J. A. SINGMASTER.

MANUFACTURE OF PRODUCER GAS.

APPLICATION FILED SEPT. 20, 1910.

1,033,127. Patented July 23, 1912.

2 SHEETS—SHEET 1.

Fig. 1.

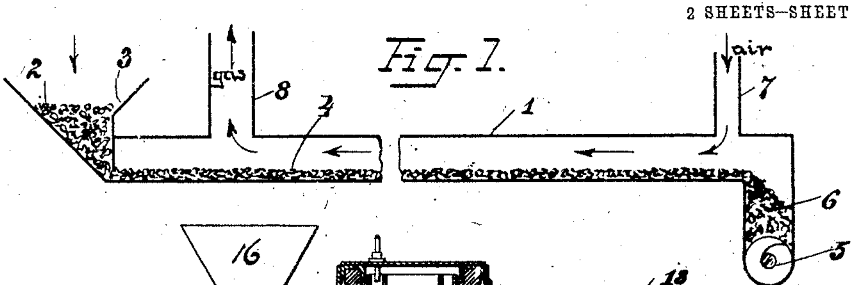


Fig. 2.

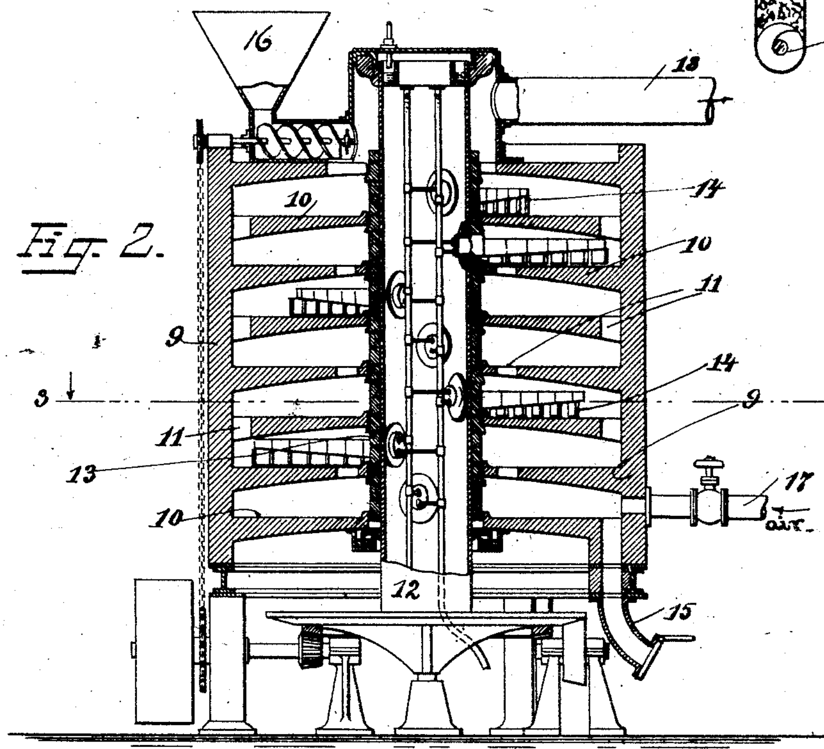
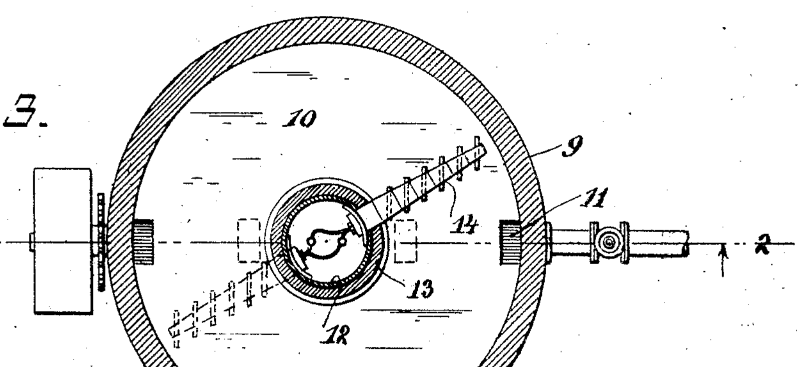


Fig. 3.



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2 SHEETS—SHEET 2.

Fig. 4.

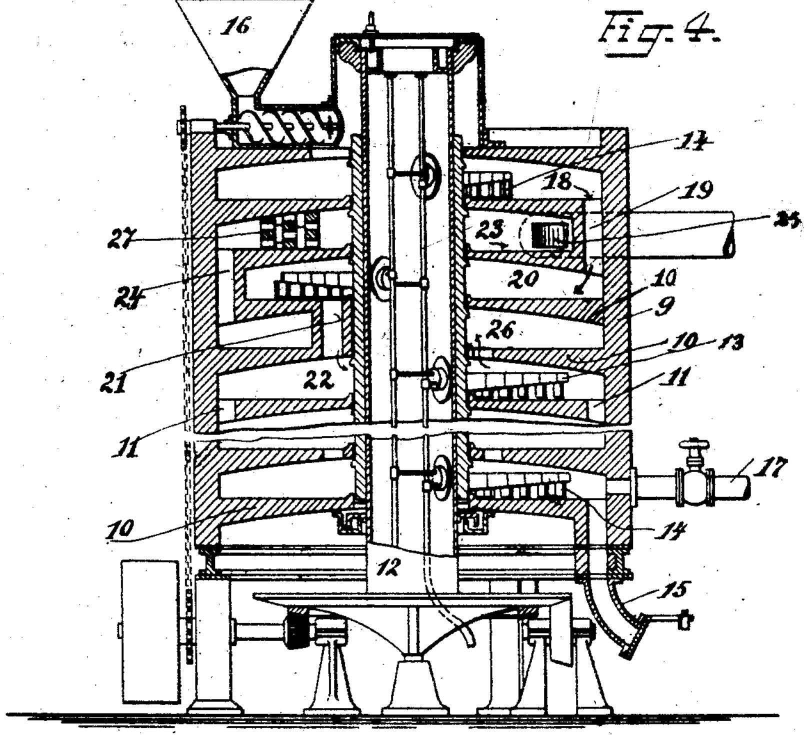
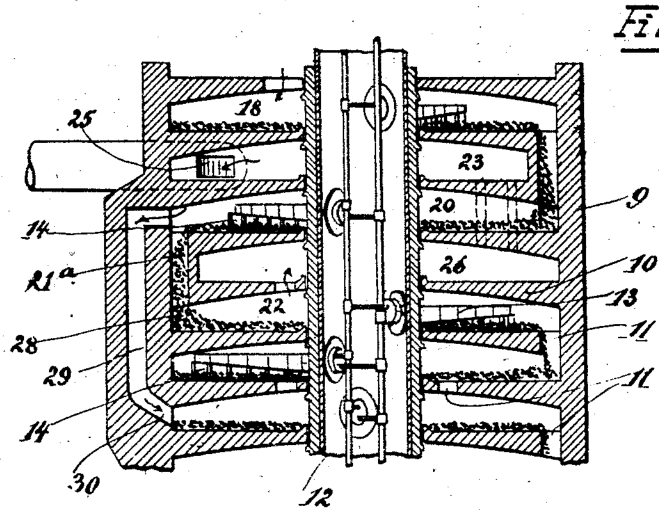


Fig. 5.



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MANUFACTURE OF PRODUCER-GAS.

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To all whom it may concern:

Be it known that I, James Arthur Singmaster, a citizen of the United States, residing at Palmerton, Carbon county, Pennsylvania, have invented the new and useful Improvements in the Manufacture of Producer-Gas described in the following and true specification.

The improvement consists in the manner of presenting the fuel to the action of the draft element, and comprises a method wherein the fuel, such as coal or coke, is caused to advance progressively in the form of a relatively shallow stream or layer in continuous contact with an advancing and relatively shallow overlying gaseous current or draft which comprises air and moves in opposite direction to the fuel as more fully described below.

In the usual methods of making producer or generator gas, a draft of air is blown or sucked through a relatively deep bed of ignited fuel held in the casing of the producer and replenished from time to time. For such methods the size of the fuel particles must be large enough to allow the draft to pass through the deep bed without becoming unduly checked and with substantial uniformity throughout the cross-section of the mass, while at the same time the particles must be small enough to insure a desirable maximum contact of the air draft with the fuel to prevent unchanged air going through the fuel to react with the gas produced. This limitation as to the size of the fuel particles excludes the use of the cheaper forms of finely divided fuel such as culm bank coal, coal dust, etc. Moreover when the gas passes downward through the deep bed of fuel, at the point where the gas escapes at the lower level, its reactivity is practically *nil* and much of the fuel for this reason is apt to go to waste. It is one object of this invention to obviate this waste of fuel. On the other hand when the draft is upward through the fuel the maximum temperature is gained in the lower part of the fuel bed where the material is relatively rich in ash, which is apt to cause slagging, clinkering and other familiar difficulties, which can only be in part obviated by mixing the air with endothermic bodies such as steam, stack gas, etc. The introduction of steam with the air draft is apt to produce an undesirable reduction of temperature at the lower zone of the fuel bed and renders the gas produced unsuitable for some purposes. In any case the deep-fuel bed method of gas-producing is more or less subject to an objectionable lack of uniformity of action, because the air draft is apt to pass through the fuel mass in greater volume at one point than another, which gives rise to cratering or pitting and other difficulties which become more conspicuously objectionable as the size of the individual fuel particles is diminished.

The present invention provides a gas producing method in which the several objections above alluded to are largely reduced or avoided and in which the smallness of the fuel particles is an advantage rather than a detriment. Instead of maintaining a deep stationary bed of fuel and passing the gas through it, I convert the fuel into a moving shallow layer, bed or stratum, and cause it to advance through a heated zone. The traveling fuel stream is supported on the floor of a low chamber or conduit in such manner as to leave a relatively shallow channel or passageway above it, between its upper surface and the roof or covering of the chamber. The draft current is passed through this channel, over and in close contact with the shallow fuel stream and in a direction that is opposite to the general movement of the latter so that the products of complete combustion at first formed are thus moved from an oxidizing region into a region of reducing characteristics wherein they are sufficiently deoxidized to acquire a desirable fuel value. On the other hand as the fuel progressively moves forward it meets a draft current of increasing oxidizing power until finally it is discharged as ash practically free of fuel value. The contact of the ash with the draft current indeed may be prolonged beyond this point since the relatively cool incoming air will prevent slagging or clinkering, while the hot ash on the other hand tends to heat up the air. The moving layer of fuel may be made to travel forward by the use of any suitable means of conveyance, and the movement is conducted in such manner that the shallow mass or layer of particles is kept in constant commotion so as to bring different and constantly changing portions or particles of the fuel to the upper surface where it may meet and have contact with the gaseous draft. All particles of fuel are thus successively brought to the upper surface. The gaseous draft encounters the fresh fuel in increasing amounts as it progresses through its course, and the successive conversion of the oxygen first into carbon dioxid and then into carbon monoxid is thus insured in an effective manner.

In the accompanying illustration I have shown, more or less diagrammatically, certain organizations of apparatus elements indicating the operation and manner of performing the present invention, and wherein—

Figure 1 is a purely diagrammatical representation of the arrangement of the fuel and air current; Fig. 2 is a vertical section of a gas producer under the present invention, certain parts being shown in elevation; Fig. 3 is a horizontal section of a more elaborate and compact apparatus adapted for carrying out the method; and Figs. 4 and 5 are modified forms of structure.

In Fig. 1, element 1 represents a conduit of any suitable refractory material and of considerable length. Into this conduit at one end is fed the fuel 2 which, advantageously and for reasons of economy, is finely divided fuel. Any suitable feeding device may be used, such as the hopper indicated at 3. The fuel is caused to advance along the bottom of the conduit as a thin traveling layer 4, by means not shown in this figure, but adapted to cause continual change in the arrangement or relative positions of the fuel particles. The conduit may rotate to cause forward feeding, but this is the least advisable means of propulsion since it is difficult to secure the best proportion between the fuel and the gas space thereabove with a rotating conduit of any capacity. The conduit should preferably be relatively thin or shallow so that in the length of the travel of the gas and fuel therethrough, each will have opportunity of thorough contact with the other, thereby providing for the desired reactions between the gas and the surface of the fuel stream. The shallowness of the fuel and gas currents is thus somewhat dependent on the length of the conduit. The relative ratio of the fuel and of the draft current should be such as to produce a combustible gas with a minimum amount of carbon dioxid. The test of appropriate proportions is the attainment of complete reaction at the termination of the gas passage. The ash is removed from the conduit by the ash conveyer 5 and the hopper 6 into which it falls, these being indicated in Fig. 1 merely in a conventional way. The air current is introduced at the inlet 7 at a point near the end of the fuel course, where the traveling layer is substantially a hot layer os ash, and, the draft being of maximum oxidizing capacity at this point, any particles of fuel still remaining unconsumed in the ash have opportunity of combustion, while the relative coolness of the entering air prevents undue temperature in the ash at this point which might cause slagging and clinkering. Reciprocally, of course the air becomes heated, taking up heat from the ash. The development of heat is of course exothermic being that due to the oxidation of the fuel by the air; and this internal development of heat takes place generally throughout the conduit and the total length of the latter is preferably such that beyond the point where the air current is all converted into fuel gas, there will be a stretch of passage in which no further oxidizing chemical action can occur, so that in passing therethrough the gas will merely be cooled by association with the cool incoming fuel and will thus leave the discharge passage 8 in a relatively cool state, having given up much of its heat to the incoming fresh coal, thereby preparing the latter for its subsequent combustion, coking it and giving some combustible gas, if bituminous fuel be employed.

The continuous straight conduit indicated by Fig. 1 would, of course, in most cases be somewhat cumbersome and undesirable in practical operations, because of its length and for the reason that radiation losses would be excessive, and therefore it is desirable to divide the course of the fuel and air currents into successive sections which can be more compactly arranged in the producer apparatus. I have found that a form of roasting furnace now on the market can be readily adapted to my purposes, and Figs. 2 and 3 illustrate enough of such apparatus to indicate the manner of its use. In Fig. 2, the vertical cylindrical tower 9 of brick, is provided in its interior with a series of superposed annular shelves 10, each of which is provided with one or more openings or drop-holes 11 leading to the next lower shelf. The drop-holes of adjacent shelves are arranged out of vertical alinement with each other. A central hollow shaft (12) is appropriately journaled, as shown, to revolve within the series or stack of shelves, fitting the inner edges of the same in a substantially gas-tight manner, and a series of radial arms 13 is carried by the shaft extending into the compartments between the shelves. Each arm 13, of which there may be several for each compartment, is provided with depending plows or stirring blades 14, the whole organization being such that material deposited on the upper shelf will be progressively pushed or scraped by the arms or blades 14 around and across that shelf and toward the drop-holes 11 thereof, through which it will fall onto the next lower shelf, on which it will be similarly moved, by the arms and blades in that compartment, and dropped to the next lower shelf, and so on, until the lowermost shelf is reached, from which the material will be discharged through a short elbow conduit 15, to be thence removed. The ash outlet is normally closed by a weighted flap door, as shown, for preventing escape of the air current therethrough. There is thus provided, in compact form, a very long conduit through which the shallow fuel layer I have above described may be caused to travel. The fuel is introduced to the first or uppermost shelf from a feed hopper, indicated at 16, or by any suitable continuous feeding means adapted to prevent escape of gas therethrough, and the revolving blades 14 propel it with a plowing or stirring action around and across each annular shelf, thereby keeping it in constant agitation or commotion so that fresh fuel surfaces will be thereby presented to the action of the gas as above explained. The shelves should be placed close together as indicated so that the passage or gas space above the fuel layer on each shelf will form a relatively shallow passage, as indicated in Fig. 1. The air is introduced through an inlet 17 near the drop-hole of the lower shelf and passes upwardly through the successive drop-holes and successively through the shallow passages above the fuel stream on each of the annular shelves, burning with the fuel thereon in the meantime, and eventually becoming converted into fuel gas as it reaches the uppermost compartment from which it escapes through the gas outlet 18.

The air current traveling against the current of fuel is preferably not admixed with endothermic bodies, such as steam, but it is possible, nevertheless, to use steam with the air when it is desired to produce a gas rich in hydrogen, and it is possible to use "balanced drafts" of air and endothermic bodies, and particularly if the draft should be introduced hot, and to make use of other modifications as desired. The movement of the air current is preferably produced by pressure rather than by suction.

Where the fuel used is high in volatile constituents, as the case with lignite, gascoal, etc., the coking in the later stage and formation of gases becomes very useful, and one embodiment of the invention contemplates, as an additional step in the procedure above described, a preliminary heating of the incoming raw fuel, before it meets the gas current, for the purpose of distilling off the volatile and tarry gases therein, so that the latter can be either utilized separately or introduced into the course of the reactive current at a point where the heat will be sufficient to break them up into fixed gases suitable for admixture with the product gas. In Fig. 4 I have illustrated a general scheme of apparatus suitable for this purpose. The apparatus there shown is identical in structure with the apparatus already described except for the addition of several upper chambers near the top of the producer furnace proper, and the arrangement of their several communications. The uppermost chamber 18 has no gas outlet. The fuel introduced therein by the feed device and moved over the chamber floor by the stirrer blades 14 thereof, falls through the long channel or conduit 19, which leads through but not into the next lower chamber, and is deposited on the floor of the second lower chamber 20. In this chamber it is worked by the stirrer arms toward and eventually falls through another similar conduit 21, isolated from the next lower chamber 26 and leading to the second lower chamber, marked 22. From thence the fuel may pass successively and directly into each of the next lower chambers through the drop-holes 11 as in the case first described. The gas current passing from the lower chambers into the chamber 22 escapes into the chamber 26 and from thence through the flue 24 around fuel chamber 20, into the intermediate chamber 23, from whence it passes to the main gas outlet 25, giving up its heat in the meantime to the fuel chambers 18 and 20 which its path embraces. These chambers, it will be seen, thus serve as muffles in which the traveling fuel is distilled out of contact with the reactive gas current. In the present instance, the resulting tarry gases and products are allowed to pass along with the fixed carbon of the fuel becoming purified thereby into contact with the gas current at a point in the chamber 22, but they may be separately conducted to any desired point in the course of the said current, if preferred, so long as they thereby become subjected to a long enough and strong enough heating to break them up as above stated, and prevent their appearance as tarry matters in the product gas. It will be understood that the number of muffle chambers thus added to the producer apparatus proper is dependent upon the amount and nature of the volatile matters in the particular raw fuel, to the end of sufficiently separating them from the fixed carbon therein, and that the number or extent of the intermediate chambers constituting the delivery end of the long gas passage needs only be sufficient to insure the desired degree of heating. For this purpose complete heat reaction may be facilitated by interposing special means to that end in one or more of the gas chambers or passages, as for instance the brick checker-work indicated partially at 27 in the chamber 23.

If desired to introduce the tarry gases to the reactive current at a point beyond the point of introduction of the fuel, that is to say, at a point below the chamber 22, the stirrer blades 14 are arranged on their arms in the chamber 20 so as to keep the passage 21[a] leading to this chamber, always filled with fuel, as indicated at 28 in Fig. 5, which thus constitutes a gas seal confining the tarry gases to the muffle chambers, from whence they may be led off by a pipe or channel 29 or in any other suitable way, to the point where it is desired to introduce them into the course of the fuel and gas currents, as for instance at 30.

The relative amounts of fuel and of draft current fed into the producer should always be such as to allow the production of a combustible gas with a minimum of carbon dioxid as an effluent. Advantageously, the amount of air in the draft current is restricted to an amount which will cause reactivity of the draft current to stop at a point some distance short of the entry of the traveling layer of fuel into the apparatus.

What I claim is:

1. The process of producing combustible gas which comprises forming and maintaining a relatively thin traveling layer of ignited fuel, passing above such traveling layer in an opposite direction of flow, a substantially unobstructed relatively thin current of reactive gas, initially comprising air and continuing the travel of the fuel in contact with said gas until said fuel substantially disappears.

2. The process of producing combustible gas which comprises forming a relatively thin traveling layer of ignited fuel and maintaining the same in commotion during its travel, passing above and in contact with such traveling agitated layer, in an opposite direction of flow, a shallow current of reactive gas suited to combine with such fuel and produce the combustible gas and continuing the travel of the fuel in contact with said gas until said fuel substantially disappears.

3. The process of producing combustible gas which comprises forming and maintaining a relatively thin traveling layer of ignited and oxidizing fuel, passing above such traveling layer in an opposite direction of flow a substantially unobstructed relatively thin stream of reactive gas comprising air, the flow of the stream of combustible gas formed from said reactive gas being continued in contact with said traveling layer for a substantial distance past the point where reaction is substantially complete.

4. The process of producing combustible gas comprising, forming and maintaining a series of moving, relatively thin, layers of ignited and oxidizing fine fuel, one such layer supplying the next such layer, and passing over the successive layers in a direction opposed to the general line of travel of such layers a relatively thin unobstructed stream of reactive gas comprising air, said stream being supplied in amount only sufficient to produce combustible gas.

5. The process of producing combustible gas comprising, forming and maintaining a series of successive, moving, relatively thin layers of ignited oxidizing fine fuel, one such layer supplying the next such layer, and passing over the successive layers in a direction opposed to the general line of travel of such layers, a relatively thin unobstructed stream of reactive gas comprising air, the flow of the stream of combustible gas formed from said reactive gas being continued in contact with said traveling layers for a substantial distance past the point where reaction is substantially complete.

6. The process of producing combustible gas which comprises feeding ignited and oxidizing fine fuel in thin traveling layers over the floors and through a succession of connected, superposed and relatively low chambers against opposed, relatively shallow, currents in the successive chambers of reactive gas comprising air, said currents being supplied in amount only sufficient to produce combustible gas.

7. The process of producing combustible gas which comprises feeding fine fuel as a thin, traveling layer through a conduit of progressively increasing temperature, conducting a relatively shallow current of reactive gas comprising air over and in contact with such layer in an opposite direction, and diverting such current from contact with said fuel at a point where it has become freely combustible.

8. The process of producing combustible gas, which comprises feeding and forming a layer of ignited and oxidizing coal-dust upon the floor of a shallow chamber and causing the same to advance toward the point of exit by stirring or plowing the same, passing a relatively shallow unobstructed reactive gaseous current through said chamber above and in contact with said fuel layer, and withdrawing said current from said chamber near the point of fuel feed, said current being supplied in amount only sufficient to produce combustible gas.

9. The process of producing combustible gas, which comprises feeding fine fuel as a thin layer upon the floor of a relatively low chamber, stirring said layer to cause it to

move over said floor to a point of exit, in contact with a shallow current of heated gases, transferring the fuel to a similar floor in a similar chamber and repeating the operation until in a final chamber it is consumed to ash, said final chamber being fed with a current of reactive gas comprising air and said current passing therefrom through the plurality of chambers until it is removed from the chamber wherein the fresh fuel is fed as combustible gas, the amount of air supplied being merely that sufficient to allow the production of combustible gas.

10. The process of producing combustible gas, which consists in preliminarily separating the volatile matters from the fixed carbon of the fuel, advancing the latter through a long conduit in contact with a relatively shallow overlying unobstructed counter current of reactive gas comprising air, and converting said separated volatile matters into fixed gases by introducing the same into a hot part of the said gas current.

11. The process of producing combustible gas, which consists in feeding fuel through a heated muffle and thence advancing the same as a shallow traveling layer in contact with a shallow counter current of reactive gas comprising air.

12. The process of producing combustible gas, which consists in feeding fuel through a muffle chamber and thence advancing the same to an ash outlet, as a traveling fuel layer, advancing a shallow overlying substantially unobstructed counter current of reactive gas comprising air from the ash outlet to the muffle, in contact with said fuel layer, and transferring the heat of said current to the said muffle chamber.

13. The process of producing combustible gas, which comprises feeding fuel into a heated muffle chamber to separate the volatile matters from the fixed carbon thereof, conducting said carbon and the volatile matters in separated condition to a point in a long combustion passage, advancing the carbon through said passage as a traveling fuel layer, and simultaneously passing an overlying substantially unobstructed counter current of reactive gas comprising air through said passage in contact with the fuel layer, whereby the said volatile matters become converted into permanent gases.

14. The process of producing combustible gas which comprises advancing a shallow traveling layer of fuel in one direction in a heated region and advancing a shallow traveling layer of a current of reactive gas comprising air thereover in the opposite direction and in contact with said fuel, the amount of air in said current being merely sufficient to maintain reaction in said fuel and to produce combustible gas.

15. The process of producing combustible gas which comprises advancing a shallow traveling layer of fuel in one direction in a heated region and advancing a shallow traveling layer of a current of reactive gas comprising air thereover in the opposite direction and in contact with said fuel, the amount of air in said current being merely sufficient to maintain reaction in said fuel and to produce combustible gas, and transferring the heat of the products of reaction to said traveling layer of fuel beyond the point of initial reaction.

16. The process of producing combustible gas which comprises advancing a shallow traveling layer of fuel in one direction in a heated region and advancing a shallow traveling layer of a current of reactive gas comprising air thereover in the opposite direction and in contact with said fuel, the amount of air in said current being merely sufficient to maintain a reaction in the traveling layer of fuel to a distance less than the total path of travel of such layer.

17. The process of producing combustible gas which comprises forming or maintaining a relatively thin traveling layer of heated fuel and passing above such traveling layer in a generally opposite direction a relatively thin or shallow contacting draft current of a fuel-oxidizing character, the temperature conditions and the relative amounts of said fuel and of said draft current being so correlated that the draft current passes away from contact in a freely combustible condition while the fuel is substantially completely consumed.

18. The process of producing combustible gas which comprises forming or maintaining a relatively thin traveling layer of heated fuel and passing above such traveling layer in a generally opposite direction a relatively thin or shallow contacting draft current of a fuel-oxidizing character, the temperature conditions and the relative amounts of said fuel and of said draft current being so correlated that the draft current passes away from contact in a freely combustible condition while the fuel is substantially completely consumed, said contact however of the draft current with the heated fuel being maintained for a time after reaction therebetween ceases.

19. The process of producing combustible gas which comprises forming or maintaining a relatively thin traveling layer of heated fuel and passing above such traveling layer in a generally opposite direction a relatively thin or shallow contacting draft current of a fuel-oxidizing character, the temperature conditions and the relative amounts of said fuel and of said draft current being so correlated that the draft current passes away from contact in a freely

combustible condition while the fuel is substantially completely consumed, and that the draft current passes for a time in contact with a traveling layer of heated ash prior to encountering combustible fuel in said layer.

In testimony whereof, I have signed this specification in the presence of two witnesses.

JAMES ARTHUR SINGMASTER.

Witnesses:
A. K. JACKS,
LIZZIE KUAUSS.