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PRODUCTION OF WATER GAS

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2 Sheets-Sheet 1

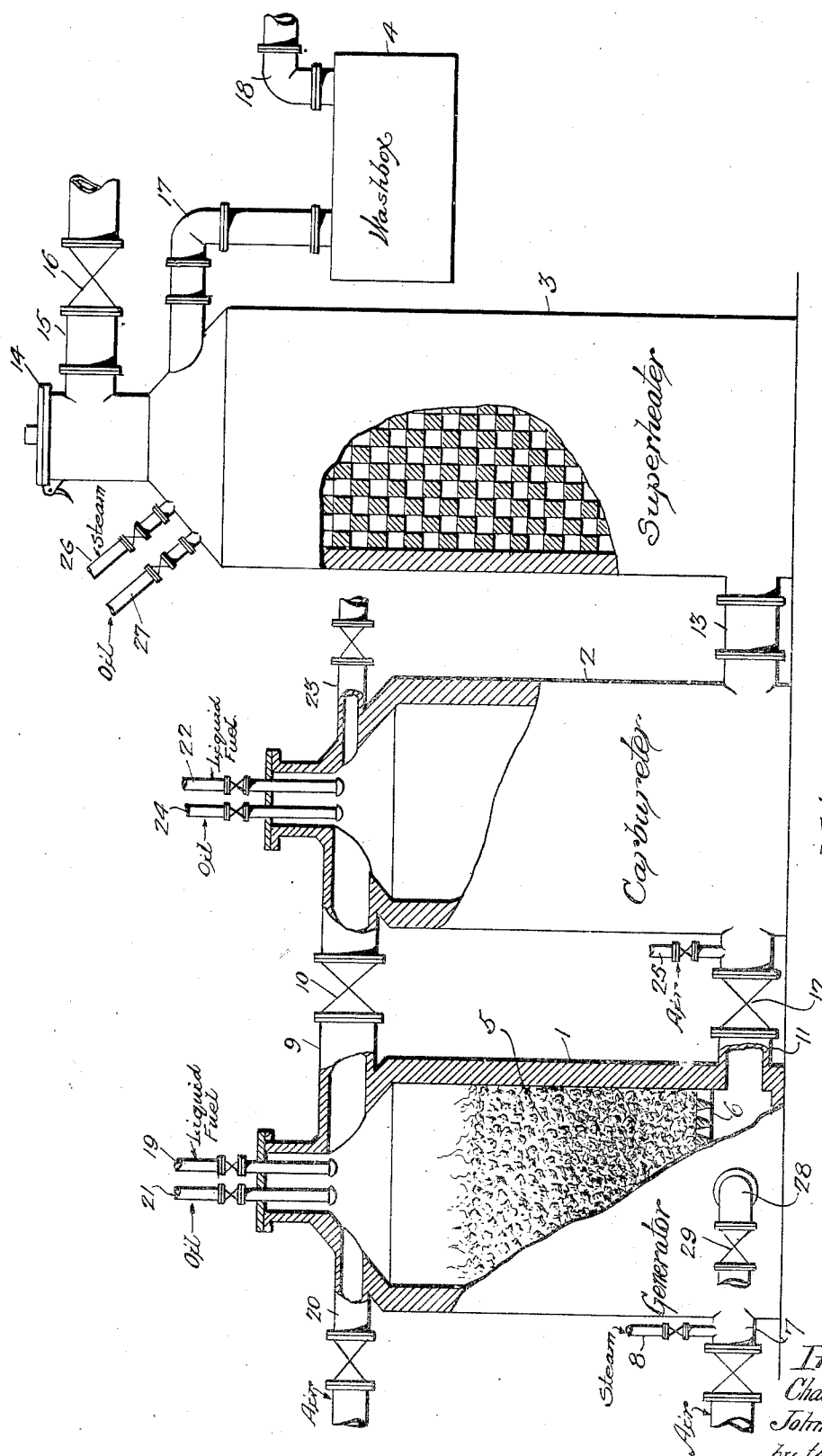


Fig. 1.

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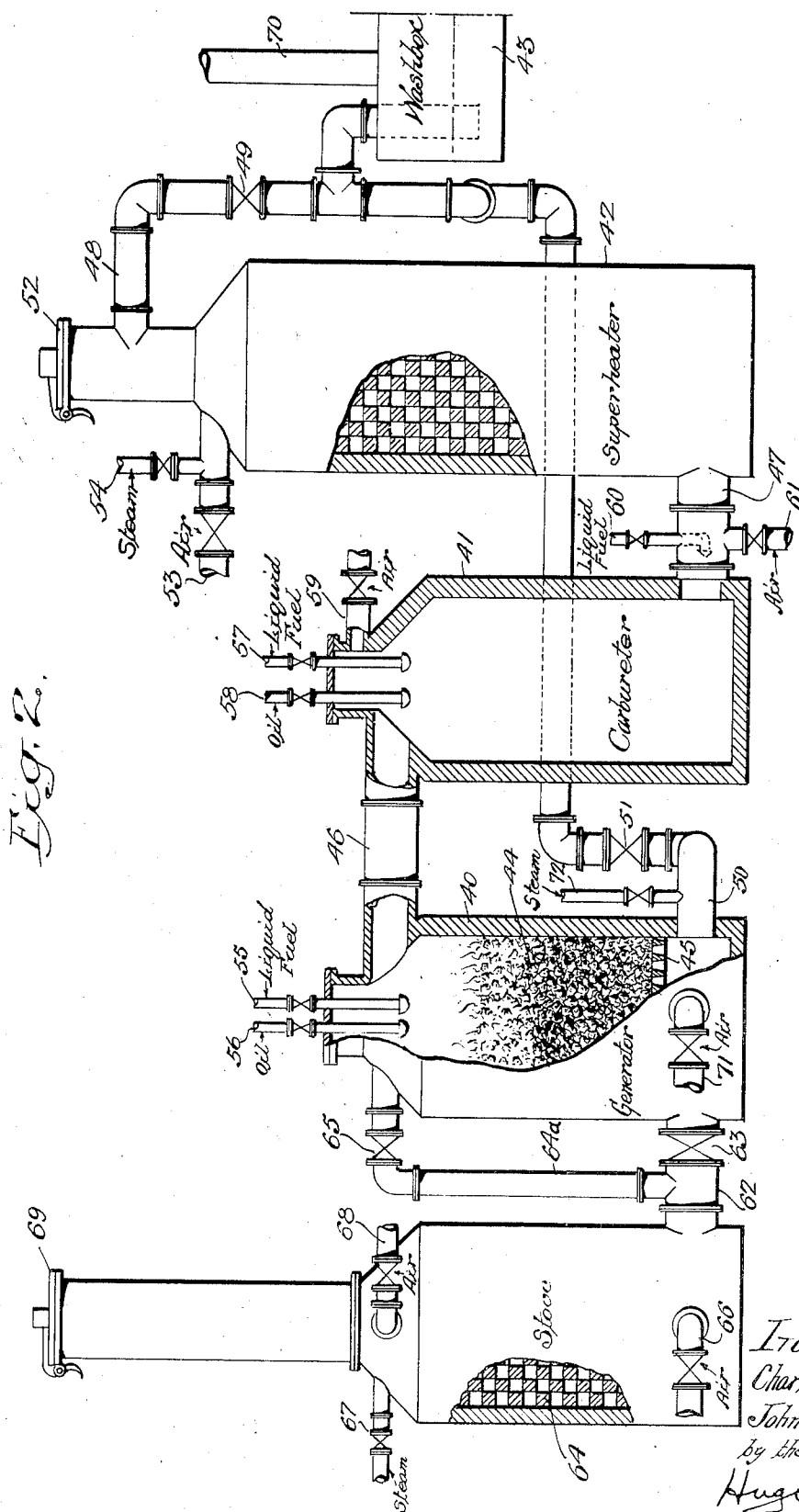
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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PRODUCTION OF WATER GAS

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11 Claims. (Cl. 48—205)

The present invention relates to the manufacture of water gas.

The conventional manufacture of water gas is performed in a cyclic process in which an ignited bed of solid fuel is alternately blasted with air and steam. The air blasting step is usually simply termed the blast. The steam blasting step is termed the run and may be alternately up and down through the fuel bed.

During each blast a portion of the combustibles in the fuel bed is consumed to raise the fuel bed temperature and to store heat in it for utilization in the succeeding run. During each run a further portion of the combustibles in the fuel bed is consumed by reaction between the steam and hot carbon to form blue water gas, a mixture consisting principally of hydrogen and carbon monoxide with some carbon dioxide. The water gas reaction is endothermic and therefore cools the fuel bed necessitating the succeeding air blasting step.

In the case of carburetted water gas manufacture, the products of the air blast are burned with secondary air and their heat stored in carburetting vessels for utilization in the vaporization and cracking of hydrocarbon oil, during the run, in the presence of blue water gas concurrently produced in the fuel bed. A portion of the heat thus stored may also be utilized in superheating steam for a part of the run. In uncarburetted water gas manufacture, the heat of the blast products may be also stored and utilized for superheating run steam.

The heat requirements for vaporizing and cracking the oil required for the usual enrichment of the water gas produced in carburetted water gas manufacture are in excess of the heat which may be recovered from the products of the minimum blasting required to condition the fuel bed for the water gas production. In the case of conventional carburetted water gas manufacture the additional heat required is derived from the combustion of a further portion of the combustible in the solid fuel bed, during the air blast.

Water gas manufacture as above briefly outlined has been developed to a high degree of efficiency. However, it sometimes happens that supplies of fluid fuel such as water gas tar or petroleum fuel oils are available, which are cheaper on a fuel basis than the solid fuel such, for instance, as the coke usually employed in the water gas fuel bed.

The principal object of the present invention is to provide a method of water gas manufacture

and apparatus therefor, in the use of which fluid fuels may be employed to reduce the quantity of solid fuel consumed for heating, while retaining the advantages of the solid fuel bed as a reactant in the water gas reaction. Other objects of the invention will appear as the specification proceeds.

Generally stated, the method of the invention comprises heating the bed of solid fuel during the first portion of the fuel bed heating period of the cycle by the combustion of fluid fuel other than fluid fuel produced by the combustion of solid fuel such, for instance, as water gas tar or fuel oil and the passage of the resultant hot products of combustion through the fuel bed.

Another feature of the invention in the case of carburetted water gas manufacture comprises heating at least a portion of the carburetting chamber or chambers by the combustion of fluid fuel other than the products produced by air blasting the fuel bed, such as for instance, water gas tar or fuel oil.

Other features of the invention reside in the steps, combinations of steps, sequence of steps and in the construction, arrangement and combination of parts, all of which together with other features will become more apparent to persons skilled in the art as the specification proceeds and upon reference to the drawings in which:

Fig. 1 is an elevation partly in section somewhat diagrammatically illustrating a three shell carburetted water gas set with the invention adapted thereto;

Fig. 2 is an elevation partly in section illustrating somewhat diagrammatically a modification of the apparatus of Fig. 1.

Referring more particularly to Fig. 1,

1 generally indicates a water gas generator, 2 a carburetter, 3 a superheater, and 4 a wash box, of a three shell carburetted water gas set. The generator is provided with the ignited fuel bed 5 supported on the grate 6. 7 indicates an air supply means for blasting the fuel bed upwardly with air. 8 indicates a steam supply means for upwardly steaming the fuel bed. The upper portion of the generator is connected to the upper portion of the carburetter by the connection 9 provided with the valve 10. The base of the generator is connected with the lower portion of the carburetter by the connection 11 provided with the valve 12. The base of the carburetter is connected with the base of the superheater by the connection 13. 14 indicates a superheater stack valve. Connection 15 provided with

valve 16 leads from the top of the superheater to a waste heat boiler (not shown). Connection 17 leads from the top of the superheater to the wash box, while connection 18 leads from the wash box to storage or other disposal.

As shown, the generator is provided with the liquid fuel burner 19 and the air supply means 20. 21 indicates an oil supply means adapted to spray oil into the upper portion of the generator above the fuel bed.

22 indicates a liquid fuel burner arranged in the upper portion of the carburetter which is also provided with the air supply means 23. 24 indicates a carburetting oil supply means for the carburetter. 25 indicates a secondary air supply means to the base of the carburetter.

The superheater may be also provided with the steam supply means 26 and the oil supply means 27. Connection 28 provided with valve 29 is a gas offtake leading from the bottom of the generator to storage or other disposal.

An illustrative cycle of operations employing the apparatus of Fig. 1 may be as follows: With valve 10 closed, valve 12 open, and either the stack valve 14 or the valve 16 open (the other being closed) liquid fuel such as oil or tar supplied through supply means 19 is burned in the space above the generator fuel bed with air supplied through air supply means 20. The hot products of combustion pass downwardly through the ignited fuel bed giving up heat to the fuel bed and raising its temperature. The products are discharged from the base of the generator through connection 11 into the base of the carburetter. Secondary air may be supplied through supply means 25 to burn whatever combustibles there may be in these combustion products.

Simultaneously, liquid fuel such as oil or tar may be supplied to the carburetter through supply means 22 and burned therein with air supplied through supply means 23, thereby heating the carburetter. The resultant products of combustion pass downward through the carburetter uniting with the products of combustion from the generator. The united products pass upwardly through the superheater and through the stack valve 14 or through the connection 15 and valve 16 to a waste heat boiler (not shown).

The preceding operation heats the fuel bed, raising its temperature, and also heats the carburetter and the superheater.

The combustion of liquid fuel in the generator and carburetter is then terminated, and with valve 10 open and valve 12 closed an up air blast is made through the fuel bed with air supplied through air supply means 7. The resultant products of combustion pass through the carburetter and superheater and exit through stack valve 14 or through valve 16 to the waste heat boiler (not shown). During their passage, these products may be burned with secondary air supplied through either or both of air supply means 20 and 23.

This operation further heats the fuel bed, rekindles the base of the fuel bed and stores further heat in the carburetter and superheater.

If desired, during the up blast, liquid fuel may be supplied through supply means 22 and burned in the carburetter, sufficient air for its combustion being supplied through air supply means 23 or 20.

The air blast is then terminated, and with valve 10 open and valves 12, 14 and 16 closed, an up run is made with steam supplied through

supply means 8. The resultant water gas passes from the generator through the carburetter and superheater to the wash box 4 and thence to storage or other disposal. During its passage through these vessels it may be carburetted by oil supplied through connection 21 to the generator or connection 24 to the carburetter, or both.

The up run is now terminated and the cycle repeated.

It will be obvious to those skilled in the art that the above cycle may be very considerably modified. For instance, with valves 29 and 10 opened and valves 12, 14 and 16 closed, a back run may be made with steam supplied through 26 and passed downwardly through the superheater, upwardly through the carburetter and downwardly through the fuel bed to the offtake 28. If desired, this back run may be accompanied by oil supplied through oil supply means 21, 24, or 21 or through any two or all of them, and the resultant oil vapors reformed in passage through the generator fuel bed.

It will be seen from the above operation that the consumption of solid fuel in the generator may be very materially reduced because of the heat supplied to the generator and to the carburetter and superheater by the consumption of supplemental liquid fuel.

The combustion of the liquid fuel in the top of the generator and the passage of the resultant combustion products through the fuel bed reduces materially the quantity of solid fuel required to be consumed to supply the heat necessary for the water gas reaction in the generator. The liquid fuel concurrently burned in the carburetter reduces the quantity of heat which must be supplied from the fuel bed to the carburetting vessels for the vaporization and cracking of the carburetting oil during the run.

The supplementary heating of the fuel bed by the combustion of liquid fuels and the passage of the resultant products of combustion through it is preferably performed as above described after the run and before the conventional up air blasting step. At the end of the run the fuel bed is at its lowest average temperature during the cycle and under such conditions there is a minimum reaction between the CO₂ in the liquid fuel combustion products and the carbon in the fuel bed to form the CO. It is desired to minimize this reaction because it is not only endothermic but it consumes a portion of the solid fuel. It is also thought desirable to supply sufficient air for the combustion of the liquid fuel to complete its combustion prior to the passage of the resultant products through the fuel bed, in order to generate as much heat from the liquid fuel as possible in a given time. It will be understood, however, that the liquid fuel may be supplied with insufficient air for complete combustion and the combustion of the resultant products completed in the carburetter after passage through the fuel bed.

Referring to Fig. 2:

40 indicates the generator, 41 the carburetter, 42 the superheater, and 43 the wash box of a three shell carburetted water gas set. The generator is provided with the ignited fuel bed 44 supported on the grate 45. The generator above the fuel bed is connected with the upper portion of the carburetter by connection 46. The base of the carburetter is connected to the base of the superheater by connection 47. The gas offtake 48 provided with valve 49 leads from the top of the

superheater to the wash box 43. The gas offtake 50 provided with valve 51 leads from the base of the generator to the wash box. The superheater is provided with stack valve 52 and with the air supply means 53 and may be provided with the steam supply means 54.

The upper portion of the generator is provided with the liquid fuel burner 55 and the carburetting oil supply means 56. The carburetter is provided with the liquid fuel supply means 57, oil supply means 58 and the air supply means 59. An alternate or supplementary liquid fuel supply means more distant from the fuel bed may be provided as for instance at 60 in the carburetter-superheater connection 47. 61 is an alternate air supply means for liquid fuel burner 60.

The base of the generator is also connected by connection 62, controlled by valve 63, with the stove 64. The stove is also connected to the top of the generator by connection 64a provided with valve 65. 66 is an air supply means to the base of the stove. 67 is a steam supply means, and 68 an air supply means leading to the top of the stove. 69 is the stove stack valve. 70 is a connection leading from the wash box to storage or other disposal. 71 is an air supply means and 72 a steam supply means leading to the base of the generator for up air blasting and steaming respectively.

An illustrative cycle will be given for the operation of the apparatus in Fig. 2. With stack valve 52 and valves 51 and 65 closed and valves 63 and 69 open, liquid fuel is admitted to the carburetter through supply means 57 and burned with air supplied through air supply means 59. Air may also be supplied through air supply means 53 leading to the top of the superheater. The resultant products of combustion pass from the carburetter through connection 46 into the top of the generator and thence downwardly through the fuel bed. In this operation the carburetter, the top of the generator, and the fuel bed are heated and their temperatures raised. The products pass from the base of the generator through connection 62 into and up through the stove 64 and exit through the stove stack valve 69. Any combustible in these products may be burned with secondary air admitted through supply means 66 to the base of the stove. The heat of these products is stored in checker brick or other heat storage material in the stove. If desired during this operation additional liquid fuel may be admitted to the space above the fuel bed through supply means 55. Liquid fuel may be supplied at 60 and air at 61 instead of or in addition to the liquid fuel and air supplied at 57 and 59 respectively, during this step. Also if desired all the air for combustion of the liquid fuel prior to the passage of its products through the fuel bed may be supplied to the superheater as at 53 and preheated therein.

The combustion of liquid fuel is then terminated and with stack valve 52 open and valves 51, 63 and 69 closed, an up blast of air is made through the generator with air supplied through air supply means 71. Simultaneously air may be admitted through supply means 68, heated by passage through the stove 62 and admitted through connection 64a and valve 65 to the space above the fuel bed to supply secondary air to the blast products issuing from the fuel bed. The products pass from the generator through the carburetter and superheater storing their heat therein. This up blast further heats the fuel bed, rekindles the fire in the base of the fuel bed and

stores further heat in the carburetter and superheater. If desired, some liquid fuel may be also burned in the carburetter during the up air blast in the generator, this fuel being admitted through supply means 57, with air if necessary through supply means 59.

After the up air blast in the generator, with valves 63, 65, 51 and 52 closed and valve 49 open, an up run is made with steam supplied through 72. The resultant water gas may be carburetted by oil supplied through 56 to the top of the generator fuel bed, or through 58 to the carburetter or both, the resultant carburetted water gas passing through the carburetter and superheater and by connection 48 to the wash box and thence by way of connection 70 to storage. A down run may then be made, with valves 63, 69, 52, and 49 closed and valves 51 and 65 open. Steam is supplied to the stove 64 through 67 and superheated in passage downward through the stove, passing by way of connection 64a to the top of the generator and thence down through the fuel bed. The resultant water gas passes by way of connection 50 to the wash box 43 and to storage. During the down run oil may be admitted through 56 to the top of the fuel bed reformed in passage through the fuel bed with the water gas.

Instead of a down run with steam supplied through the stove, a back run may be made with steam supplied through 54 and superheated in its passage through the superheater, and carburetter to the top of the fuel bed. The steam passes down through the fuel bed, the resultant water gas passing through connection 50 to the wash box and thence to storage. In this operation, valve 65 is closed. As in the case of the down run, oil may be admitted through 56 during the passage of the steam as well as through 58 to the carburetter if desired and the resultant oil vapors and gas reformed in passage through the fuel bed.

If desired during the up run steam may be admitted to the stove at 67, superheated therein and passed through connection 62 and valve 63 to the base of the generator and thence up through the fuel bed.

In the operation of the above cycles it will be understood by those skilled in the art that purges of the apparatus are to be made when necessary.

The invention provides a useful method and apparatus therefor, for utilizing relative cheap supplies of fluid fuel, while retaining the known advantages of the solid fuel bed in water gas generation. The availability of such fluid fuel supplies may be quite transient or long continuing. It frequently happens, for instance, that difficulty is encountered in advantageously disposing of all the water gas tar produced in carburetted water gas manufacture, leading to inconvenient accumulation. Such tar may be advantageously used in accordance with present invention, without dehydration, as wet tar emulsion may be efficiently burned in properly designed tar burners. In this connection it is to be understood, that the means illustrated in the drawings for supplying fluid fuel and air for its combustion are largely diagrammatic and that in practice advantage would be taken of suitably designed burners.

If wet tar emulsion is employed, it will not of course develop as much heat on combustion as will dry tar or oil due to the latent heat of evaporation of its water content. Also, it will not heat the fuel bed to the same extent, other conditions being equal, due to the lower temperature of its products of combustion and probably also

due to an increased endothermic reaction of their higher water vapor content with the fuel bed. Such an increased water gas formation will increase the combustible content of the products issuing from the fuel bed, producing more heat for storage on their combustion with secondary air.

Excess air may be admitted with the fluid fuel providing for its complete combustion prior to passage through the fuel bed, the excess air reacting with the fuel bed as ordinary air blast.

It will be seen that combustion of fluid and solid fuel may be balanced so that the heating of the fuel bed is limited to that required for the water gas generation, the excess heat required for carburetion being introduced elsewhere. Also it will be seen that the consumption of solid fuel may be readily reduced well below that required for the water gas generation were solid fuel alone relied on.

Cheap supplies of gaseous fuel are less likely to be available in localities where water gas is produced but should they exist they may be advantageously employed in accordance with the present invention.

In modern carburetted water gas practice especially with the use of heavy oil for carburetting, a portion of the oil is frequently sprayed into the top of the generator above the fuel bed. In such case the upper portion of the generator becomes in effect a carburetter. The terms carburetting vessels or carburetting chambers herein may include such a portion of the generator.

It will be obvious to those skilled in the art that the illustrative cycles above given, and the apparatus illustrated in the drawings, are capable of much modification within the scope of this invention. Among such modifications may be mentioned the employment of blow runs, the order of up, down or back runs and oil reforming steps, the employment of an empty or checkered carburetter, the use of the waste heat boilers and the consolidation of the set into two shell or one shell apparatus.

These and other modifications may be made without departing from the spirit of the invention which is only limited as the prior art may require.

We claim:

1. In the manufacture of water gas in a gas making set containing an ignited bed of solid fuel by a cyclic process comprising alternately heating said fuel bed during a heating period by burning a portion of said solid fuel by air blasting said fuel and alternately generating water gas during a water gas generating period by passing steam through said heated fuel bed, the steps of heating said fuel bed during the first portion of said heating period of the cycle by introducing liquid hydrocarbon fuel into said set, burning it therein with air, passing hot products of combustion produced thereby downwardly through said fuel bed, and during a succeeding portion of said heating period heating said fuel bed by upward air blasting.

2. In the manufacture of water gas in a gas making set containing an ignited bed of solid fuel and heat storage material by a cyclic process comprising alternately heating said fuel bed during a heating period by burning a portion of said solid fuel with air and alternately generating water gas during a water gas generating period by passing steam through said heated fuel bed, the steps of heating said fuel bed during the first portion of the heating period by introducing liq-

uid hydrocarbon fuel into said set, burning it therein with air, passing hot products of combustion produced thereby downwardly through said fuel bed, leading hot products from the base of said fuel bed, burning combustibles in said hot products with secondary air and storing heat therefrom in said heat storage material, during a succeeding portion of said heating period heating said fuel bed by upward air blasting, and during said water gas generating period recovering said stored heat by superheating steam employed for the generation of water gas by passage through said fuel bed.

3. In the manufacture of water gas in a gas making set containing an ignited bed of solid fuel and heat storage material by a cyclic process comprising alternately heating said fuel bed during a heating period by burning a portion of said solid fuel with air and alternately generating water gas during a water gas generating period by passing steam through said heated fuel bed, the steps of heating said fuel bed during the first portion of said heating period of the cycle by introducing liquid hydrocarbon fuel into said set, burning it therein with air, passing hot products of combustion produced thereby downwardly through said fuel bed, leading off hot products of combustion from the base of said fuel bed, burning combustibles in said hot products with secondary air and storing heat therefrom in a portion of said heat storage material, during a succeeding portion of said heating period heating the fuel bed by upward air blasting, burning the resulting products of upward air blasting with secondary air preheated by means of the stored heat from said downwardly passed hot products of combustion, and storing heat of said products of upward air blasting in another portion of said heat storage material.

4. In the manufacture of carburetted water gas in a carburetted water gas making set containing an ignited bed of solid fuel and a heated carburetting chamber or chambers containing heat storage material by a cyclic process comprising alternately heating said fuel bed during a heating period and alternately generating water gas during a water gas generating period by passing steam through said heated fuel bed and carburetting the resulting water gas in said carburetting chamber or chambers containing heat storage material during said water gas period, the steps of heating said fuel bed during at least the first portion of said heating period of the cycle by introducing liquid hydrocarbon fuel into said set, burning it therein with air and passing the resulting heat products of combustion downwardly through said fuel bed, leading said products of combustion from the base of said fuel bed through said carburetting chamber or chambers, burning combustible in said products with secondary air, and storing heat therefrom in said carburetting chamber or chambers.

5. In the manufacture of carburetted water gas by a cyclic process comprising alternately heating and steaming an ignited bed of solid fuel and carburetting the water gas produced during the steaming period in a heated carburetting chamber or chambers, the steps of heating the fuel bed during the first portion of the heating period of the cycle by burning liquid hydrocarbon fuel and passing the resultant hot combustion products downward therethrough leading said products from the base of the fuel bed through said carburetting chamber or chambers, burning combustible in said products with secondary air

and storing heat therefrom in said carburetting chamber or chambers, and during the succeeding portion of said heating period heating the fuel bed by upward air blasting, passing the resultant products of combustion through the carburetting chamber or chambers, burning combustible in said products of up air blasting with secondary air and storing heat therefrom in said carburetting chamber or chambers and during said heating period heating said carburetting chamber or chambers by introducing liquid hydrocarbon fuel thereto and burning it therein.

6. In the manufacture of carburetted water gas by a cyclic process comprising alternately heating and steaming an ignited bed of solid fuel and carburetting the water gas produced during the steaming period in a heated carburetting chamber or chambers, the steps of heating the fuel bed during the first portion of the heating period of the cycle by burning liquid hydrocarbon fuel and passing the resultant hot combustion products downward therethrough leading said products from the base of the fuel bed through said carburetting chamber or chambers, burning combustible in said products with secondary air and storing heat therefrom in said carburetting chamber or chambers, and during the succeeding portion of said heating period heating the fuel bed by upward air blasting, passing the resultant products of combustion through the carburetting chamber or chambers, burning combustible in said products of up air blasting with secondary air and storing heat therefrom in said carburetting chamber or chambers and during said first portion of said heating period heating said carburetting chamber or chambers by introducing liquid hydrocarbon fuel thereto and burning it therein.

7. In the manufacture of carburetted water gas by alternately heating and steaming an ignited fuel bed in a water gas generator and carburetting the resultant water gas in a heated carburetter and superheater by heat stored therein, the steps of heating said fuel bed by burning liquid fuel with air during the first portion of the heating period in said carburetter, air for said combustion being introduced to the superheater and preheated therein, passing the resultant products downwardly through the fuel bed, leading off the said products from the base of the fuel bed, burning said products with secondary air and storing their heat in a heat storage vessel, and in a succeeding portion of the heating period upwardly air blasting said fuel bed and burning the resultant products in the carburetter and superheater with secondary air heated by passage through said heat storage vessel and storing the heat from said up air blast products in the carburetter and superheater, passing steam through the fuel bed and carburetting the resultant water gas by passing it through said carburetter and superheater and simultaneously vaporizing and cracking carburetting oil by the heat stored therein.

8. In the manufacture of carburetted water gas by alternately heating and steaming an ignited fuel bed in a water gas generator and carburetting the resultant water gas in a heated carburetter and superheater by heat stored therein, the steps of preheating said fuel bed by burning liquid fuel with air in said carburetter, air for said com-

bustion being introduced to the superheater and preheated therein, passing the resultant products downwardly through the fuel bed, leading off the said products from the base of the fuel bed, burning said products with secondary air and storing their heat in a heat storage vessel, thereafter in a succeeding portion of the heating period upwardly air blasting said fuel bed and burning the resultant products in the carburetter and superheater with secondary air and storing heat from said up air blast products in the carburetter and superheater, and thereafter superheating steam by heat stored in said heat storage vessel and passing said superheated steam downwardly through the fuel bed, steaming said fuel bed upwardly and carburetting the resultant water gas by passing it through said carburetter and superheater and simultaneously vaporizing and cracking carburetting oil by the heat stored therein.

9. The process according to claim 8, in which the products of upwardly air blasting the fuel bed are burned with secondary air preheated in said heat storage vessel.

10. A cyclic process of manufacturing carburetted water gas when practiced in a carburetted water gas set comprising a generator containing an ignited fuel bed and a carburetter superheater and heat exchanger which comprises, preheating air in the superheater and passing said preheated air thence to the carburetter, introducing liquid fuel to the carburetter and burning it with said preheated air, preheating the fuel bed by passing the resultant products of said oil combustion downwardly therethrough, burning the products and storing heat therefrom in said heat exchanger, thereafter in the heating period of the cycle upwardly air blasting the fuel bed and burning the resultant products in the carburetter and superheater with secondary air heated in said heat exchanger and storing heat in said carburetter and superheater, superheating steam in said heat exchanger and passing said superheated steam downwardly through the fuel bed, then passing steam upwardly through said fuel bed and carburetting the resultant water gas by vaporizing and cracking carburetting oil introduced into the carburetter and passed with said water gas through the superheater.

11. In the manufacture of carburetted water gas in a carburetted water gas-making set containing an ignited bed of solid fuel and a heated carburetting chamber or chambers by a cyclic process comprising alternately heating said fuel bed during a heating period and alternately generating water gas during a water gas generating period by passing steam through said heated fuel bed and carburetting the resulting water gas in said carburetting chamber or chambers during said water gas generating period, the steps of heating the fuel bed during the first portion of said heating period of the cycle by introducing liquid hydrocarbon fuel into said gas-making set, burning said liquid hydrocarbon fuel therein with air, passing the resulting hot products of combustion downwardly through said fuel bed, and during the succeeding portion of said heating period heating said fuel bed by upward air blasting.

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