Oct. 13, 1931. S. W. PARR ET AL 1,827,483

APPARATUS FOR COKING COAL

Original Filed Jan. 2, 1926 4 Sheets-Sheet 1

Fig. 1.

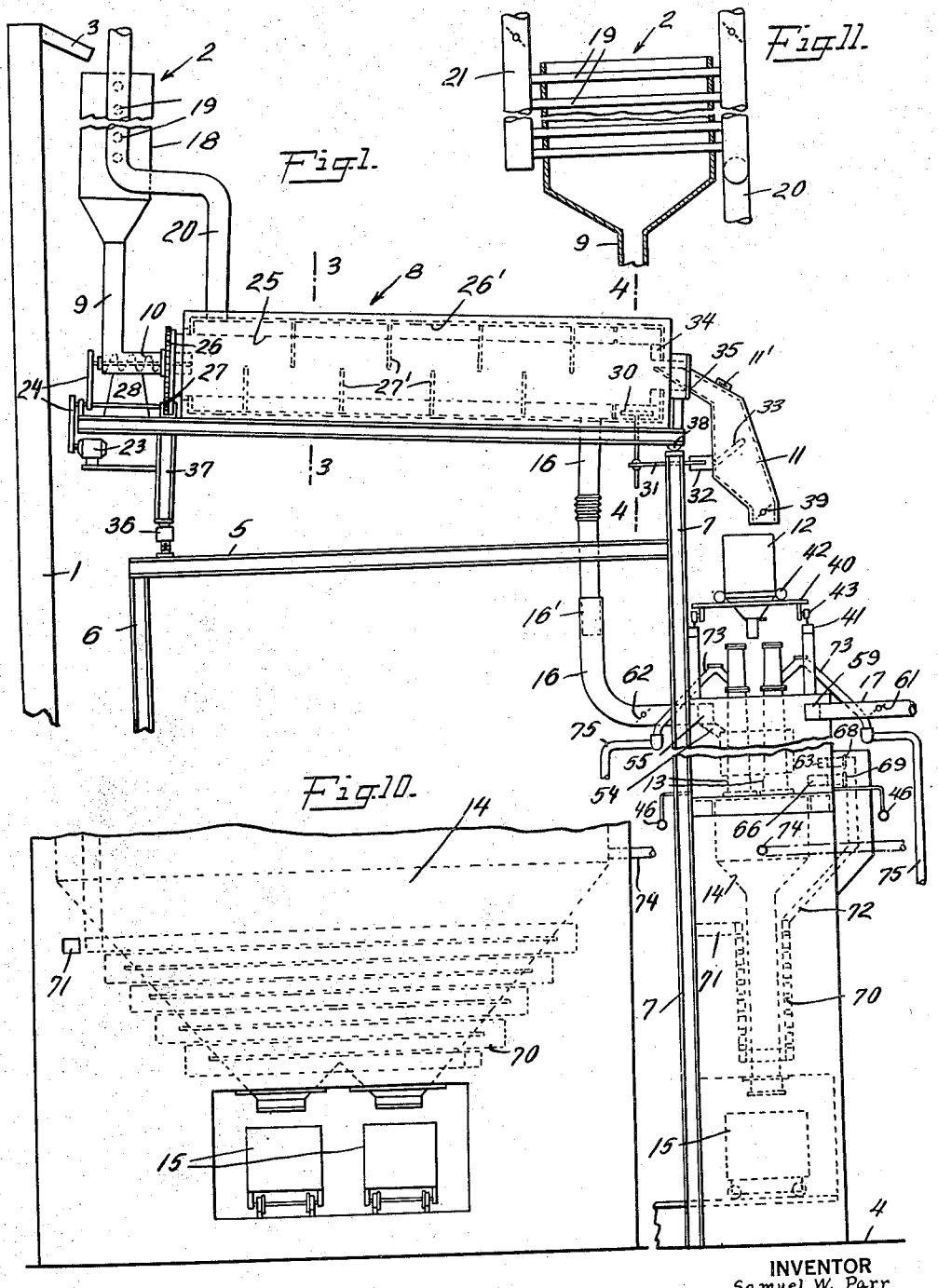


Fig. 11.

Fig. 10.

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Fig. 2.

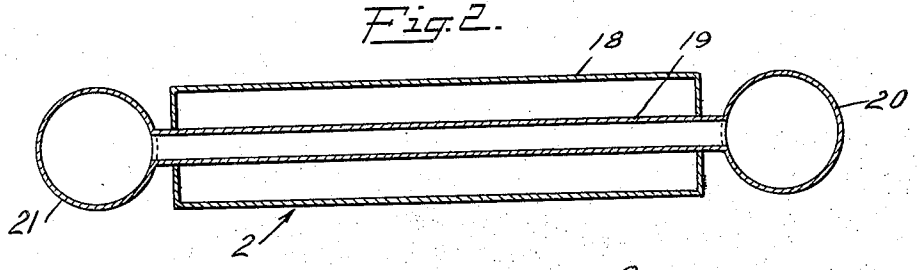


Fig. 3.

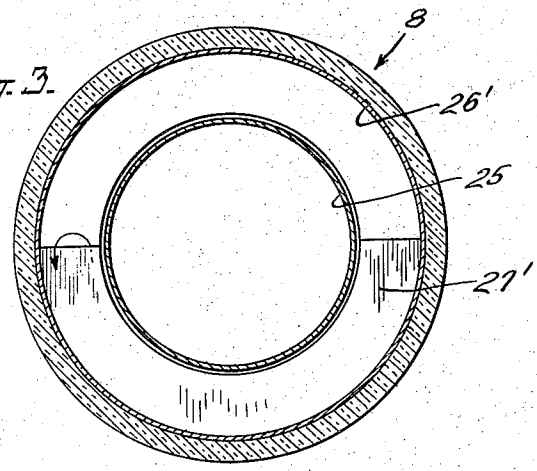
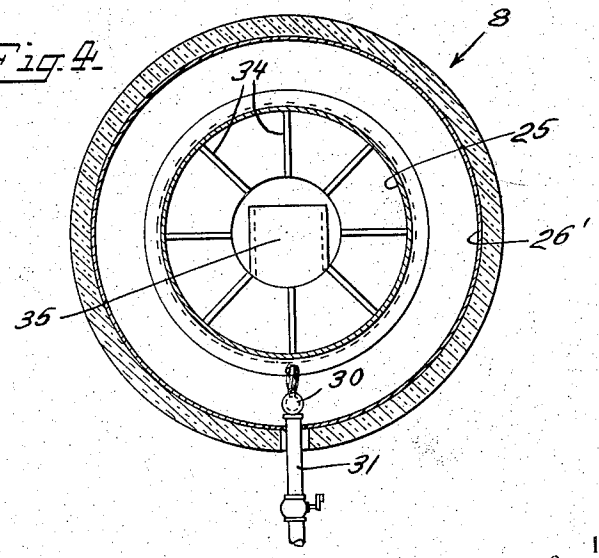


Fig. 4.



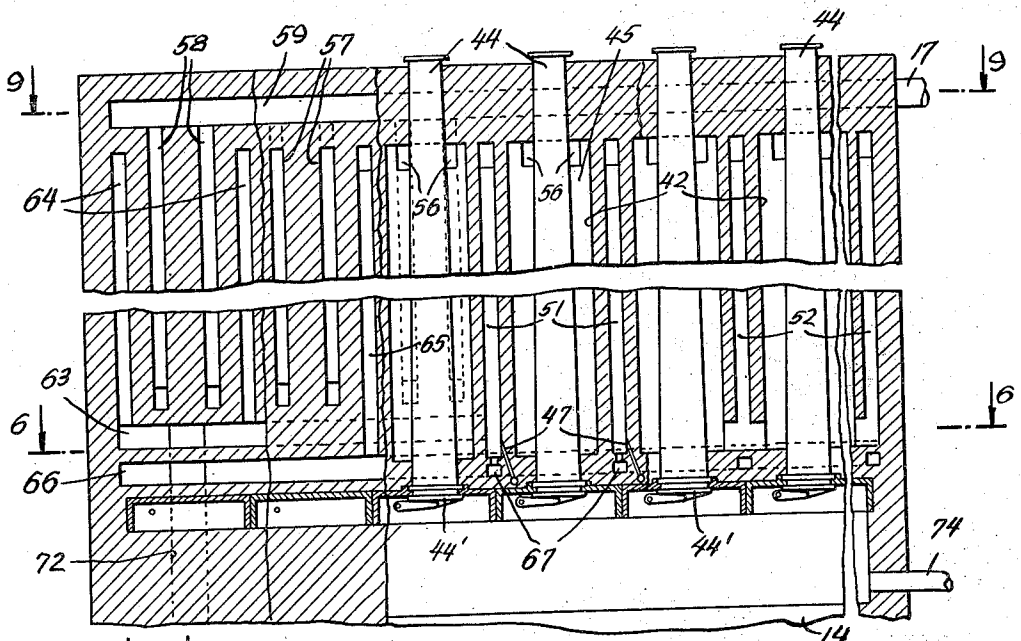
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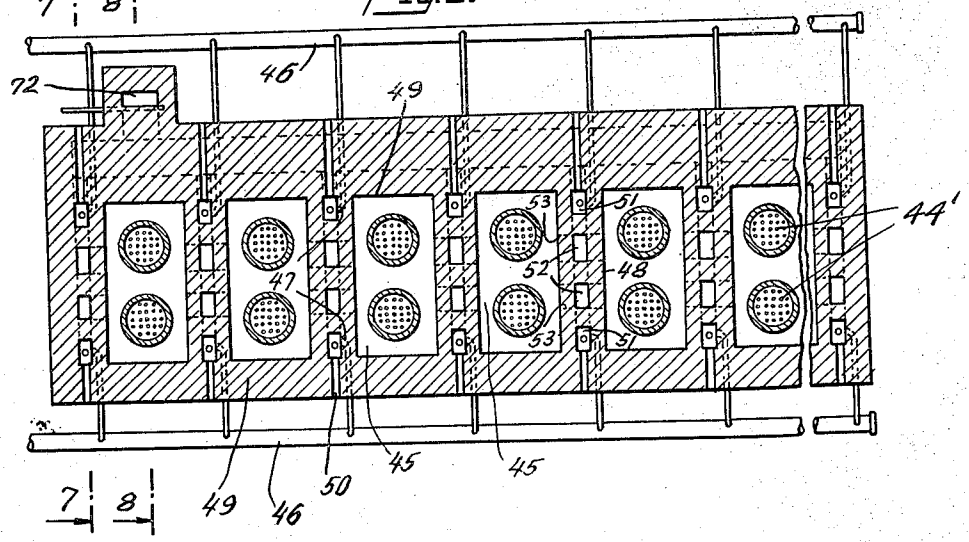
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Fig. 5.



7 8

Fig. 6.



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APPARATUS FOR COKING COAL

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Fig. 7.

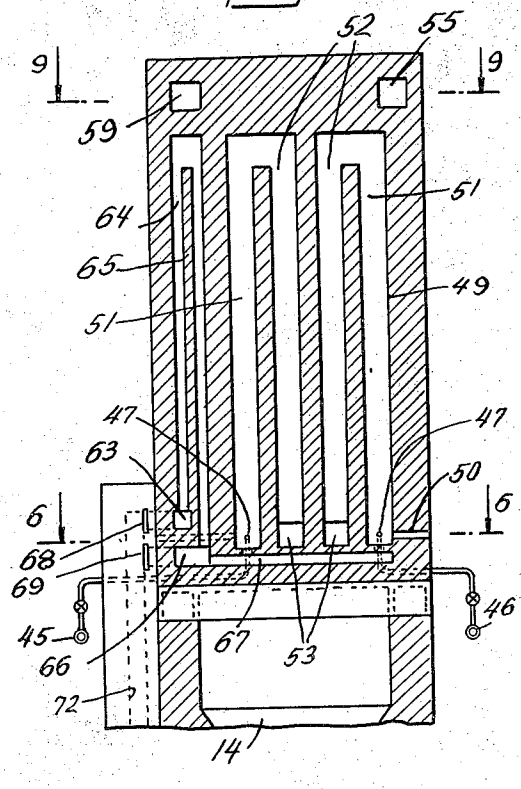


Fig. 8.

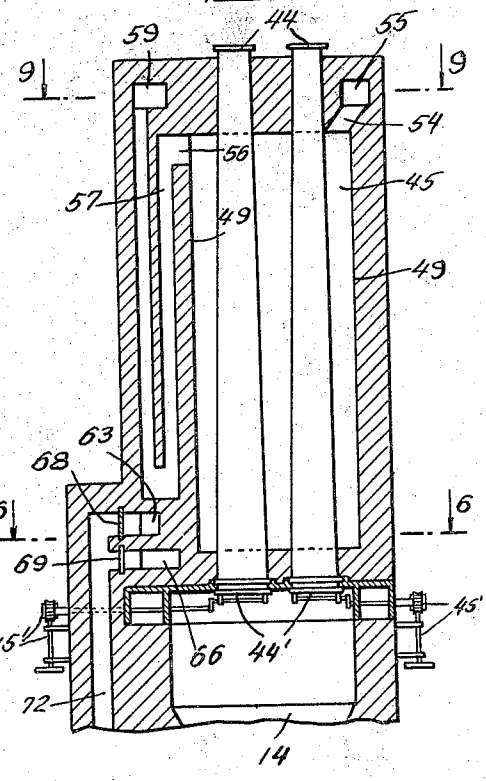
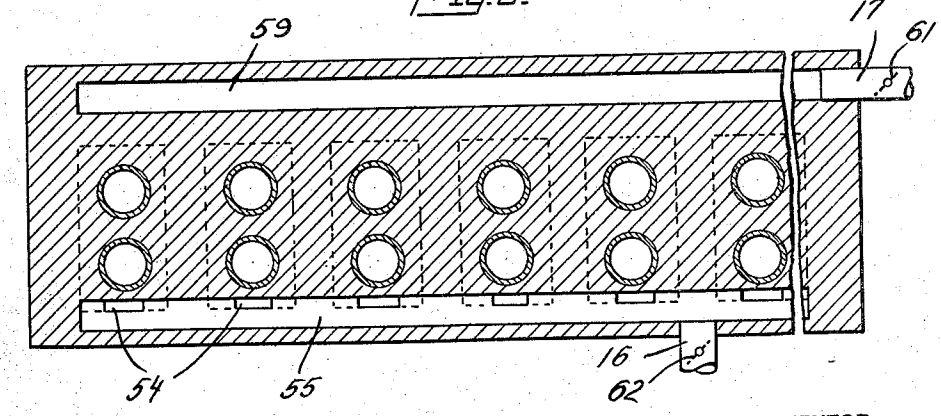


Fig. 9.



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UNITED STATES PATENT OFFICE

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APPARATUS FOR COKING COAL

Original application filed January 2, 1926, Serial No. 78,959. Divided and this application filed March 26, 1926. Serial No. 97,518.

Our invention relates to the treatment of coal for the purpose of educing hydrocarbons therefrom and converting the fuel into coke; and more particularly to an apparatus whereby such treatment can be carried out. This application is a division of our application Serial No. 78,959 filed January 2, 1926, wherein claims are made on the process herein disclosed.

According to present practice, coal is coked either in "bee-hive" ovens or in the more modern by-product ovens. In the former type, the coal is spread upon a hearth and ignited with insufficient supply of air and the volatile constituents of the fuel are all either consumed or wasted. In the ordinary by-product process, the coal is charged into externally heated coking chambers and the gases and vapors are led away for recovery of the valuable constituents. In both of these processes the coal is submitted to temperatures and to conditions which are not conducive to economical production of the desired products, and in the case of the by-product processes the vapors are exposed to temperatures and conditions which seriously reduce the proportions of some of the more valuable constituents and bring about secondary reactions which yield undesirable products.

The present invention relates particularly to by-product practice; that is to say, the coking is done in a coking chamber and the gases and vapors are led away for the recovery of their valuable constituents. It is the purpose of our invention to provide an apparatus whereby fuel can be coked so as to produce, even from poorly coking coals, a high grade product and educe the volatile constituents without setting up undesirable secondary reactions. A further object of our invention is to reduce the consumption of fuel employed in the operation and to shorten the time for carrying out the carbonization process. Another object is to make available for use in by-product practice, coals of the character now commonly designated as "non-coking coal". Our invention makes it possible to produce from either coking coals or so-called "non-coking" coals a coke particularly adapted for domestic use or, if desired, a coke for metallurgical purposes, while at the same time securing as by-products oils, tars and other products, rich in valuable constituents and less contaminated with objectionable substances than is the case with ordinary by-product processes.

In general our process consists of heating fuel such as coal to a uniform temperature close to but below the temperature at which hydrocarbon vapors begin to form, and then confining the fuel in a closed container and supplying it with sufficient heat to complete the coking operation. The preliminary heating up to close to the critical temperature is best performed by agitating the fuel while supplying heat thereto. We prefer to carry out the process in this manner so as to avoid the formation in the body of fuel of zones of different temperatures in which the fuel is in various stages of decomposition and where part of it is converted prematurely into coke. Where fuel is placed in the ordinary by-product retort and slowly heated to the usual coking temperature of from 900 to 1000° C., the heat slowly penetrates the fuel due to the low heat conductivities of some of the layers of the fuel. As a result, the outside layer is heated to a very high temperature before the central portion of the mass of fuel is heated sufficiently to give off its volatile matter.

According to the preferred embodiments of the present invention, the fuel is first flooded with heat uniformly throughout, that is, extraneous heat is supplied to the fuel in a closed container so as to rapidly bring the temperature of the fuel up to close to the critical temperature at which hydrocarbon vapors are educed. Thus all of the fuel is heated up to a temperature near the critical temperature in the most efficient manner. The fuel while being so treated is brought into an improved condition for the carbonization process which is to follow, through the instrumentality of certain reactions which result in the removal of deleterious oxygen and oxygen compounds such as H_2O and CO_2. These reactions if allowed to occur simultaneously with the reactions of the carbonization stage would result in a weakening of the bonding material and conse-

quently produce a coke of inferior quality. It is to be understood that the reactions involved in the process of carbinization occur at temperatures accompanying and immediately following the pasty stage and are entirely different in character from those of the preliminary treatment stage. There is, therefore, the advantage that the preheating may be not only so controlled as to bring the mass up to within a few degrees of the pasty stage where carbonization begins, but there is secured also a control of the chemical reactions involved whereby those of a deleterious character are segregated from the carbonization reactions, thus producing a stronger coke as well as discharging, as undesirable material, the CO_2 and H_2O resulting from the preliminary heating.

When the fuel reaches the critical temperature, and the decomposition process which results in the formation of coke begins, chemical reactions take place which generate a certain amount of heat. These exothermic reactions serve to change the chemical composition of the fuel in a pronounced manner and to raise the temperature of the mass to a considerable extent. A characteristic of our invention is the utilization of this exothermic heat in raising the temperature of the fuel after the preliminary heat treatment. Because of the fact that the fuel is first heated uniformly throughout up to close to the critical stage, the exothermic reactions augmented by the heat of the retort bring about the more pronounced exothermic reactions of decomposition and these occur throughout the whole mass of coal. This rise in temperature produces more exothermic reactions, and proceeds autogenously and with a cumulative effect so that not only does the pasty stage spread throughout the mass but the increased conductivity of the pasty condition promotes the transmission of heat from the retort walls and this together with the heat resulting from the reactions quickly carries the carbonization process to completion. The autogenous progression of the exothermic reactions oftentimes has the effect of subjecting the fuel at the center of the mass to higher temperatures than those obtaining near the outer edge of the mass.

We prefer to supply extraneous heat to the fuel while the exothermic reactions are taking place for the purpose of avoiding heat loss by radiacation, thus conserving the exothermic heat and supplying any heat which may be necessary to insure the progress of the exothermic reactions to the fullest extent and ultimately to convert the plastic mass into coke and without the necessity of carrying a high heat head on the exterior of the retort and so permitting of the maintenance of low temperature condition.

Although the preliminary heat treatment is preferably carried on while the fuel is being agitated, we have found that it is desirable to maintain the fuel in a quiescent condition while the exothermic reactions are taking place and the plastic mass converted into coke.

According to the preferred embodiments of our invention, the fuel is agitated during the preliminary heating thereof, and maintained substantially quiescent while it is being changed from a plastic mass to coke.

The preferred embodiments of our improved apparatus includes a device whereby fuel, such as coal, can be uniformly heated throughout up to close to the critical temperature. This means serves to heat the fuel in thin layers, or while it is being handled so that the heat quickly and uniformly reaches every part of the fuel undergoing treatment, thus insuring a uniform temperature rise throughout the body of fuel. Our preferred embodiment of this portion of the apparatus comprises a cylinder into which the raw fuel, preferably in finely ground condition, is charged and then simultaneously tumbled about and heated by revolving the cylinder or drum in a heating chamber. The cylinder or drum may be heated by flue gas or other waste gases, or a gas or oil burner can be installed in close proximity to the cylinder for the purpose of supplying heat thereto. We prefer to have the latter heating device available to serve as at least an auxiliary heating means for the reason that it makes it possible to control the heat in such a manner as to bring the mass to the exact temperature prescribed for the particular coal in hand.

The other principal part of the apparatus consists of a retort, or preferably a group of retorts, into which the uniformly preheated fuel is deposited for the purpose of converting it into coke and discharging the hydrocarbon vapors which are educed as the temperature of the fuel increases. This retort is conveniently located in close proximity to the preheating device. We prefer to provide a chamber between the preheating device and the retort proper for the purpose of holding a reserve supply of preheated fuel. This reserve chamber should hold enough fuel to fill at least two retorts completely and it should be properly lagged to prevent radiation losses. The fuel itself is naturally a poor conductor of heat and experience has shown that there is a very slow heat loss through radiation at the temperatures employed, and the coke produced is of as high quality as that produced by charging the preheated fuel immediately into the retort. The retort may be of the vertical type in which the coal is introduced at the top and the coke is removed at the bottom. Means is provided for supplying heat to the outside of the retort for the purpose of raising the temperature of the fuel up to the point where the exothermic re-

actions commence and to supply whatever additional heat is necessary to conserve the exothermic heat and complete the coking operation.

Our process and the embodiment of our apparatus illustrated in the accompanying drawings can best be understood after a consideration of the nature of the material treated and its behavior at different temperatures.

It is well known that bituminous coal (and likewise semi-bituminous coal) consists mainly of lignin or so-called degraded cellulosic material, and resinic or bituminic substances resulting from the geological transformation of the vegetable matter in the formation of coal. The two main components of all coals of the bituminous or semi-bituminous types may be separated by using a suitable solvent such as phenol, and the characteristics of each component may be studied with reference to the rôle it plays in the coking reactions. The lignin, or insoluble part, consisting mainly of lignin, is one of the original components and also a resultant formed in the degradation processes affecting the original plant cellulose ($C_6H_{10}O_5$). In the transformations that have taken place, the greatest change probably has occurred with reference to the oxygen, which has dropped from a percentage of nearly 47 in the original cellulose, down to 12 or 15% in the cellulosic residue. This residue has certain specific properties of marked importance in connection with the coke formation. It does not melt or fuse together at any temperature and accordingly it has no coking or bonding property whatever. It is fairly stable and does not decompose by the action of heat up to a temperature of 200° C. Above that temperature, and especially as 300° C. is approached, certain initial decompositions begin, characterized mainly by a rearrangement of the elements of which the material is composed. Oxygen combines with hydrogen to form water and with carbon to form carbon dioxide and some carbon monoxide. At higher temperatures, decomposition of a positively different type occurs, which results in the formation of compounds of carbon and hydrogen, and of carbon, hydrogen and oxygen. Finally there is a residue of carbon, which is neither coherent nor caked and cannot be called coke.

The cellulosic residue has a marked avidity for oxygen which it readily absorbs and retains even though heated to a fairly high temperature. In fact, as the temperature is increased, the oxygen enters into chemical combination before being discharged.

The bituminic or soluble component of the bituminous or semi-bituminous types of coal is of a complex nature and includes substances directly related to the resins. These resinic substances have undergone very little decomposition. This component also includes pitch-like compounds in quantities predominating over the resinic substances; hence the designation "bituminic substance".

The soluble or bituminic substance has a much smaller percentage of oxygen and a greater percentage of hydrogen than the cellulosic component of the fuel. The bituminous substance is like the cellulosic material in that it resists decomposition at temperatures up to 200° C., but unlike this material, it softens and melts readily at temperatures above say 250° C. (the exact temperature depending upon the particular variety of coal), and this without appreciable decomposition of the carbon compounds until after a temperature of approximately 350° C. has been passed.

When both the cellulosic and bituminous substances are heated above the melting point of the soluble material, the latter, in effect at least, has the property of dissolving or agglomerating the cellulosic substance so that if the heating process is continued, the entire coal mass will be of a pasty or viscous consistency, and upon cooling from this point, will have a vitreous appearance and glistening fracture, indicating that the mass has become homogeneous throughout and has lost entirely the segregated or laminated structure of the original coal.

For some time it has been the generally accepted theory that the oxygen content of a coal is largely or entirely the criterion for determining whether that particular coal is a coking or a non-coking coal, and there is authority for the view that the ratio of oxygen to hydrogen available for combining therewith is the determining factor. Our investigations have demonstrated that the coking quality, as we shall hereinafter designate the capacity for producing a coke of high resistance to crushing strain, is promoted by the removal of the oxygen of the cellulosic substance in the form of H_2O and CO_2 or CO in a manner such as described under our discussion of preheating up to approximately 300° C.

Another feature of our invention consists of an improved furnace construction whereby heat can be supplied to the retorts in a very efficient manner, the intensity of heat being substantially uniform throughout the length of each retort. According to our invention the hot gases are used first to heat a refractory wall which in turn radiates heat to the retorts. The gases are finally led into direct contact with the retorts and are finally discharged into the preheating chamber of the preheating device.

The preheating treatment is used for the purpose of heating the raw coal up to a uniform temperature close to the critical temperature, that is, close to the temperature at which the coal would become plastic. Most kinds of bituminous coal become plastic

throughout at a temperature somewhere between 325° C. and 450° C. The particular temperature at which a given kind of coal becomes plastic is fairly constant, and can be readily determined. Accordingly, it is entirely feasible to control the supply of heat to the preheating drum so as to increase the temperature of the fuel up to a predetermined value below that at which the fuel would become plastic.

It is desirable to supply the additional heat necessary to cause the preheated fuel to become plastic, as rapidly as possible. If this additional heat is applied slowly the melting point of the fuel is raised, and, indeed, it is possible to heat coals of certain varieties having a high deleterious oxygen content, so slowly that the property of becoming plastic is entirely destroyed. For this reason, it is desirable to bring about the change from the dry preheated state as rapidly as possible. It is not necessary to supply this additional heat to the preheated fuel immediately after it has been preheated, because until the plastic temperature is practically attained there is no danger of the heat treatment being carried out so slowly as to destroy the capacity of the fuel for becoming plastic.

In carrying out our invention we prefer to utilize the waste flue gases for preheating the coal in the preheating chamber, and the gases may thereafter be passed in heat exchanging relation to the raw coal being fed to the preheating drum. In this way the flue gases are utilized to the best advantage, the final temperature of the gases being little above that of the raw coal being fed to the preheating chamber. We also prefer to preheat the air which is supplied to the combustion chamber of the furnace by passing this air in heat exchanging relation to the coke withdrawn from the retorts. Where the supply of flue gases from the retort is in excess of that required to preheat the coal in the preheating drum, we prefer to use some of these gases to further heat the air supplied to the combustion chamber. For this purpose we have provided a recuperator which can be used whenever there is an ample supply of flue gases. Another feature of our invention consists of a storage chamber for coke discharged from the coking retorts, and we prefer to provide means for withdrawing any vapors or gases formed in this coking chamber. These gases and vapors are of a character similar to those withdrawn from the coking retorts and may be mingled with the gases from these retorts.

The various objects and advantages of our invention can be best understood by considering the accompanying drawings which illustrate one embodiment of the improved apparatus by means of which our improved process can be performed. In the accompanying drawings:

Fig. 1 is an elevation of a coking apparatus embodying our invention;

Fig. 2 is a vertical section view of the preheating apparatus shown in Fig. 1;

Fig. 3 is a transverse section view taken on line 3—3 of Fig. 1, showing the construction of the preheating device;

Fig. 4 is a transverse section view taken on line 4—4 of Fig. 1 showing further details of construction of the preheating device;

Fig. 5 is a vertical section view of the battery of retorts shown in Fig. 1,—parts being cut away to show the details of construction;

Fig. 6 is a transverse section view taken on line 6—6 of Fig. 5, showing the construction of the battery of retorts;

Fig. 7 is a transverse vertical section view taken on line 7—7 of Fig. 6;

Fig. 8 is a transverse vertical section view taken on line 8—8 of Fig. 6;

Fig. 9 is a longitudinal section view taken on line 9—9 of Fig. 5;

Fig. 10 is an enlarged elevation of the coke storage chamber shown at the bottom of Fig. 1; and

Fig. 11 is a transverse section view of the coal hopper showing the heating pipes extending therethrough.

The apparatus shown in Fig. 1 comprises a hoist 1 for elevating previously ground coal up to the top of the structure where it can be dumped into a hopper 2 through a chute 3. The hoist 1 may extend from the basement floor 4 of the building containing the apparatus, or merely from the floor above shown at 5. Suitable columns 6 and 7 support the floor 5 and support one end of the preheating device indicated generally by the reference character 8. The fuel hopper 2 communicates with the fuel preheating device 8 by means of a chute 9 and a screw conveyor 10. The preheating device 8 communicates with a discharge hopper 11 which empties into a car or lorry 12. This lorry can be moved back and forth along the top of a battery of coking retorts 13 so that fuel can be discharged from the lorry into any one of these retorts. From the retorts, where the fuel is converted into coke, the fuel is discharged into a coke storage chamber 14. The coke can be discharged from this chamber into cars 15 which carry the coke away from the apparatus.

Air is passed through a number of passages surrounding the coke storage chamber 14 and then supplied to a combustion chamber at the base of the coking retorts 13. The flue gases from the flues surrounding the retorts may pass through a pipe 16 into flues surrounding the preheating drum. Some of these gases instead of being utilized in the preheating device may be passed through a recuperator directly adjacent to the coking retorts and ultimately discharged through a pipe shown at 17 in Fig. 1.

The several parts of our improved appara-

tus described in general terms in preceding paragraphs will now be described more in detail.

In Figs. 2 and 11 we have illustrated the preferred construction of the raw fuel hopper which supplies fuel to the preheating device. This hopper comprises a suitable container 18 having an open top for receiving coal from the hoisting device 1. A plurality of pipes 19 extend through the body portion of the container 18 and serve to convey hot gases through this container, the gases being thus brought into heat exchanging relation through the coal being deposited in the hopper. The gases are supplied to these pipes through a pipe 20 which connects with the flues surrounding the preheating drum, and these gases are discharged through a pipe 21. A chute 9 at the base of the container 18 delivers the coal to the screw conveyor 10 which is operated by means of a motor 23 connected to the screw conveyor by means of belts or chains 24. The conveyor 10 is adapted to deliver the fuel to the interior of a preheating drum 25 which is caused to rotate by means of the gears 26 and 27, the latter of which is fixed to a shaft 28 driven by the motor 23. The gear 27 meshes with gear 26 which is fixed to one end of the preheating drum. The preheating drum 25 is enclosed within the heating chamber 26′ containing a number of baffles 27′ which cause the heating gases to circulate around the drums. The baffles 27′ form a series of flues within the heating chamber which are supplied with heating gases through a pipe 16 located near the discharge end of the drum 25. The gases are withdrawn from the preheating chamber through the pipe 20 which conducts them to the pipes 19 in the fuel hopper 2. Within the combustion chamber and between the discharge end of the pipe 16 and the discharge end of the drum 25 we have provided a gas burner 30 for heating the discharge end of the drum 25. A pipe 31 supplies gas to this burner and the rate at which this gas is supplied is controlled by an automatic temperature regulating device 32 having a thermocouple 33 which is responsive to the temperature of the fuel discharged from the preheating drum. We have not deemed it necessary to describe the details of this automatic temperature regulating device inasmuch as any suitable device of this type can be employed, such devices being in general commercial use. We prefer to employ some means for controlling the temperature of the fuel at the discharge end of the preheating drum, and we have found the automatic gas burner illustrated in Fig. 1 to be suitable for this purpose. This makes it possible to bring the coal up to a temperature within say 30° of that at which it would become plastic, and this is done in such a manner that there is no danger of the fuel being overheated.

A plurality of baffles or plates 34 are arranged within the discharge end of the drum 25 for the purpose of lifting the fuel and dropping it into a chute 35 where it comes in contact with the thermocouple 33 of the automatic regulating device. The fuel may be discharged from the chute 35 into the lorry 12 shown in Fig. 1 as described above.

We prefer to construct the preheating device so that the inclination of the drum 25 can be changed as desired. Accordingly we have illustrated a jack 36 resting on the floor 5 and engaging a column or support 37 which carries the end of the preheating device which receives the raw fuel. The discharge end of the preheating device is supported on the column 7 by means of a pivot joint 38, and it will be understood that the inclination of the drum 25 can be changed by simply raising or lowering the column or support 37 by means of the jack 36. In this way the rate at which the fuel travels through the rotating drum 25 can be carefully regulated. The rate at which the fuel passes through this drum can also be varied by changing the speed of the motor 23. Increasing the speed of the motor serves to increase the speed of the conveyor 10 as well as that of the drum 25, and the motor may be connected to the automatic regulating device 32 in any well known manner so as to cause the motor speed to change in accordance with changes in the temperature of the fuel discharged from the drum 25. The arrangement should be such that when the regulating device operates to supply more gas to the combustion chamber at the discharge end of the drum 25, the speed of the motor 23 will be decreased. Thus the combined effect of the gas burner and the motor will be to increase the temperature of the fuel at the discharge end of the drum 25.

A suitable valve 39 controls the flow of preheated fuel through the hopper or chute 11 which serves as a means for conveying the preheated fuel from the preheating drum 25 to the lorry or car 12. This lorry is mounted on a compound track or runway comprising a transverse portion 40 and a longitudinal portion 41. The lorry can be moved transversely, along the portion 40, suitable rollers 42 being provided for this purpose. The portion 40 carries rollers 43 which engage the track portion 41 so that the lorry can be moved along this track. We prefer to employ the lorry 12 and the parts associated therewith, or some equivalent device, adapted to supply the preheated fuel to any one of a plurality of coking retorts, although it will be understood that our invention can be used to advantage even where only a single retort is employed.

A gas and water vapor relief valve is shown at 11'.

We have found that considerable economy can be effected by employing a plurality of retorts for receiving the preheating fuel, the group or battery of retorts being supplied with preheated coal by a single preheating device such as the preheating drum 25 illustrated in Figs. 1, 3 and 4. An arrangement of retorts which we have found to be particularly satisfactory is illustrated in Figs. 1 and 5 to 9 inclusive. We have illustrated a battery of retorts comprising a number of vertical retorts 44 arranged in pairs, each pair being surrounded by heating flues. Each of the retorts 44 may be constructed out of a single piece of metal or other suitable material and we prefer to provide retorts which are of slightly greater diameter at the base than at the top, thus facilitating the removal of the coke charges from the retorts. It is not necessary to employ temperatures above say 750° C. and, accordingly, it is quite satisfactory to make the retorts out of any of the well-known heat resisting alloys. Each retort is provided with a hinged plate 44' at the bottom thereof which can be swung downward to permit the coke to drop out. The plate 44' may be perforated if desired. Mechanism for operating the hinged plates 44' is shown at 45' in Fig. 8. Suitable valves (not shown) are provided at the top of each retort for the purpose of permitting the preheated fuel to drop from the lorry 12 into the retorts and to close the retorts while the coking operation proceeds within the retorts. By maintaining the valves closed at the top of the retort for a short time after charging and allowing the gases to discharge through the perforated bottom 44' the dust from the charging process is retained by the coal mass while the vapors pass out of the retort through the coke chamber and escape through the vent 74.

While heat may be supplied to the retorts in various ways, yet we prefer to employ the special heating system disclosed in the accompanying drawings. Upon referring to Figs. 5 to 9, inclusive, it will be noted that each retort 44 is surrounded by a heating chamber 45. One of the distinctive features of our improved heating system is the provision of means whereby heat is radiated to each of the retorts from the wall of the heating chamber surrounding each retort, heat being supplied to the chamber wall from the outside thereof. One or more gas mains such as those illustrated at 46 may be provided for the purpose of suppling gas to burners 47 located near the lower portions of the several retorts but separated therefrom by the heating chamber wall 48. These burners 47 are enclosed within flues which are adjacent to the exterior of the heating chamber walls 48 and these flues are enclosed by a heat insulating wall 49 which encloses the entire battery of retorts and heating chambers. Openings 50 are provided through the wall 49 for the purpose of permitting inspection of the burners 47 and to provide such access to the burners as is necessary to light them.

Our improved flue construction as illustrated in Figs. 5 to 9 inclusive, includes vertical passages 51 extending up from the burners 47 and communicating with adjacent vertical passages 52 extending down to the lower portions of the retorts where they communicate with the heating chambers surrounding the retort through short transverse passages 53. The hot flue gases thus pass up through the passages 51, down through the passages 52 through the short passages 53 and into direct contact with the retorts 44. Thus the hot gases come in contact with the exterior portions of the chamber walls 48 and do not come in contact with the retorts 44 until after they have passed up through the passages 51 and down through passages 52. In this way, the walls 48 are heated to a fairly high temperature and radiate heat to the retorts 44 in a substantially uniform manner throughout their length.

After the flue gases pass through the short passages 53 near the bottom portions of the retorts 44, they pass up around these retorts and escape through short passages 54 communicating with a manifold 55. This manifold 55 communicates with the pipe 16 which conveys the gases to the preheating device above described. This pipe 16 is provided with a flexible joint as shown at 16', which permits elevation of the forward end of the preheating device without interfering with the supply of hot gases to the preheater.

We prefer to provide means whereby some of the hot gases supplied to the heating chambers 45 can be used for the purpose of supplying heat to the air admitted to the burners 47. Such a recuperator is illustrated in Figs. 5 to 9 inclusive. In these figures, we have illustrated small passages 56 leading from the upper portions of the heating chambers 45 into communication with vertical passages 57 leading downward and communicating with similar passages 58 leading upward to a manifold 59. The gases are discharged from the manifold 59 through a suitable pipe connection 17 as shown in Figs. 1 and 9. Valves 61 and 62 are provided in the pipes 17 and 16 for the purpose of regulating the relative amounts of flue gases passing through these portions of the system. The valve 61 may be closed entirely, in which case all of the flue gases pass up from the pipe 16 to the preheating device, or the valve 61 may be only partially closed, in which case some of the flue gases escape through the pipe 17. The air to which heat is supplied by the flue gases which ultimately pass out through pipe 17 is admitted to pas-

sages 63 near the base of the system as best shown in Fig. 7. The air flows upward through passages 64 and then downward through passages 65, through the horizontal passages 66 and 67 and through short vertical passages near each of the burners 47. In this way, the air supply to the burners is preheated by a portion of the flue gases which have previously come in contact with the retorts 44. Valves 68 control a supply of air to the passages 63 in the base of the recuperator. Similar valves 69 control the supply of air directly into the horizontal passages 66 from which it may flow to the burners 47. This air, which may be supplied either to the recuperator or directly to the burners, may, of course, be taken from the atmosphere immediately surrounding the battery of coking retorts but we prefer to supply some heat to the air before it reaches this point. One embodiment of such a means for preliminarily heating the air is described hereinafter.

The rate at which heat is supplied to the retorts 44 can be closely regulated by regulating the supply of gas to the burners 47. In this way, it is a relatively easy matter to supply to the retorts just enough heat to bring the preheated coal up to the temperature at which it commences to become plastic throughout; that is, to a temperature at which the exothermic reactions are initiated and proceed throughout the mass of fuel.

When the mass of coal in any one of the retorts 44 is completely coked, the hinged plate 44′ at the bottom of this retort can be released so as to permit the coke to drop down into a coke storage reservoir such as that illustrated at 14 in Figs. 1 and 10. The coke is allowed to cool down in this storage reservoir, below a red heat. In order that the heat given off by the coke during this cooling operation may be utilized, we prefer to provide a number of passages surrounding the coke storage chamber and through which air may be passed preliminary to supplying it to the gas burners 47. We have shown such passages at 70 in Figs. 1 and 10. The air may be drawn in through a suitable connection 71. It then passes in a circuitous path around the storage chamber to the base thereof and then back up and through a passage 72 which communicates with the valves 68 and 69 above described. These valves control the supply of air to the recuperator and to the passage which leads directly to the base of each burner 47.

We prefer to construct the coke storage chamber 14 with inclined walls so that the coke may be discharged into conveyor cars 15 through openings in the bottom of the storage chamber.

Our improved process of making coke can be carried out in a very economical manner by utilizing the apparatus above described. This apparatus is designed to utilize, to the best advantage, all of the heat which is ordinarily wasted during the process of converting coal into coke. The hot gases after leaving the retorts are conducted first to the preheating device and then to the flues extending through the hopper 2. Some of these gases may be brought into heat exchanging relation to the air which is being conducted to the burners near the base of each retort. Furthermore, the heat given off by the coke discharged from the retorts is utilized for the purpose of raising the temperature of the air which is to be supplied to the burners.

The raw coal is deposited in the hopper 2 where it receives some heat from the gases passing through the flues 19 in this hopper. The coal then passes into the rotating drum 25 where it is simultaneously tumbled and advanced while additional heat is being supplied thereto. The coal then passes into the chute 11 and from this chute it is discharged into the lorry 12. These two parts of the apparatus may be of large capacity so as to store a sufficient quantity of preheated fuel to fill several retorts. The lorry 12 can be moved into close proximity to any one of the retorts 44 for the purpose of discharging the preheated fuel into the retort. The final coking operation is performed within the retorts 44, the hydrocarbon vapors being withdrawn through pipes 73 shown in Fig. 1. The storage bin 14 communicates with the lower end of each of the retorts 44 and is adapted to receive the coke discharged from these retorts. The coke is ultimately discharged from the bin 14 into suitable receptacles such as the cars illustrated at 15 in Fig. 10.

A vent 74 is provided from the coke storage chamber 14, which connects with the gas conduits 75 leading from the retorts. This passageway permits of steaming the red hot coke for increasing the yield of gas and and ammonia and modifying the sulfur content. It is evident also that the gases which may escape around the loosely fitting bottom plates of retorts will find their way into these gas conduits. The necessity of securing a gas-tight fit between the swinging bottoms and the lower edge of the retorts is thus obviated.

It is to be understood that the various details of the process and apparatus above described can be modified and, in some instances, eliminated without departing from the spirit of our invention which is not limited to the particular embodiments illustrated and described but includes such modifications thereof as fall within the scope of the appended claims; for example, the preheating device is capable of use by itself for the purpose of heating material such as solid

fuels of various kinds. The automatic regulation of the heat supplied to the fuel in the preheating device renders this device of value for many purposes.

We claim:

1. An apparatus for coking coal, comprising an inclined rotatable drum for tumbling and advancing the coal and having a discharge end, means for supplying heat to said drum to preheat the coal therein, a chute arranged near the discharge end of said drum and arranged to receive the preheated coal from said drum, a plurality of coking retorts, a movable lorry for receiving the preheated coal from said chute and means whereby said lorry can be moved close to any one of said retorts to discharge coal into the same.

2. An apparatus of the type described, comprising a coking retort, a chamber adapted to receive coke from the retort, a burner for supplying hot gases to the exterior of the retort, means for conveying air to the burner, said means being arranged to bring the air into heat exchanging relation to the coke in said chamber and to at least a portion of the gases which have previously been supplied to the exterior of said retort.

3. An apparatus of the type described, comprising means for receiving coal, means communicating therewith for agitating and advancing the coal, a retort for receiving the coal from said agitating means, means for supplying hot gases to the exterior of said retort, and means for conveying said gases from the exterior of said retort to the exterior of said agitating means and then into heat exchanging relation with the coal in said receiving means but out of contact with the coal in said receiving means whereby the fuel is progressively heated throughout and out of contact with the heating gases as it advances through the said receiving means and the agitating means.

4. An apparatus of the type described, comprising means for receiving coal at least one flue for conducting gases in heat exchanging relation with, but out of contact with, the interior of said receiving means, means communicating with said receiving means for agitating and advancing the coal, a retort for receiving the coal from said agitating means, burners for supplying hot gases to the exterior of said retort, means for supplying air to said burners, and means for conveying said gases from said retort into heat exchanging relation with the air being supplied to said burners and for then conducting the hot gases to the exterior of said agitating means and finally to the flue of said receiving means, whereby the fuel is progressively heated throughout and is maintained out of contact with the heating gases as it advances through the said receiving means and the agitating means.

5. An apparatus of the type described, comprising a coking retort, a burner for supplying hot gases to the exterior of said retort, means for supplying air to the burner and means for conducting the hot gases which have previously been supplied to the exterior of the retort into heat exchanging relation with the air being supplied to the burner.

6. An apparatus of the type described, comprising means for receiving coal, at least one flue for conducting gases in heat exchanging relation with the coal in said receiving means and out of contact with the coal therein, means communicating with said receiving means for agitating and advancing the coal, a retort for receiving the coal from said agitating means, means for supplying hot gases to the exterior of said retort out of contact with the coal therein, and means for conveying said gases from the exterior of said retort to the exterior of said agitating means and then to the flue of said receiving means, whereby the fuel is progressively heated throughout and out of contact with the heating gases as it advances through the said receiving means and the agitating means.

In testimony whereof we affix our signatures.

SAMUEL W. PARR.
THOMAS E. LAYNG.