

June 28, 1966

H. SCHENCK ETAL
METHOD FOR PRODUCING COKE

3,258,409

Filed July 5, 1962

6 Sheets-Sheet 1

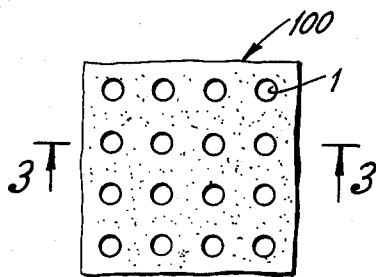


FIG. 1

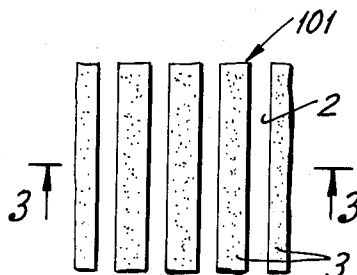


FIG. 2

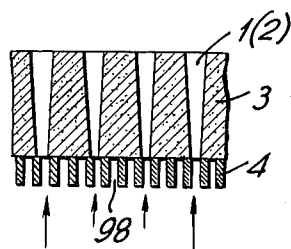


FIG. 3

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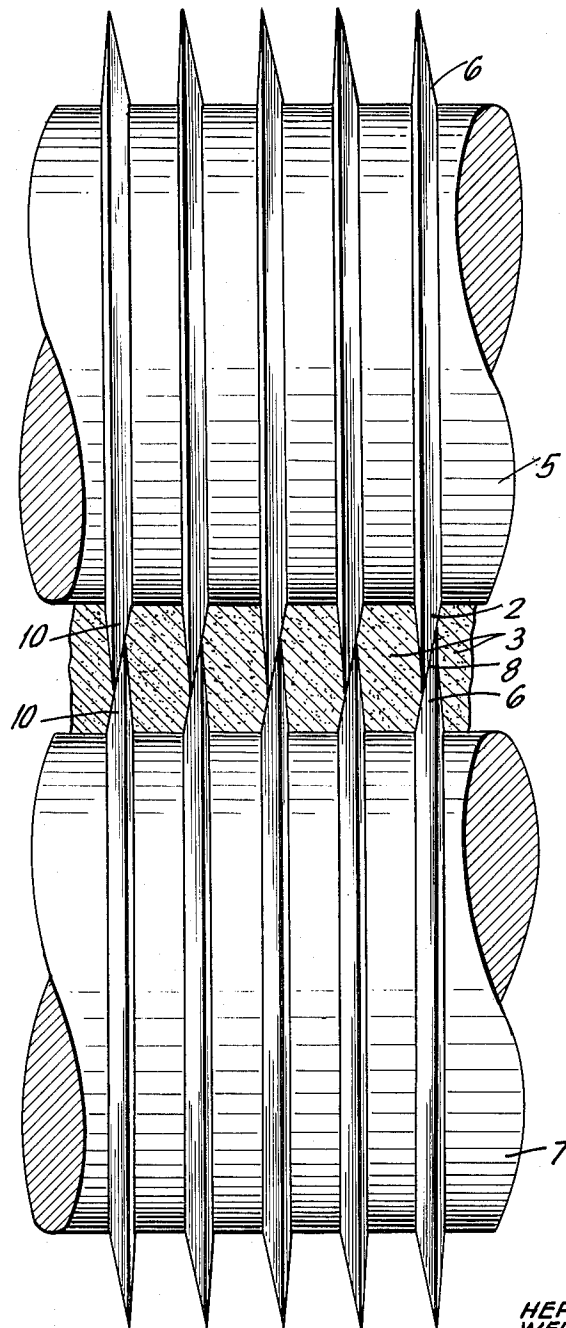


FIG.4

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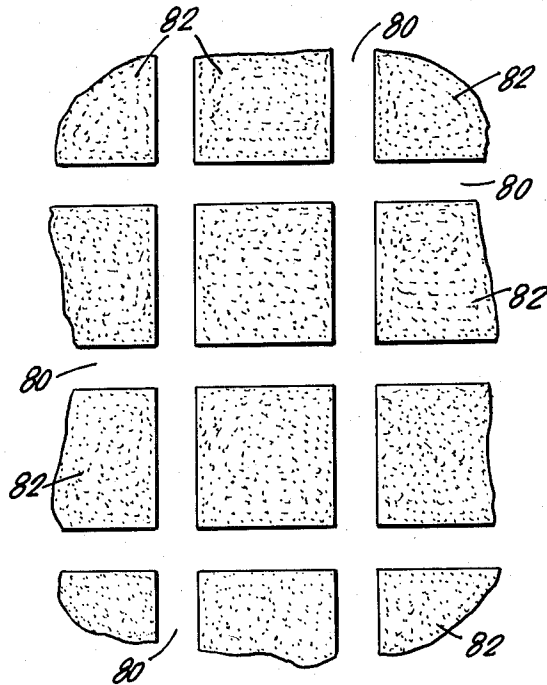


FIG. 5

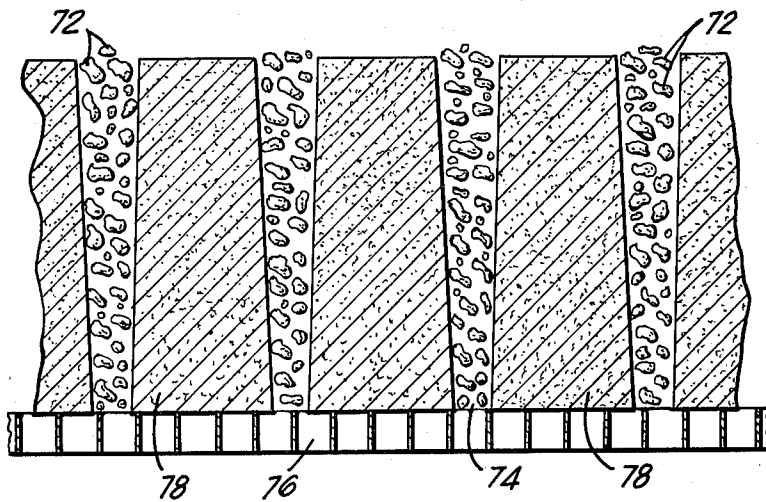


FIG. 6

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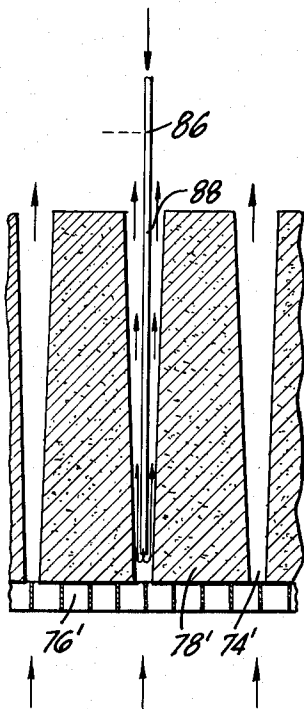


FIG. 8

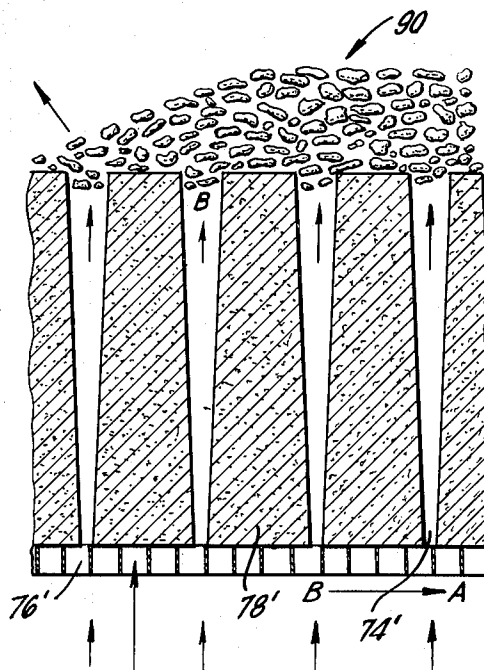


FIG. 7

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FIG. 9a

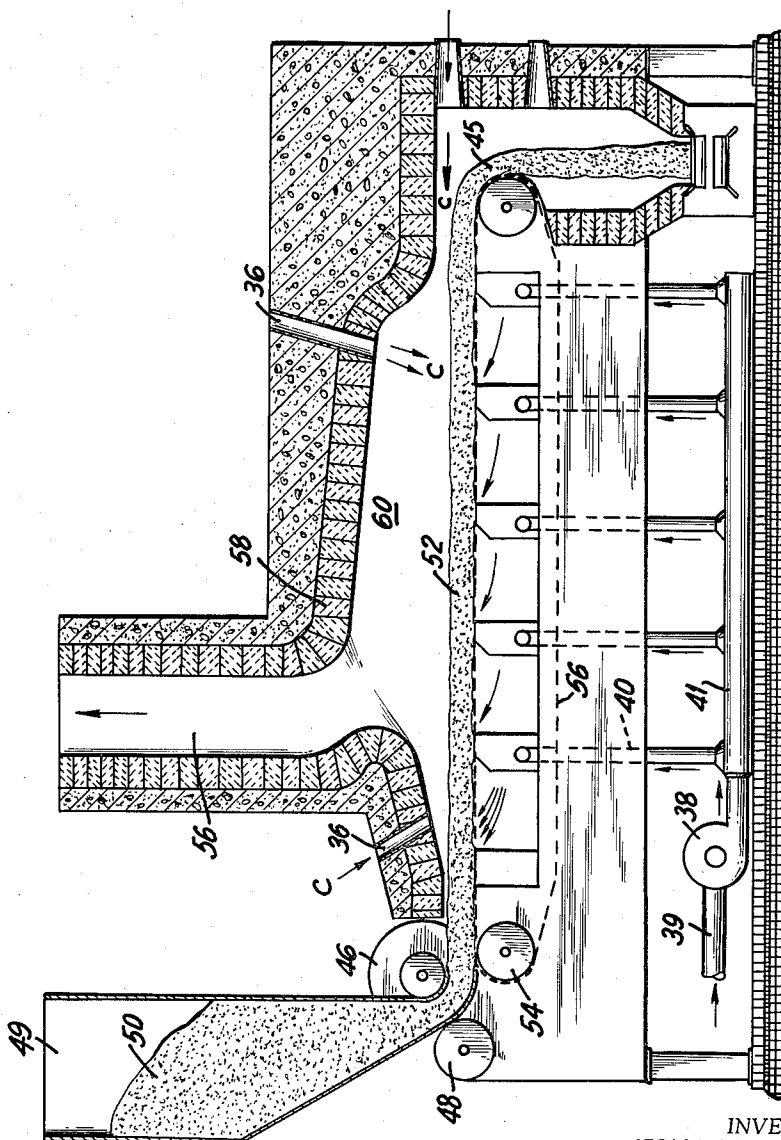


FIG. 9

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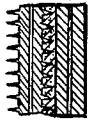


FIG. 10a

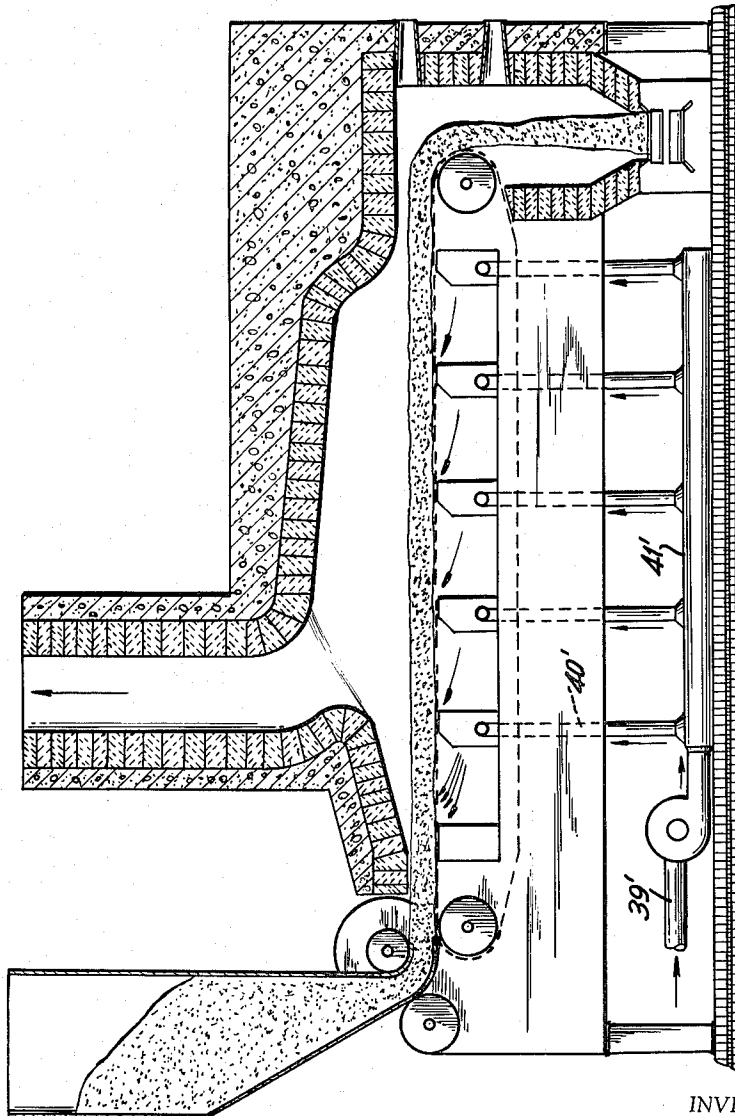


FIG. 10

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3,258,409

METHOD FOR PRODUCING COKE

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Filed July 5, 1962, Ser. No. 207,751

Claims priority, application Germany, July 20, 1961,
Sch 30,016; Dec. 5, 1961, Sch 30,667

20 Claims. (Cl. 201-6)

This invention generally relates to coke production and is particularly directed to an improved method for producing coke from fine-grained bituminous materials on stationary or movable coking grates or grinds (hereinafter referred to as grates). Considered from one aspect, the invention provides for a novel method for shaping bituminous material into self-supporting structures suitable to be coked on grates.

Considered from another aspect, the invention is concerned with a novel coke producing process wherein fine-grained bituminous materials are coked on grates in a much shorter period than is possible with prior art procedures and wherein the coking procedure results in the formation of high-quality coke and in fuel-rich gases having considerable calorific content and thus great heating power (rich gas). The invention is applicable to coke production both on stationary and movable grates.

For the purpose of this application, including the appended claims, the term "bituminous materials" is deemed to include any bituminous substance suitable for coke manufacture, such as various kinds of coal, oil shale, mixtures of petroleum and mineral substances, wood and wood waste.

The term "coke," in turn, includes, for the purpose of this application, coke proper and also metalliferous and metallurgical coke.

As is well known to those skilled in coke production, successful operation of prior art methods for coking bituminous material on stationary or moving grates requires as a prerequisite that the bituminous material has a grain size which permits a considerable gas permeability through the entire layer of bituminous material to be coked. This, in turn, means that the bitumen content of the material is not allowed to exceed a certain limit value as otherwise the gas permeability is insufficient.

Thus, for example, it is well known in the industry that fine-grained bituminous coal having a grain size of up to 10 mm. with the predominant portion of the coal consisting of grains or particles below 5 mm. cannot successfully be coked on grates at an economic speed. Experience has demonstrated that bituminous coal having a volatile content of above 16% is particularly unsuitable as raw material for the prior art grate coking methods. This is so because during the coking, swelling and agglomeration phenomena take place due to the heating so that the original gas permeability of the material is considerably reduced if not eliminated.

Accordingly, it is an object of this invention to provide for a method of coking bituminous material which permits the employment of finer-grained bituminous materials having a bitumen content in excess of 16%, as for example, customary coking coals.

According to one feature of the present invention, the coking of bituminous material, such as for example, coking coals may advantageously be performed jointly and simultaneously with the reduction of ores with a view to producing in this manner metalliferous coke.

In the present grate coking methods, the coking of the bituminous material layer on the grates progresses in zones from the top towards the bottom. By contrast, and in accordance with a further feature of this invention, the coking of the bituminous layer is initiated and conducted to completion substantially simultaneously

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throughout the entire layer thickness of the bituminous material. This manner of operation results in a significant shortening of the coking time.

Pursuant to another feature of the inventive procedure, a substantial portion of the gaseous products emanating from the bituminous material and escaping therefrom during the coking procedure (hereinafter referred to as "coke gases") may be recovered in the form of fuel-rich gases having an extremely high calorific content. The remaining portion of the coke gases formed has to be burned in order to supply the heat necessary for maintaining the coking.

In the known grate coking procedures wherein bituminous material is coked or carbonized at relatively low temperature, the bituminous material is placed on the grate in a layer thickness of about 3 to 50 cm. The grate with the layer thereon is then moved below an igniting arch structure or crown of the furnace and the layer is thereby ignited at its top surface. It should be emphasized in this connection that the igniting exclusively takes place within a very thin surface region of the layer. Preferably pre-heated air is simultaneously blown through the bituminous layer either from below upwardly, or in the reverse, from the top downwardly. The coke gases which, due to this procedure, are liberated from the bituminous material burn with the air within the layer structure. Due to the heat generated in this manner, the coking of the layer gradually progresses from the top downwardly, or in the reverse, through the entire layer formation. It has been established that this prior art procedure can only be carried out in an economical and practical manner if the combustion air is blown through the bituminous layer to be coked from below upwardly and provided the bituminous layer consists of relatively large pieces of, for example, 5 to 30 mm. grain size and has non-agglomerating characteristics. Thus, for example, coal in piece form has previously been coked in this manner.

While this prior art coking method is extremely simple, it will be realized that it has the great disadvantage to the effect that it requires large piece bituminous particles. In other words, the individual pieces of coal or the like constituting the bituminous layer have to be sufficiently large so as to ensure sufficient gas permeability through the layer. Further, the bituminous raw material, during the heating, is not allowed to melt, fuse or swell, as otherwise the gas passages within the bituminous layer become clogged. This, in turn, means that the bitumen content of the coal or the like bituminous material has to be relatively low. For the reasons hereinabove advanced, coking of ordinary coking coals, gas flame coals and gas coals was hitherto not possible in a grate coking apparatus.

By contrast, the method of the present invention enables grate coking of extremely fine-grained, bitumen rich coals, as for example, coking coals.

In accordance with this invention, it has been ascertained that grate coking of bituminous materials of the kind indicated can successfully be carried out if the bituminous layer on the grate is imparted with channels or passages which traverse the layer and through which combustion air and the combustion products of the air with the coking gases, respectively, flow during the coking.

In a preferred embodiment, the passages referred to extend vertically through the layer.

The invention also provides for procedures for forming such channels or passages within the bituminous layer. Thus, for example, punches or plungers may vertically be pressed into and caused to penetrate the layer whereby bituminous material is laterally displaced. Upon removal of the punches or plungers, vertical passages remain through which the air and gases can readily pass. The passages thus act in the manner of flues. According to one embodiment of this inventive procedure, the plungers are

passed through the layer from above. There are other means for forming the passages or flues referred to. Thus, for example, a tube or pipe plunger may be pressed vertically into the layer so that the material located within the tube is removed from the layer upon retraction of the tube. Again, a vertical passage is thus formed within the layer. The plungers or tubes may have a circular cross section. Extensive experiments have shown that particularly advantageous results are obtained if the plunger or tube tapers in the direction of penetration. It will be realized, however, that the invention is not limited to passages of circular cross section. Excellent results are also obtained with flues or passages of rectangular or the like polygonal cross sections. Further, the passages need not necessarily extend in vertical direction only, but they may traverse the layer, for example, parallel to the feed direction of a movable grate. It is also feasible to provide vertical passages within the layer in such a way the passages may cross over somewhat in the manner of a chess board pattern. If the passages are provided in such manner, then pillar-like shapes of bituminous material are defined between them whereby formed coke is produced in an exceedingly simple manner.

According to a further feature of this invention, compacted coke of any desired shape is readily produced by compressing or compacting the bituminous material prior to the coking proper. The compression results in an increased density of the bituminous layer and facilitates at the same time the formation of coke of desired shape. The compression may, for example, be performed by vertically compressing the bituminous layer to be coked or by vibrating the layer, as is known in the art.

In accordance with a preferred embodiment of this aspect of the invention, the compression is effected simultaneously with the formation of the channels or passages referred to. This is accomplished by passing fine-grained bituminous material such as coal between the nip of a profiled roller pair. The profiles of the roller pair are adapted so that parallel channels or passages are impressed into the bituminous compacted layer formed between the rollers in the direction of movement of the layer. The profiles may be arranged on either the upper or the lower roller, or both rollers may be provided with such profiles.

In the event that both rollers have channel-forming profiles, it is advantageous to arrange opposing profiles in somewhat offset manner and so that the profile ends or heads project or overlap, i.e., each profile extends beyond the center line of the nip. The flanks of adjacent opposite profiles adapted to form a single passage preferably contact each other or are in closely juxtaposed position during operation. For this purpose, wedge-shaped profiles may be used which are easily removed from the compressed bituminous layer without resulting in unfavorable constrictions in the passages or channels.

As previously mentioned, the inventive method lends itself particularly well to the production of metalliferous coke from mixtures of, e.g., iron ore and bituminous material, such as coal. According to the prior art methods, metalliferous coke is produced in coking retorts. These prior art methods have the serious disadvantage that the iron ores tend to attack the chamber walls of the retort whereby, of course, the retorts are rapidly worn. Frequent replacement or re-lining of the retorts is therefore required. This disadvantage is entirely overcome by the present procedure.

If metalliferous coke is to be produced by simultaneously reducing, for example, iron ore and bituminous material, then, in accordance with this invention, the passages of the bituminous layer referred to are filled with the ore while the bituminous layer, moreover, is covered with a layer of the ore. The ore should have a grain size which does not obstruct the passage of the gas flow.

The provision of an ore layer on the bituminous layer has a favorable effect on the consistency and stability of the coke to be formed, because the relatively heavy ore,

for example, iron ore, tends to compress the bituminous layer during the coking procedure. It has been established that the covering of the bituminous layer with the ore should preferably be effected after ignition of the bituminous layer and after the coking of the bituminous layer has progressed to about 2 to 3 cm. below the surface thereof.

The aspect of the invention concerning the formation of flue passages within the bituminous layer will now be explained in detail in conjunction with the accompanying drawings forming part of this application, wherein:

FIG. 1 is a plan view on a coal layer to be coked on a grate;

FIG. 2 is a plan view of a different coal layer to be coked on a grate;

FIG. 3 is a vertical section through a coking grate carrying a coal layer to be coked;

FIG. 4 is a somewhat diagrammatical representation of the formation of a coal layer to be coked on a grate;

FIG. 5 is a plan view on a coal layer with gas passages arranged in chess board-like manner;

FIG. 6 is a diagrammatic representation of a coal layer on a grate wherein the vertical passages are filled with granular iron ore;

FIG. 7 is a diagrammatic representation of a movable grate with a coal layer placed thereon, wherein a layer of granular iron ore is placed on the coal layer after the coal layer has been ignited;

FIG. 8 shows diagrammatically a coal layer with vertical passages placed on a movable grate wherein the igniting gas is introduced into the vertical passages through reciprocable pipes entering the passages;

FIG. 9 is a diagrammatical representation of a grate coking device operated according to one of the procedures of this invention;

FIG. 9a is a sectional view through the layer forming feed rollers employed in the embodiment of FIG. 9;

FIG. 10 is a diagrammatic representation of a grate coking device operated according to another procedure of this invention; and

FIG. 10a is a sectional view through the layer forming feed rollers used in the embodiment of FIG. 10.

Referring now to the drawings, and particularly to FIG. 1, it will be noted that the coal layer is generally indicated by reference numeral 100. The coal layer is traversed by a plurality of passages 1 which extend in a direction perpendicular to the plane of the layer. These passages act as flues as previously explained.

According to the embodiment of FIG. 2, the coal layer 101 is also traversed by passages. However, as contrasted to the vertically extending passages 1 of FIG. 1, the layer 101 of FIG. 2 is provided by a plurality of parallel extending passages or channels 2 which extend between solid coal layers or rod formations 3. In this embodiment, the cross section of the individual channels 2 is substantially rectangular.

Turning now to the embodiment of FIG. 3, the grate structure proper is generally indicated by reference numeral 4. The combustion air rises through the spaces 98 formed between the individual grate elements in the direction indicated by the arrows. Reference numerals 1 and 2, respectively, indicate the passages formed between the individual bituminous strata or portions 3. If FIG. 3 is viewed as a section along line III—III of FIG. 1, then reference numeral 1 indicates the vertical passages. If, however, FIG. 3 is viewed as a cross-section along line III—III of FIG. 2, then reference numeral 2 connotes the respective passages of the latter figure.

FIG. 4 diagrammatically illustrates the production of a bituminous coal layer 3 having parallel extending passages to be traversed by gas. The bituminous layer is formed by feeding fine-grained bituminous coal particles between a roller pair consisting of an upper roller 5 and a lower roller 7. Both rollers 5, 7 are provided with parallel extending profile members 6 of identical

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shape. It will be noted that the profile members 6 have wedge-shaped end portions 10 which are arranged in opposing relationship so that one side of the upper wedge 10 contacts the opposing side of the lower wedge 10. In this manner a continuous bearing surface 8 between these wedge portions or sides is created. When the coal particles are fed between the roller pair, the roller pair not only compresses the particles into a compartmented layer 3, but at the same time, the profiles 6 penetrate the layer and form continuous channels therein. These channels or passages extend in vertical manner. It will be noted that due to the offset arrangement of the ends of opposing profile members 6 with the contacting side or flank portions, channels of substantially uniform cross-section are obtained.

The roller pair is advantageously arranged at the charging end of the grate so that the bituminous particles are compacted and imparted with channels while being fed to the grate. If the grate is moving, the speed of the grate may be synchronized with that of the rollers.

A different form of coal layer is illustrated in FIG. 5, wherein the passages or channels 80 extend in chess board manner defining substantially square coal portions 82.

The embodiment of FIGS. 6 and 7 refers to a procedure for the production of metalliferous coke as previously explained. As shown in FIG. 6, the coal layer 78 is placed on the grate 76 and comprises a number of vertically extending substantially downward tapering passages 74. Granular iron ore 72 is inserted into the passages 74. It will be noted that the grain size of the ore is relatively large so as not to obstruct the passage of gas through the gas passages 74.

As seen in FIG. 7, the grate 76' is moving in the direction of the arrow A with the coal layer 78' placed thereon. The movement of the grate is intermittent. After the coal layer 78' has been ignited and combustion air is passed from below upwardly through the passages 74' as indicated by the upwardly directed arrows B, a layer of granular ore, for example, iron ore as generally indicated by reference numeral 90 is placed on the coal layer. As previously mentioned, the provision of the ore layer on the bituminous coal layer has a favorable effect on the consistency and stability of the coke to be formed, because the relatively heavy ore tends to compress the coal layer during the coking.

As previously mentioned, in prior art grate coking procedures, the bituminous layer is ignited from above by an igniting arch structure arranged above the layer, while combustion air, at the same time, is blown through the layer. Customarily, the combustion air flow is blown from below through the grate into the bituminous layer and thus traverses the layer in a direction upwardly. The gradual ignition of the layer takes place in a direction opposite to the flow direction of the combustion air, that is, from the top downwardly. Heat is evolved by the combustion of the coke gases liberated from the bituminous material with the combustion air flowing through the layer.

Again, this prior art grate coking procedure has only practical importance for the coking of coal or the like bituminous material in piece form. If it is intended to coke fine-grained material in this manner at reasonable speed, then it is necessary to pre-shape the fine-grained material into briquettes. Such briquettes, which usually have the shape of eggs, form on the coking grate an irregular layer.

In accordance with this invention, the fine-grained bituminous material can be supplied to the coking grates in the layer form as obtained in accordance with the procedure explained in connection with FIGS. 1 through 4. Thus, the material in the form of rods or elongated bodies with traversing passages may continuously and without additional feeding means be applied to the grates. It has conclusively been established that the pre-formed layers are exceedingly strong and do not tend to break

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if transported from the press, for example the roller pair, to the grate. In this manner, any clogging of the gas passages is prevented and the economy of the grate coking is correspondingly increased.

As previously mentioned, the invention is not only concerned with the formation of passage-containing bituminous layers to be coked on coking grates, but considered from another aspect, the invention also provides for drastically reducing the coking time of the pre-formed layers referred to. The inventive method for shortening the coking period is applicable not only to pre-shaped passage-containing bituminous layers of the kind hereinabove described, but is equally applicable to prior art briquettes or to bituminous layers which have not been subjected to any pre-shaping or forming whatsoever.

According to this aspect of the invention, it has been ascertained that a considerable acceleration of the coking procedure proper is obtained if, for the purpose of initiating the coking, a rapid and vigorous ignition of the entire outer and free inner surface formation of the bituminous layer takes place. It will be recalled that in accordance with the prior art procedures, merely the outer upper free surface of the bituminous layer is initially ignited, and that the ignition of the remaining layer formation progresses slowly downwardly. By contrast, in the present method, the entire free surface of the individual particles of the layer structure is substantially simultaneously ignited. Once the entire free surface of the bituminous layer has been ignited, partial combustion is then simultaneously caused within the entire bituminous layer structure between the coke gases and combustion air flowing through the layer. The coke gases are liberated throughout the entire bituminous layer formation, that is, from the surfaces of the individual bituminous particles. By contrast, in the prior art methods, the combustion of the coke gases takes place successively in individual horizontal strata of the bituminous layer from the top downwardly.

In accordance with the inventive method, different measures may be taken in order to cause rapid and substantially simultaneous ignition of the entire free inner surface of the bituminous layer so as to cause rapid coking.

In accordance with one embodiment for effecting rapid and substantially simultaneous ignition of the entire free surface of the layer, an igniting flame of a gas which burns above the bituminous layer is urged from the top downwardly through the bituminous layer. The flow of the gas may be caused either by positively pressing the hot gas flame through the layer or by suction applied below the layer. This igniting flame is passed through the layer for such a period until ignition of the surface of all the bituminous particles, including those adjacent the grate, has taken place. With a view to preventing that the particles at the top surface of the layer are ignited only, it is necessary to pass through the layer a relatively strong igniting gas flow which has a temperature sufficient for igniting the particles. The temperature of the gas flow has to be maintained throughout its travel through the layer and at least to a level slightly above the level of the grate. The passage of this hot igniting gas flow results in the advantages referred to. The importance and the effect on the coking of this igniting gas flow is basically novel to the art and has not been previously recognized.

After ignition of the entire free inner surface has taken place, combustion air, as in the prior art processes, is passed from below upwardly through the bituminous layer. In the igniting phase of the coking process, the gas flow is thus, in this embodiment, in the reverse to the flow in the coking phase proper. This embodiment is particularly suitable for the grate coking of bituminous coal layers which are composed of coal in piece form or which consist of small coal briquettes, for example in egg form. This embodiment of the invention, however, is also applicable to the coking of pre-formed bituminous

layers having vertical passages of the kind previously referred to.

In the event that bituminous layers of the kind, as for example, explained in connection with FIGS. 1 through 4, are to be coked in accordance with this invention, it has been established that, according to a second mode of operation for causing rapid ignition of the total inner surface, it is advantageous to insert gas supply pipes into the vertical passages. These pipes are introduced from above and extend to a level just above the grate. The gas which exits through these pipes forms with the combustion air, which rises through the grates and through the passages, an igniting flame which burns within the passages from below upwardly and thus ignites the walls of the passages. The gas supply from above may be terminated, for example, by removing the gas supply pipes from the passages, as soon as the total inner surface has been ignited.

Such an embodiment is diagrammatically shown in FIG. 8. It will be noted that the coal layer 78' resting on the grate 76' again defines vertical flow passages 74'. Combustion air is passed from below upwardly through the passages, while igniting gas is introduced into the passages by means of pipes 88. As the movement of the grate 76' is intermittent, the pipes 88 are lowered into the passages 74' when the grates are at rest. Before the grate starts moving again, the pipes are retracted upwardly, for example, up to the marking as indicated by reference numeral 86.

A modification of this second embodiment for causing rapid ignition of the total inner free surface of the bituminous layer resides in that the combustion air for causing combustion of the igniting gas is blown into the passages of the layer at a level just above the grates. This is done by means of air pipes which extend parallel to the gas supply pipes previously referred to. Such procedure is particularly recommended in the event that the coking of the passage-containing bituminous layer is performed on a moving grate which is moved in the direction of the individual layer rods or shapes. In such event the pipes for the igniting gas may be stationarily arranged at a predetermined position above the moving grate, while the bituminous rods or shapes lying on the grate are moved past the igniting flame and are thus ignited at the interior particle surfaces.

According to a still further variation for accomplishing rapid ignition of the entire inner surface of the layer particles, the ignition is accomplished upwardly through the grate. In doing so, hot gases with a corresponding oxygen content are blown through the grate into the bituminous layer and traverse the layer vertically upwardly. The temperature of the gases should be so high that ignition of the interior particle surfaces takes place instantaneously. The ignition in this case rapidly progresses with the hot gas flow in a direction from the grate upwardly through the layer. The temperature of the igniting gas at the point of entry into the bituminous layer should be in excess of 500° C. in order to ensure immediate ignition. As the igniting flame is extinguished upon ignition of the interior surface and combustion air of lower temperature is then blown through the grate until the coking has been completed, the mean coking temperature will still be sufficiently low, even if the initial igniting temperature is high, so as not to affect the stability of the grate structure. It is, of course, well known that the mean coking temperature is an important factor in determining the life of the grates.

This last embodiment as hereinabove described may be modified to the extent that the combustion air which is blow through the grate into the bituminous layer is preheated to a temperature above the ignition point of the bituminous layer to be coked. In this event, the bituminous layer will be directly ignited by the combustion air and the igniting procedure progresses upwardly from the grate with the gas flow through the bituminous

layer. As air temperatures of at least 600° C. and above are necessary for this type of procedure, the grate structure must consist of refractory, highly resistant steel.

FIG. 9 diagrammatically indicates a coking procedure according to one of the embodiments, wherein the layer is ignited from the top downwardly. The coker comprises a combustion chamber 60 defined by the arch structure 58. The combustion chamber merges upwardly with a flue gas exit 56 which leads, for example, to a boiler or the like. Below the combustion chamber 60, there is mounted a movable grate generally indicated by reference numeral 56. The grate is trained about the rollers 54 and supports the coal layer 52. Coal 50 is introduced through the hopper 49 and at the discharge of the hopper the coal pieces are compressed and shaped by profile rollers 48 and 46 which may be of the construction as indicated in FIG. 4. A cross-section through the rollers 48 and 46 is seen in FIG. 9a. The compressed coal in layer form 52 is then coked within the coker and the finished coke is discharged from the grate 56 at the exit side thereof as indicated by reference numeral 45. Primary combustion air is introduced through the grate structure and thus through the coal layer 52 by means of a manifold 41 connecting a plurality of vertically rising gas pipes 40. The manifold, in turn, is supplied through the pipe 39 with the blower 38. Secondary air flows in direction of the arrows C through flue passages traversing the arch structure 58, the passages being indicated by reference numeral 36. This secondary air causes partial combustion of the coke gases rising through and from the layer 52.

According to the embodiment of FIG. 10, the construction of the coking device is substantially the same as that of the embodiment of FIG. 9. However, it will be noted that the passages 36 for the secondary air C, as provided in the embodiment of FIG. 9, are omitted and instead, hot air having a temperature of about 650° C. is supplied to the manifold 41' through the pipe 39' and thus to the vertically rising gas pipes 40'. While the rising gases in the embodiment of FIG. 9 have a discharge temperature of about 1450° C. due to the partial combustion with the secondary air, the temperature of the waste gases in the embodiment of FIG. 10 is only about 900° C. and the calorific value being about 750 Kcal. It will thus be noted that in the embodiment of FIG. 9, the ignition of the coal layer is performed from above while the coke gases exiting from the coal layer are at least partially burned with secondary air. By contrast, in the procedure as illustrated in FIG. 10, the ignition of the coal layer is performed by means of hot air introduced from below so that combustion with secondary air supplied above the grate is not necessary.

In addition to the various measures described for the purpose of accomplishing simultaneous and rapid ignition of the entire outer and inner surfaces of the particles of the bituminous layer formation to be coked, the invention also provides for further measures which may be employed in connection therewith. These further measures may, for example, be of chemical nature. Thus, for example, the igniting gas or air may be enriched with oxygen in order to reduce the igniting temperature of the bituminous layer. Another physical measure, for example, resides in that igniting flames are employed which are intensified by sound oscillations.

According to a still further aspect, the invention provides for the recovery of the fuel-rich gases having considerable calorific content and thus heating power (rich gas) from the grate coking.

In the prior art methods, the bituminous materials are converted into coke by first igniting the top surface of the bituminous layer which rests on a grate, whereafter combustion air is blow from below through the grate and the layer, which air causes combustion of the coke gases emanating from the layer, whereby the bituminous layer to be coked is heated.

These waste gases formed in this type of grate coking process consist of the gaseous combustion products between the coke gases and the air blown through the grate. These waste gases have a correspondingly high nitrogen content and a correspondingly low calorific value.

Serious attempts have been made to recover in grate coking processes a waste gas which corresponds with regard to composition to the valuable gases obtained in customary coking processes. For this purpose, it has been suggested partially to exhaust the waste gases from the apparatus. For example, it has been proposed to provide or associate a moving grate with several separated zones. In this proposal, the zones are alternately positioned one after the other in the direction of the grate movement. One of the zones is intended for receiving the combustion gas blowing through the bituminous layer, while escaping coke gas is sucked from the adjacent zones downwardly through the grate and through the bituminous layer.

The practical realization of this proposal, however, is extremely difficult because hermetic separation of the adjacent gas spaces or zones is technically not feasible. This is so because the exhausted coke gases will always be contaminated by fresh or partially consumed combustion air from the two neighboring or adjacent zones.

Accordingly, it is a further object of this invention to provide a procedure for recovering rich gas in grate coking procedures which overcomes the difficulties mentioned.

In accordance with this aspect of the invention, it has been ascertained that rich distillation or coke gases can be readily recovered, separate from the combustion gases necessary for causing heating of the bituminous layer, by operating the grate coking periodically in successive time intervals for

(a) Partial combustion of the coke gases, and

(b) For recovery of the unconsumed or substantially unconsumed coke gases, respectively.

Thus, a grate coking apparatus in accordance with this invention is, for example, provided in the combustion air supply line to the grate with a throttle member by means of which the air supply is periodically throttled to a fraction, e.g. to about one fifth to one twentieth, preferably one tenth of the amount of air ordinarily supplied to the grate coker. If the throttle member is in open position so that the grate is supplied with the full amount of air, then a considerable portion of the coke gas formed by the bituminous particles in the layer, for example 50%, is burned within the bituminous layer while the layer will be correspondingly heated. The waste gas which in this period of the operation escapes from the grate, has a relatively low heating value and cannot be used as a rich gas. Such gas, for example, may be used for operating a boiler or the like. If, however, for example, after a blowing period of about five minutes with the full amount of air, the air amount is then throttled or reduced to one tenth thereof, the distillation and coke gas escape within and from the bituminous layer or coke layer, respectively, continues, due to the stored heat within the layer, until the temperature has dropped considerably. The reduced air amount rising through the grate, that is, only one tenth of the normal amount, however, is still sufficient to prevent exit of the distillation or coke gases from the grate downwardly into the air supply passages and thus combustion of these distillation or coke gases is prevented. This distillation or coking phase with the reduced air amount may, for example, last for about five minutes whereafter, again, the full amount of air is supplied for the next five minutes.

In the path of the gases exiting from the layer, an adjusting or reversing means is provided which causes that the flow of partially burned gas formed during the full air supply heating period is separated from the rich coke gas escaping during the throttled air supply distillation period. According to one embodiment of this procedure,

the rich distillation or coke gas thus formed is exhausted from the space above the coking grate.

Further, in order to displace the nitrogen containing gas of the full air supply heating period, a short but strong injection of steam into the gas space may be effected before the throttled air supply period is again initiated. The steam may be injected for ten to fifty seconds and the steam-gas mixture formed may be withdrawn during the full supply air period.

The invention will now be described by several examples in the form of comparison tests which clearly demonstrate that the coking time is considerably reduced in accordance with the procedures of this invention if compared with the time necessary in the prior art methods. It should be realized, however, that these examples are given by way of illustration and not by way of limitation and that many changes in operation can be effected in method conditions in general without changing in any way the scope and spirit of this invention as recited in the appended claims.

EXAMPLE I

First comparison test

A. For comparison purposes, this test was carried out in accordance with prior art procedures as follows: The raw material was bituminous coal having a grain size of 0.01 to 6 mm. The volatile content of the coal was about 22%. The coking was performed on a moving grate onto which the coal referred to had been poured in a layer thickness of 6 cm. No compression or compacting of the coal was effected prior to the coking. The grate was of ordinary construction and moved at a speed of 0.15 cm. per second. The coal layer on the grate was ignited in accordance with prior art procedure, that is, the moving grate was passed below an igniting arch while combustion air in an amount of 2Nm³ (cubic meters at normal pressure "N") per kg. of coal was blown through the layer from below upwardly. The coking time was 65 minutes. The coke thus formed had a volatile content of 4%, while the ash content was 14%. The bulk weight of the coke was 0.36 gram per cubic cm.

B. The same raw material as under A was first compressed in accordance with this invention between a pair of rollers which moved synchronous to the grate. The compression between the rollers was effected at a pressure of 70 kg./cm.². The coal was compressed into rod-like structures or shapes having a height of 22 cm. and a width of 8 cm. The rollers were provided with profiles of the kind illustrated in FIGS. 1 through 4 in order to form passages within the shapes. The rods or shapes were spaced on the grate at a distance of about 1 cm. and were thereafter ignited in accordance with this invention. The ignition was effected by passing for 10 minutes a strong igniting flame from the top downwardly through the coal shapes, which flame reached to a level just above the grate. The igniting flame had a temperature of about 1300° C. The pressure drop of the igniting flame within the coal layer amounted to 0.1 atm. By applying this flame for 10 minutes, the entire free inner surface of the rod structures was substantially simultaneously ignited. The same specific volume of combustion air as in A was blown from the top downwardly through the carbon layer. The other conditions were the same as under A. The coking period, however, inclusive of the igniting period, amounted to only 40 minutes. Analysis of the coke showed the following characteristics:

Volatile components	percent	2
Ash	do	11
Bulk weight	g./cm. ³	0.4

This, of course, means that the quality of the coke was much improved as compared with the coke obtained under A.

EXAMPLE II

Second comparison test

This test was carried out with a bituminous coal having a grain size of 10 to 30 mm. and a volatile content of 16%. The layer thickness of the coal on the grate was 15 cm. The coal layer without compression was thereafter ignited according to the prior art by an igniting arch structure and by blowing combustion air through the layer from the bottom upwardly. The coking period was 58 minutes.

By contrast, a coking layer of the same composition and physical consistency as above was thereafter ignited by pressing, from the top downwardly, a strong igniting flame for five minutes through the layer. The length of the flame reached almost to the level of the grate. Combustion air was then blown from the bottom upwardly. The coking period was reduced to 26 minutes.

EXAMPLE III

Third comparison test

This test was carried out with bituminous coal in the form of egg-shaped briquettes. The individual briquettes had a volume of about 40 cubic cm. The bitumen content of the coal was 8%. The egg briquettes were placed on a grate in a layer thickness of about 10 cm. and coking was performed in accordance with the procedure described in test IA. The coking period was 50 minutes.

A second layer of a thickness of 10 cm. was thereafter subjected to the procedure in accordance with this invention as described under IB. The coking period was reduced to 40 minutes.

EXAMPLE IV

Fourth comparison test

This test was carried out with bituminous coal having a volatile content of 45%. The coal was compressed into rod shapes of 4 cm. width and 11 cm. height. The space between adjacent rods on the grate was about 1 cm. The rods were then ignited and coked according to the prior art as described under IA, that is, ignition from above, and simultaneous blowing of air through the grate from below. This resulted in a coking period of 50 minutes.

A comparison test was then carried out with coal of the same composition which had been compressed into rods of the same width as above, but the height of the rods was 19 cm. The entire free inner surface between and within the coal rods was then simultaneously ignited in accordance with the invention. This was accomplished by pressing an igniting flame from the top through the passages down to a location adjacent the grate. The igniting flame was thus passed through the bituminous layer for five minutes. Thereafter, combustion air was blown through the passages from below upwardly. The coking period amounted to 32 minutes.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. In a coke producing process, wherein a layer of fine-grained bituminous material is ignited on a grate and an oxygen-containing gas flow is passed through the layer, the improvement which comprises forming essentially vertically extending flow passages in said layer prior to ignition by moving a passage forming means through the bituminous material and igniting said layer by passing through said layer a hot gaseous medium having, during the passage through said layer, a temperature sufficient to cause rapid ignition of said layer, and passing combustion air through said layer after ignition thereof by said hot gaseous medium.

2. The improvement of claim 1, wherein said layer, prior to ignition, is compressed to a higher density.

3. The improvement as claimed in claim 1, wherein said hot gaseous medium is positively urged through said layer from above.

4. The improvement as claimed in claim 1, wherein said hot gaseous medium is positively urged through said layer in a direction from below said layer upwardly.

5. The improvement as claimed in claim 1, wherein the volume of combustion air passed through said layer intermittently varies between a full supply amount sufficient to cause combustion of gases liberated from the bituminous material and a reduced supply amount sufficient to prevent escape of such gases downwardly through the layer.

6. The improvement of claim 1, wherein said passages have a substantially circular cross-section.

7. The improvement as claimed in claim 1, wherein said bituminous layer essentially consists of coal.

8. The improvement as claimed in claim 1, wherein said bituminous layer essentially consists of a mixture of coal and iron ore.

9. The improvement as claimed in claim 1, wherein said grate is movable.

10. The improvement of claim 1, wherein the grate is movable and a first number of said vertical passages extend in the feed direction of said movable grate while a second number of said vertical passages extend in a direction substantially transverse to the feed direction, said first and second numbers of passages forming a chess-board pattern in said layer.

11. The improvement as claimed in claim 10, wherein a layer of iron ore is placed on said bituminous layer after ignition of said layer.

12. The improvement of claim 10, wherein said hot gaseous medium is in the form of an igniting gas flame traversing substantially the entire thickness of said layer in a generally vertical direction.

13. The improvement of claim 12, wherein said hot gaseous medium is an oxygen-containing gas flow traversing said layer in a generally vertical direction.

14. In a coke producing process, wherein a layer of particles of fine-grained bituminous material is ignited on a grate and an oxygen-containing gas flow is passed through the layer, the improvement which comprises forming essentially vertically extending flow passages in said layer prior to ignition by moving a passage forming means through the bituminous material, igniting substantially simultaneously the free surfaces of the particles of said layer by passing through said layer a hot gaseous medium having, during the passage through said layer, a temperature sufficient to cause rapid ignition of said particle surfaces, said layer, upon ignition, forming gaseous products rising from said layer, passing, after ignition, intermittently large and small portions of combustion air through said ignited layer to cause combustion between said gaseous product and said combustion air, said large and small portions of combustion air being composed of respectively larger and smaller quantities of air flow per unit of time withdrawing a portion of said gaseous products rising from said layer at a time when said small portions of combustion air are passed through said layer to obtain a high calorific gas substantially uncontaminated by products of combustion between combustion air and said gaseous products, and separately withdrawing another portion of said gaseous products after said other portion has burned with said combustion air and at a time when said large portions of combustion air are passed through said layer.

15. A process of preparing a layer of bituminous material to be coked on a grate, which comprises compressing fine-grained bituminous material into a self-supporting layer and forming passages in said layer which traverse said layer in a substantially vertical direction by passing a passage forming means through said layer.

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16. In a process of coking bituminous material, wherein a layer of bituminous material is ignited on a grate to evolve gaseous products and wherein combustion air is passed through the ignited layer to burn with said gaseous products, the improvement which comprises passing successively first and second amounts of combustion air through said ignited layer, said first and second amounts being composed of respectively larger and smaller quantities of air flow per unit of time, said first amount of air being sufficient at least partially to burn said gaseous products while said second amount is between about one fifth to one twentieth of said first amount, withdrawing said gaseous products from the layer at a time when said first amounts of air are passed through the layer and separately withdrawing the products of combustion between combustion air and said gaseous products when said second amounts of combustion air are passed through said layer.

17. The process as in claim 16, wherein steam is injected for a short period through said layer at a time between passing said first and second amounts of air through the layer.

18. In a process of coking fine-grained bituminous material on a grate, wherein a layer of particles of the bituminous material on said grate is ignited to form gaseous products rising within and from said layer and wherein combustion air is passed through said ignited layer for burning with said gaseous products, the improvement which comprises forming vertical passages in said layer prior to the ignition thereof by passing a passage forming means through said layer, igniting substantially simultaneously substantially the entire free surfaces of the particles of said layer by passing through said layer a hot gaseous medium having a temperature, while passing through said layer, sufficient substantially instantaneously to ignite said particle surfaces, successively passing large and small portions of combustion air through said ignited layer, said large and small portions of combustion air being composed of respectively larger and smaller quantities of air flow per unit of time, said large portions being sufficient to cause at least partial combustion of said gaseous products, said small portions being a fraction of said large portions, withdrawing the gaseous products formed in said layer when said small portions of combustion air are passed therethrough and separately withdrawing the products of combustion formed between said gaseous products and said large portions of combustion air when said large portions of air are passed through the layer.

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19. In a coke producing process, wherein a layer of fine-grained bituminous material is ignited on a grate and an oxygen-containing gas flow is passed through the layer, the improvement which comprises forming essentially vertically extending flow passages in said layer prior to ignition by moving a passage forming means through the bituminous material, filling said passages with iron ore and igniting said layer by passing through said layer a hot gaseous medium having, during the passage through said layer, a temperature sufficient to cause rapid ignition of said layer, and passing combustion air through said layer after ignition thereof by said hot gaseous medium.

20. In a coke producing process, wherein a layer of fine-grained bituminous material is ignited on a grate and an oxygen-containing gas flow is passed through the layer, the improvement which comprises forming essentially vertically extending flow passages in said layer prior to ignition by moving a passage forming means through the bituminous material and igniting said layer by passing through said layer a hot gaseous medium having, during the passage through said layer, a temperature sufficient to cause rapid ignition of said layer, and passing combustion air through said layer after ignition thereof by said hot gaseous medium, said hot gaseous medium being in the form of an igniting flame which is passed through pipes arranged within said passages.

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