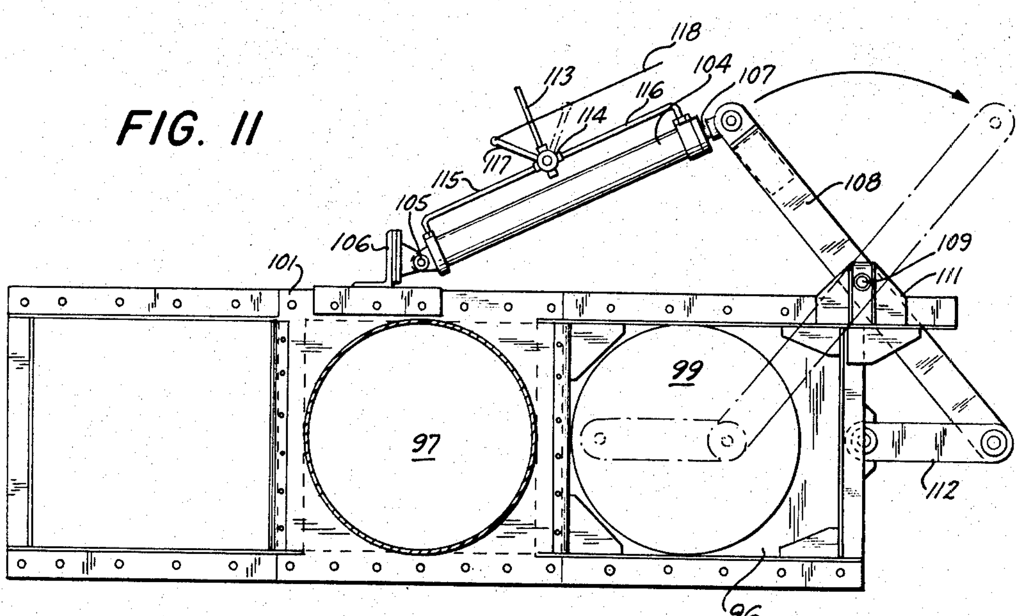


FIG. 11



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METHOD AND APPARATUS FOR AUTOMATICALLY CHARGING THE COKING CHAMBERS OF COKE OVEN BATTERIES

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Continuation of application Ser. No. 282,351, May 22, 1963. This application Oct. 20, 1966, Ser. No. 588,217
8 Claims. (Cl. 201—8)

This application is a continuation of application Ser. No. 282,351, filed May 22, 1963, now abandoned.

This invention relates to method and apparatus for automatically charging coal into the coking chambers of coke oven batteries.

Conventional charging of the coking chambers of coke oven batteries involves for each battery a charging larry travelling on rails at the top of the battery and having charging hoppers, equal in number to the number of charging holes in the roof of each coking chamber, from which hoppers the charge of coal is fed into the coking chamber to be charged. The larry moves back and forth, receiving a charge of wet coal, containing from 2% to 8%, usually 7% to 8%, moisture, from the coal bins positioned at one end of the battery and delivering this charge into the empty coking chamber to be charged after the charging hole covers of the latter have been removed. Thus, this procedure entails the initial cost and expense of the maintenance and operation of the larry, the labor of removing and replacing the charging holes covers usually performed manually under the unpleasant working conditions existing on the top of the battery, the added expense of constructing the coking chambers with charging hole openings and providing covers therefor, and the objections inherent in the charging of coking chambers with wet coal, particularly the markedly longer coking times requird for producing a good grade of metallurgical coke with consequent reduction in the capacity of the battery.

My Patent 3,047,473, granted July 31, 1962, entitled, "Drying, Preheating, Transferring and Carbonizing Coal," discloses process and apparatus for drying and pre-heating wet coal and charging the dried coal to the coking chambers either by a larry having charging bins or hoppers which are supported over the coking chamber to be charged after removal of the covers, or through a coal-charging pipe having valve-controlled branches, one for each coking chamber of the battery. An inert gas, such as coal gas, is supplied to the coal-charging pipe to effect flow of the dried coal particles therethrough. The charging of each coking chamber is effected by opening a valve in the branch pipe communicated with the coking chamber to be charged, and closing this valve when the desired charge has been introduced into the coking chamber.

This invention is an improvement on the latter type of charging apparatus for the coking chambers of a coke oven battery involving the drying and heating of the wet coal and the feed of the dried and preheated coal to each coking chamber to be charged through a transport main provided with branches, each individual to a coking chamber.

It is a principal object of the present invention to provide an improved method and apparatus for drying and preheating coal.

It is another object of this inveintion to provide a method and apparatus for charging the coking chambers of a coke over battery with dried and preheated coal automatically after the pushing of each coking chamber of the battery and the replacement of the doors at the opposite ends of the chamber, which process and apparatus effects such charging efficiently, particularly in that the charging is carried out under conditions which tend to prevent clogging of the mains through which the coal is fed to each coking chamber during the charging thereof.

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It is another object of this invention to provide a method and apparatus for charging the coking chambers of a coke oven battery which method and apparatus involves the delivery of the coal to each chamber is preheated dried condition and in a free flowing form so that the charge is self-leveling.

It is a further object of this invention to provide a method and apparatus for regulating the drying, preheating and charging of the coal to the coking chambers to supply each chamber to be charged with a predetermined amount of dried and preheated coal, and this in accordance with a selected order of pushing and charging the coking chambers of the battery to obtain optimum conservation of heat and coking times for the production of metallurgical coke.

Other objects and advantages of this invention will be apparent from the following detailed description thereof.

In accordance with this invention, wet coal at ambient temperature, hammermilled so that it has a particle size (by "particle size" as used herein is meant the largest dimension of the particle) not exceeding about one inch, from 4% to 25% of the particles are larger than ¼ inch, from 15% to 40% of the particles are larger than ⅛ inch, and over 40% of the particles are larger than 0.04 inch, and usually containing from 2% to 10% of moisture (i.e., coarsely comminuted coal) is fed to a preheater through which it passes downwardly countercurrent to hot gases which dry and preheat the coal. These gases are advantageously combustion gases from a furnace which may be fed with solid, liquid or gaseous fuel, for burning in the furnace. The coal is thus dried and preheated to a temperature of from 220° F. to 700° F., preferably from 400° F. to 600° F.

The preheated coal is fed into a first hot bin or storage zone for preheated dried coal, in which zone during operation a supply of the preheated coal is maintained for feeding the preheated coal periodically, as required, into a second hot bin or feed zone through a valve-controlled port. Alternatively, the preheated dried coal may be fed intermittently directly to the feed zone. This second hot bin or feed zone has a capacity preferably equal to the amount required for the charging of a coking chamber. The second hot bin or feed zone after receiving predried coal from the drier or first hot bin, as the case may be, is sealed, and a carrier gas, preferably steam or coke oven gas, is introduced thereinto to suspend the charge of dried coal therein, i.e., produce a mixture of hot coarsely comminuted coal and carrier gas which is free flowing.

When the charge in the second hot bin or feed zone has been admixed with the carrier gas to produce a free flowing mixture, a valve controlling the discharge end is opened and the charge carrier gas mixture is delivered through a metering crusher which controls the flow of the hot, dried coal from the second hot bin or feed zone and eliminates any oversized coal particles, so that the carrier gas coal mixture exiting from the metering crusher enters an acceleration zone free of oversized particles or agglomerates. This acceleration zone is of general truncated conical configuration converging from the metering crusher to the inlet end of the transport main; the cross-sectional area of the exit end of the acceleration zone is the same as the inlet end of the transport main. The longitudinal extent of the acceleration zone, which as noted is of truncated conical configuration and thus converges in cross-sectional area from the metering crusher where it receives the hot, dried coal free of oversized particles or agglomerates, to the inlet end of the transport main, is such as to provide for a free fall and concurrent acceleration of the coal particles from the metering crusher into the inlet end of the transport main. This is important because it prevents the formation of accumulations of coal particles at the inlet end of the transport main which might tend to pack and result in clogging of the transport main either at the inlet end or along its length.

The transport main communicates with branch or charging pipes, one individual to each coking chamber, positioned at the top and desirably passing through one end wall just below the roof thereof. Steam, coke oven gas or other transport gas is jetted into the transport main at spaced points along its length to maintain the coal in a free flowing state and effect the flow of the coal particles therethrough into the coking chamber to be charged.

The coal entering the coking chamber in a free flowing condition, i.e., suspended in the carrier gas, has flow properties similar to that of a liquid in its tendency to seek the lowest level of the confined surface into which it is introduced. Thus the suspension or dispersion of coal particles flows from one end of the coking chamber across the length of the coking chamber forming a bed which is of substantially uniform depth. During the flow of the coal dispersion along the floor of the coking chamber and while the bed of coals builds up in thickness, disentrainment of the carrier gas from the coal particles takes place. The carrier gas leaves the deposited coal particles and flows up through the chamber towards the top, exiting through the uptake pipes which communicate with the collector main or mains at one or both sides of the battery.

The coal subjected to drying can be any of the coking coals commonly employed as feed for the coking chambers of the battery and may include coals of higher oxygen content than customarily coked. In the case of foundry coke production, preferably the hammermilled coal fed to the drier, has admixed therewith anti-fracturant material, such as anthracite coal fines, petroleum coke fines or pulverized coke breeze in any desired amount including amounts of from 10% to 20%, as disclosed in my Patent 3,047,473, which larger amounts can be used with preheated coal and improve the quality of the metallurgical coke as well as minimize the danger of excessive expansion pressures being generated during the coking.

Preferably oil, such as residual fuel oil, having a gravity higher than about 6° Baumé desirably from 10° to 20° Baumé, in an amount of about from 0.5% to 5%, is added to the coal subjected to drying. The addition of oil to the coal before it is fed into the preheater conditions the coal to minimize loss of coal, particularly fines, during the preheating; entrainment of coal fines in the heating gases leaving the preheater is minimized.

The novel preheater of the present invention comprises one or more grates or spaced coal-supporting members or baffles, each provided with a scraper reciprocal thereon. The scrapers push the coal off the stationary baffles. The spacing of the staggered stationary grate bars forming the grates is such that when a coal mass above the grate is quiescent, no coal falls through the grating, but when the mass is agitated by reciprocation of the scrapers, coal falls through the grate openings. The spacing of the openings is such, however, that at all times, whether or not the scrapers are stationary or moving, heating gases can pass through the grate and the coal supported thereon.

The amount of coal passing through each grate assembly in unit time depends upon the rate of reciprocation of the scrapers. Advantageously two or more grate assemblies with associated scrapers are employed, the number depending primarily on the desired thermal efficiency of the installation for effecting the drying and preheating of the coal. The grates and scrapers with regulatable power drives provide a rugged and effective means of drying the wet coal, and controlling the flow rate of the dried, preheated coal into the first hot bin and thus ultimately the production rate of coke, i.e., the number of tons per day.

In the accompanying drawings forming a part of this specification, showing for purposes of exemplification, a preferred form of this invention without limiting the claimed invention to such illustrative instances:

FIGURE 1 is a diagrammatic elevation, partly in section, of one embodiment of apparatus which can be employed to practice the process of this invention;

FIGURE 2 is a fragmentary plan view of the apparatus shown in FIGURE 1;

FIGURE 3 is a fragmentary side elevation view of the apparatus of FIGURE 1;

FIGURE 4 is a fragmentary section through a transport main and a carrier gas jet associated therewith;

FIGURE 5 is a section taken in a plane passing through line **5—5** on FIGURE 4;

FIGURE 6 is a plan view, partly in section of the coal drier for drying and preheating wet coal for feed to the first hot bin;

FIGURE 7 is a vertical section of the drier on line **7—7** of FIGURE 6.

FIGURE 8 is a plan view of one form of metering crusher;

FIGURE 9 is a vertical section taken in a plane indicated by line **9—9** on FIGURE 8.

FIGURE 10 is a vertical section taken in a plane indicated by line **10—10** on FIGURE 9 and shows the drive for the metering crusher in broken lines; and

FIGURE 11 is a horizontal section taken in a plane indicated by line **11—11** of FIGURE 10 illustrating the gate mechanism controlling flow of the coal to the metering crusher.

As shown in FIGURE 1, the coal drier A comprises a vessel **21** in which is positioned one or more drying units or grate assemblies, hereinafter described. In FIGURE 1, two such grate assemblies are indicated diagrammatically at **22** and **23**, but it will be understood the drier A can contain any desired number of such assemblies. The vessel **21** communicates at its top with a charging hopper **24** supplied with wet coal, from any suitable source of supply, not shown. A flight conveyor, not shown, can carry coal into vessel **21** and maintain a level bed of coal on the top of grate assembly **22**. Vessel **21** has in its base beneath the lowermost drier unit **23**, and desirably in the truncated conical discharge section **25** thereof, an inlet **26**, for hot products of combustion or other heating gases. The top of bin **21** is provided with a waste gas exit line **27**.

In the diagrammatic showing of FIGURE 1, each drier or grate assembly **22** and **23** comprises scrapers **28** positioned immediately above staggered grate bars **29**. Scrapers **28** are reciprocated back and forth over the grate bars **29** by the actuating arms **31** having their interior ends fastened to connecting members **32** which, when moved back and forth, effect the reciprocatory motion of the scrapers **28**. Actuating arms **31** extend through suitable parking glads in the wall of bin **21** and are provided with racks **52** actuated by pinions **51** to effect reciprocation of the scrapers, as hereinafter more fully described.

Drier

The preferred form of scraper grate-bar type of drier shown in FIGURES 6 and 7 will now be described. As noted, one, two or more such driers can be positioned in the drier vessel **21**. The construction of FIGURES 6 and 7 comprises a housing **33**, which desirably forms the side walls of the drier **21**, open at its top and communicating in the case of the topmost drier unit with the discharge end of the coal hopper **24**, and thus adapted to receive raw, wet hammermilled coal through the inlet **35** at its top. Fixed to the opposite walls of housing **33** is a series of staggered horizontal baffles or grate-bars **29** in staggered arrangement as shown in FIGURE 7, to prevent the downward passage of quiescent coal in the drier.

The bottom baffle **29***a* is positioned to provide a stop or obstruction for the space or passageway **36**, defined by the oppositely disposed side edges of the baffles **29***b* thereabove, which side edges define the passageway **36** diverging in an upward direction. Bottom baffle **29***c* acts as a stop for the space or passageway **37** defined by the adjacent side edges of baffles **29***d* thereabove. Space or passageway **38** is disposed below baffle **29***c* and diverges from top to bottom providing passageway for both ascending hot gases and freely falling coal. Spaces or passageways **39**, and **41**, i.e., areas through which coal can fall, are provided in the drier; space **39** is positioned contiguous to wall of housing **33** and space **41** at the opposite side of the drier beneath top baffle **29***f* and above the base wall **42**. The coal exit of the drier communicates through spaced ports or discharge openings **43**, **44** and **45** with the passageway leading into the drier therebelow; in the case of the lowermost drier unit, and where only one drier is used, ports **43**, **44** and **45** lead into the discharge section **25** of the drier bin **21**.

Reciprocating on the grate bars or baffles **29** are a series of the scrapers **28**, so arranged as to agitate and move the coal in the drier to dislodge the coal from the supporting baffles or grate bars **29** and cause it to fall through passageways **36**, **37**, **38**, **39** and **41** thence through the discharge ports **43**, **44** and **45**. Scrapers **28** are rigidly fixed to a frame **46** comprising longitudinal bars **47** connected to a vertical cross member **48** at the opposite ends of the bars **47** so that all the scrapers **28** reciprocate together, including top scrapers **28***a* movable to scrape the top of the left hand end of baffle **29***c*. Top scraper **28***a* is fixed to one end of arms **49** (FIGURE 6), the opposite ends of which are suitably fastened to the upper edge of scraper **28***a* shown in FIGURE 7.

Reciprocation of the scrapers is effected by oscillating toothed pinion **51** meshing with rack **52** which reciprocates on rollers **53** rotatably supported, as is pinion **51**, on frame **54** (FIGURES 6 and 7). The reciprocating motion of rack **52** is transmitted to the frame carrying scrapers **28** by means of rod **55** which at one end is threaded and pinned to rack **52** at **56**, passes through seal **57**, and at the other end is fastened to cross member **48** of the scraper frame **46**.

Seal **57** is mounted in stub cylinder **58** welded to head plate **59** which is bolted to and closes flanged extension **61** of housing **33**.

Oscillating pinion **51** may be operated by any suitable drive, preferably provided with speed control, to give any desired rate of feed of the coal.

The coal in its descent through the drier loses its moisture and is heated, and the heated coal is discharged into the discharge section **25** of drier bin **21**, in a hot, dry condition. It will be clear that by suitable regulation of the speed of reciprocation of the scrapers **28**, and employing the necessary number of drier units depending upon the thermal efficiency desired for the installation, the downward flow of coal can be so controlled with respect to the upward flow and temperature of the combustion gases that the coal is delivered to the discharge section **25** at the desired temperature, within the range of 220° F. to 700° F., preferably 400° F. to 600° F. at a rate to supply the first hot bin or storage zone B or to supply directly the second hot bin or feed zone C, with the desired quantity of predried coal, to effect the successive charging of the coking chambers, as hereinafter described. Thus the baffle or grate bars **29**, in combination with the scrapers **28**, serve to meter the coal flow countercurrent to the hot gases rising up therethrough, and the operation thereof can be controlled, and adjusted whenever necessary by changing the rate of reciprocation of the scrapers **28** to give the optimum metered rate of flow for efficient charging of the coking chambers.

Hot bins and transport container communicating with transport main

In the embodiment of the invention shown in FIGURE 1, drier **21** communicates with the first hot bin B positioned directly beneath drier A through conduit **65** containing a shut-off gate valve **66**. A valved inlet **67** leads into the base of the first hot bin B for admitting steam, coke oven gas or other carrier gas therethrough to produce a flowable suspension in the carrier gas of the charge of preheated coal introduced into the first hot bin B. Such introduction takes place after valve **66** is closed, as hereinafter more fully described. The carrier gas, preferably steam, employed is at a temperature at least equal to and preferably above the temperature of the dried coal so as not to cool it. For brevity of description hereinafter, for the most part, reference will be made to "steam" as the carrier gas medium for the dried and preheated coal; it will be understood, however, that this invention is not limited to the use of steam, which is preferred, and that instead of steam, other carrier gas, such as coke oven gas, can be used.

The first hot bin B communicates through a conduit **68** with the second hot bin or feed zone C. Positioned in conduit **68** is a gate valve **69**, which when closed isolates the first hot bin B from the second hot bin C, and when open permits discharge of the predried coal and carrier gas mixture, produced by the introduction of steam through inlet **67**, from the first hot bin B to the second hot bin C.

The second hot bin C is provided at its base with a steam inlet **71** and communicates through a conduit **72** with the top of the accelerator section D. A gate valve **73** is positioned in conduit **72**. Positioned at the top of the accelerator section D is the metering crusher **74**, hereinafter more fully described, which meters and controls the rate of flow of the predried coal introduced into the top of the accelerator section D through conduit **72** when valve **73** is open, through the accelerator section D into the transport main M. The metering crusher **74** has the further important function of crushing any oversized particles or agglomerates, thus ensuring the delivery to the transport main M of hammermilled or coarsely comminuted coal having a maximum particle size conducive to trouble-free transport through main M into the coking chambers, and free of larger particles or agglomerates. The net result is that all particles which pass through the metering crusher **74** are small enough to be suspended in the carrier gas to form a suspension of the solid particles in the gaseous medium having the properties of flowing in a manner comparable to that of a liquid, i.e., when the suspension is introduced into a coking chamber, it flows downwardly onto and along the floor of the chamber, and onto and along the bed formed as the depth of coal in the chamber builds up, across the full length of the coking chamber, seeking its level. Thus the coal suspension is self-leveling when fed at a proper rate by the metering crusher.

As shown in FIGURE 1, the accelerator section D is of truncated conical shape. The base **75**, where this chamber joins the inlet end of the transport main M, is of the same diameter as this inlet end. The joint between the two is such that streamlined flow takes place from the exit of accelerator section D into the main M; this joint is free of any obstructions to flow therethrough. The longitudinal extent, i.e., the length of the portion of the accelerator section D from the exit of the metering crusher **74** to the discharge end **75** or the inlet to the transport main M, which length is indicated by the reference character L on FIGURE 1, is at least sufficient to permit accelerative fall of the suspension of coal particles from the metering crusher into the inlet end of transport main M without any tendency for accumulation of coal particles to take place in the accelerator section D. This is important because by having this distance L so dimensioned, accumulation of solid particles in the lower end of the accelerator, which, if permitted to form, would tend to obstruct or clog the flow into the transport main M, is prevented.

The dimensions of the accelerator section, as well as those of the drier A and bins B and C will, of course, vary for each installation, and in general depend on the capacity of the coking chambers, the charging cycle used, the fluidizing or carrier gas used, and the size of the coal charged. The capacity of hot bin B, if used, and hot bin C is appreciably greater than the amount of the charge required for a single coking chamber. An important factor is that the accelerator section D have the length L long enough to provide for free fall of the coal therethrough to accelerate to pipeline speed and avoid any accumulation of coal in the base of accelerator section D.

Metering Crusher

A preferred form of metering crusher **74** will now be described, with reference to FIGURES 8 to 11, inclusive. It comprises two parallel horizontal shafts **81** and **82** journaled in bearings **83**, **84**, **85** and **86** fixedly mounted in the walls of accelerator section D. Bearings **83** and **84** through which the shafts protrude from accelerator section D are provided with gas-tight stuffing glands **87** and **88**. Shaft **81** has keyed or otherwise fixed thereto a plurality of radial crusher arms **89** spaced along the length of the shaft and rotating therewith. In FIGURE 10, a construction is shown involving four arms spaced 90 degrees apart, but any desired number of such crusher arms can be used. Shaft **82** has keyed or otherwise fixed thereto a plurality of similar sets of spaced crusher arms each 90 degrees apart, rotating with the shaft and spaced along its length. As seen in FIGURES 8 and 10, the distance between shafts **81** and **82** and the lengths of arms **89** and **90** are such that the circles of revolution of arms **89** and **90** overlap. The relative spacing of the arms on the two shafts is such that when rotating arms **89** pass between arms **90** and vice versa.

Counter rotation of shafts **81** and **82** and the arms **89** and **90** is effected by meshing gear wheels **91** and **92**, keyed to these shafts respectively. Gear **92** is larger than **91** so that the rotational speed of shaft **81** and arms **89** carried thereby is greater than that of shaft **82** and arms **90**. This provides for improved agitation and effective crushing of oversize lumps of coal. The maximum size of the coal passing through the metering crusher is determined by the clearance between arms **89** and **90**. This clearance is selected to insure that no oversize particles exit from the metering crusher.

Keyed to the outer end of shaft **81** is a sprocket wheel **93** connected by a chain **94** with a variable speed drive **95** driven from any suitable source of power. The rate of rotation imparted to shaft **81** by variable speed drive **95** is regulated responsive to the pressure at the base of accelerator section D as described hereinafter.

Mounted above metering crusher **74** is the gate valve **73** which in the embodiment shown in FIGURES 10 and 11 comprises a sliding member **96** having an opening **97** substantially congruent with the cross-section through conduit **72** and a solid portion **99** of sufficient area to completely close conduit **72**. Member **96** is a flat plate slidably supported between fixed angle iron guides **100** and **101**. Conduit **72** has at its base, flanges **103** positioned directly above flanges **102** at the top of the inlet to accelerator section D. Member **96** slides between these flanges; the assembly of these flanges and member **96** therebetween is designed to provide a gas-tight seal at the joint between the base of conduit **72** and the inlet to the accelerator section D. When member **96** is in the position shown in FIGURE 11 with the solid portion **99** in conduit **72**, flow of coal from hot bin C to accelerator section D is shut off. When, however, member **96** is moved to the left, viewing FIGURE 11, so that opening **97** is positioned in conduit **72**, coal will flow through conduit **72** from hot bin C onto the metering crusher **74** in the accelerator.

Movement of member **96** is effected by a double acting pressure cylinder **104** (FIGURE 11) supplied with pressure fluid. At one end cylinder **104** is pivoted at **105** on a bracket **106** fixedly mounted on angle iron guide **101**. Cylinder **104**, as conventional, contains a piston from which extends piston rod **107** pivotally connected to one end of lever **108**. Lever **108** is pivotally mounted on fixed pin **109** carried by bracket **111** mounted on guide **101**. The other end of lever **108** is pivotally connected to link **112**, pivotally attached to member **96**. Pressure fluid is admitted to either end of the cylinder **104** from pressure line **113** and flows through a conventional four part valve **114** and lines **115** and **116** as required. The direction of application of pressure fluid is controlled by lever **117** actuated from the control unit hereinafter described by means of rod **118** to effect opening and closing the gate valve **73**.

Transport main

The transport main M leads from the exit of the accelerator section D to one end of main M' which extends the full length of the battery, preferably at a point just below its roof. As shown in FIGURE 3, main M' is provided along its length with branches **121**, each individual to a coking chamber, extending through the roof and opening into the top of the coking chamber at one end thereof as shown at **122** in FIGURE 1. Each branch **121** is provided with a valveo **123** actuated by a pressure fluid cylinder or motor **124**.

A steam line **125** has a control valve **126** therein actuated by a pressure fluid cylinder or motor **126*a***. A branch **128** extends from line **125** to the base of first hot bin B. Branch **128** has a line **129** leading into the base of second hot bin C. Branch **128** has therein a valve **131** actuated by solenoid **131*a*** for controlling flow of steam into first hot bin B. Line **129** has therein a valve **132** actuated by a solenoid **132*a*** for controlling flow of steam to second hot bin C. In the case of valves **131** and **132** as well as all other power actuated valves indicated to be actuated by solenoids, it will be understood that electric or pressure fluid motors can be used instead of the solenoids.

Steam line **125**, as best shown in FIGURE 1, extends parallel to transport main M for substantially its full length and is provided with branches **133** along its length at spaced points each leading into the tranport main M. These branches **133** supply steam to the transport main in the direction of flow therethrough to thus impart an impulse or velocity to the flowing suspension of coal and maintain the coal in suspension and flowing through the transport main. The direction of steam introduction is indicated by the arrows in FIGURE 1. The number of branches used depends on the particle size of the coal particles, the capacity and dimensions of the installation, and the pressure of the carrier fluid in vessel C. Desirably the number of branches **133** used is more than adequate to maintain trouble-free flow through the transport main M and for the full length of main M'. The branches **133** may be provided with valves **134** which can be adjusted to give the desired velocity of flow into the transport main M or can be closed when it is desired to reduce the number of branches **133** supplying steam to the transport main M. Main M' can also be provided with branches **133** leading from steam line **125**, if desired.

A preferred form of jet is shown in FIGURES 4 and 5, which jet is simple, inexpensive and efficient in operation. It comprises a polygonal, preferably hexagonal, plug **135** having a threaded end **136** threaded into threaded bore **137** in the wall of transport main M. Plug **135** has a group of radiating nozzles **138**, three in the embodiment shown in FIGURE 5, which through channels, each having a divergent exit portion **138*b*** and converging portion **138*c***, communicate with a common passage **139** leading into the central bore **141** in plug **135**. Desirably each nozzle **138** delivers a jet at an angle of about 20 degrees to the walls of main M as indicated in FIGURE 4. End **142** of plug **135** is threaded to receive the threaded end of branch **133** leading from steam supply line **125**. This construction provides fan-like jets of steam imparting velocity or impulse to the flowing stream of coal suspension in the direction of flow. Each plug **135** is, of course, positioned within its threaded opening to properly dispose the nozzles **138** so that the jets of steam passing therethrough flow in the same direction as the suspension of coal particles flowing past the jets and impart the desired impulse thereto. As shown in FIGURE 4 the jets are of the convergent-divergent type to maximize impulse on the coal.

A motor M1 drives a variable speed drive M2 of any conventional type which supplies the motive power for driving the scrapers **28** of the coal drier A. The variable speed drive M2 is actuated from the programmer controller E to control the rate of reciprocation of the scrapers **28** and thus control the rate of drying and preheating of the coal to feed the desired amount of predried coal to the first hot bin B. Programmer controller E can be of any known type for controlling electrically or hydraulically operated valves in timed sequence. For example, controller E can be of a type commonly employed for control of operating cycles of water gas and oil gas sets. In this type of controller each of a series of cams operates a 3-way valve individual to that cam controlling hydraulic fluid supply selectively to opening and closing ends of the hydraulic drive unit for each valve of a set such as the valves in fuel, air and steam supply lines and in gas and waste product exhaust lines. The series of cams is mounted on a motor driven shaft with lift segments in predetermined angular relationship so that upon rotation of the shaft the valve associated with each cam may be closed and opened in predetermined timed relation with respect to each of the other valves.

Valves **66**, **69** and **73**, each preferably of the reciprocating type, as described in connection with valve **73**, are operated by pressure fluid cylinders or motors *66a*, *69a* and *73a*, respectively. The operation of these motors is controlled by the programmer controller E which effects opening and closing of these valves in desired timed sequence during each cycle of operation as hereinafter explained. As shown in FIGURE 1, control lines lead from the programmer controller E to the solenoids **131***a*, **132***a* and pressure fluid motor **126***a*. The operation of these solenoids and pressure fluid motor **126***a* to effect opening and closing of the respective steam valves, is thus controlled by the programmer controller E, in proper timed relation with the operation of the valves controlling flow of the dried and preheated coal through the equipment.

A level control line **141'** leads from near the top of hot bin B to the programmer controller E. A device of any known type responsive to the level of coal in bin B energizes the programmer controller E to effect the closing of valve **66** and thus interrupt the further supply of dried and preheated coal to bin B wherever the level of coal reaches a predetermined height therein. This height can be set so that just enough coal to fill a coke oven chamber is thus measured into bin C from bin B.

A pressure control line **142** leads from the base of accelerator section D to the programmer controller E. If the pressure should increase in the base of accelerator section D, and hence in transport main M above a predetermined point, i.e., whenever excessive back pressure is created, the controller E reduces the speed of the metering crusher **74** by actuating the variable speed drive **95** therefor. This effects a decrease in the coal feed and hence the coal-steam ratio delivered to the transport main M and thence to M'. As the back pressure is relieved, the speed of the metering crusher is increased until it reaches the predetermined speed chosen for optimum feed rate of coal to the transport main M.

Operation

Hammermilled coal is delivered to charging hopper **24** and flows through drier A countercurrent to combination gases at a rate controlled by the rate of reciprocation of the scraper **28** which is set to produce the desired tonnage of coke per day. Programmer controller E controls the quantity of combustion gas responsive to the temperature of the coal delivered to the base of discharge section **25** to deliver thereto a continuously flowing stream of coal during operation preheated to a temperature of 220° to 700° F., preferably 400° to 600° F. With valve **66** open and valve **69** closed the dried and preheated coal is delivered to the first hot bin B. After collection in bin B of enough coal to fill an oven, chamber valve **66** is closed by the controller and steam valve **131** opened by the programmer to introduce steam into hot bin B to produce a flowable coal steam mixture in bin B. Valve **69** is then opened by the programmer to deliver the coal charge to bin C. Valves **69** and **131** are then closed and valve **132** opened to admit steam to bin C to pressurize the charge of coal therein, i.e., produce a coal steam mixture under pressure so that the hot coarsely comminuted coal steam mixture is free flowing.

Valve **73** which had been closed is then opened by the programmer and simultaneously valve **126** is opened to supply steam to the transport main M at spaced points along its length. Steam at a pressure of 30 to 400 p.s.i.g. and at a temperature of 270° to 650° F. is satisfactory. Valve **123** in the branch main of the coking chamber to be charged is simultaneously opened by the pressure fluid motor **124** actuated by the programmer controller E. The metering crusher **74** is also actuated to feed the coal and crush any oversized lumps and thus deliver coal of the desired maximum particle size as a free falling suspension in the carrier gas to the inlet end of the transport main M. With the aid of steam jets produced by the steam flowing through the branches **133**, valve **126** having been opened, the suspension of coal flows through the transport main M into the coking chamber to be charged, flowing across the length of the chamber and building up the charge to the desired height; the charge as above explained has been found to be self-leveling.

Should excessive back pressure develop in the transport main M for any reason, such as plugging in any portion of the transport main M, the pressure control **142** through the controller E reduces the rate of rotation of the metering crusher **74** to decrease the coal-steam ratio until the back pressure is relieved. When this happens the controller E speeds up the rotation of the metering crusher to its original predetermined speed chosen for optimum operation.

In one mode of operation when bin C is empty, the capacity of this bin being chosen to supply the desired charge to a coking chamber, valve **123** in the branch **121** of the charged chamber and valves **126** and **132** and **73** are closed, and valve **69** readied for opening upon completion of the cycle and when the refilling of bin B is completed for charging the next empty coking chamber. A level control in bin C responsive to the discharge of substantially all of the coal in this bin or to the pressure therein is connected to the programmer controller E, as indicated by line **143**, to energize the controller to effect the closing after a suitable delay of valve **123** in the branch **121** leading into the chamber which has just been charged, valves **126**, **132** and **73** and readying for opening of the valve **69** when bin B is filled to the preset level.

In another modification of this invention, the programmer controller E is operated to deliver dry preheated coal to hot bin C at a rate to always maintain a charge of coal therein. In this modification, valve **73** can be omitted. Valve **66** is periodically opened and closed to deliver coal to hot bin B; after delivery of the desired charge, valve **66** is closed, valve **131** opened and immediately thereafter valve **69** opened to deliver the coal steam mixture to bin C. Steam is admitted continuously through line **129** to maintain the coal steam mixture in a free flowing condition in bin C. The coal flows continuously to the metering crusher which meters and thus controls the rate of coal feed into the transport main M. The valves **123** in the respective branches **122** are opened and closed in timed sequence so that as soon as the desired charge has been delivered to one coking chamber, the valve **123** in the branch **121** individual thereto is closed and the valve **123** controlling the flow of coal to the next chamber to be charged is opened. This mode of operation can only be used in a battery of coking chambers operated on a coking cycle such that upon the completion of the charging of one coking chamber, an empty chamber to be charged is always available.

It will be noted that this invention provides an improved technique for drying and preheating coal, the scraper grate bar construction providing for feed of the coal at a pre-set rate, set by the rate of reciprocation of the scrapers, to give a discharge of dry and preheated coal with automatically controlled flow of preheating gases through the coal, and the coal rate to metering crusher set to give optimum feed of preheated coal to the hot bins but automatically controlled to avoid plug-ups, and thence to and through the metering crusher to the accelerator which supplies the transport main M with coal at the proper velocity and steam-coal ratio for pipeline transport. The operation of the metering crusher is responsive to the pressure in the transport main and is controlled to reduce the coal carrier gas ratio whenever the pressure tends to build up. This tends to insure trouble-free flow of the coal suspension through the transport main into the coking chamber to be charged.

With proper coal-carrier gas ratio, as herein disclosed, the suspension of coal in the carrier gas has been found to be self-leveling, thus eliminating the necessity for mechanically leveling the charge.

The present invention enables the charging operation of the coking chambers to be effected automatically with dried, preheated coal, with consequent saving in labor, heat requirements for coking the coal, shorter coking cycle and hence greater capacity of the coke oven battery for given size and number of coking chambers.

Since certain changes can be made in carrying out the above process and in the apparatus for practicing same, without departing from the scope of this invention, it is intended that all matter contained in the above description or illustrated in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A process for charging coal to the coking chambers of a coke oven battery in which the individual ovens are charged and discharged in timed sequence and having a confined conduit for pnuematic transport of a measured and heated coal charge said conduit extending from an inlet, longitudinally of the battery, with branches leading therefrom to each of the ovens of said battery for selectively placing the individual ovens in fluid communication with said confined conduit and interrupting such communication, comprising establishing fluid communication between said conduit and a discharged hot oven, measuring a charge of coal in a closed preheat section in controlled communication with said confined conduit, forming from said measured charge of coarsely comminuted coal capable of filling said oven and preheated to about 220° F. to about 700° F. a stream thereof suspended in pressurized inert conveying carrier gas, and rapidly feeding said pressurized stream by means of said gas in the inlet of said conduit until said charge is exhausted, pneumatically conveying said stream of coarse coal through said conduit under the influence of inert pressurized gas and into said oven while subjecting the coal to a series of jet impulses of upwardly directed high velocity jets of inert gas introduced through the bottom of said confined conduit at spaced points laterally along the length thereof, feeding said measured preheated charge until exhausted, and after completion of the feeding of the charge to said oven interrupting the fluid communication between it and said conduit, and upon completion of discharge of the next oven

in the battery repeating the aforesaid steps with respect thereto.

2. A process for charging the coking chambers of a coke oven battery in accordance with claim **1** which process comprises, passing coarsely comminuted coal particles counter-current to upwardly moving hot gases to heat the coal particles to about 220° F. to about 700° F., said coal particles being coarsely comminuted so that no particles are larger than one inch, 4–25% are larger than one fourth inch, and 15–40% are larger than one eighth inch, passing the thus heated coal particles into a closed storage zone, passing carrier gas into said storage zone to form a suspension of said coal particles in said carrier gas, passing said coal suspension and additional carrier gas downwardly through a vertically extending conduit as a measured charge for one oven under the influence gravity to accelerate movement of its suspension and to form a stream thereof and thence laterally through said conduit.

3. A process for charging coking chambers of a coke oven battery, in accordance with claim **2** which includes intermittently passing an amount of dried and preheated coal at least sufficient to charge a coking chamber from said storage zone into a feed zone, introducing a carrier gas into said feed zone to pressurize it and to form a suspension of coal in said carrier gas in said feed zone and intermittently passing the coal suspension from said feed zone to said transport conduit to the coking chamber to be charged and providing along the length of said transport conduit longitudinally directed jets of carrier gas in the direction of flow to propel the coal suspension through said transport conduit, continuing the flow of coal suspension through said transport conduit, into the coking chamber until the desired charge has been delivered thereto, thereafter, interrupting the flow of coal suspension to said coking chamber and again introducing preheated coal from said storage zone into said feed zone and repeating the aforesaid steps following the introduction of the desired charge into the feed zone, cyclically to effect the successive charging of the coking chambers of the battery.

4. The process as defined in claim **1** in which the carrier gas is steam.

5. The process as defined in claim **1** in which the carrier gas is coke oven gas.

6. A process for charging the coking chambers of a coke oven battery, in accordance with claim **1** which process comprises, passing wet coarsely comminuted coal counter-current to hot combustion gases to dry and preheat the coal to about 220° F. to about 700° F., continuously passing the thus dried pre-heated coal into a feed zone, continuously introducing into said feed zone a carrier gas to pressurize it and to maintain the coal in said feed zone in suspension in said gas, continuously feeding said preheated coal suspension from said feed zone downwardly through a vertically extending confined conduit in a measured charge under the influence of gravity to accelerate movement of the suspension and thence laterally through a confined transport conduit such that the coal suspension flows readily through said transport conduit, said coal particles being coarsely comminuted so that no particles are larger than one inch, 4–25% are larger than one fourth inch, and 15–40% are larger than one eighth inch, continuously flowing the hot coal suspension from the feed zone through the transport conduit, continuously introducing into said transport conduit, at spaced points along its length, jets of carrier gas upwardly and longitudinally to impart propulsion to the coal suspension flowing through said transport conduit, flowing the coal suspension from said transport conduit into a coking chamber to be charged until the desired measured charge of coal has been introduced thereinto, shutting off flow of said coal suspension into the coking chamber being charged when the desired measured charge has been introduced thereinto, thereafter flowing the coal suspension into the next coking chamber to be charged until the desired charge of coal has been introduced thereinto, and successively interrupting the flow of coal suspension to each coking chamber being charged when the desired measured charge has been introduced thereinto and commencing the introduction of a succeeding measured charge said coal suspension into the next coking chamber to be charged, the feed being actuated at a speed proportional to the pressure at the inlet end of the transport conduit, the speed of the feed being reduced whenever said pressure increases above a predetermined level to thus reduce the ratio of coal to carrier gas fed to said transport conduit, thereby preventing accumulation of coal in said transport conduit which would interfere with the flow therethrough.

7. Apparatus for charging the coking chambers of a coke oven battery with coarsely comminuted coal, in combination, a closed storage bin for receiving preheated coal, means for introducing a carrier gas into said storage bin to form a suspension of the preheated coal in said gas, an accelerator container of generally conical configuration communicating at its upper end with said storage bin, a confined transport main leading from the lower end of said accelerator container and thereafter longitudinally, said transport main having branches leading from the horizontal path thereof to the coking chambers with one branch individual to a coking chamber, each of said branches having valve means therein for controlling flow therethrough, and orifices for supplying jets of a carrier gas at spaced points along said confined horizontal transport main upwardly directed to effect propulsion of the suspension of coal passing therethrough, said accelerator container having at the upper end thereof a crusher through which coal from said storage bin is passed for reducing over-sized lumps of coal and controlling the rate of coal feed through said accelerator container, the distance between the exit end of said crusher and the exit from the truncated conical base of said accelerator container being sufficient to provide for a free fall of coal from said metering crusher into the inlet end of said transport conduit without accumulation of coal taking place at said inlet end of said transport conduit in the movement of a measured charge of coal to said transport conduit.

8. Apparatus for charging the coking chambers of a coke oven battery with coal, in combination, a coal drier and preheater; a first closed storage bin for receiving preheated coal from the pre-heater; a second closed storage bin communicably connected with the first storage bin; a closed accelerator container downwardly directed communicating with the exit end of the second storage bin; a metering crusher in the accelerator container; a confined transport main leading from the accelerator container and having a horizontal section and having branches leading

from said horizontal transport section to the coking chambers of the battery, each coking chamber having a branch individual thereto; valve means in each branch of said transport main for controlling flow therethrough; the preheater having an inlet near its bottom for hot combustion gases, an exit for gases near its top, a charging port at its top for fresh coal, at least one scraper grate in the path of the hot combustion gases, and a valved exit conduit communicating with the first storage bin; a gas inlet in said first storage bin near the base thereof for introducing a carrier gas into said first storage bin; a gas inlet in said second storage bin for introducing a carrier gas thereinto; the said accelerator container converging downwardly and leading into said transport main for streamlined flow from said accelerator container into said transport main; the said transport main being provided at spaced points along its length with jet nozzles for jetting carrier gas into said transport main and effect flow of coal suspension therethrough, said apparatus including automatic means for regulating the flow of coal from the first storage bin to the second storage bin and from the second storage bin to the accelerator container and for driving said metering crusher at a rate proportional to the pressure at the exit end of said transport container, said accelerator container being a truncated conical configuration converging from a level just below the exit of said metering crusher to the inlet of said transport main, the length of the truncated conical portion between said level and said inlet is sufficient to provide for the passage of coal suspension from the metering crusher into the inlet end of said transport main without accumulation of coal at the said inlet to said transport main.

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