

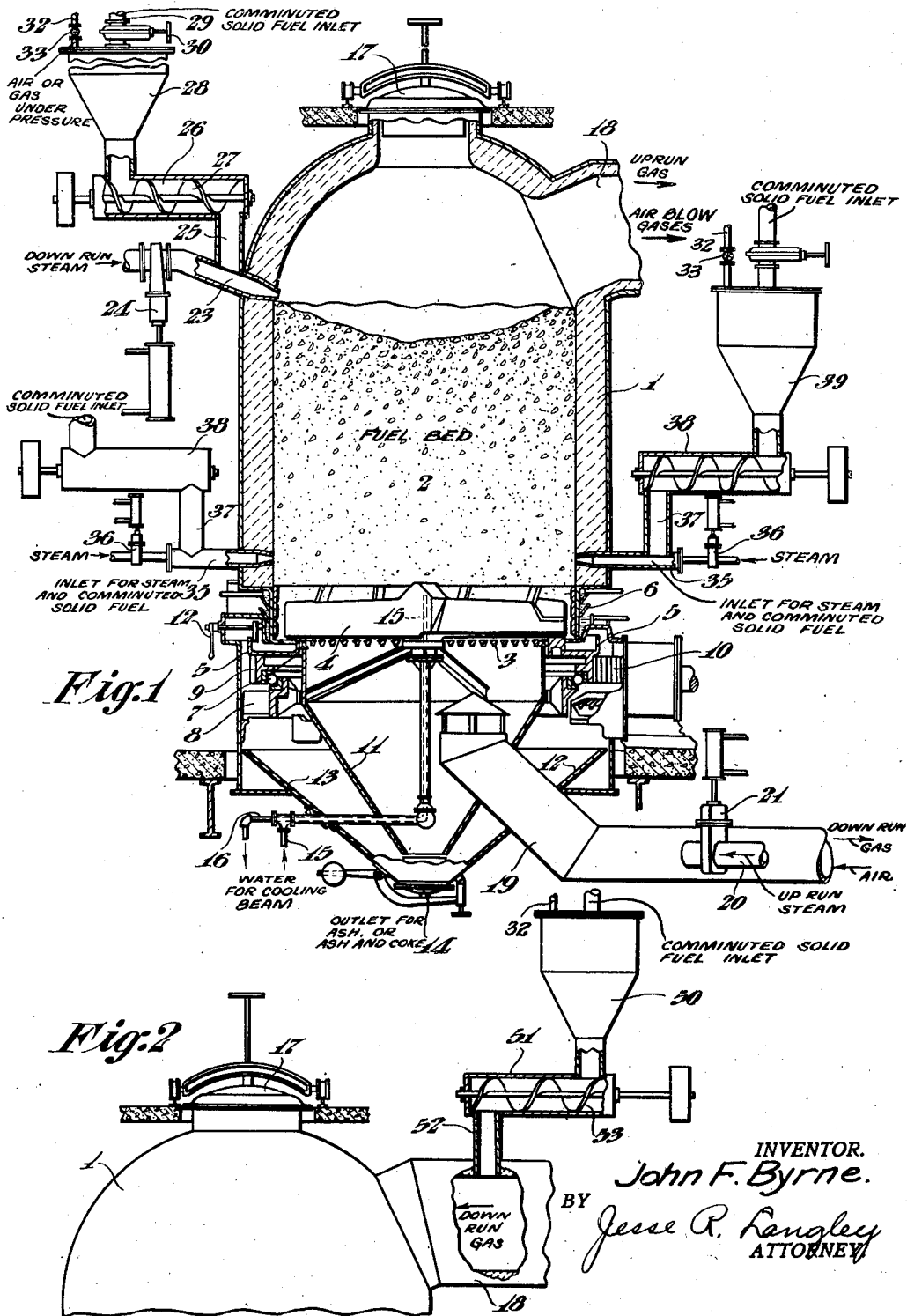
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PROCESS OF MANUFACTURING GAS AND CARBONIZED FUEL

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PROCESS OF MANUFACTURING GAS AND CARBONIZED FUEL

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This invention relates to the manufacture of gas, such as water gas, or water gas and coal gas, from carbonaceous material such as coal. It relates also to the incidental carbonization of such material, whether the carbonized product is to be removed as such, burned, or gasified.

My invention has a particular relation to the manufacture of water gas by reason of the fact that it is adapted to be carried out in conjunction with the manufacture of water gas in apparatus and by a process only slightly modified with respect to existing apparatus and processes, yet with novel and hitherto unattainable results, of great advantage.

My invention furthermore presents a novel and practicable method whereby the carbonization of coal, whether for coking purposes alone or for gasification of the resulting product, may be carried out by means of the sensible heat contained in a bed of incandescent or highly heated fuel, such, for example, as is maintained within the gas generators of current and prior practice.

The objects of my invention are to secure the operative advantages and results herein set forth, with provision for apparatus and process whereby they may be secured, and also such other operative advantages and results as may by implication be found herein after to obtain, and including such modifications and improvements relating thereto as are within the scope of the claims hereinafter made.

It is known that it is advantageous for many reasons to accomplish the carbonization of coal substantially entirely by means of the sensible heat contained by a fuel bed, rather than by means of the sensible heat of gases passing therethrough, or evolved therein, but the principle has hitherto been found to be difficult of application by reason of the difficulty of bringing the coal to be carbonized into effective contact with the heated fuel bed. It is obvious that uniform distribution is essential, and practical results have indicated that the actual depth or thickness of the layer of coal to be carbonized must be small to permit effective carbonization. Under these requirements, it has been found dif-

ficult to utilize any great proportion of such a fuel bed as might ordinarily be employed for this purpose, e. g., the fuel bed of a water-gas generator.

It has been attempted to utilize the aforesaid principle by dropping a layer of coal upon the top of the fuel bed within a gas generator, but this procedure has produced a coke that is unsatisfactory by reason of its fluffiness and poor structure. Moreover, this procedure is ill adapted to the requirements of the gas generator, both with respect to fuel and operation.

It has also been proposed to introduce a charge of fuel into the highly heated interior of a fuel bed by means of a stoking or ramming device, but it is obvious to those skilled in the art that the mechanical difficulties are great and that full penetration of the fuel bed can not be realized in this manner.

I have found that when finely comminuted coal is suspended in a gas or vapor about to be passed through a fuel bed of, for example, such thickness and general characteristics as is ordinarily maintained in a water-gas generator, and allowed to enter the fuel bed so suspended, the fine particles of coal are caused to penetrate the fuel bed and to be distributed substantially uniformly and entirely throughout the same.

Accordingly, I suspend suitably comminuted coal, for example, coal of such particle size as is now commonly used for combustion purposes in boilers and the like, in a gaseous fluid about to be passed through a gas generator. Preferably, I so conduct this operation with respect to the manufacture of the gas and other conditions within the fuel bed that the finely divided fuel thus added is first carbonized rather than burned as coal, and after partial or complete carbonization, is then either partly or wholly consumed by the reactions occurring in the fuel bed, whether those are incidental to the combustion of the coke or the gasification thereof with steam.

Insofar as concerns the manufacture of water gas by means of the usual cyclic form of process, I prefer to introduce the finely divided coal in suspension in the steam used for

the production of the actual water gas, or "make" gas, rather than in the air used for maintaining the high temperature of the fuel bed, but my invention in its broadest aspect contemplates the use, as a carrier for the coal, of any gaseous fluid or vapor that is to be passed through the generator.

The amounts and proportions of coal and the gas carrier will, of course, vary with the results to be attained, the requirements of the process as a whole, and the like, but in any case will be so regulated and controlled that substantially uniform penetration of the fuel bed is secured, while avoiding any excesses that might tend to carry large amounts of the finely divided coal over into the subsequent apparatus traversed by the gas, such as the carbureter and superheater of a carburetted water-gas set.

The amounts of finely divided coal added to the fuel bed may be varied considerably, and while it is preferred to introduce an amount at least sufficient to satisfy the requirements of the water-gas reaction, that is to say, sufficient coal to supply enough carbon to react with substantially all of the active steam, my invention also contemplates the addition of greater amounts in order that an excess of carbonized fuel or coke may be produced.

My invention further contemplates the preferably continuous removal of this coke from the generator, together with the ash remaining after the combustion or gasification of the other fuel in the generator. The high-ash coke, or mixture of ash and coke, thus discharged may be utilized as a low-grade fuel in boiler settings and elsewhere, or it may be treated for the removal of ash and be thereby made useful for many other purposes.

It will thus be apparent that, in contradistinction to the prior art, my invention contemplates a process in which finely divided coal is carried into a highly heated and preferably incandescent fuel bed in such manner that the coal penetrates the fuel bed substantially uniformly. The coal particles adhere to the incandescent coke of the fuel bed and are coked largely by the sensible heat of the fuel bed, rather than by the sensible heat of gases passing therethrough or by the sensible heat of the generator lining. The coke formed from the coal is then burned or gasified or is removed as such; that is to say, sufficient coal may be added in this manner to supply an excess over the requirements of the combustion and gasification reactions.

With regard to the terms "combustion" and "gasification", it is intended that these shall designate reactions of exothermic and endothermic effect, respectively. It is, of course, well known to those skilled in the art that these may go on concurrently, as for example during the air-blasting period of the

cyclic water-gas process, or during the manufacture of producer gas. It is also obvious that the term "gasification" refers not only to an external reaction, such as the water-gas reaction, but also to an internal reaction, such as the destructive distillation of coal.

In order that my invention may be fully set forth and understood, I now describe, with reference to the accompanying drawing, which illustrates a preferred embodiment or embodiments of the apparatus of my invention, the preferred manner in which it is embodied and practiced. In this drawing,

Figure 1 is a vertical sectional view of the water-gas generator that is equipped with means for introducing finely comminuted fuel thereto and for removing ash or a mixture of ash and coke therefrom; and

Fig. 2 is a view, partly in elevation and partly in section, of a portion of a water-gas generator and including an alternate form of apparatus for introducing finely comminuted fuel thereto.

Similar characters of reference designate similar parts in each of the views of the drawing.

Referring to the drawing and more particularly to Fig. 1, a water-gas generator is shown as constituted of a refractory structure 1 of a common form and configuration and which contains a fuel bed 2 that is supported on a stationary grate 3. While my invention may be practiced in some of its aspects and modifications in a generator having a simple stationary grate, I prefer to practice my invention in a water-gas generator that is provided with a grate device of the "self-clinkering" type whereby ash or a mixture of ash and carbonized fuel may be substantially continuously withdrawn from the fuel bed 2.

A particular form of such device is illustrated, consisting in part of a water-cooled beam 4 that is mounted for rotation in a horizontal plate immediately above and adjacent to the stationary grate 3. The beam 4 consists principally of two arms of triangular cross-section which may be either straight or slightly curved after the manner of an inverted S.

The ends of the beam 4 are integrally attached to a revoluble pan 5 that is situated immediately below an annular metal crushing ring 6 that forms that part of the wall of the generator 1 immediately above the level of the grate 3. The weight of the beam 4 and pan 5 are largely carried through a plurality of bearings 7 and support brackets 8 and the pan 5 is provided with a ring gear 9 which meshes with a gear 10 connected to a suitable prime mover (not shown).

Preferably, the beam 4 is rotated in a series of short stepwise movements at a speed of about one revolution in 50 minutes. The effect of this rotation is to agitate the fuel

bed and to prevent the formation of large masses of clinker when proper conditions of fire bed are maintained. A portion of the ash or mixture of ash and carbonized fuel drops through the orifices of the grate 3 into a hopper 11 and an additional amount is carried, by the outstroking action of the beam 4, to a point adjacent to the crushing ring 6 and falls into the moving pan 5 to be removed therefrom by a stationary adjustable plough 12 to fall into a hopper 13. The material contained in the hoppers 11 and 13 is conveniently removed through a trap door 14.

Water is admitted to the interior of the beam 4 through an inlet conduit 15 and flows therefrom through a drain 16, the upper end of which is so positioned that the beam 4 remains substantially full of water at all times. The pressure ring 6 is also provided with water-cooling means, as shown.

The generator 1 is provided with a removable cover 17, an offtake connection 18 leading from the upper part of the generator, and a conduit 19 terminating beneath the grate 3 and which may serve as an offtake connection for down-run gas or as a means for introducing air, steam or gas to the bottom of the generator for subsequent upward travel through the fuel bed 2. In the present instance, the conduit 19 serves as an air blast connection during the blow period of the water-gas cycle and as an uprun steam connection during a part of the run period of the cycle. For the latter purpose, a steam line 20 is provided which terminates in the conduit 19 and which is provided with a suitable valve mechanism 21.

Finely comminuted coal or other carbonaceous material such as finely divided solid pitch or the like is supplied to the fuel bed 2 according to my invention in such manner as to substantially uniformly penetrate the same and preferably by being suspended in the steam about to be admitted to the generator 1. A portion or all of such fuel, depending largely upon the quantity of fuel to be added, may be supplied to the fuel bed 2 by suspending it in the steam that is to be passed downwardly through the same. For this purpose, a special down-run steam connection 23 is provided, having a valve 24. The down-run steam connection 23 communicates through a vertical passage 25 and a horizontal passage 26 having a conveyor 27 therein with a hopper 28 that is supplied with suitably comminuted fuel through a charging line 29 having a valve 30.

For the purpose of balancing the steam pressure in the line 23, a pressure connection 32 having a valve 33 is provided for the hopper 28. The pressure connection 32 is preferably connected to a supply of compressed air or other gas for the reason that the introduction of steam into the hopper 28 under ordinary conditions would cause

condensation of moisture and agglomeration of the finely divided fuel particles.

By suitable manipulation of the valves 30 and 33 and the screw 27, an adequate quantity of fuel may be maintained in the hopper 28 and released therefrom into the steam nozzle 23. The size of the hopper 28 should be at least sufficient to accommodate fuel for one operating cycle.

It may also be desired to supply finely comminuted fuel to the fuel bed 2 by suspending it in a gaseous fluid to be passed upward through the same. When the usual type of stationary grate is employed, it is in most cases satisfactory to introduce the pulverized coal into the uprun steam before the latter passes through the grate.

In the present instance, in which a particular form of continuous grate device is used, it has been found that the construction of the latter device is such that the entry of considerable portion of the fuel supplied in this manner to the generator is prevented, and this will be true of certain other continuous grate devices offering more resistance to the flow of the gases than do the stationary grates of the prior art.

For this reason, I provide means for introducing a portion of the uprun steam above the level of the grate 3 and means for suspending finely comminuted fuel in said portion of the uprun steam in addition to the means already described for introducing the remaining portion of the uprun steam in which no fuel is suspended.

Such means comprises a plurality of steam inlets 35 inserted in the walls of the generator 1 just above the crushing ring 6. The inlets 35 are provided with steam valves 36 and communicate through passages 37 and 38 with a corresponding plurality of fuel hoppers 39 similar to the fuel hopper 28 already above described except that the individual fuel hoppers 39 ordinarily need contain considerably smaller amounts of fuel than the hopper 28.

Provision is made for supplying fuel from the bins 28 or 39 whenever the corresponding steam valves 24 or 36 are opened. In this manner, when steam is introduced through conduit 23 or conduits 35, it carries in suspension a considerable amount of finely comminuted fuel and during the passage of the steam through the fuel bed this fuel is distributed through the same for the purpose of the present invention.

In general, it is advantageous to superheat the steam supplied to the generator, and this may be done by any of the well-known devices for that purpose, or by provision of a regenerator for extracting the necessary heat from any of the hot gases leaving or passing through the water-gas apparatus.

In general, also, the ordinary rates of air and steam admission have been found satis-

factory for the purpose in view, and excessive rates tending to carry considerable quantities of fuel through and out of the fuel bed should be avoided. This is a matter largely within the discretion and observation of the operator.

To illustrate the invention more clearly, the performance of a simple operating cycle will be reviewed. This cycle consists essentially of a heating period called the "blow" and a gas-making period called the "run".

During the blow, air is admitted through the conduit 19 and passing upward through the fuel bed 2 causes partial combustion thereof, which results in the generation of carbon monoxide and in an increase in the temperature of the fuel whereby the reactions during the rest of the cycle which are endothermic and which require high temperatures may be satisfactorily carried on. The air-blast gases escape through the offtake connection 18 into the usual combustion chamber of the gas-making apparatus (not shown).

When a sufficient temperature has been attained, the supply of air is shut off and steam is admitted to the generator for the run. Generally steam is first passed through the fuel bed 2 in an upward direction. In the present instance, sufficient steam to provide a carrier for the fuel to be introduced is admitted through the inlets 35 carrying in suspension the finely comminuted fuel. Additional amounts of steam for this uprun may be admitted through the conduits 20 and 19 by opening the valve 21.

The steam carries the carbonized fuel into and throughout the fuel bed 2 and deposits it in the interstices of the same. The fuel thus introduced adheres to the fuel already present in the generator and is carbonized by the sensible heat of the same. Some of the carbonized fuel then reacts with the steam to form blue water gas, which is removed through the offtake connection 18.

For the purpose of controlling the temperature conditions within the fuel bed 2, steam is also passed through the fuel bed 2 in the downward direction during a portion of the run known as the down-run. This portion of the cycle may be accomplished by closing the valves 21 and 36 and opening valve 24, thus allowing steam to enter through the inlet 23 carrying in suspension finely comminuted fuel from the hopper 28 and passing downward through the fuel bed 2, the comminuted fuel being deposited in the fuel bed 2 as before and the resultant blue water gas passing out of the generator into the conduit 19.

During the run, the performance of the endothermic reactions of carbonization and gasification causes the temperature within the fuel bed 2 to fall until these reactions are no longer efficiently supported and it be-

comes necessary to again introduce air to the fuel bed.

Before a new blow can be performed, the blue water gas beneath the grate 3 must be removed in order to prevent an explosion upon the subsequent admission of air. For this purpose, a second uprun is ordinarily performed, steam being admitted through the conduits 20 and 19 and passing upward through the fuel bed 2. Ordinarily during this second brief uprun period, it is not necessary or desirable to continue the addition of fuel to the generator.

While any amount of finely comminuted coal may be added to a water-gas generator according to the present invention for any of the various purposes herein cited, it is preferred to add a sufficient amount of fuel in this fashion to at least satisfy the requirements of the water-gas reaction. Especially when only this much finely divided fuel is added, an additional amount of coarser fuel may be added by removing the cover 17. Coke, for example, may be added in this fashion either for the purpose of supplying the carbon for the blow or for decreasing the density of the fuel bed or both.

The addition of a certain amount of coarser fuel to the fuel bed may be found desirable in any instance, for the purpose of maintaining the fuel bed in a sufficiently porous condition to permit adequate passage of gases and thorough penetration of the bed by the finely comminuted coal introduced.

For example, it is generally preferable to inaugurate the operation of a water-gas machine to be operated according to my invention by charging it, in the first instance, with coke or other fuel of relatively coarse size.

When no coke is withdrawn from the generator by a continuous grate device, the subsequent additions to the fuel bed should consist substantially entirely of finely divided coal. The coke serves merely as a framework for the practice of my invention, and is not to be regarded as the real generator fuel, even though small portions thereof may incidentally be consumed in the process.

Under certain circumstances, it may be desirable or even preferable to add sufficient finely comminuted coal to the fuel bed 2 in the manner above described to satisfy the entire requirements of the generator with respect to both the exothermic reactions of the blow and the endothermic reactions of the run.

In either of these instances, the beam 4 is operated to remove as little carbon as is practicable.

By reason of the fact that the coke resulting from the carbonization of the finely comminuted coal is correspondingly small, the reactivity of this coke with both air and steam is very high, and this fact promotes the efficiency of the water-gas process as a whole.

With regard to the fineness of the coal particles, it has been found that it is preferable to use coal that has been pulverized to such extent that not more than about 95 percent nor less than about 90 percent will pass a 100-mesh screen, and not more than about 85 percent nor less than about 65 percent will pass a 200-mesh screen. However, it is obvious that these figures cannot be precisely adhered to in practice, and that slight deviations therefrom will not materially reduce the effectiveness of the process.

The advantages of the present invention under certain other circumstances are more fully realized when finely divided coal is introduced to the generator in excess of the gas-making requirements of the same, whether incident to the air blow or the steam uprun. For example, it may be desired to produce a small amount of comparatively rich gas and concurrently to produce a low grade fuel comprising in reality a mixture of ash and wholly or partially carbonized coal suitable for use in boiler installations and elsewhere.

In this instance, the amount of steam is reduced to an amount merely sufficient to carry the suspended coal particles and to assist in removing the gaseous products from the generator and the beam 4 is operated to remove not only ash but also an amount of carbonized fuel equivalent to the fuel added in excess of the blow and uprun requirements.

It is obvious that the coal gas produced from the coal being carbonized is added to and enriches the blue water-gas formed by reaction with the steam. Some of this coal gas may be cracked and some of the tar content of the coal gas may also be cracked, thus adding small proportions of cracked coal gas and cracked tar gas to the total gas.

Furthermore, it is obvious that the grate device will, in this instance, necessarily remove some of the coarser fuel that constitutes the "framework" of the fuel bed, and that it may consequently be desirable to replace this loss by an equivalent addition of such relatively coarse fuel, in order to maintain the fuel bed in a state of suitable porosity. As in the previous instance, however, this coarse fuel is substantially inert, except as to the storage of sensible heat, with respect to the reactions involved.

In Fig. 2, a special installation is provided for use in conjunction with the so-called back-run process of carburetted water-gas manufacture. In that process, the down-run steam admitted to the generator is first caused to pass through the superheater and carburetter of the carburetter water-gas set and enters the generator through the generator carburetter connection 18.

Accordingly, I provide a suitable fuel hopper 50 and means comprising conduits 51 and 52 and a conveyor 53 in the conduit 51 for introducing finely comminuted fuel from

the hopper 50 to the superheated steam passing through the conduit 18 into the generator 1.

The following summary of results is of particular interest as showing the results to be expected from the practice of my invention under various operating conditions.

Cycle	A	B	C
Blow, minutes.....	3	3	3
Run, minutes.....	3	3 3/4	3
Total, minutes.....	6	6 3/4	6
Average air blast, cu. ft. per minute.....	12,000	12,000	12,000
Average steam rate, lbs. per minute.....	174	190	32
Steam	A	B	C
Steam per cycle, lbs.....	522	714	192
Steam decomposed, per cent.....	77	50	50
Steam decomposed per cycle, lbs.....	402	357	96
Coal (8% ash)	A	B	C
Coal added for blue water gas per cycle, lbs.....	393	351	93
Coal added for blast per cycle, lbs.....	510	510	510
Coal added for solid fuel per cycle, lbs.....			1,317
Total coal added per cycle, lbs.....	903	861	1,920
Coke removed per cycle, lbs.....			922
Ash in coke removed, per cent.....			16.7
Gas	A	B	C
Total gas produced per cycle, cu. ft.....	22,410	20,226	15,570
Coal gas, per cent.....	24.2	25.6	74
Blue water gas, per cent.....	75.8	74.4	26
Thermal value, B. t. u. per cu. ft.....	360	365	505

Under columns A and B are listed the results from a cycle with three minute blow, with 77% and 50% steam decomposition, respectively. While under ordinary water-gas practice the steam decomposition does not ordinarily exceed 50%, it has been found that as much as 77% decomposition or even more can be attained by proper use of a continuous grate device of the type illustrated and described herein, and by reason of the reactivity of the finely divided coke within the fuel bed.

Under column C are listed the results from a cycle similar as to the blow but in which the amount of steam admitted to the generator is reduced to a minimum and an excess of coal is added for carbonization purposes. It will be observed that, in this instance, the heat balance is such that 922 pounds of coke may be removed from the generator and that the gas produced has a thermal value of approximately 505 B. t. u. per cubic foot. It is apparent that a water-gas generator so operated becomes, in effect, a carbonizing retort.

While my invention has been described in connection with various specific illustrative examples, it will be obvious to those skilled in the art that many modifications are possible which do not, however, depart from the spirit of the invention and are included in the scope of the claims hereinafter made.

For example, while my invention has been described particularly with respect to apparatus for generating blue water-gas or a mixture of blue water-gas and coal gas, it is obvious that my invention is equally applicable to the manufacture of carburetted water gas and it is apparent that for a given thermal requirement the quantity of oil necessary for carburettion may be materially reduced in such a process, especially when the process is operated to produce a gas consisting largely of coal gas, as in one of the instances hereinabove described.

My invention thus presents a practical and advantageous process of realizing a principle hitherto only realized with difficulty—i. e., the carbonization of coal by means of the sensible heat of a fuel bed, and my invention further provides a process or processes whereby this principle may be applied and utilized in the manufacture of fuel gas of characteristics variable over a wide range of results.

I claim as my invention:

1. The process of manufacturing water gas and carbonized fuel in a water-gas generator having a bed of solid carbonizable fuel, which comprises alternately heating said fuel bed by blasting it with air and generating water-gas by passing steam through the thereby heated fuel bed, maintaining said fuel bed by introducing to it while suspended in steam passed through the same sufficient finely divided solid carbonizable fuel to provide an excess over that amount required for the combustion and gasification reactions which are set up in said fuel bed by said air and steam, and removing from the generator fuel bed solid fuel in carbonized form.

2. The process of manufacturing water gas and carbonized fuel in a water-gas generator having a bed of solid carbonizable fuel, which comprises alternately heating said fuel bed by blasting it with air and generating water-gas by passing steam through the thereby heated fuel bed, maintaining said fuel bed by introducing to it while suspended in steam passed through the same sufficient finely divided solid carbonizable fuel to provide an excess over that amount required for the combustion and gasification reactions which are set up in said fuel bed by said air and steam and in substantially continuously removing from the generator fuel bed solid fuel in carbonized form.

3. The process of manufacturing water gas and carbonized fuel in a water-gas generator having a bed of solid carbonizable fuel, which comprises alternately heating said fuel bed by blasting it with air and generating water gas by passing steam through the thereby heated fuel bed, the direction of flow of the steam through the fuel bed being upward during at least a portion of the steaming period, maintaining said fuel bed by suspending finely comminuted solid carbonizable fuel in the

up-flow steam just before it traverses said fuel bed, in amount sufficient to provide an excess over that amount required for the combustion and gasification reactions which are set up in said fuel bed by said air and steam, and removing from the generator fuel bed solid fuel, in carbonized form.

4. The process of manufacturing water gas and carbonized fuel in a water-gas generator having a bed of solid carbonizable fuel, which comprises alternately heating the fuel bed by blasting it with air and generating water gas by passing steam through the thereby heated fuel bed, the direction of flow of steam through the fuel bed being reversed from an up-flow to a down-flow during a portion of the steaming period, maintaining the fuel bed by suspending finely comminuted solid carbonizable fuel in the up-flow steam and the down-flow steam just before they traverse said fuel bed, in amount sufficient to provide an excess over that amount required for the combustion and gasification reactions which are set up in said fuel bed by said air and steam, and removing from the generator fuel bed solid fuel, in carbonized form.

In testimony whereof, I have hereunto subscribed my name this 20th day of June, 1928.

JOHN F. BYRNE.