H. L. DOHERTY.

PROCESS OF MAKING GAS.

APPLICATION FILED JUNE 22, 1909.

1,008,450.

Patented Nov. 14, 1911

3 SHEETS—SHEET 1

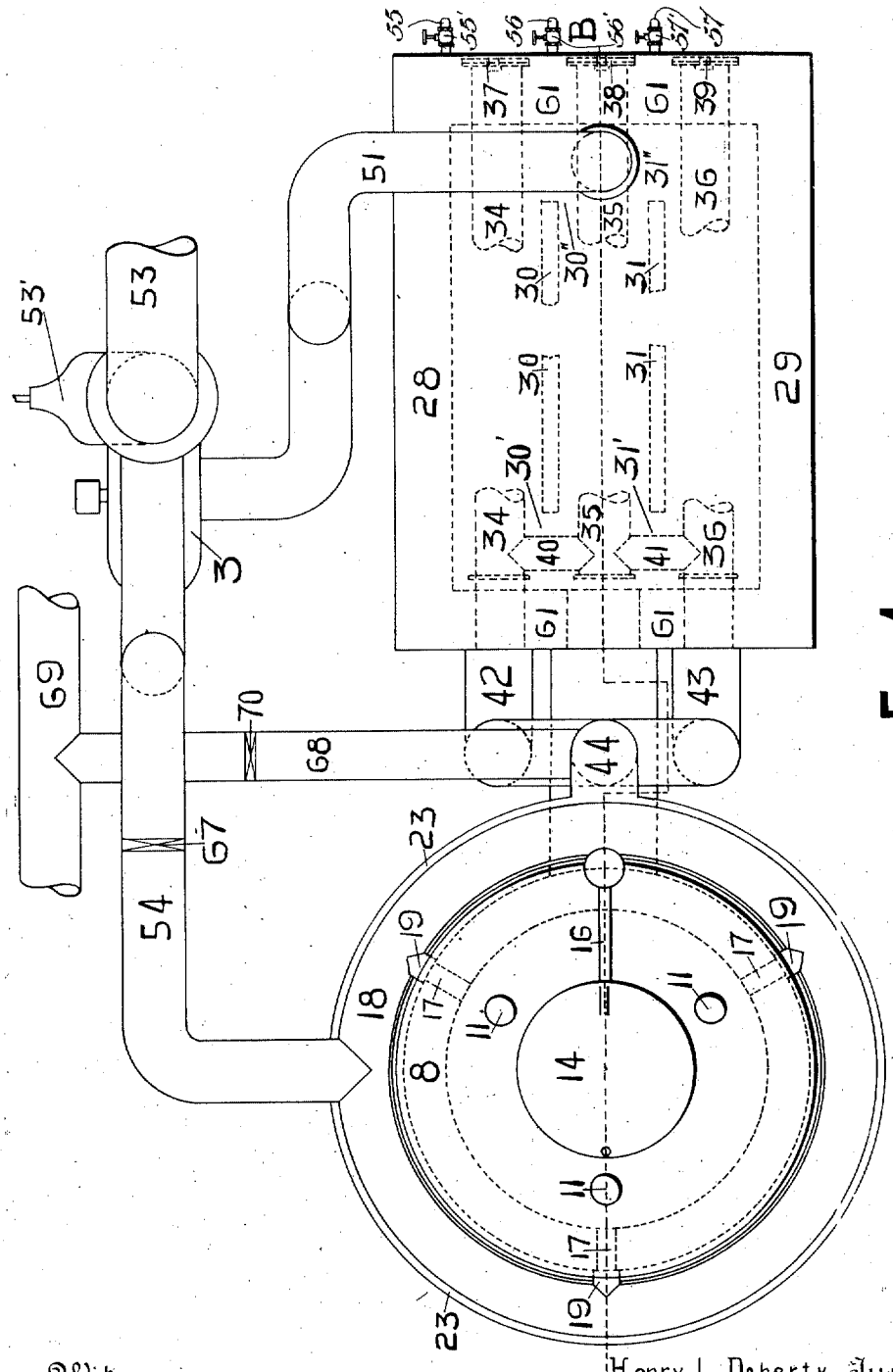

FIG. 1.

Witnesses:
Nelson G. Berryman
Fred B. Mulcox

Henry L. Doherty, Inventor
By his Attorney Frank S. Young

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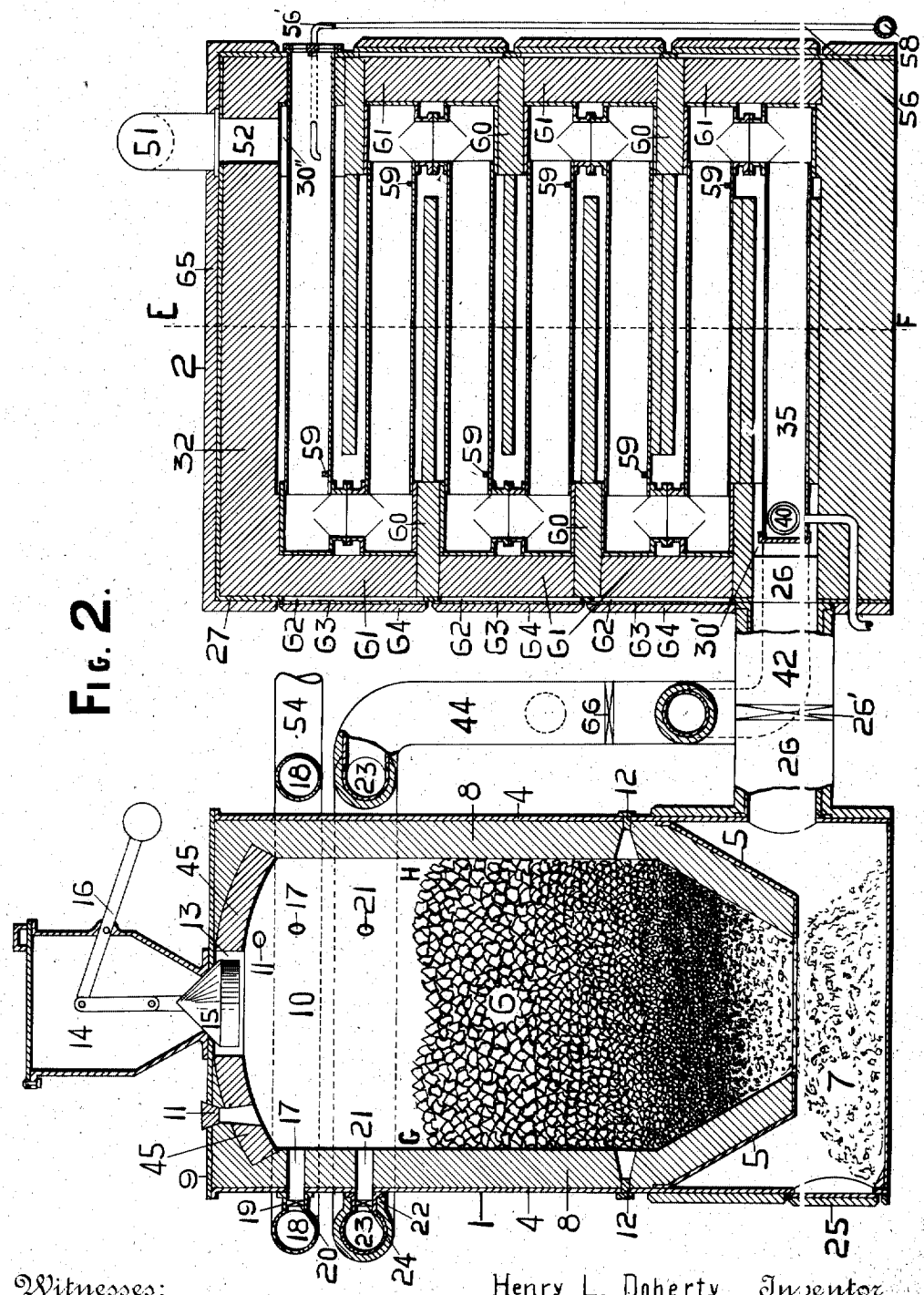

FIG. 2.

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3 SHEETS—SHEET 3.

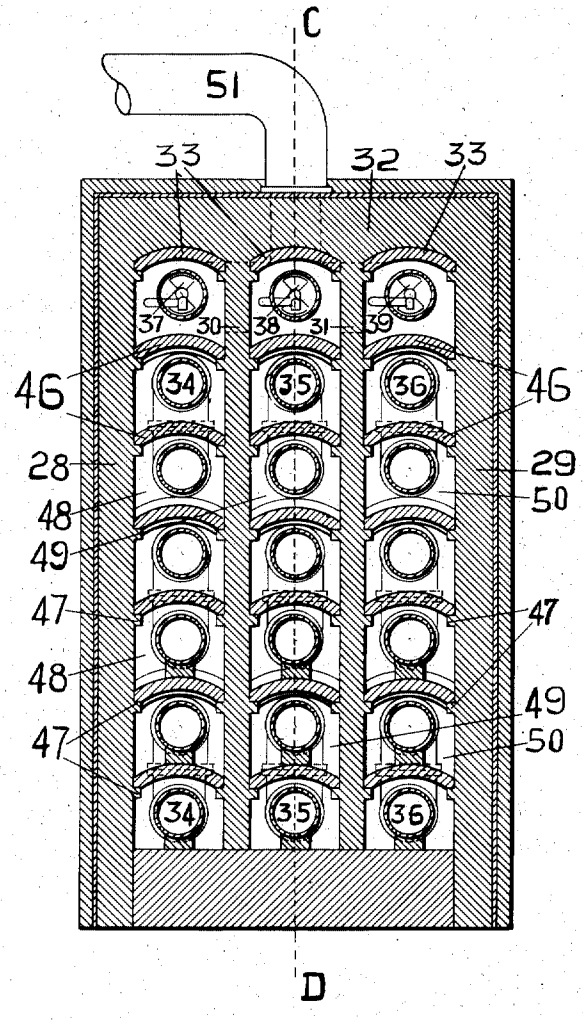

FIG. 3.

Witnesses:
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UNITED STATES PATENT OFFICE.

HENRY L. DOHERTY, OF NEW YORK, N. Y.

PROCESS OF MAKING GAS.

1,008,450. Specification of Letters Patent. Patented Nov. 14, 1911.

Application filed June 22, 1909. Serial No. 503,747.

To all whom it may concern:

Be it known that I, HENRY L. DOHERTY, a citizen of the United States, residing at New York city, in the county of New York and State of New York, have invented new and useful Improvements in Processes of Making Gas, of which the following is a specification.

My invention relates to processes for gasifying bituminous slack, and particularly to that kind of such processes in which the bituminous slack is subjected to a preliminary coking operation and the volatile products of the coking operation passed downward through a deep bed of coke from previously coked slack.

The particular object of my invention is the furnishing of a method whereby "slack" bituminous coal may be gasified, in such a way as to permit of the use of a bed of fuel in the gas producer of the depth customary in practice.

With the processes of gasification in producers, at present in use, it is, practically, impossible to use slack or fine coal as the fuel, owing to the tendency of the slack to pack and cake. This causes the formation of a dense impenetrable layer of material in the upper portion of the fuel bed which cuts off the draft of the gaseous current therethrough necessitating the use of an abnormally high blast pressure to insure the penetration of the blast, which, in turn, causes a disarrangement of the gasifying process, with a low make of gas of poor quality. Besides, in the ordinary updraft producer, the high percentage of ash of easy fusibility in most forms of slack coal, makes its use impossible owing to the excessive formation of clinkers.

In the herein-revealed process of gasification, I accomplish the above mentioned object by subjecting the freshly charged slack to a coking temperature immediately upon its entry into the producer chamber by burning a portion of the gas made in the upper part of said chamber in immediate contact with the latest charged layer of fuel in said chamber. By this treatment, the fine slack is quickly coked with the formation of comparatively large aggregates. The coking is accompanied by an initial swelling of the mass, followed by a contraction, which causes a cracking and fissuring of the masses, first formed. By using comparatively small charges and charging at frequent intervals, I am able, in this way, to keep the fuel bed in an open condition, the coked slack being in comparatively large pieces, thus leaving a due proportion of voids in the fuel bed. The combustion gases from the gas flame, the excess air and the distillation gases from the raw coal, are drawn down into the fuel bed, and react with the carbon therein, with the ultimate formation of a rich producer gas, and the entire avoidance of tar in the finished gas.

In the drawings, Figure 1 shows a diagrammatic plan of the apparatus for applying my process. Fig. 2 is a vertical, longitudinal, section through the apparatus, somewhat diagrammatic in character, taken on a plane through the line A B of Fig. 1 and C D of Fig. 3. Fig. 3 is a cross-section on a vertical plane through the recuperator on the line E F of Fig. 2 looking toward the gas discharge end.

1, designates the gas producer, 2 is an apparatus for vaporizing water and preheating the air-water vapor current supplied to the producer.

3, is an exhauster having its suction-pipe connected with the gas discharge pipe of the recuperator.

The gas producer has a metal shell, 4, with an inverted truncated conical shell, 5, attached to its interior near the bottom, thereof. 5, divides 1 into an upper or gasifying chamber, 6, and a lower or ash chamber, 7. Supported by 5 is a thick refractory lining, 8, to the chamber 6. A thick dome, 45, likewise of refractory material, protects the top, 9, of the producer from the high temperature prevailing in the upper portion of the gasifying chamber, 6, which I will designate, 10. Poke-holes, 11, in the top of the producer, closed by suitable plugs, permit of access to the fuel bed for the purpose of barring the same, when necessary. Similar poke-holes, 12, around the periphery of the chamber, 6, just above the conical bottom thereof, permit of the barring of the lower part of the fuel bed at the ash zone, thereof. An opening, 13, in the dome of

the producer establishes communication between the chamber 6 and a charging hopper, 14. 14, has a conical shaped plug, 15, of refractory material closing its bottom. This plug, 15, is actuated by a lever mechanism, 16.

The upper portion of the gasifying chamber 6, which I have designated, 10, has a plurality of passages, 17, in its walls which communicate with a bustle-pipe, 18, through the short connecting pipes, 19, on which are valves, 20. The bustle-pipe, 18, serves to distribute the gas, which is returned to the producer, to the gas inlets, 17. Passages, 21, connect through the pipes 22 with an air bustle-pipe, 23. Valves, 24, on 22, regulate the supply of air to the passages 21.

The ash chamber, 7, is provided with an ash door, 25, and has a gas discharge-conduit, 26, conducting the gas from the chamber 7 of the producer to the recuperator, 2. Recuperator 2, has a metal shell, 27, with lining walls, 28 and 29, therein; walls, 30 and 31, divide the main chamber inclosed by the shell into three compartments. Each of these compartments has an arch at its top supported by the walls mentioned, which arches, 33, together support the layer of non-conducting material, 32, which prevents the loss of heat by conduction and radiation to the surrounding air. Located in these compartments are return-bend flues, 34, 35 and 36. The upper sections of these flues are prolonged through the wall of the recuperator and have dampers, 37, 38 and 39, respectively, for regulating the admission of air, thereto. In operation the air enters the flues 34, 35 and 36, through the dampers, mentioned, and passes down through the recuperator. The lowest section of the flue 35 has cross-connections, 40 and 41, to the flues 34 and 36, respectively. The flues 34 and 36 are prolonged through the wall of the recuperator and connected by the pipes, 42 and 43, with the main hot air pipe, 44, which conducts the hot air to the air bustle-pipe, 23.

Each of the three compartments or stalls of the recuperator 2 is subdivided by arch-shaped tiles, 46, supported by ledges, 47, formed by letting rows of the bricks of which the wall is formed project. The compartments are thus subdivided into substantially horizontal sub-flues. By omitting one or more of the tiles, 46, at alternate ends of adjacent sub-flues, communication is established between the sub-flues in such a way as to form a continuous return-bend flue of each of the compartments, numbered 48, 49 and 50, respectively, the said return-bend flues enveloping the air flues, 34, 35 and 36. Flues, 30′ and 31′, in the walls 30 and 31, respectively, establish a cross-connection between the lowest sections of the flues 48, 49 and 50. The gas conduit 26 communicates with the lowest section of 49, and through 30′ and 31′ with 48 and 50, respectively. The uppermost sections of 48, 49 and 50 have a cross-connection through the flues 30″ and 31″ in the walls 30 and 31. A pipe, 51, connects with the passage, 52, opening out of the uppermost section of 49. This pipe, 51, conducts the comparatively cool gas from the recuperator to the exhauster, 3. The discharge-pipe, 53, of the exhauster has a valve or damper, 53′, and opening out of it below the damper, 53′, a pipe, 54. This pipe, 54, is connected with the gas bustle-pipe, 18.

To the uppermost sections of the air flues 34, 35 and 36 are connected water pipes, 55, 56 and 57, which latter are all connected with the common service pipe, 58. Valves, 55′, 56′ and 57′, on the respective pipes regulate the flow of water therethrough. Obstructions, or dams, 59, in each section of the air flues serve to retain a shallow layer of water in the section when water is supplied thereto. Arches, 60, at either end of the sub-flues of the gas flues 48, 49 and 50, serve to furnish support to the sections of the air flues. The space at each end of each section of the sub-flues of 48, 49 and 50 between the shell and the ends of the sections of 34, 35 and 36 is filled in with blocks, 61, of some good non-conducting, refractory material. Openings, 62, are provided in the shell of the recuperator, opposite each end of each section of the sub-flues of 48, 49 and 50, provided with covers, 63. Slabs of lagging, 64, cover each of the doors or covers 63, and a jacket, 65, the remainder of the shell.

Valves, 66 and 67, on 44 and 54, respectively, and 26′ on 26 serve to cut off communication between the gas producer, 1, and the recuperator, 2, when it is desired to "bank" the former during a temporary shut down or, to repair the apparatus.

The method of operation is as follows: To start the producer, cinder, or other material, is charged into the producer until a bed of such material has been built up to about the level of the poke-holes, 12. Coke is now charged until a thick bed has been built up in the chamber 6, reaching to the line G H, which indicates the level at which I prefer to carry my fuel bed. Kindling is now placed upon the top of the fuel bed, the valves 24, 53′ and 26′ and dampers 37, 38 and 39 are opened and the exhauster, 3, started. The kindling is now ignited, the hot combustion gases being drawn down through the fuel bed in chamber 6, through the pipe 26 and the flues 48, 49 and 50 of the recuperator, and out from the latter by 52 and 51 to the exhauster, discharging from the latter through the pipe 53, and thence through a valved bleeder (not shown) to the

atmosphere. As the combustion penetrates into the fuel bed, the character of the gas changes from one containing, principally, CO_2 and N to one containing, principally, CO and N or, in other words, to a producer gas. When this condition has been attained the valves 20 and 67 are partly opened, permitting a portion of the gas passing through 53, to pass through 54, 18 and the passages 17 and 19, into the combustion chamber, 10. The high temperature prevailing in 10 causes the ignition of the gas immediately on issuing from the passages 17, the flame, under the influence of the draft produced by the exhauster, being drawn downward and into the fuel bed. The producer is now in condition to begin the normal production of gas. Raw coal—bituminous slack, for example—is charged onto the fuel bed and spread, if necessary, by bars introduced through the poke-holes 11. It is immediately subjected to the high temperature prevailing in 10, and rapidly coked. The products of the combustion of the gas and the distilled matter from the coal pass down through the incandescent coke, some of the constituents of the gases reacting with the coke. These reactions absorb heat from the lower portion of the fuel bed, there being a gradual drop in temperature in the fuel bed from the top thereof down into the ash chamber.

In order to insure that the temperature in the lower part of the fuel bed shall be low enough to prevent clinkering of the ash of the fuel, I load the air current supplied to the producer with a sufficient quantity of an agent, such as carbonic acid or water, having an endothermic reaction with carbon, to cause an absorption of heat sufficient to keep the temperature in the lower layers of fuel at a safe point. This temperature varies for each coal and, often, with the different grades of coal from the same vein—the average being, about, 1800° F. In regard to the endothermic agent used, I may, either, use flue gases from boiler or other furnaces or from the exhaust of a gas engine, containing a considerable proportion of CO_2. Which is used depends upon the quality of gas desired and upon the local conditions. When a gas high in hydrogen is desired, as, for instance, when the gas is to be used for high temperature work, I use water as the endothermic agent. When the gas is to be used for gas engines, I prefer to use products of combustion on account of the greater uniformity in the quality of the gas which I am able to secure in that way. When I use flue gas as the endothermic agent, I simply open valve 70, partially closing dampers 37, 38 and 39, until the proper proportion of the gas is being drawn in with the air current to insure the maintenance of the proper temperature gradient in my producer. The suction of the exhauster is, usually, sufficient to overcome the partial vacuum in the flue 69 and draw in the flue gas with the air. Of course, should the suction of the exhauster be insufficient to overcome the partial vacuum in 69, a separate draft-producing means may be used on the flue gas line, 68.

In the usual method of operating gas producers with down-draft, there is always a comparatively thick layer of raw coal on top of the incandescent carbon. Now, since the depth of the fuel bed is limited by the risistance to the passage of the draft current offered by the total thickness of the fuel and ashes, it is apparent, that, in the method of working heretofore used, the ignited zone of the fuel bed has been comparatively limited. This has resulted in a considerable part of the hydrocarbons distilled off from the coal going through the fuel bed unchanged. Likewise, in working with an up-draft, the hydrocarbons of the coal are distilled off at a comparatively low temperature and, in this case, do not come into contact at all with incandescent carbon. In both the usual methods of working, therefore, the use of bituminous coal in producers, in connection with a recuperative system, is practically impossible, on account of the condensation of tarry matter in the flues of the recuperator. When the gas is to be used for gas engines, the presence of tar is still more objectionable as it soon clogs the valves, etc., rendering operation of the engine impossible. By my method of working, according to the herein revealed process, I secure a practically complete elimination of all tarry matter from the gas. By passing the heavy tarry vapors, which are the initial products of the distillation of bituminous coal, through the incandescent coke, I "crack" them down completely to compounds of lower molecular weight and free hydrogen, which are all, either, permanent gases (so-called) or difficultly-condensable vapors. Many of these, such as benzene, ethylene, etc., possess a very high calorific and illuminating value. In the ordinary method of working, where the heavy products of the initial distillation are condensed from the gas, the fuel and illuminating value of such compounds are lost to the gas. The presence of illuminants in a producer gas increases its practical heating effect in a greater proportion than the actual B. T. U. added to the gas. This is due to the fact that a luminous flame has a much higher heat-radiating value than a non-luminous flame. Besides retaining in the gas, therefore, all of the calorific value of the original coal that is practically possible, I, in my present process, so modify the

gas, as compared with ordinary producer gas, as to obtain greater percentage efficiency for its practical heating value than is obtained with ordinary producer gas.

When flue gas is used as the medium of endothermic control in my present process, the reactions which take place are as follows:—The hot current of air and flue gas (containing CO_2) burns the gas entered in chamber 10. The gaseous current passing into the fuel bed consists of N_2, CO_2, O_2 and H_2O (vapor). In contact with the incandescent carbon the CO_2 of the gas is dissociated according to

$$(1)\quad CO_2+C=2CO.$$

The water vapor being present in small quantity, in this case, since it is derived exclusively from the water vapor in the air and the hydrogeneous compounds of the coal, is dissociated almost exclusively by the reaction,

$$(2)\quad H_2O+C=H_2+CO.$$

The O_2 reacts with the C according to

$$(3)\quad O_2+C_2=2CO,$$

since sufficient CO_2 is mixed with the gaseous current to satisfy the equilibrium tension of CO_2 under the conditions in the fuel bed.

Since, according to the well known chemical laws, reactions in which gases are involved only proceed to the point where the gases have attained to the equilibrium tension corresponding to the conditions under which the operation is carried on, there is always present in the finished gas a small proportion of CO_2. As, in the above described modification of my method I am adding CO_2 to the draft current supplied to the producer, I satisfy the necessary equilibrium tension of CO_2 in the finished gas by CO_2 produced outside of the gas-making fuel bed. I am, therefore, able in this modification to burn all of the fuel in my producer to CO. When it is remembered that, in ordinary producer practice, seldom less than 10% of the carbon burns to CO_2, a gas useless for combustion, the great advantage that I secure by the modification mentioned is obvious.

Since in my Letters Patent, 829,105, dated Aug. 21, 1906, and 848,729, dated Apr. 2, 1907, I have described and claimed the use of products of combustion for endothermic control of the temperature of the fuel bed in gas producers, I only claim it herein as it forms a step in my present process.

When, for any reason, it is desirable to use water vapor as the medium of endothermic control instead of CO_2, the reactions which take place are as follows:—As before, the draft current of air and water vapor burns the gas in 10, the gaseous current entering the fuel bed consisting of N_2, CO_2, O_2 and H_2O vapor. The CO_2 is dissociated, as before, by

$$CO_2+C=2CO.$$

The water, in the upper and hotter portion of the fuel bed dissociates, principally, according to

$$H_2O+C=H_2+CO.$$

In the lower part of the fuel bed, however, where the temperature is designedly kept at a low plane, the conditions favor the dissociation of such of the water vapor as penetrates to this zone of the fuel bed according to the reaction

$$2H_2O+C=2H_2+CO_2.$$

The O_2 of the draft current reacts according to the ordinary producer reaction,

$$O_2+C_2=2CO,$$

sufficient CO_2 being formed from the initial combustion of the gas to satisfy the equilibrium pressure of CO_2 under the conditions in the fuel bed.

Briefly, my invention may be summarized, as a method of gasifying slack bituminous coal by subjecting the freshly charged coal to the direct action of a coking flame, and passing the products of combustion of such flame, the draft current supplied to the producer, and the distillation gases from the coal, down through the fuel bed in a common current, sufficient endothermic agent being supplied to the draft current to keep the lower part of the fuel bed in the producer below the clinkering temperature of the coal.

Having described my invention, what I claim is:—

1. The process of gasifying slack coal which consists in charging repeated small portions of the said slack coal onto a bed of ignited coke in a gas producer, said coke being derived from previous portions of said slack, subjecting each of said small portions of slack coal to coking by directly contacting the same with a flame of previously made gas from said slack, whereby the said slack is formed into masses of coke, breaking up said masses of coke, introducing a draft current of air commingled with water vapor into the upper part of said gas producer above the bed of fuel in the same, whereby the combustion in the said flame is sustained and the combustible volatile matter distilled from the said coal slack is burned, passing the products of the said combustions and the excess of air and water vapor downward through the fuel bed of said producer and withdrawing the combustible gas so formed, substantially as described.

2. The process of gasifying slack coal which consists in charging said coal onto a

bed of ignited fuel in a down-draft gas producer, burning a portion of the previously made gas from said gas producer in contact with the freshly charged slack, evaporating water and heating air by the sensible heat of the gas discharging from said gas producer, passing the so heated air and water vapor into the gas producer above the fuel bed therein, whereby oxygen is supplied for burning said portion of gas and the distillation products of said slack coal, passing the excess air, the water vapor and products of said combustion downwardly through said bed of ignited fuel, and removing from the lower part of said bed the gaseous products resulting from contacting the said air, water vapor and products of combustion with the incandescent carbon of said fuel bed, substantially as described.

3. The process of making gas in a down-draft gas producer which consists in repeatedly charging small portions of slack coal onto the fuel bed in said gas producer, coking said coal by burning a portion of the gas previously made in said gas producer in contact with said coal by air preheated by the gas discharging from said gas producer, whereby the fine slack coal is caused to form into coherent lumps of coke and the fuel bed is kept in a condition permeable to the draft current, commingling with the gases from said coking operation, another portion of air and a sufficient quantity of a gas reacting endothermically with incandescent carbon to reduce the temperature in the lower portion of said fuel bed below the clinkering temperature of the ash of said coal, the said air and endothermically-reacting gas having been preheated by the sensible heat of the gas discharging from said producer, passing said commingled gases downward through the fuel bed in said gas producer, and withdrawing from said fuel bed the gases resulting from the contacting of said commingled gases and the carbon of said fuel bed, substantially as described.

4. The process of making gas in a down-draft gas producer, which consists in charging successive portions of coal onto the fuel bed in said gas producer, coking said coal by burning a portion of the gas previously made in said gas producer in contact with said coal by air preheated by the gas discharging from said gas producer, commingling with the gases from said coking operation, another portion of air and a sufficient quantity of water vapor to reduce the temperature in the lower part of said fuel bed below the clinkering temperature of the ash of said coal, the said water vapor having been evaporated and the air and water preheated by the sensible heat of the producer gas discharging from said gas producer, passing said current of commingled gases and vapors downward through the fuel bed of said gas producer, and withdrawing from the lower part of said fuel bed the gases resulting from the contact of said commingled gases with the incandescent coke of said fuel bed, substantially as described.

5. The process of making gas which consists in continuously conducting the hot producer gas from a gas producer through the gas flues of a recuperator, continuously passing air through the air flues of said recuperator, whereby a portion of the sensible heat of said producer gas is transferred to said air, conducting a portion of the gas discharging from said recuperator to the upper part of the gasifying chamber of said gas producer, and repeatedly charging portions of coal onto the fuel bed in said gas producer, admixing with said heated air sufficient of a fluid reacting endothermically with incandescent carbon to reduce the temperature in the lower part of the fuel bed in said gas producer below the clinkering temperature of the ash of the fuel therein, conducting said heated air and endothermic fluid to the upper part of the gasifying chamber of said gas producer, whereby the said portion of gas is burned therein in contact with the freshly charged coal in said producer by a portion of said heated air, whereby the volatile matter of said coal is distilled therefrom and burned, passing the remainder of said heated air, the said endothermic fluid and the products of the combustion of said volatile matter downward through the bed of incandescent fuel in said gas producer, and withdrawing from the lower part of said fuel bed the gases resulting from the contact of said air, endothermic fluid and products of combustion and the incandescent fuel, substantially as described.

6. The process of making gas which consists in continuously conducting the hot producer gas from a gas producer through the gas flues of a recuperator, evaporating water in the air flues of said recuperator in sufficient quantity to furnish sufficient water vapor to reduce the temperature of the fuel bed in said gas producer below the clinkering temperature of the ash of the fuel burned therein, passing air in admixture with the water vapor from said evaporation through the said air flues, whereby the major portion of the sensible heat of said producer gas is transferred to said air-water-vapor-current, conducting a portion of the gas discharging from said recuperator to the upper portion of the gasifying chamber of said gas producer, repeatedly charging small portions of coal onto the fuel bed of said producer, conducting the heated current of air and water vapor to the upper part of the gasifying chamber of said gas producer, whereby the said portion of gas returned to the gasifying chamber

of said gas producer is burned and each of said portions of coal is coked and its volatile matter distilled therefrom and burned by a portion of said air before the charging of another portion of coal, passing the remainder of said heated air, the said water vapor and the products of the combustion in the upper part of said gas producer through the bed of incandescent coke in said gas producer, and withdrawing from the lower part of said fuel bed the gases resulting from the contact of said air, water vapor and combustion products with the coke, substantially as described.

7. The process of making gas in a downdraft producer which consists in repeatedly charging slack coal onto the fuel bed in said producer, coking said coal by burning a portion of the gas previously made in said producer in contact with said coal by air preheated by the gas leaving said producer, commingling with the gases from said coking operation, another portion of air and a sufficient quantity of a gas reacting endothermically with incandescent carbon to reduce the temperature in the lower portion of said fuel bed below the clinkering temperature of the ash of said coal, the said air and endothermically reacting gas having been preheated by the sensible heat of the gas leaving said oven, passing said commingled gases downward through the fuel bed in said producer, and withdrawing from said fuel bed the gases resulting from the contacting of said commingled gases and the carbon of said fuel bed, substantially as described.

8. The process of making gas in a downdraft producer, which consists, in charging coal onto the fuel bed in said producer, coking said coal by burning a portion of the gas previously made in said producer in contact with said coal by air preheated by the gas leaving said producer, whereby the fuel bed is kept in a condition easily permeable to draft current passing therethrough, commingling with the gases from said coking operation, another portion of air and sufficient water vapor to reduce the temperature in the lower portion of said fuel bed below the clinkering temperature of the ash of said coal, the said water vapor having been evaporated and the air and water preheated by the sensible heat of the producer gas leaving said gas producer; passing said current of commingled gases and vapors downward through the fuel bed of said producer, and withdrawing from the lower part of said fuel bed the gases resulting from the contacting of said commingled gases and the incandescent coke of said fuel bed, substantially as described.

9. The process of making gas which consists in continuously conducting the hot producer gas from a gas producer through the gas flues of a recuperator; continuously passing air through the air flues of said recuperator, whereby a portion of the sensible heat of said producer gas is transferred to said air; conducting a portion of the gas leaving said recuperator to the upper part of the gasifying chamber of said producer repeatedly charging slack coal in comparatively small portions into said producer; admixing with said heated air sufficient of a fluid reacting endothermically with incandescent carbon to reduce the temperature in the lower part of the fuel bed in said gas producer below the clinkering temperature of the ash of the fuel, therein; conducting said heated air and endothermic fluid to the upper part of the gasifying chamber of said producer, whereby, the said portion of gas therein is burned in contact with said coal by a portion of said heated air, whereby the volatile matter of said coal is distilled therefrom; passing the remainder of said heated air, the said endothermic fluid and the gases distilled from said coal downward through the bed of incandesent fuel in said gas producer; and withdrawing from the lower part of the said fuel bed the gases resulting from the contacting of the said heated air, the said endothermically reacting fluid, the gases from the combustion in the upper part of the gasifying chamber and the volatile matter of said coal, with the incandescent coke, substantially as described.

10. The process of making gas, which consists, in continuously conducting the hot producer gas from a gas producer through the gas flues of a recuperator; evaporating water in the air flues of said recuperator in sufficient quantity to furnish sufficient water vapor to reduce the temperature of the fuel bed in said producer below the clinkering temperature of the ash of the fuel therein the said water being evaporated by the sensible heat of the said producer gas; passing air in admixture with the water vapor from said evaporation through the said air flues whereby, another portion of the sensible heat of said producer gas is transferred to said air-water-vapor current; conducting a portion of the gas leaving said recuperator to the upper part of the gasifying chamber of said producer; charging coal onto the fuel bed of said producer; conducting the heated current of air and water vapor to the upper part of the gasifying chamber of said producer; whereby, the said portion of gas therein is burned in contact with said coal by a portion of said heated air, whereby the volatile matter of said coal is distilled therefrom; passing the remainder of said heated air, the said water vapor, the gases from the burning of said portion of gas and the distillation gases from the coal downward through the bed of incandescent

coke in said gas producer; and, withdrawing from the lower part of said fuel bed, the gases resulting from the contacting of the said heated air, the said water vapor, the combustion gases formed in the upper portion of the gasifying chamber, and the distillation gases from the coal, and the incandescent coke, substantially as described.

Signed at New York city in the county of New York and State of New York this 18th day of June, A. D. 1909.

HENRY L. DOHERTY.

Witnesses:
WILSON G. BERRYMAN,
FRED B. MULCOX.