

Oct. 8, 1946.

F. PUENING

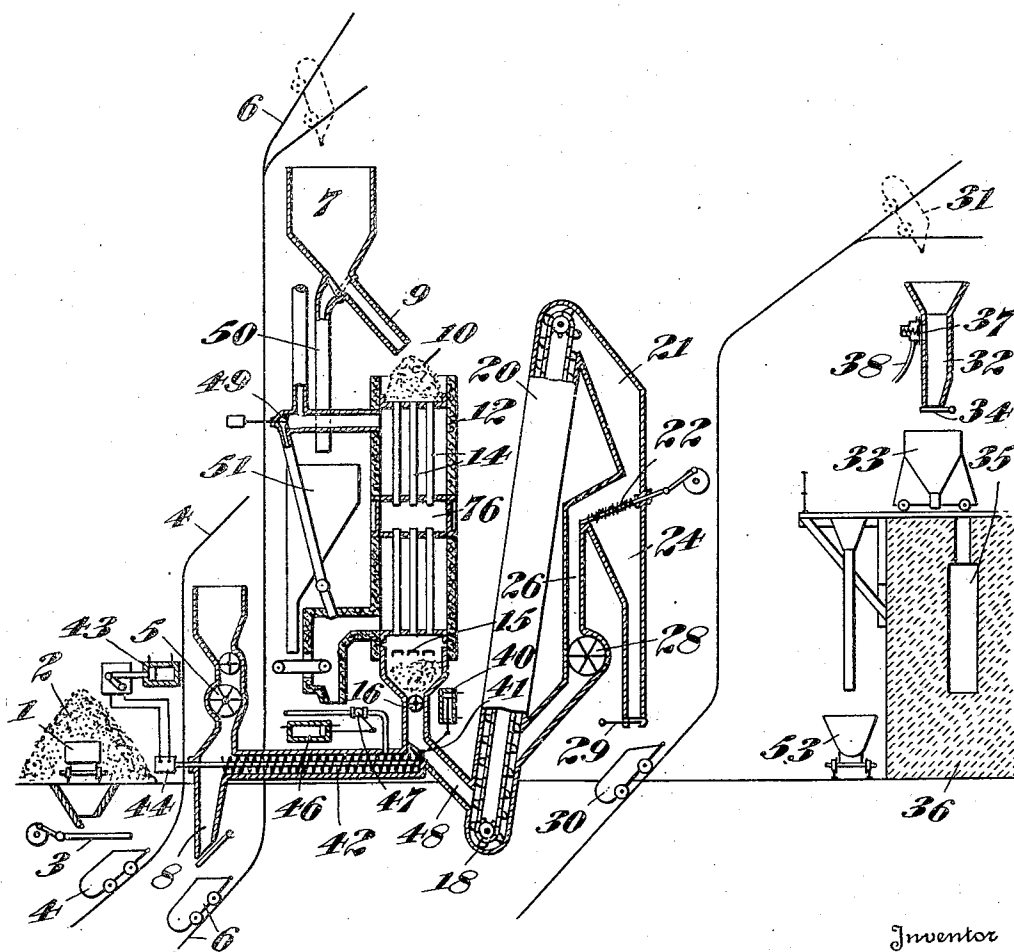
2,408,810

METHOD AND APPARATUS FOR PREPARING COAL FOR COKING

Filed Sept. 11, 1942

8 Sheets-Sheet 1

Fig. 1.



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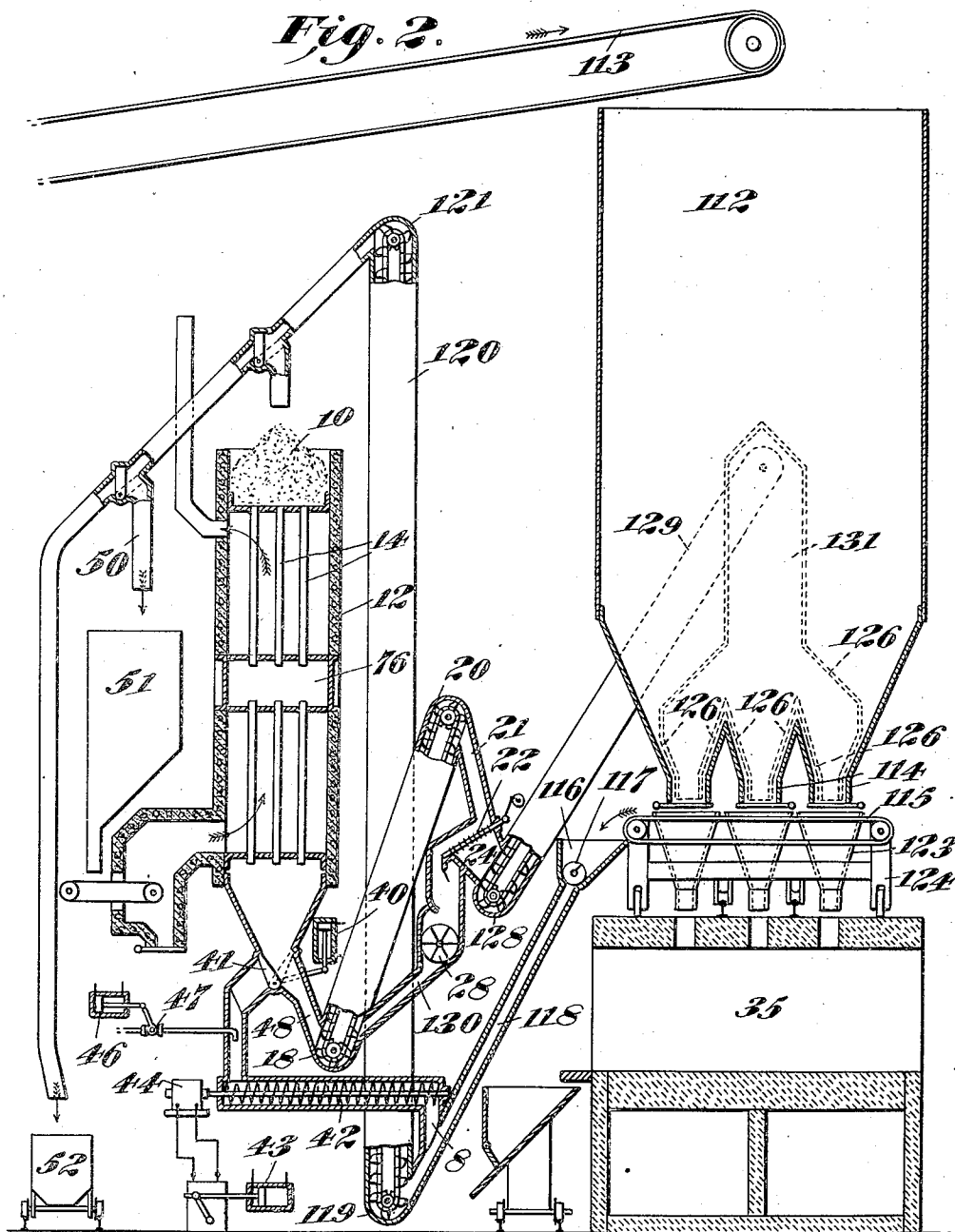
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Fig. 2.



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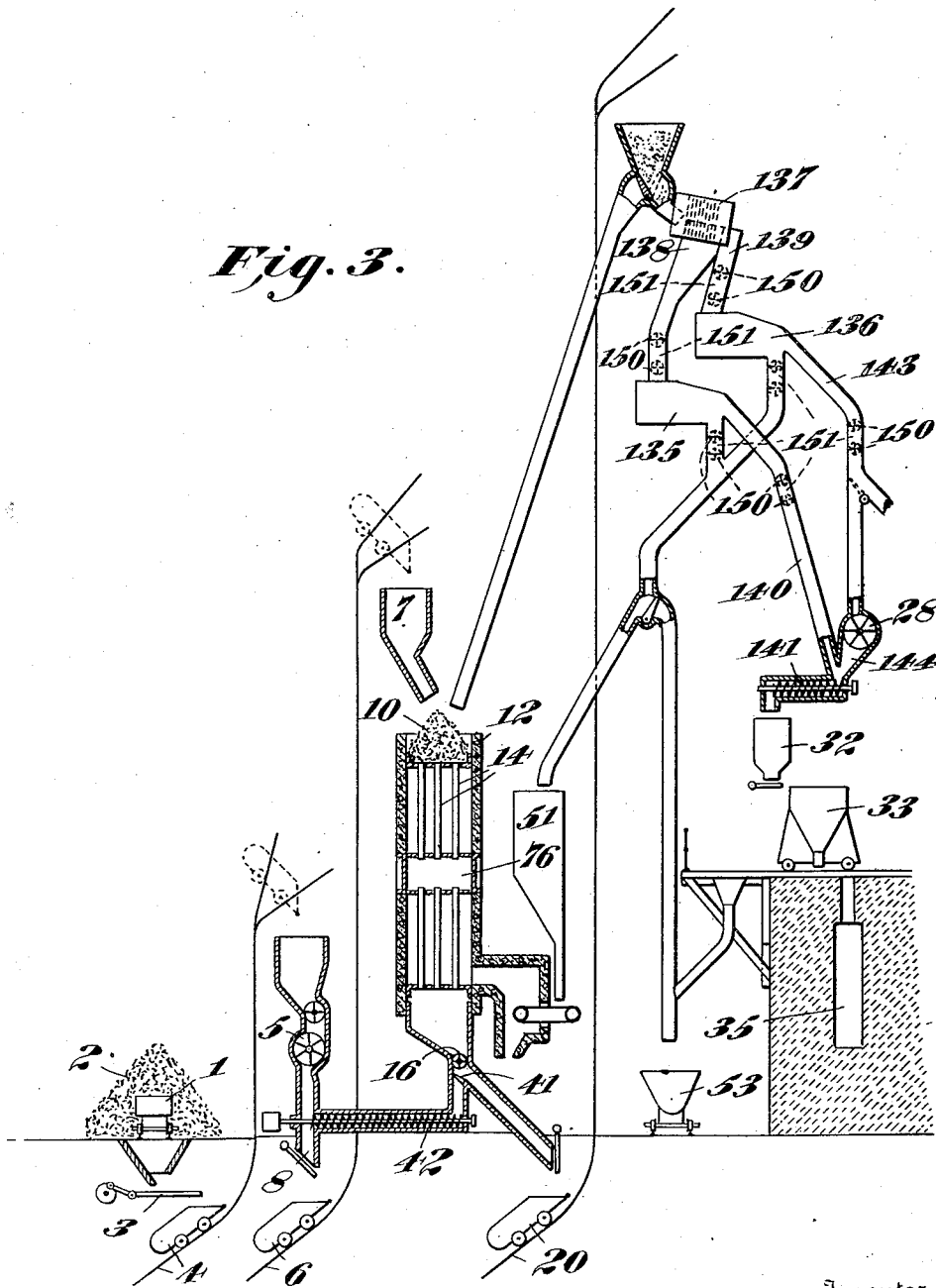
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METHOD AND APPARATUS FOR PREPARING COAL FOR COKING

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Fig. 3.



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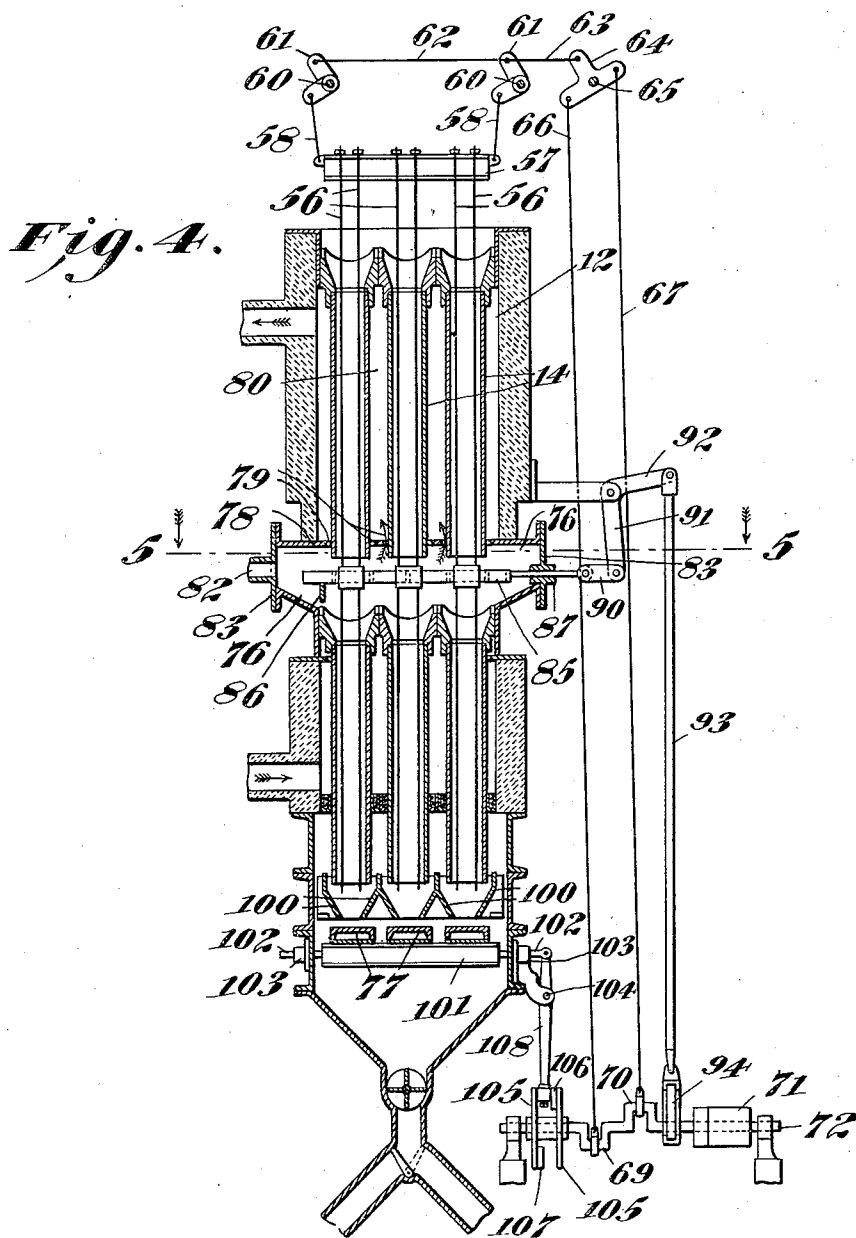
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METHOD AND APPARATUS FOR PREPARING COAL FOR COKING

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Fig. 5.

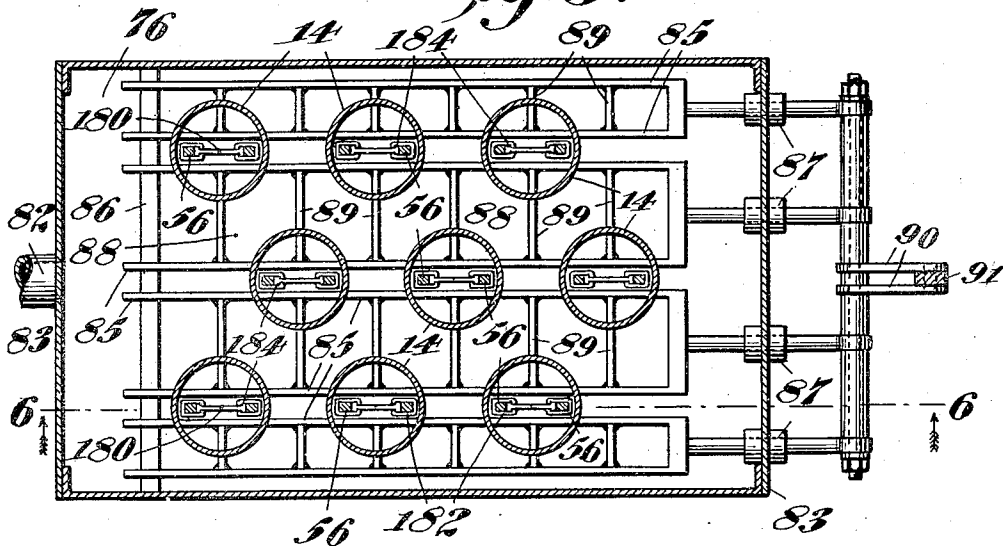
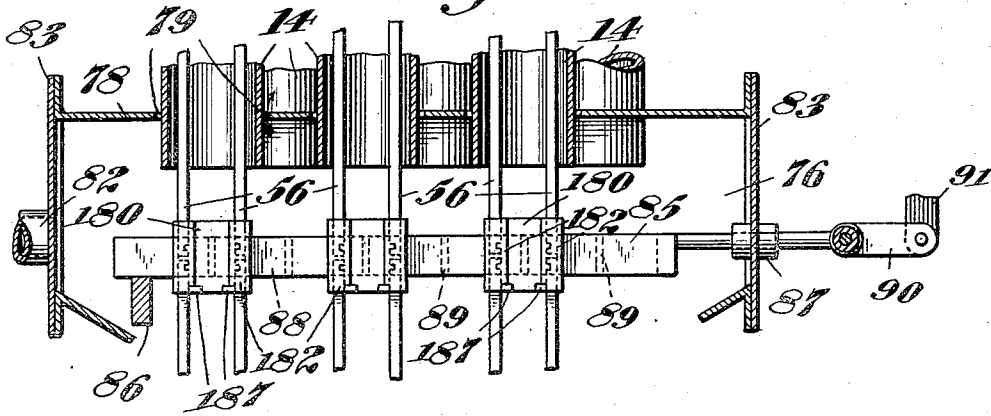


Fig. 6



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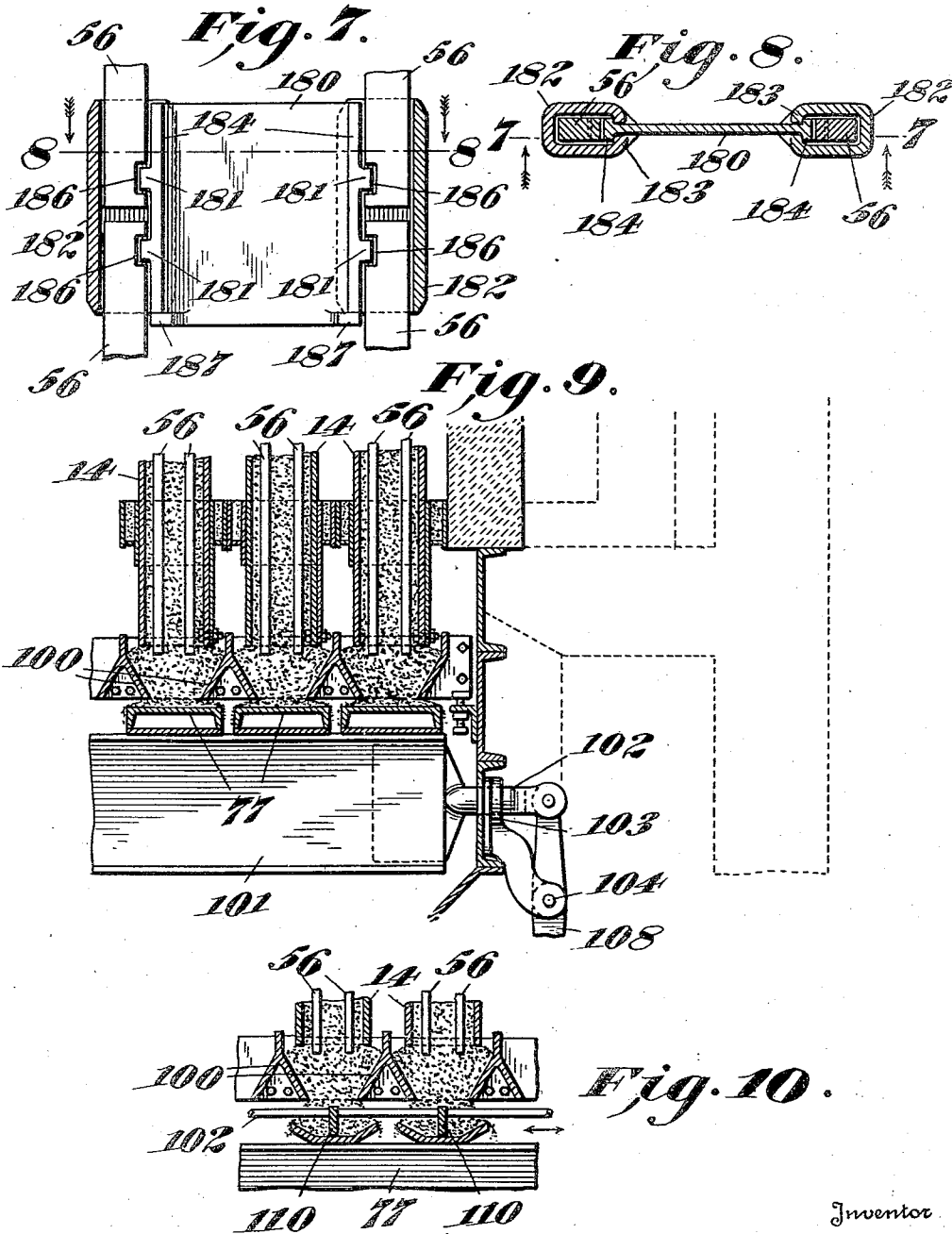
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METHOD AND APPARATUS FOR PREPARING COAL FOR COKING

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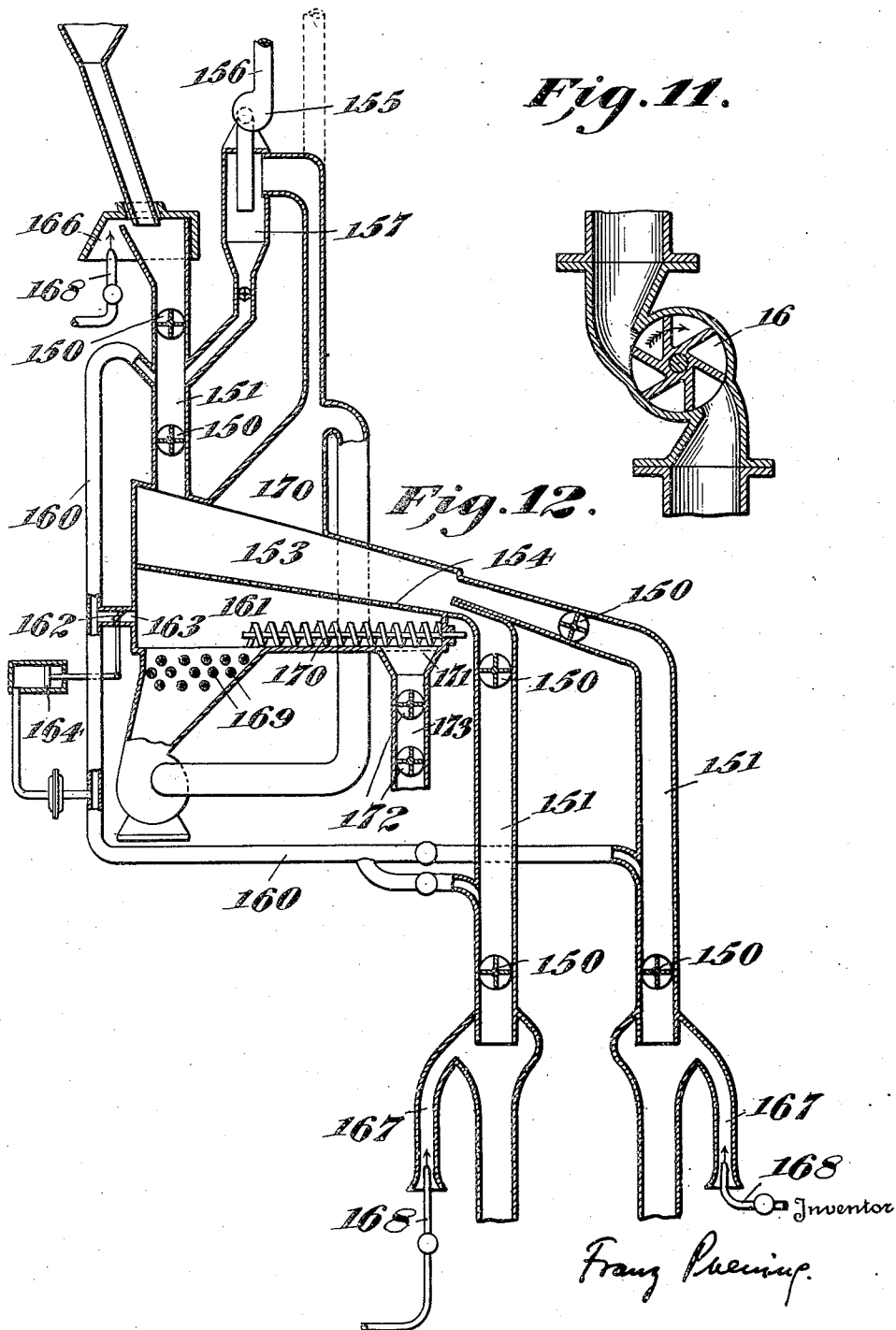
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METHOD AND APPARATUS FOR PREPARING COAL FOR COKING

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METHOD AND APPARATUS FOR PREPARING COAL FOR COKING

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Fig. 13.

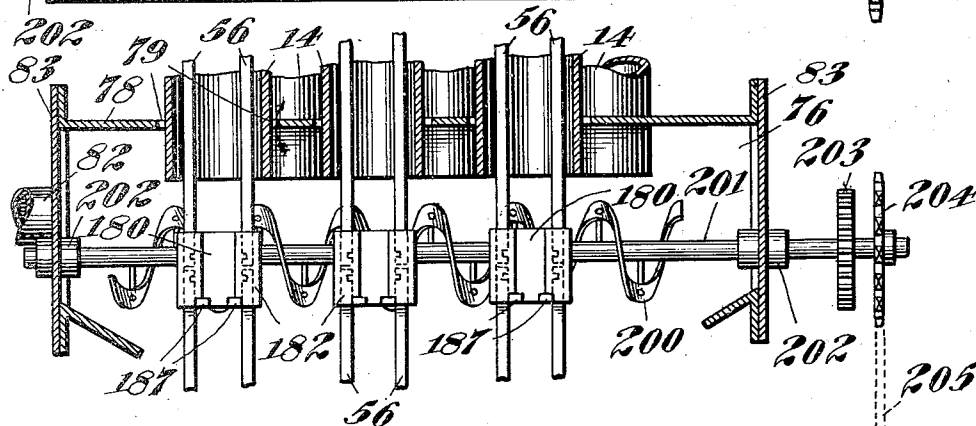
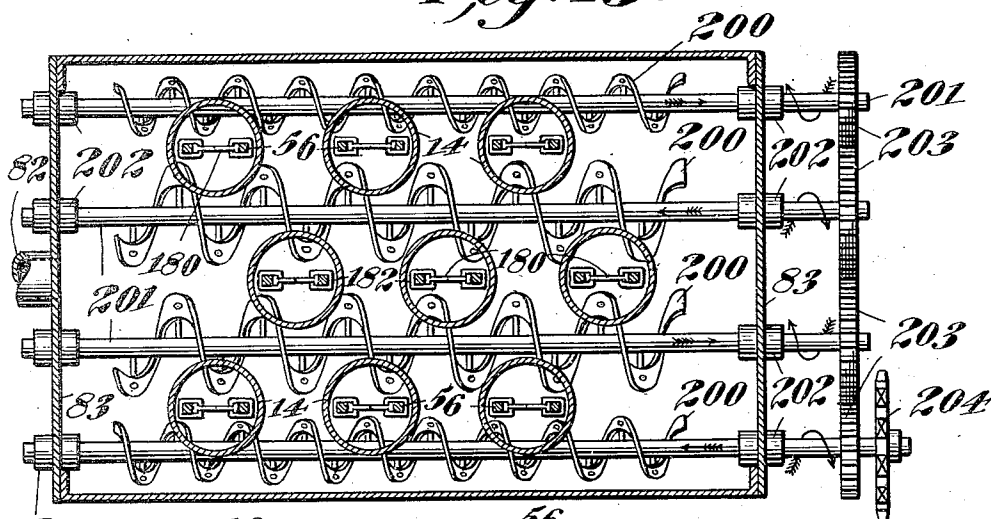
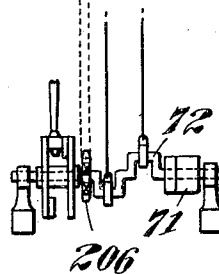


Fig. 14.



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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR PREPARING
COAL FOR COKING

Franz Puening, Bethlehem, Pa.

Application September 11, 1942, Serial No. 457,960

10 Claims: (Cl. 202—27)

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My invention relates to an improved method and apparatus for preparing coal for coking purposes, and more particularly it relates to a method and apparatus for preparing coal for mid-temperature coking for the purpose of making coke suitable for blast furnace charging.

Coke for blast furnace consumption must be sufficiently firm and strong to resist shattering in handling and cracking-up under the pressure exerted by the heavy burden, and therefore it should receive all the strength of which the coal is capable. For greatest contact surface and highest reactivity the coke also must possess a uniform and fine cellular structure, and must be voluminous and light without loss of strength. Sulphur content should be as low as possible, ash should be fairly low, and the price should also be low.

The presence of such qualities in the coke depends very largely on the condition of the coal at the time when it is charged into the ovens. It has already been proposed to preheat the coal before coking to make a stronger and cheaper coke, and the advantages in improved coke structure and reduced coking time, of preheating and subsequently coking at medium temperatures were convincingly demonstrated a number of years ago by the late Professor Samuel Wilson Parr at the University of Illinois. It is likewise known that coal preheating will produce considerable savings in the operation of the by-product plant.

Nevertheless it is a fact that coal preheating has not yet been adopted by the coking industry, for the simple reason that prior to my invention these advantages have been more than outweighed by serious economic, technical and operating disadvantages.

Previous preheating systems, for instance, have required storage of a supply of hot coal sufficient for 6 or 8 hours of continuous operation, but it has been overlooked that this involves huge volumes, which even in a small steel plant having only 2 blast furnaces means the storing of 750 or 1000 tons of hot coal.

The danger or possibility of these 750 or 1000 tons rising in temperature by exothermic reaction, or becoming oxidized and losing their coking power and producing objectionable coke, entails such grave consequences that no responsible operator or executive has so far taken the responsibility of installing the older arrangements.

For obtaining the desired low sulphur and ash content of the coke, it is a more common practice to clean or wash the coal in currents of water or air. It has been figured that a sulphur reduc-

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tion of 0.1% or 0.2% will lower the cost of making pig-iron by 15 to 40 cents per ton. The reduction of ash serves to strengthen the coke and increase its reactivity and is therefore of especial importance for weakly coking coals.

Even coal cleaning, however, is not practiced as much as should be expected in view of the known benefits. Washing with water introduces an excess of moisture, which is always undesirable because it reduces the efficiency of the carbonizing process and adds to the volume of waste liquors to be disposed of. Air cleaning methods as usually practiced do not accomplish optimum cleaning results and tend to produce uncontrolled and undesired oxidation, particularly of hot coal. Other objections have been to elaborate and expensive cleaning equipment, to high operating costs in power, labor and loss of coal substance, and to miscellaneous difficulties connected with refuse disposal. As a result under ordinary methods, the expected saving of 15 to 40 cents per ton as mentioned above was often discovered to have been entirely dissipated by the cost of cleaning.

It is a leading object of this invention to overcome the above described defects in preheating as well as in cleaning and to so improve and organically link the two improved processes that ideal blast-furnace coke, as described above, becomes a commercial reality.

It is another object to overcome the uncertainties heretofore connected with preheating regarding weight and density of coal charge and resulting coke.

It is still another object of this invention to provide for safe interruption of preheating service in case of emergency, for instance the interruption of coking or preheating operations.

It is also an object, in case coal acceptance by the oven is interrupted, to provide means which avoid accumulation of hot coal, yet avoid stoppage of heat supply to the preheater and simultaneously guard the preheater and the coal in the preheater against overheating and permit the gradual lowering of the preheater temperature, until cold, without the piling up of coal.

Another object is to avoid the necessity of emptying the preheater while so much heat is accumulated in the setting that the preheater surfaces would be damaged.

Numerous other objects and advantages will be apparent from the following description, wherein reference is made to the accompanying seven sheets of drawings illustrating the invention and wherein like numerals of reference indicate like parts.

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Figure 1 is a diagrammatic view of my invention as applied in a new installation;

Fig. 2 is a diagrammatic view of my invention as adapted and applied to an existing coking plant of usual type;

Fig. 3 shows, also diagrammatically, my invention as above with the addition of air cleaning tables for partial elimination of sulphur and ash from the preheated coal;

Fig. 4 is a vertical section of my preheater, showing particularly the preferred means for continuous agitation and mixing of the coal;

Fig. 5 is an enlarged horizontal section of the preheater taken on lines 5—5 of Fig. 4;

Fig. 6 is a partial elevation of Fig. 5 taken on line 6—6;

Fig. 7 is an enlarged vertical section of the clasp used for the vertical agitating rods;

Fig. 8 is a horizontal section of Fig. 7 taken on the lines 8—8;

Fig. 9 is an enlarged vertical section of the lower portion of the preheater shown in Fig. 4, illustrating particularly the bottom sealing means and reciprocating extractor table;

Fig. 10 shows details of an alternative extracting means;

Fig. 11 is an enlarged vertical section of the rotating valves shown in Figs. 1, 2, 3, 4 and 12;

Fig. 12 is a diagrammatic view of my improved coal cleaner for preheated coal; and

Fig. 13 is an enlarged horizontal section of the preheater as in Fig. 5 but showing rotating screw portions; and

Fig. 14 is a partial elevation of the parts shown in Fig. 13.

It is intended to employ my new process preferably in conjunction with medium temperature coking processes, because coke produced at temperatures of 1450° F. to 1700° F. is decidedly stronger and more suitable for blast-furnaces than coke made at the high temperature of 1800° F. to 2100° F. However, it is also intended to employ the new process in connection with high temperature coking ovens, or with ovens held at a sub-high or intermediate temperature of 1700° F. to 1800° F., should such use be desired.

Referring now to Figure 1 of the drawings, the coal to be prepared may be assumed to come into the plant in coarse run of mine sizes, either in rail-cars 1 or from a previously accumulated stock-pile 2; and when it is to be coked the coal is moved by feeder 3 and elevator 4 to pulverizer 5.

In older proposals involving the use of coal preheating, such pulverizers are adjusted to provide the ultimate grain-fineness with which the coal is finally charged into the coke ovens, this ultimate fineness in the case of standard coking practice usually being from 70% to 100% of the coal passing through 3 mm. sieve. In the new process, however, the pulverizer 5 is preferably adjusted to produce a larger size of coal, for instance a screening size permitting 100% to pass through a 9 mm. sieve. From pulverizer 5 this 9 mm. coal is hoisted by hoist 6 to storage bin 7.

The size and location of bin 7 depends on reliability of coal supply and on conditions of Sunday-labor and capital investment. In Figure 1, bin 7 is shown to be small and it is therefore necessary to hoist coal into bin 7 more frequently and for the same reason pulverizer 5 and hoist 6 may be provided in duplicate, which is cheaper than a very large bin. However, bin 7 may be made quite large, for instance large enough for a 12-hour supply so that coal is supplied into it during the daytime only.

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The wet 9 mm. coal in bin 7 then flows through chute 9 and reaches coal pile 10 above preheater 12. Preheater 12 contains vertical tubes 14, through which the coal flows being extracted at the bottom by a reciprocating extracting device 15 which drops the coal to rotating extractor 16 which delivers the hot coal to elevator boot 18, from where it is hoisted by elevator 20 to hopper 21 from which it flows over vibrating screen 22 in which the coal is separated into two size-classes, the finer, embracing the fine sizes, for instance below 1 mm., entering funnel 24, and the coarser class containing the larger sizes above 1 mm. entering funnel 26. The coarse size coal thereupon enters post-heat pulverizer 28, which is set to reduce the coarse sizes, so that as much of it as is economically possible will pass through 1 mm.; whereafter all coal from pulverizer 28 is drained into boot 18, hoisted to hopper 21 and rescreened on screen 22, the fine sizes below 1 mm. falling into funnel 24 while the oversize again passes through pulverizer 28. The preheated, below 1 mm. coal is then discharged into skip-bucket 30 which is of large capacity, in order to keep the coal hot, by opening valve 23, which is preferably operated automatically, bucket 30 travelling up to high position 31 where the bucket is emptied into charge hopper 32 from which it is drained into larry-car 33 by opening valve 34. The larry-car carries the charge to one of the coking ovens 35 in battery 36. Charge hopper 32 is of small capacity, preferably just enough to accumulate one coking charge plus a small operating margin.

The danger contained in older proposals, of giving hopper 32 storage-bin capacity sufficient for a 6-8 hour supply of coal, is avoided, together with the danger of oxidation of hot coal and development of exothermic heat. Instead of storing so much hot coal a new system is used by means of which the supply of hot coal is stopped immediately and automatically as soon as an interruption in the coking operation takes place. For this purpose charge-hopper 32 is equipped with a constant coal level device. This device may be a sensitive diaphragm 37 inserted in one of the side walls of the hopper, being actuated and moved by the static pressure of the coal, and transmitting this pressure as an impulse through pipe 38 to one of the known automatic regulators, for instance of the "Askania" type which thereupon by means of oil pressure acting upon hydraulic pistons automatically stops the motors driving feeder 3 and elevators 4 and 20. Additional hydraulic cylinders, actuated by the same impulses, are provided as follows; see also Figure 2: Cylinder 40 reverses the position of valve 41 so that the hot coal flows into screw conveyor 42, piston 43 starts motor 44, which thereupon rotates screw conveyor 42, and delivers the coal into chute 8 of elevator 6, piston 46 opens water valve 47, which supplies quenching water into screw-conveyor 42.

The motors operating screen 22 and pulverizer 28 may be kept running in case of short interruptions, or they may be stopped by hand or automatically by additional pistons. In case of short interruptions of operation the fire supplying heat to the preheater does not need to be extinguished at once but can be continued until the operator has established of what duration the interruption will be. The quenched coal is thus returned from the bottom of the preheater to its top. The time required by preheater 12 for preheating the coal is very short, namely

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some 30 to 100 minutes, depending upon quantities and dimensions and by water quenching the coal is cooled instantly. Normal good coking coals are not injured in their coking power by such quick preheating and by such subsequent cooling and quenching so that in case of short interruptions of the coking process the coal which was recirculated through the preheater and then quenched and reheated can be used in the ovens without detriment to coke quality. Therefore, as soon as coking activity is resumed and coal is drawn again from hopper 32, the constant-coal-level device automatically reverses the position of the hydraulic pistons mentioned before and normal operation and supply of hot-coal into hopper 32 is resumed. Instead of only one there may, of course, be installed two coal-level controllers, a high level controller for stopping the coal supply as described and a low level controller for turning it on again.

If the interruption is of long duration the recirculated coal receives several preheating and quenching actions and when it can be foreseen that the interruption will be of many hours, the firing of the preheater may be stopped while fan 49 recirculating the waste gases is kept going till the entire preheating apparatus is cooled down. In this case the coal receives several preheating and quenching actions and if the coal is of sensitive type, it may become unsuitable for coking, or might be suspected of having become so. Such coal may then be left in the cooled preheater till the oven operation begins again, when this coal may be drained through chute 50 into fuel bin 51 containing the fuel for heating the preheater. In case the preheater is fired by gas or tar, the recirculated coal may be drained into a railroad car 52 shown in Figure 2 and be taken to the boiler-house. In such case also the hot coal in hopper 32 may be drained into car 53, Figures 1 and 3.

The term "coking charge" means the amount of coal required by the oven and supplied to it at one moment, whether the charge is filled into one coking chamber as in large high-temperature coke ovens, or into sub-divided multiple smaller chambers as is customary in certain low or medium temperature ovens. Charge hopper 32 is preferably heat insulated.

The fine post-heat pulverization effected by pulverizer 23 is of great importance in the new process because I have observed that, depending upon the degree of temperature to which coal is preheated, preheating will have opposite effects upon the density of the coal, while it arrives in the oven itself, i. e., coal preheated by high-temperature preheating to temperatures of 450° F. up to 650° F., when entering a high temperature coke oven will immediately begin to gasify with great energy, with the result that the volumes of gas and vapors which are produced must force their way through the body of coal accumulating in the oven, and thereby loosen-up or fluff-up the coal charge so that the bulk density of the coal in the oven is lower than for cold wet coal. High temperature preheating can therefore produce a light coke suitable for blast-furnaces. However, I have also observed that such high temperature preheating while it is able to make light coke is otherwise unsuitable because it causes the initial energy of gasification to become too high, forcing objectionable clouds of dust and smoke and flame out of the oven. Furthermore I have observed that such high temperature preheating produces

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great quantities of roof carbon in the ovens, which is quite objectionable. On the other hand, I have observed that low temperature preheating to temperatures between 215° F. and 350° F. up to 400° F. does not produce excessive clouds of dust and flame and does not produce roof carbon, but unfortunately as far as blast-furnace coke is concerned, produces a high-bulk density of the charge and therefore a dense coke. Thus I have observed that coke from such coal may weight 10% more than coke from wet coal. As a result of such or similar densification, low-temperature preheating has the bad effect of reducing shrinkage of the coke in the ovens, and making the coke stick in the coking chambers, sometimes so badly as to make it quite impossible to push the ovens.

The new fine post heat pulverization overcomes these objections and makes low-temperature preheating of coal for the manufacture of strong but light coke possible, and economically profitable.

The fineness of the new post heat pulverization depends upon the type of coal. Extra fine pulverization is needed most for the great amount of excellent low volatile coking coals available in this country or for mixtures containing a high proportion of such coals. These coals produce a coke of good density and great strength when coked in wet condition and when pulverized to the customary fineness of 70-100% through 3 mm. mesh, the coke however having a tendency to stick in the oven. When preheated to a low temperature, the cokes become altogether too dense and give increased difficulties in pushing the oven. Coals of this type are therefore subjected to the finest post heat pulverization.

Other coals of high volatile types like those of the Pittsburgh district have the advantage of being very stable and not easily oxidized, but they produce a light and fragile coke so that a denser coke is often desired. In this case the densification of the charge which results from preheating is desirable, and therefore the ultimate extra fine pulverization after preheating is much reduced in intensity, or may be omitted.

In case of the high volatile, high oxygen coals found in Illinois and Utah, which are very sensitive to oxidation and weathering and which make a very fragile light coke, it is desirable that storing and subsequent preheating and cleaning take place while the coals are still in the coarsest possible size, in order thus to protect the coals. Thereafter a limited degree of finer pulverization should be performed sufficient to give greater strength to the coke, but not sufficient to make the charge too light.

Preheater 12 is of the vertical tube type and is designed, in its mechanical details, to permit the use of coal pulverized to 30 mm. or less.

Each tube 14 (see Figures 4, 5 and 6) contains two or more hanging rods, which are lifted and pushed down alternately so that the tendency of the wet coal to arch over the inlet openings of the tubes and to fail to enter and move down through the tubes is overcome.

The vertical agitation is performed by rods or flat iron bars 56 depending from beam 57. Beam 57 is connected by connecting rods 58 to shafts 60 connected with each other by levers 61 and strut 62. Levers 61 by means of connecting rod 63 are connected to lever 64, which is oscillated to the right and left around fulcrum 65 by means of two pulling rods 66 and 67, which are connected to cranks 69 and 70 which are rotated by

motor and speed reducer 71 turning shaft 72. The use of two agitating rods per tube is sufficient when the coal is not very wet but more rods may be used if the moisture is unusually high.

The total height of the preheater tubes 14 is subdivided into two or more superposed nests of tubes. One or more mixing and venting chambers 76 are provided between these superposed nests of tubes, with the result that the large volume of steam which must disengage itself from the coal during its descent, finds opportunity to do so without carrying with it undue amounts of coal dust. The agitating rods 56 are preferably continued through each of these venting chambers and through each of the next lower tube nest, so that the repeated re-entrainment of the coal and its vertical motion through the tubes is assured. The rods could be discontinued after the coal has entered the lowest nest of tubes but at least one of the rods is preferably continued down to a point, immediately above the reciprocating extracting tables 77. The steam disengaging itself in venting chamber 76 may be led away from the venting chamber through annular spaces surrounding tubes 14 in tube sheet 78 as indicated by arrow 79, thus entering the heating chamber 80 and mixing with the heating gases, or the steam may be conducted away through special suction connections, indicated by broken-off pipe 82 which may connect to the waste heat recirculating fan 49 in Figure 1. Covers 83 are provided for excluding air and rain from the venting chambers.

The venting chambers are also provided for the purpose of intermingling the descending coal, thus obtaining a more uniform temperature of the coal. For this purpose, various devices for deflecting the coal from its vertical passage downward in venting chamber 76 may be provided as for instance a cork-screw-portion 200, as shown in Figures 13 and 14, which may be inserted between the upper and lower part of each rod 56 at the elevation where the rod passes through the venting chamber. These screw portions 200 are fastened to shafts 201 passing through bearings 202, the shafts being forced to rotate by spur-gears 203, sprocket 204, chain 205, sprocket 206, shaft 72 and motor 71, the said shaft 72 and motor 71 being also shown in Figure 4.

However the device for stirring and mixing the coal shown in Figure 4 is preferred because it performs this task more thoroughly. The device consists of levelling bars 85 which pass through between the rods 56. The levelling bars are supported by beam 86 and glands 87 connected by link 90 to lever 91 which is actuated by crank-arm 92 connecting rod 93 and eccentric or crank 94 fixed upon shaft 72. As a result of this actuation, levelling bars 85 are moved through the coal alternately to the left and right, with the result that those coal portions which just happen to be passing through the openings 88 in the bars or in their vicinity are moved with the bars and thus become mixed with other coal in the neighborhood, with the result that the concentric bodies of hot and colder coal issuing from tubes 14 are thoroughly mixed before continuing downward. The levelling bars 85 are equipped with vertical ploughs or ribs 89 as shown in Figures 5 and 6.

Figures 5 and 6 show each of the two agitating rods 56 located adjacent the inner wall-surfaces of tubes 14 with the effect that the coal which is hottest near the tube wall is stimulated to move down fastest. Being good heat conductors the rods 56 also pick up heat near the

tube wall and convey it deeper into the coal. Said agitating rods 56 are subdivided inside of each venting chamber 76 at the elevation of the levelling bars 85 and the pieces are linked together by connecting clasps which consist of centerpiece 180 having four short projecting ribs 181 and of two side-pieces 182 which with their arms 183 reach around the long vertical side flanges 184 of center piece 180. Top and bottom ends of agitating rods 56 have been notched by notches 186 which fit around short projections 181 and rods 56 are locked in place by slipping the side pieces 182 down until they rest on ledges 187. The clasps thus keep the two rods 56 at a fixed distance and overcome their tendency to drift toward the center of the tube. The clasps are made of abrasion resisting metal, for instance cast iron, and by being located at the elevation at which levelling bars 85 are reciprocated they protect the vertical agitating rods 56 against abrasion. While only 9 tubes are shown in plan view 5 the new preheater has the advantage that it can be built with great numbers of tubes having huge capacities and in the most compact form, occupying small floor space, which is most important.

The coal finally enters discharge funnels 100, (see also Figures 9 and 10) and passing through them finds itself resting upon reciprocating extraction tables 77, which are horizontally reciprocated by means of carriers 101, supported by shafts 102, which are slidably supported in bearings 103. Carriers 101 are then reciprocated by means of two cam-disks 105 having sloped projections 106 and 107 which alternately oscillate lever 108 to the left and right around fulcrum 104 as shaft 72 and disks 105 rotate.

Instead of reciprocating the tables 77, these tables may be made stationary, while movable scrapers 110, see Figure 10, may be placed on top of them, which are then reciprocated over the tables by levers 108 as described before. The decision which one of these coal-extraction mechanisms is best suited depends mainly upon the size of the coal.

The various agitating motions caused by motor 71 and cranks or cams 94, 70, 69, and 105 can also be produced by other equivalent means, such as hydraulic cylinders and pistons moved by air or liquid pressure. Or each motion may be produced by its own independent motor and cam, thus allowing for instance a speeding up of extraction-tables 77, while the other motions are unaffected, or vice-versa.

In case of a coal having an excessive agglutinating power, provision may be made for its partial oxidation and for this purpose preheated air may be blown through the coal in small accurately measured amounts while it passes through the preheater.

Figure 2 shows how the new process is applied to an existing coking plant. In this arrangement use has been made of the large storage bin 112 for cold wet coal as it is often found in existing plants.

The raw coal, which in standard high temperature plants is usually pulverized to a size of 70% up to 100% through 3 mm., arrives on belt 113 and is dropped into the huge coal bin 112 holding enough coal for twenty-four up to forty-eight hours.

Belt 113 may have received the raw coal from a pulverizer similar to the one shown at 5 in Figure 1. A portion of the coal in bin 112 is then drained through bin-hoppers 114 upon travelling

belt 115, which throws the coal into trough 116, containing conveyor screw 117 which transfers the coal into chute 118 guiding it down into the boot 119 of elevator 120, which hoists it to high discharge point 121 from where it glides down to coal pile 10 above the preheater tubes 14.

In large standard high temperature coking plants, coal bin 112 is usually located between adjoining batteries, so that larry-car 123 alternately travels to the left and then to the right of bin 112. The extraction-belt-carriage 124 carrying belt 115 can therefore remain undisturbed in its operating position below wet-hoppers 114, while larry-car 123 is being filled with a charge of hot coal from hot charging hoppers 125, and while the charge is carried over to one of the ovens next to dry-hoppers 126. However belt-carriage 124 has to relinquish its operating position when a charge of coal is to be carried to one of the ovens next to the wet-hoppers 114.

The extraction of coal from bin 112 is therefore intermittent and the extracting and conveying capacities of belt 115, screw 117, and elevator 120 are therefore made large enough to take care of this intermittent extraction. Furthermore the coal storage space 10 above preheater tubes 14 is made amply large for this intermittent coal supply, or an extra bin may be added, similar to bin 7 shown in Figure 1.

In large plants belt carriage 124, carrying belt 115 is made independent of the larry-car but in smaller plants with ample time between coal charges, belt 115 and its driving and supporting mechanism may be attached to larry-car 123.

From coal pile 10, the coal proceeds again through preheater tubes 14, and thereafter through chute 43; reaching boot 18 of elevator 20, which hoists it to chute 21 above screen 22 in which the hot coal is separated into two sizes, the fine coal passing directly through chute 24 into boot 128, of elevator 129 while the coarse coal passes through post heat pulverizer 28 and is pulverized to a size, for instance, passing 80% through a 20-mesh screen, whereafter the pulverized coal in its entirety is drained back through chute 130 into boot 18 of elevator 20 and subjected to a second screening action, the fines being drained into boot 128 of elevator 129 which discharges all hot-fine-coal into chute 131, above hot-coal hoppers 126, the coal soon afterwards being drained into larry-car-hoppers 123, which carry it to the coke ovens.

Also in this case as before in Figure 1, large bins sufficient for keeping a six or eight hour supply of hot coal are avoided and replaced by automatic means for immediately recirculating the preheated coal through the preheater tubes 14 and, if necessary, quenching it. Thus one of the main objections to coal preheating is avoided.

As in the case shown in Figure 1, it is now superfluous to fill big bin 112 with a coal finely pulverized to ultimate coking fineness as it is customary at the present time. Instead bin 112 is filled with a coarser coal and fine pulverization takes place only after the coal is preheated, whereby the coal is protected against deterioration in bin 112 and in the preheater, and pulverization itself is made cheaper.

The means for withdrawing the wet coal from bin 112 are extremely simple and reliable. They do not require the least alteration of standard bin 112.

In the arrangement shown in Figure 3 dry cleaning tables 135 and 136 have been added for the partial elimination of sulphur and ash from

the coal after it has been preheated. The coal to be coked in this case is assumed to be of a size from 9 mm. down to zero and to be of fairly low volatile type requiring post-heat pulverization to below 3 mm. in order to avoid coke stickers, and to be of a type which can successfully be cleaned if separated into only two sizes. For this purpose the hot coal is conducted to separating screen 137 and segregated into two distinct size classes, the coarser size class containing the coal from 9 mm. down to 3 mm. and the finer size class from 3 mm. to 0 mm.

From screen 137 the two size classes enter chutes 138 and 139 which lead the finer class into fine cleaning table 135 and the larger class into coarse cleaning table 136.

From fine cleaner 135, the fine size class enters through chute 140 into mixing screw chamber 141, while the coarser size class from cleaner 136 through chute 143 enters pulverizer 28 and then through chute 144 enters the same mixing screw chamber 141, both coals being mixed by the screw and thereafter discharged into charge-hopper 32, from where they are drawn off into charging car 33, which carries them into ovens 35.

The dry cleaning tables used in the new process are substantially of standard design. New and special means are however provided in view of the fact that the coal passing through the above cleaners is preheated. While normally in dry cleaning processes, cold air is blown through the cold coal, in the new process the preheated hot coal is cleaned by the use of hot and inert gases, so that uncontrolled and undesired oxidation of the coal is avoided. Furthermore, measures have been taken for the purpose of making the entry of air into the cleaner box practically impossible and for maximum recirculation of hot inert cleaning gases through the cleaner box and for reducing losses of hot inert gases out of the recirculating circuit to a minimum, and for maintaining the preheater at the desired temperature of the preheated coal and for replacing heat losses and losses of inert hot gases and for accomplishing the above objects without having coal dust leaving the gas circuit and entering the building containing the cleaning tables.

In order to obtain the above objects the air cleaner is equipped as follows:

Pairs of inlet and outlet valves 150 (see also Figure 12) are provided in series for moving the coal into the cleaner and for removing cleaned coal and refuse away from it. The clearances in each of these rotating valves 150 are made smaller than for wet coal, which is permissible because dry coal flows more freely than wet coal. Between each pair of valves arranged in series are provided intervalve spaces 151.

The coal-cleaning compartment 153, Figure 12, above perforated bottom 154 is subjected to only a low suction, for instance of 1" water column. The mentioned low suction of 1" is created by fan 155 set for 1" suction, stack 156 and dust precipitating cyclone 157. This 1" suction in room 153 assists in preventing escape of dust from the cleaner.

Provision of the two valves in series serves to establish in the intervalve space 151 between the two valves a pressure of $\frac{1}{2}$ " being intermediate the atmospheric pressure and the suction of 1" kept in coal compartment 153, the provision of the double valves thus serving to reduce the in-flow of air into the cleaning box. This arrangement is however further improved for sensi-

tive coals and for more economic operation, as follows:

A supply line for hot inert gases is connected to intervalve spaces 151 these inert gases being supplied by conduit 160 which receives them from room 161 through regulating valve 162 and line 163. Valve 162 is automatically operated by known automatic devices 164 so that a vacuum in the intervalve space is maintained slightly below atmospheric pressure of, for instance, $\frac{1}{8}$ " water column, which is so low that very little air is now pulled into the cleaner through the pairs of valves. The gas which is piped into intervalve spaces 151 may also be supplied by fan 155 after the coal dust has been removed.

For very sensitive coals and high preheating temperature the "pulling-in" of even so small amounts of air into the cleaner may however be objectionable and in this case a supply of inert gas is provided, for instance as shown at 166 and 167 where burners are provided which continually furnish a small supply of hot inert gases, which gases due to their buoyancy press themselves into the voids between the coal particles, in preference to the heavier cold air that might otherwise leak in. These gas burners also help to maintain the temperature of the coal in the cleaner-box.

Coal gas, purified of inorganic sulphur is preferably used in burners 168 the high temperature of the cleaning and recirculating apparatus precluding any condensation of sulphurous gases. The temperature of the coal is preferably further maintained by provision of steam heating coils as shown, for instance, at 169.

The coals entering the cleaning boxes are usually accompanied by very fine dust amounting to 8 or 9% of the total, the dust having a size below 40 mesh being carried out of the boxes by the gases. Means have been provided to reduce this dust to a minimum by provision of dome 170, which tends to precipitate the dust. Additional means are however provided for removing this dust from other places where it may collect for instance from pressure room 161. Mechanical means, for instance screw conveyor 170 may be provided on the floor of this room for conveying the dust which collects on this floor into funnel 171 from where it will be released to the outside by a pair of rotated valves 172.

No provision has been shown in Figures 3 or 12 for producing and for removing so called middlings from the cleaner, but if such middlings are produced they will be removed from the cleaner, and if desired reintroduced into it by means similar to those shown for coal and refuse.

Inert gases may of course also be introduced into the other cooperating apparatus shown in Figure 3, such as the screens, the chutes, and the conveyors. Thus the steam from the preheater may be passed through much of the other cooperating apparatus.

Means for stirring the coal while it travels over the perforated floor 154, or for otherwise keeping it in motion, may of course be used as is customary in dry cleaners.

All other connections leading into and out of the cleaning box, which might cause air leaks into the cleaners or gas leaks out of it, may be safe-guarded in a similar way by application of double valves or double sealing devices, similar in principle to the double valves and their intervalve spaces. Gas or air leaks are thus reduced to a minimum, but whatever small volumes still may enter are removed by suction fan 155

and are freed of coal dust by centrifugal force in cyclone 157. By reducing the volume of dust laden gases to a minimum the high expense and trouble caused by huge dust precipitating and filtering equipment, usually needed in case of air cleaners, is minimized.

This dust nuisance is however reduced still further in the new process. The dust is hard to clean, except by expensive flotation methods and the dust is therefore in the older processes simply left uncleaned and added to the cleaned coal thus increasing the impurities in the cleaned coal considerably. In the new process this situation is improved by the fact that the coal is hot and therefore has a much higher mobility than wet coal, the dry particles of the coal sliding more easily against each other than wet ones. This fact permits the screens to accomplish a much more accurate separation of the coal into the various size classes, an advantage which in turn assists the cleaners in their work of separating the clean coal from refuse, thus making it possible to cut down on the amount of inert gases blown through the coal with the result that the percentage of dust carried away by the gases is reduced. Thus the weight of fine dust, which cannot well be cleaned is reduced while that part of the dust which is retained in the boxes due to the lower gas velocity is exposed to the cleaning action of the process and becomes purified. In fact it can be expected that the fine dust which still leaves the boxes in the new process can now be cleaned in a cleaner in which a specially well regulated low gas velocity is maintained. Provision can also be made to counterbalance the rarefied condition of the inert gases blown through the coal resulting from their higher temperature. For this purpose the pressure of the gases recirculated through the cleaners may be raised high enough either partially or completely to re-establish the usual atmospheric density used for cleaning cold coal. Thus if hot gases of 300° F. are recirculated, their reduced density can be raised to normal by putting them under a pressure of 15 feet water column. The provision of double or multiple sets of coal-valves 150 as described above, with the intervalve spaces 151 kept under slight suction, permits this operation. This pressure operation can be facilitated by preheating the coal merely to dryness, for instance, by heating it to 220° F., whereafter it is cleaned by hot gases of 220° F., which are then kept under a pressure of only 9.7 feet water column, which is sufficient to re-establish their normal density at 220° F., whereupon the temperature of the coal may be raised to 300° F., or more. In case of this pressure operation exhaustor 155 is superfluous the pressure of the gases being sufficient to vent any surplus gases out of the cleaners.

The vibrating screen for separation of coal into two or more size classes may be replaced by other equivalent means for instance a mechanical air separator of centrifugal type, or by a rotating screen.

Dry-coal cleaners may of course be installed also in the arrangement shown in Figure 2. Character and size of the coal entering the cleaning-plant may of course differ from the case mentioned above. The coal may be of a type that is more effectively dry cleaned in a larger size, of for instance, 20 mm. down to 0 mm. In this case the best suitable screen openings in screen 137 might be such as to separate the coal into a coarser size from 20 mm. to 9 mm. and a finer size from 9 mm. to 0 mm. or possibly the separa-

tion may be made at 6 or 7 mm. instead of 8. In these cases it may be necessary in the interest of obtaining a light weight coke, to pulverize not only the large size above 6 or 9 mm., but also the finer size below 6 or 9 mm., and evidently this may be done either by providing a second post-heat pulverizer for the smaller size or by leading both classes through one pulverizer. Again for other coals of poor washability finer grinding than 100% through 9 mm. may be advisable, for instance, down to 6 mm. or less which sometimes permits a more efficient cleaning.

In Figure 3 a screen for only two size classes and only two cleaning tables are shown. However, screens may be provided for separating the coal into as many size classes as may be needed, each of the classes being cleaned upon separate cleaning tables. This question is governed by the facility with which the coal submits to cleaning and no claim to invention is made in this respect. However, after cleaning has been accomplished those size classes which are too large in grain sizes and therefore would produce too high a bulk density will be subjected to a finer post-heat pulverization in one or more pulverizers before they are charged into the ovens, the fineness depending upon the density desired in the charge.

Thus a coal of 30 mm. may be separated into four classes: a largest size from 30 mm. to 20 mm., the next size from 20 to 9 mm., the third from 9 mm. to 3 mm., and the fourth from 3 to 0 mm. It may however be advantageous first to crush such coal down to a finer size, for instance, all through 20 mm. thus simplifying the layout, separating the coal into three classes, for instance, from 20 mm. to 9 mm., from 9 to 3 and from 3 to 0 mm. Again a difficult coal of a maximum size of 9 mm. may be separated into more than two size-classes.

Separation itself may proceed in steps, the coal first being separated into two size-classes, whereafter each class is split again.

Many advantages are obtained by the new method and apparatus. Large storage bins containing enough coal for twenty-four or forty-eight hours supply (if they are used at all), do not need to contain coal which is pulverized to ultimate coking fineness. The coal in such bins can now be much coarser, say passing through 9 or even 30 mm., this size to conform to the optimum, suitable for dry cleaning of the coal. Weathering and deterioration of sensitive coal in these bins is thus avoided.

The higher expense of pulverizing coal, while wet, to an ultimate coking fineness of, for instance, 2 or 1 mm. which may be required for an expanding low volatile, preheated coal is thus avoided, the later post-heat pulverization of the dried coal to this fineness being decidedly cheaper.

By letting a coarser size of coal travel through the conveyors and preheaters, venting away of the steam from the preheaters is facilitated, the dust trouble caused by steam disengaging itself from the coal in the preheaters is reduced and the better passage of the steam through the more open coal improves the distribution of the heat through the coal.

The highly objectionable storing of preheated hot coal for as much as six or eight hours is avoided; storage bins for this purpose are not used, and usually only oven-charge-hoppers, for the purpose of filling the larry-car, are provided.

Weathering of the hot coal is thus avoided, as

well as exothermic increase in temperature. Heat losses by large bins for hot coal containing a six or eight hour supply of hot coal are avoided.

By postponing to the last minute the fine grinding to ultimate coking fineness after the coal has been preheated, the coal is protected against deterioration in the entire preceding equipment, which is most important for sensitive coals.

Furthermore the power consumption for this fine grinding is reduced to about one-half, because dry coal is so much more easily pulverized than wet coal. It is further reduced by preliminary screening and by finely pulverizing only the larger size, which usually amounts to only about $\frac{1}{3}$ of the total.

Thus the employment of low temperature preheating as a valuable means for making better and less expensive coke is made possible. By interposing between the preheater and the coke ovens means for reduction of the bulk density of the coal, two bad effects of preheating are avoided, namely that the coke cannot be discharged from the oven, due to insufficient shrinkage and that it becomes too heavy for use in blast-furnaces.

This lower bulk density imparted to the hot coal by post-heat pulverization is of a specially secure and valuable type because it is not upset or annulled by occurrences in the coke oven. While low density can be imparted to coal by fine grinding and raising its water content, it is known that this method is unreliable because condensation of moisture and some tar components into the cold coal takes place temporarily, the moisture and the tar vapors being furnished by the coal under distillation in adjoining layers, with the result that the grains of coal are lubricated by the condensate and slide more closely together, making the coal slump down in the oven, thus increasing its density. However, after the coal has been preheated to 300° F. condensation of water into the hot coal is quite impossible and condensation of tar is reduced. Neither can other parts of the charge in the oven become heavier by becoming dry, for instance, by vaporization of water out of the charge, because the charge is already dry. Nor does the new method reduce the coking capacity of the plant, as it is done by the addition of water but to the contrary it increases its coking capacity; nor can the low density of the charge once created by the post-heat fine pulverization be vitiated by a loss in temperature in the hot coal, or by a reduction in the temperature of the oven. Thus the new method definitely disposes of the uncertainties and dangers of too high density, i. e., too heavy coke, and coke sticking in the oven.

This post-heat pulverization also produces more numerous bodily contacts between the coal grains, thus making a more uniform and stronger coke, at a lower cost than before. Furthermore post-heat pulverization of the larger sizes counteracts the tendency of the charge to segregate in the hoppers and in the oven itself, which segregation is detrimental to uniformity and strength of coke. Fine post-heat pulverization thus benefits coke quality.

In cases where the sulphur and ash contents of the coal is to be reduced, the new process interposes dry-cleaning means in the best possible location between preheater and coke ovens.

Preheating creates the pre-requisite for perfect separation of the coal into size classes, because dry coal particles separate much more easily from each other than wet ones. Therefore, the coal

can also be sub-divided into more size classes than before and cleaning can be extended to smaller sizes.

Perfect segregation into size classes in turn facilitates optimum results from the gas-cleaning tables so that reduction of the sulphur and ash contents of the coal becomes more perfect.

Simultaneously the dry-cleaning process becomes less expensive, because the air-cleaning tables can be operated with a smaller air-supply in case well sized and dry coal is used, thus decreasing their power consumption.

Furthermore, the capital cost of dry cleaning is reduced. In the new method the cleaners are interposed between the preheaters and the coke ovens, both of which are in continuous 24-hour service. Because of this interposition the cleaners are also put into continuous 24-hour service, which is a great advantage over their present location, for instance, at the coal mines where cleaning tables are worked only at such times when the miners are at work, namely seven hours per day, and twenty-two days per month which means that the cleaning tables are idle 78% of the time. In the new process the number of cleaning tables required to be kept in operation is therefore reduced to $\frac{1}{4}$, resulting in much lower capital charge. By operating the cleaners twenty-four hours per day the further advantage is obtained of the cleaners receiving a steady flow of coal which is of great benefit because frequent starting up and stopping of the cleaners reduces the quality of their work. Furthermore, continuous operation of the cleaners makes it possible to reduce the size of the expensive surge-tanks.

In cases where many separate size classes are produced in order to facilitate the work of the dry cleaners only the larger size classes will be finely pulverized, which results in a saving of power. After pulverization all sizes are preferably mixed thus reducing the time required for filling charge hopper 32 and shortening the time of exposure of the coal to deterioration. Furthermore, by arranging the operations of cleaning and fine grinding between the operations of preheating and coking and by arranging them in close proximity of each other, the cost of floor space and of supervision and of operation and maintenance is greatly reduced.

Another advantage is that the heat needed by the preheater can now be furnished by burning the hot refuse from the adjacent cleaner, or by burning a portion of the hot dust or the middlings. By using these preheated fuels for preheating, a corresponding portion of the valuable gas fuel, burned at the ovens, is saved. By burning this preheated refuse at the preheater the coal contained in the refuse is usefully applied while at the same time the weight of the refuse is reduced to about one-half; furthermore, by clinkering the remaining ash, the bulk of the refuse is reduced and it is put into a more advantageous form for disposing of it. The expense of shipping the refuse away from the coking plant, and finding dumping space for it, is thus alleviated by the installation of the preheater. The refuse and the dust and the middlings by being preheated have become improved fuels, so that they can advantageously be burned for instance under the boilers, thus obtaining further alleviation of the refuse problem. As a result of this alleviation, it is then permitted to subject the coal to a more vigorous cleaning action. Thus the new process permits a more energetic removal of sulphur, to a lower figure than has been customary before.

The new process of preheating, cleaning, fine grinding and coking is therefore much superior to the combined wet cleaning and coking process. It completely avoids the possibility of the ready coal freezing in winter. Its cost is so greatly reduced that it is now possible to use poorer qualities of coal which previously were uneconomical to deal with. The new process therefore makes for a lower cost of mining by permitting the mining not only of the better but also the poorer coal, thus giving a higher recovery per acre of coal field and reducing the financial provision for depletion of the field.

If a wet washing plant is already in existence at a coke plant, which efficiently cleans the largest sizes of the coal, it is still of advantage to dry clean the smaller sizes which lend themselves better to dry-cleaning and in this case the two kinds of coal can be made to travel through separate preheaters.

As to the machinery required for the operation of the new process, the new invention has many advantages. For the ever present possibility that the coking activity of the ovens may be temporarily interrupted, it provides automatic means for recirculation of the coal through the preheater so that the provision of huge storage bins for hot coal is avoided. It maintains a continued influx of coal of low initial temperature into the preheater tubes even if charging of the coal is temporarily stopped, thus protecting the preheater and all conveying means against overheating.

By agitating the coal in a special way in each tube the difficulty of making wet coal flow into and through narrow tubes is overcome, and the heat transfer is improved. By the provision of venting chambers, containing devices for intermingling parallel streams of coal of different temperatures the preheating is made uniform and the steam released. Thus a tubular preheater is produced, capable of being built in huge capacities and at low cost in which the expensive ceaseless recirculation of hot coal as part of the regular continuous preheating operation is avoided.

The new invention also simplifies the means for withdrawing the coal from the main raw bin 112, in Figure 2, avoids the many partly inaccessible conveyors, hoods, shutters built into the bin, which cannot be maintained and repaired without shut-down of the raw coal supply. By making use of the movable extraction belt 115 for withdrawing the coal, greatest simplification is obtained. Furthermore, the means for withdrawing the preheated coal from the bottom opening of tubes 14 are simplified.

Charge hoppers 32 and 126 which were described as containing substantially only one oven-charge of coal, may be made somewhat larger, especially in large plants. Assuming the coking capacity of the plant to which the preheater is attached to be 4800 tons per 24-hours or 200 tons per hour and the volumetric capacity of one oven-charge to be 16.6 tons, then 12 charges must be filled into the ovens per hour. This means that the time interval between charges is only five minutes. It is, however, not possible in such large plants, to conduct all operations with such precision that the larry-car will return to the hot coal hopper and receive its charge exactly every five minutes. On the other hand, I have observed that preheated coal is not damaged and will not rise in temperature by exothermic reaction if it is held, for instance, for thirty minutes. Depending upon the size of the plant

the charge hopper may therefore be given a capacity somewhat in excess of one charge. A thirty minute capacity in a 4800-ton plant would be equivalent to six charges at five minute intervals, each of 16.6 tons, requiring a charge hopper of only 100-tons capacity. This is an enormous improvement over old proposals in which the hot coal was to be stored, for instance, six to eight hours which would require 1200 to 1600 tons of hot coal to be stored instead of 100.

The requirement that coke should have uniformly small cells is fulfilled by the fine post-heat pulverization.

The present invention overcomes two other faults in the preparation of blast-furnace coke. Figure 2, as was stated, represents the case of the standard high temperature plant in which the coking chambers are maintained, for instance, at an average of 2000° F. However, almost all these ovens are heated by flames burning upwardly in vertical flues, and as a result the lowest portions of the coking chambers are always overheated, sometimes as much as 250° F. As a result of this drawback, the coke in the lowest part of the oven is always heated to a higher temperature than the desired average and often it is severely over-coked and cracked up into small pieces, very undesirable for blast-furnace purposes.

A second drawback of the overheated bottoms is that the first quantity of preheated coal which enters the oven and spreads itself over the overheated floor and sidewalls is carbonized with excessive speed, especially if preheated to a fairly high temperature, so that the resultant coal gases on their way out of the oven while the coal is still falling into the oven carry with them into the collecting main some of the fine coal dust which then enters the tar, reduces its value, and thus increases the price of the blast-furnace coke. Both drawbacks are overcome by an addition to the new process, which consists in first filling a layer of cold and possibly moist coal into the oven practically covering the overheated portions of the sidewalls and especially the floor and thereafter placing preheated coal on top of the cold coal. In the arrangement shown in Figure 2, this can be accomplished by first placing the larry-car under the cold coal bin 112, filling it only partially with cold coal, and thereafter filling it completely with hot coal from hot coal accumulator 126. Thus by placing the colder coal against the hottest surfaces their excess heat is absorbed and coke of much greater uniformity is produced, which is most essential in blast-furnace operation. This arrangement can be further refined by placing cold coal into the bottom part of the oven and hot coal into the top part and coal of intermediate possibly graded temperature into the middle section of the oven, the intermediate temperature being produced by mixing cold and hot coal.

The coal entering into contact with the bottom portions of the heating walls may even be artificially increased in moisture, either before it enters or after it has entered the larry-car, so that an extra amount of heat is absorbed from the bottom wall portions, the extra steam thus developed assisting in the gasification of wall- and roof-carbon, sometimes accumulating in overheated ovens.

Although I have thus described my invention in considerable detail, I desire it to be clearly understood that I reserve the right to use such substitutions, modifications or equivalents thereof as are embraced within the scope and spirit of my

invention, or as are pointed out in the appended claims.

Having thus described my invention what I claim as new and useful and desire to secure by Letters Patent is:

1. The process for preparing and for holding available for coking minimum quantities of hot coal comprising the following steps: withdrawing cold coal intermittently from conveyances or storage yards or bins and putting it into storage permanently available for preheating, continuously feeding coal from such storage into a preheater and preheating the coal, delivering the pre-heated coal without immediately storing it into a one-oven charge hopper, adapted to fill the oven larry car, and in case of interruption of coking operations discontinuing the intermittent withdrawal of cold coal from storage or from conveyances and automatically stopping the supply of preheated coal to the one-oven-charge-hopper and deflecting the hot coal from the preheater and recirculating it through the preheater, and recooling it before entering the preheater.

2. The process of preparing coal for coking comprising preheating it and accumulating in a charge hopper only one one-oven coal charge plus a safety margin covering operating irregularities, terminating automatically the further accumulation of hot coal as soon as said volume of coal has been accumulated and diverting and cooling the hot coal leaving the preheater and recirculating it again through the preheater, while the heating of the preheater continues, and continuing this recirculation until the level of the accumulated coal in said charge hopper has dropped sufficiently to receive another charge of hot coal.

3. A method of supplying preheated coal to a coking battery, which comprises intermittently extracting coal from carriers, yards or bins and intermittently delivering such coal into storage permanently available for preheating such coal, then preheating such coal and conveying the hot coal without intermediate storage into a one-charge-hopper adapted to fill a charging larry, and in case of the one-charge-hopper being filled, deflecting and recirculating the preheated coal through the preheater and cooling it before re-entering the preheater.

4. An apparatus for preparing coal for coking, comprising a coal preheater, a hot coal accumulating hopper for the accumulation of a volume of hot coal, substantially equivalent to one coke oven charge plus a reasonable safety margin for minor interruptions in coking or preheating service, means for forwarding coal through the preheater into said hopper, means for by-passing said hopper and for diverting and recooling and recirculating the hot coal from the preheater, automatic level control devices connected to said hopper, said devices being adapted to start and stop the coal forwarding and by-passing means and thus maintain a supply of hot coal in the hopper.

5. The process for preparing coal for coking, comprising the storing, conveying and preheating of raw coal in coarser grain sizes, which are adapted to protect the coal against the deleterious action of air and carbon dioxide, then segregating the hot coal into size classes, of larger and smaller particle size, then pulverizing the larger size class to a greater fineness, adapted to produce a reduced bulk density of the coal when mixed with the smaller size-class, then intimately mixing the

several classes and accumulating the mixture in a charge hopper, ready for coking.

6. The process of preparing coal for coking in coke ovens, comprising preheating the coal to a low preheating temperature of between 200 and 400° F., adapted to preclude smoke nuisance and roof carbon formation in the operation of the ovens, but simultaneously adapted to increase the bulk density of the coal charge in the ovens and to cause coke stickers, then subjecting the preheated coal to a screening operation in which it is separated into a fraction containing the coarser particles and a second fraction containing the fine particles, then subjecting the coarser fraction of the preheated coal to a finer pulverization adapted to nullify the increment in bulk density experienced by the coal while being preheated and then intimately mixing both fractions.

7. The process of preparing coal for coking, comprising breaking the raw coal to a grain size, which is best adapted for efficient work of the dry cleaning process to which the coal will be subjected for reduction of its sulphur and ash, then preheating the broken coal, then segregating the coal into size classes best suitable for dry cleaning, then dry cleaning those of the size classes which can be economically cleaned, then subjecting the size classes containing the larger grain sizes to a finer pulverization, adapted to create a bulk density of the cleaned coal, which is adapted to avoid stickers in the ovens, then intimately mixing the coal and accumulating it into the charge hopper.

8. The process of preparing coal for coking which comprises preheating raw coal in coarsely broken sizes, thereby expelling its moisture and increasing its bulk density, then separating the preheated coal into larger particles adapted to produce increased and undesired bulk density and into smaller particles, adapted to produce the desired bulk density, then pulverizing the larger particles till they have assumed the size of the smaller particles, then re-combining and intimately mixing all particles and charging them as desired.

9. A method of preparing coal for coking in coke ovens which comprises preheating the coarsely pulverized coal, separating the heated coal into a coarser and a finer size class, cleaning the coarser size class by circulating hot inert gases therethrough, repulverizing the cleaned coarser size class and mixing it with the finer size class and charging the mixture into a hopper for charging into coke ovens.

10. Apparatus for preparing coal for coking which comprises a preheater for heating the coal, an enclosure adapted to separate the coal into branches of different purity, by passing it through a current of inert hot gases recirculated therein, and pairs of sluice gates for avoiding loss of or dilution of recirculated gases by causing the coal to pass into the enclosure and the coal branches to pass out of the enclosure therethrough, the space between each such pair of gates being supplied with inert hot gas.

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