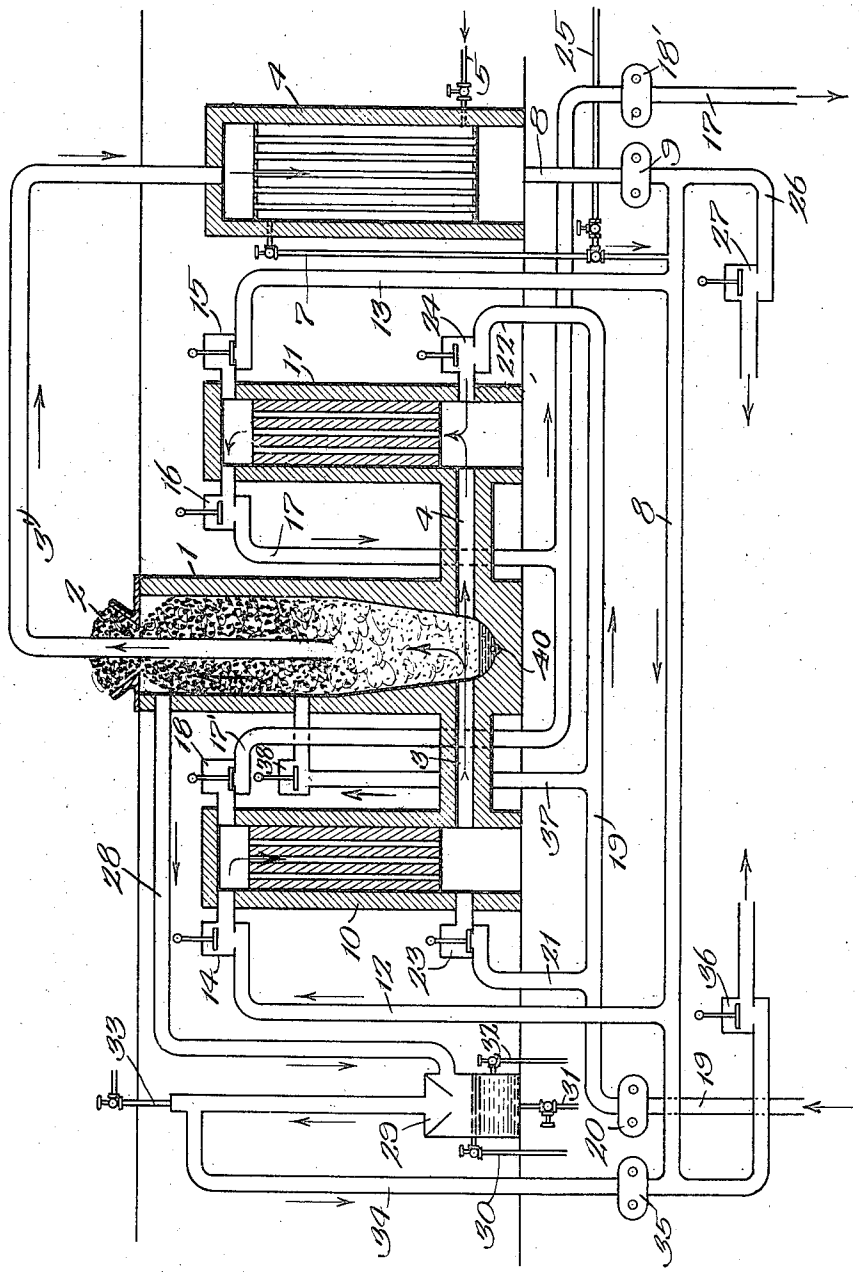
Sept. 11, 1923. 1,467,957

F. T. SNYDER

METHOD OF GENERATING GAS

Filed Oct. 13, 1919



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Patented Sept. 11, 1923. 1,467,957

UNITED STATES PATENT OFFICE.

FREDERICK T. SNYDER, OF OAK PARK, ILLINOIS.

METHOD OF GENERATING GAS.

Application filed October 13, 1919. Serial No. 330,314.

To all whom it may concern:

Be it known that I, FREDERICK T. SNYDER, citizen of the United States, residing at Oak Park, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Methods of Generating Gas, of which the following is a full, clear, concise, and exact description.

My invention relates to a method of generating gas and has many objects and advantages in view. The method of the invention enables the employment of a single generator that holds carbonaceous fuel and in the lower part of which a fixed gas is produced which is preferably water gas, but may be producer gas or a mixture of water gas and producer gas. The heat of the ascending gas serves to distill carbonaceous fuel that is above the gas producing zone to produce other gas and attendant by-products. The resulting gas is caused to flow in a closed circuit or loop defined by piping and equipment of the system and, in its passage, serves to heat water to steam which is injected into a stream of water gas which mixture is directed to the lower zone of the generator to react upon the fuel there located to form the gas. The combined steam and gas is heated to a white heat before its injection into the generator in order to have the necessary gas producing reaction upon the fuel. The heat for superheating the combined gas and steam is furnished in a stove in which heat is stored from the preparatory burning in the stove of a portion of the gas produced by the system.

I will explain my invention more fully by reference to the accompanying drawing which is a diagrammatic elevation illustrating my preferred form of apparatus that may be employed to practice my method.

An upright cylindrical generator 1 has the upper end of its stack provided with a hopper 2 through which the fuel to be reduced is passed to the furnace, such as bituminous, lignite, or anthracite coals, shale, or hard and soft woods, or any suitable combination of these fuels. The upper part of the generator acts as a fuel distilling retort and the lower part as a gas generator. The selected fuel is charged into the generator through the hopper preferably at atmospheric temperature.

A fixed-gas is generated by admitting a stream of hot water gas and steam to the bottom zone of the generator through either passage 3 or 4 usable alternately as ingress or egress passages in alternated cycles of operation. The greater portion of the resultant gases rises within the generator and heats and distills the descending fuel which cools these gases, the heat absorbed in distilling the fuel being furnished by these rising gases produced and flowing within the generator instead of being passed through the refractory generator wall. A certain portion of the fixed gas from the lower zone is conveyed through the top of the generator by piping 3′ that extends axially through the hopper 2 to the zone of the generator where producer or water gas is produced. This piping conveys the producer or water gas to the waste heat fire tube boiler 4 where it serves to heat water furnished to the boiler through the water pipe 5, the resultant steam passing from the boiler through the pipe 7 into the pipe 8 that conveys the cooled gas from the boiler after the water therein has been heated thereby to form steam and has served to reduce the temperature of the gas to a point where it may be passed through a positive displacement blower 9 that is employed to effect its forced passage from the boiler.

Stoves or regenerators 10, 11, have their lower ends respectively in communication with passages 3 and 4. Pipes 12 and 13 branch from the pipe 8 and discharge intermingled gas and steam respectively into the upper ends of said stoves 10 and 11 in alternate cycles the branch pipes being controlled by valves 14 and 15. In one cycle of operations, valve 14 is opened to permit the steam and gas to flow through pipe 12 into the stove 10 and thence through passage 3 to the generator 1, and valve 15 is closed to prevent flow of gas and steam from pipe 13 into stove 11. In this same cycle of operations valve 16 is open to connect the upper portion of stove 11 with the outlet pipe 17 that has a positive displacement blower 18′ therein to promote the passage of gases of combustion from the stove 11 to insure the proper passage of a portion of the gas from the lower end of the generator 1 as indicated by the horizontal arrow in the figure and passing thence through the stove 11. This gas thus passing upwardly into stove 11, is burnt within this stove to heat the checker

work or other heat storing structure therein, such heat storing structure within stove 10 having been similarly heated in a previous cycle of operations. Air for combustion in the stove 11 is supplied through the pipe 22. In the cycle of operations being described, valve 18 is closed to disconnect the upper portion of stove 10 from the outlet pipe 17' so that the mixture of gas and steam being admitted to the upper part of the stove is bound to pass downwardly therein through the previously heated heat storing structure thereof to be passed into the bottom of the generator through the passage 3 at white heat, a temperature sufficiently high to have the necessary reaction upon the fuel in the lower zone of the generator 1 to produce a fixed gas. In the next cycle the flow of the heated mixture of gas and steam is reversed so as to have it enter the generator through the passage 4 instead of the passage 3. In this succeeding cycle the adjustment of the valves 14, 15, 16, and 18 is reversed with results that are obvious from the previous description.

Each cycle is continued as long as the temperature of the stove which is supplying heat to the gas and steam is sufficiently high to dissociate the steam. During this period, the other stove is being heated by the combustion of a portion of the gas therein, air being admitted through the pipe 21 or 22 for this purpose. The stove may be heated to any desired extent by regulating the amount of gas and air admitted thereto for combustion. The periods of heating the stove and making the gas may, therefore, be long or short, as desired.

Air for combustion in one of the stoves 10 or 11 may be forced through the pipe 19 by the positive displacement blower 20 and into one or the other of the branch pipes 21, 22, depending upon the adjustment of the valves 23, 24, respectively included therein, this being the preferred arrangement for furnishing combustion supporting air to the stove 10 or 11 in which gas admitted to the lower part of the stove is burnt to heat the checker work to required temperature.

If the steam furnished by the boiler 4 to the gas in pipe 8 is not sufficient, it may be supplemented by steam furnished through a steam pipe 25 from a supplemental source. The portion of the gas that has passed from the boiler 4 but which is not passed to the stoves finds exit through a branch pipe 26 as "blue gas" and is passed to points of consumption. A valve 27 is employed to regulate the amount of the gas passing to the piping 12 and 13 and to the piping 26.

The hot blast of mixed steam and gas at 3 or 4 meeting the carbon in the lower zone of the generator 1 results in a mixture of carbon monoxide and hydrogen. A portion of these gases pass upward through the fuel in the generator, heating the fuel and being themselves cooled. When cooled to a temperature of about 1000 degrees C., about two-thirds of the gases are removed from the furnace through the central vertical branch of the outlet pipe 3' and passed through the waste heat boiler 4. The other third of the gases passes on upward through the fuel surrounding the aforesaid branch of pipe 3' and serves to heat the incoming fuel and to distill and absorb from it the moisture and volatile hydrocarbons which the raw fuel contains. These volatile and distillation products pass out of the top of the genator through pipe 28 mixed with the carbon monoxide and hydrogen of the heating cases into a condenser 29 where the mixture of gases and volatile constitutents is cooled and the condensible portions removed. The light oils are passed off through pipe 30, the heavy oils and tars through pipe 31 and the hot water through pipe 32. The condensing water is admitted at pipe 33. Either at this time or subsequently the ammonia carried over with these gases is absorbed by water or sulphuric acid for the production of ammonium sulphate. The gases may then be drawn off through a down-pipe 34 by means of an exhauster 35, the outlet of this pipe being controlled by means of a suitable valve 36.

The action of the hot steam blast at 3 or 4 on the fuel in the lower zone of the generator and the resulting generation of water gas absorbs a large amount of heat in chemical transformations and in heating the fuel. This heat is carried into the generator 1 from the hot blast stoves 10, 11. Within the range of temperatures practically available, the steam required will not hold enough heat to supply these heat requirements. To carry the required additional heat from the hot blast stoves to the generator, a portion of the cooled gas leaving the waste heat boiler 4 is directed into the cold end of one or the other of the stoves as described and is used to carry forward to the generator the extra required amount of heat. Whenever the temperature of the stove is reduced below the temperature sufficient to furnish this amount of heat, the direction of the flow of gas is reversed so that the stove will again be heated to the proper temperature by the combustion of air and gas therein. It will be noted that the heat carrying gas circulates in a closed loop or circuit, passing in succession through one hot blast stove, up the lower section of the generator 1 to the pipe 3' thence through the waste heat boiler 4 and the positive displacement blower 9 and returning to said hot blast stove. Any required amount of heat can therefore be transferred from a stove to the generator within practical temperature limits by continuing this gas cir-

culation. This same gas circulation serves to transfer to the boiler 4 the necessary heat for the generation of all the steam required for gas making and also for the operation of the blower engines. After the system is in operation, the hot gas drawn off from the incandescent zone of the furnace carries enough heat for this operation without the need of partial combustion or the addition of steam through the auxiliary line 25, though auxiliary steam may be used, if desired, and is necessary when the system is first being put into operation and before it has acquired the amount of heat necessary to perform the various operations herein described. In practice the steam generated by the waste heat boiler 4 is introduced into said gas circulation loop or circuit as illustrated. This steam produces excess gas and this may be removed as cool gas from the said circulation loop or circuit by the pipe 26 after leaving the boiler and before the introduction of the steam. This excess gas removed here, has a heating value of about 300 B. T. U. per cubic foot and may be used separately or combined with the richer gas from the condenser 29 that flows through the piping 34 (connected with pipe 8) with the aid of the positive displacement blower 35 and controlled in its flow by the valve 36 through which the combined gases pass for utilization. The combined gases may be further enriched by the addition of oil gas to bring the total production up to the legal requirements for city gas purposes.

The flow of gas from the generator is continuous and uniform, so that the minimum holder capacity is required. The temperatures used in my method are substantially the same as those of standard open hearth furnace steel practice. At these temperatures no available gas valve construction is durable. The amount of gas diverted into the second stove 11 is therefore controlled without "hot" valves, by both supplying the air blast to the stove 11 and removing the products of combustion by the positive displacement blowers 18′ and 20. By controlling the relative speed of these blowers, the necessary amount of gas is taken from the base of the generator and efficiently burned in the second stove 11 to store up the amount of heat that will be required from this stove on the next cycle. At regular intervals the functions of the two stoves are reversed, the first stove then storing heat from the burning gas and the second stove giving up heat to the generator.

In the system illustrated all of the coke formed from the distillation of the fuel is completely consumed in the production of gas without removal from the generator. The high terminal temperature of the final coke consumption also serves to fuse the ash, so that it may be tapped from the generator in a liquid form through a tap hole 40, and so free from any entangled solid carbon.

The gases and steam from the stoves enter the generator at a temperature well above the melting point of the ash in the fuel. The ash is therefore slagged and is removed from the generator by tapping. This slagging is facilitated by adding lime with the fuel. Such lime addition has the further advantage in the distillation zone of the generator of fixing the organic acids which develop in the decompositions of the destructive distillation. The absorption of these acids in this zone protects the ammonia from attack until it escapes with the low boiling point volatile constituents.

In the hotter temperatures of the lower gas zone these organic lime salts are broken up and the lime released for slagging combination with the silica of the ash, the organic acids themselves being decomposed into permanent gas additions to the gas produced directly from the fuel.

The slagging of the ash in the generator makes practical the use of iron ore for sulphur fixation. This iron ore is added with the fuel charged into the top of the generator. At the low temperatures near the top of the distillation zone the iron ore is reduced by the free hydrogen of the gases to metallic iron sponge. Such nascent iron has sufficient affinity for sulphur to remove it from most organic compounds and to fix it in permanent form under reducing conditions as a sub-sulphide pyrrhotite which is fusible at the temperatures of the lower part of the generator and accumulates in liquid form with the slagged ash. When tapped from the generator with the slag, this pyrrhotite settles into the conical bottom of the slag pot and when solidified may be readily knocked off and accumulated for sale to sulphuric acid makers. As the conditions in the generator of my system are more strongly reduced than in an iron blast furnace a considerable portion of the sulphur in the fuel may also be fixed in the slag as calcium sulphide by the addition of further lime to the charge. In the same way most of the phosphorus in fuel can be fixed and taken out as calcium phosphide.

The coke resulting from the distillation zone surrounding the branch of pipe 3′ within the furnace passes red-hot and without quenching down into the water gas zone, whereby the sensible heat of this coke and the water otherwise required for quenching it are both saved. In this way the heat absorbed in the water gas reaction in the lower zone of the generator is not obtained by interrupting the gas generation and blowing air, but is continuously carried into the generator by the stream of hot gas and white hot steam from the hot blast stoves.

In both the distilling and gas generating zones of my equipment the heat is supplied internally by an incoming current of hot gases. Important advantages result from this method of heat supply. In the usual externally heated coal distilling retort, the inside of the retort walls is necessarily hotter than the products of decomposition being given off, in order to provide a temperature gradient for the essential heat flow. When the volatile constituents of the distillation come into contact with the hot walls, they are broken up into higher boiling point constituents of less commercial value and carbon, there being then deposits of carbon on the furnace walls that interfere with the heat flow. In my system the walls are cooler at any level than the charge and gases within them, due to the temperature gradient required to cause the flow of the heat that is being radiated from the external surface of the generator.

The gases as they move upward are cooled by their contact with the downcoming fuel. From this counter movement and counter temperature gradients of the fuel and gas it follows that as soon as any constituent of the fuel reaches its distilling temperature and becomes gaseous, that it is at once reversed in its direction of movement and is swept into a region of temperature lower than its distilling point. No opportunity exists in the generator of my system for a distillation product of any distilling temperature to come into contact with a higher temperature than that at which it is distilled. This applies also to the ammonia which exists as such when the coal is distilled or which may be formed by the direct combination of hydrogen and nitrogen. As soon as the temperature is reached at which the ammonia is released it is at once taken up by the gas current and removed without being exposed to a higher destructive heat.

In the generator of my invention the relative speeds of the positive displacement blowers 35 and 9 removing the gases through the condenser 29 and through the boiler 4 are so adjusted as to maintain approximately atmospheric pressure above the incoming fuel inside the generator. The volume of the incoming heating gas is about six times that of the volatile constituents of distillation. Of the total atmospheric pressure at the top of the fuel the products of distillation therefore carry only one-seventh. As the physical action of any one gas in an enclosure is practically without interference with any other gas present in the enclosure at the same time, the distillation of the fuel in the generator of my system therefore takes place under conditions equivalent to a vacuum of some twelve pounds to the square inch, with corresponding results on the temperatures of distillation and the complete removal of the volatile constituents and the illuminants.

As the volatile constituents of low boiling points are removed and the fuel sinks down into zones of higher and higher temperatures, the proportion of volatile constituents to heating gas is reduced, so that the residuals remaining in the coal are subjected to the equivalent of a higher and higher vacuum, at the same times as the temperatures increase. The result is a very complete extraction of the volatile constituents of the fuel without injury to any of them. At the same time the actual total pressure at all points in the generator is never below atmospheric pressure, so that there is no tendency for air leakage.

It will thus be noted that while the total pressure of the gases within the generator is never below atmospheric, the partial pressure of each of the component gases is necessarily less than this total pressure, giving the equivalent of a partial vacuum, so far as the effect on each of the component gases is concerned.

As the gases move upward in the distillation zone they become cooler and the proportion of volatile constituents increases. This means an increase in the portion of the total atmospheric pressure carried by each constituent. The result is that constituents of higher boiling points condense and are deposited on the incoming fuel. No constituents having a boiling point much above the temperature of the "top gas" can leave the distilling zone. This top temperature of the leaving distillation gas is controlled by the volume of gas passing through the distillation zone and this in turn is controlled by the speed of the positive displacement blower 35 taking the non-condensible gases from the condenser 29.

As a result of this retarding action of the cool top layer of fuel in the generator of my invention volatile constituents of higher boiling points which usually go over in other distillation equipment, are held back in this generator and, dripping down into hotter and hotter zones, are progressively stripped of their illuminants and volatile constituents of low boiling point, until the eventual residual coke passes down with the other coke to the gas making zone below. From this action it results that the residual tars of higher boiling points can be kept back from going over with the distilled gases to any desired extent.

The usual tar fog which is difficult to remove from many coal distillation gases consists of liquid tar bubbles filled with gaseous products of lower boiling points. These bubbles may be the result of exposing gases of low boiling point to temperatures much higher than their boiling point, resulting in the decomposition of the sur-

face of the bubble into liquids of higher boiling points. During this decomposition the hydrogen or light hydrocarbons escape.

As the tars are continually dripping back in the distillation zone of the generator of my system, they would eventually interfere with the passage of the heating gas. This is avoided by maintaining the cold upper surface of the fuel in the form of a cone. No gates are required on the hopper as the pressure inside the generator is maintained at about atmospheric pressure at this point. Consequently a considerable amount of freedom is maintained for poking the upper layers of the fuel charge through the hopper and top poke holes substantially without the entrance of air or the escape of gas. The trapped tar zone maintains itself approximately parallel to the cool upper conical surface of the fuel, the tar tending to escape all along this surface. Therefore the downward movement of the fuel results in a horizontal shifting of any particular part of the tar deposit and its eventual degradation to coke, and serves to close up the outer ring of the fuel charge and in part to check the tendency of the gases to pass more freely up along the lining of the generator. This outward shifting of the tar zone leaves the inner zone correspondingly more permeable to the passage of the gases. Some heat flows through the central pipe 3′ from the hot outgoing water gas into the coal being distilled and correspondingly reduces the amount of heating gas required.

With the usual coal gas coal, the amount of water gas produced from the resulting coke is just about enough after deducting the gas burned in the stoves 10 and 11 to carry in the heat required in the distillation zone. With leaner coals, more water gas is made than is needed for this purpose. If this excess gas were put through the coal it would raise the temperature of the top of the coal above that necessary to hold back the tar. This excess gas is therefore taken off from the regenerator boiler loop circulation at 26, 27, just after leaving the boiler.

If the coal is unusually high in volatile constituents the coke remaining may not produce enough water gas to carry in all the required distilling heat. In this case a blast of secondary air is blown in at the base of the distillation zone by the blower 20, through the pipe branch 37 which is then opened by the normally closed valve 38 for this purpose. Part of the water gas entering this zone is thus burned releasing whatever heat may be needed to complete the distillation. This combustion produces water vapor, the presence of which in this zone increases the yield of ammonia. For this purpose water gas may be diverted after leaving the cooler even when lean coals and high ammonia yields secured by burning part of the remaining water gas in the distillation zone.

Even with rich coals and resulting lower yield of blue gas, sufficient gas may be obtained to carry in the distillation heat by making part or all of the steam in an outside coal fired boiler and in this way avoid burning the gas otherwise required for the heat of steam making. The volume of gases available for carrying the heat of distillation may also be increased by allowing some air to enter the generator zone with the hot gas, by slightly opening the otherwise closed valve 23 or 24, the nitrogen of this air passing into and forming a part of the gas made. In this way also an additional temperature range may be secured in the base of the generator, if any such temperature is necessary to melt an especially unfusible ash. The amount of the air so introduced is necessarily small, as it, of course, combines with some of the water gas, thus introducing a certain amount of incombustible CO_2 into the system.

It is to be noted that the differential distillation of my method, whereby only low boiling point fractions are taken off, is due to keeping the top of the fuel charge cool. In the usual gas equipment the gases coming off of the top are much hotter than the temperature of the incoming fuel and consequently carry with them fractions of higher boiling points, which with my equipment can be more profitably held back and stripped of their low boiling point constituents.

In the water gas zone also, other important advantages result from the use of heat generated outside in the hot blast stoves and transferred to the generator on the current of gas and steam. The most important of these is that the generation of gas becomes continuous, reducing the necessary size of a holder to a minimum and permitting gradual adjustment of the operating conditions of the equipment to the best working positions. In the usual water gas generator with air blown internally there is a tendency to continue the air blast unduly with corresponding waste of fuel. As only gas is burned in my stoves 10, 11, complete combustion can be secured by a minimum excess of air.

The water gas from the generator of my system is produced from coke which has been exceptionally well deprived of its volatile constituents in the prior distillation in the upper zone of the generator. The water gas is therefore low in hydrocarbons. Such hydrocarbons as it contains are broken up in the hot stoves. Most of the soot combines with the hot steam. The portion of the soot depositing in the refractories of the stove, is burned out again by the excess air in the next cycle.

While I have herein shown and particularly described the preferred embodiment of the apparatus of my invention which is well adapted to the practice of my method, I do not wish to be limited thereto.

Having thus described my invention I claim as new and desire to secure by Letters Patent the following:—

1. The method of producing gas which comprises subjecting one portion of a mass of carbonaceous fuel to the decomposing action of water gas and steam to generate additional water gas, subjecting another portion of the same mass of fuel to the distilling action of the heat of the produced gas to produce other gas, simultaneously burning some of the gas generated in the one cycle and with the resultant heat heating the gas to which the first mentioned fuel portion is subjected in a subsequent cycle.

2. The method of producing gas which consists in subjecting one portion of a mass of carbonaceous fuel to the action of gas and steam to generate additional gas, subjecting another portion of the same mass of fuel to the distilling action of the produced gas to produce other gas, simultaneously burning some of the produced gas and with the resultant heat in subsequent cycle heating the gas to which the first mentioned fuel portion is subjected.

3. The method of producing gas which consists of subjecting one portion of a mass of carbonaceous fuel to the action of a superheated mixture of gas and steam to generate additional gas, subjecting another portion of the same mass of fuel to the distilling action of the heat of the produced gas to produce other gas, subsequently utilizing a portion of the gas produced in the first mentioned portion of the fuel as the gas to which this fuel portion is again subjected, simultaneously burning some of the produced gas and with the resultant heat in subsequent cycle heating the gas to which the first mentioned fuel portion is subjected.

4. The method of producing gas which consists in subjecting one portion of a mass of carbonaceous fuel to the action of combustible gas and steam to generate additional gas, subjecting another portion of the same mass of fuel to the distilling action of the heat of the produced gas to produce other gas, simultaneously burning some of the gas produced in the first mentioned fuel portion and with the resultant heat in a subsequent cycle heating the gas to which the first mentioned fuel portion is subjected.

5. The method of producing gas which consists in subjecting the lower portion of a mass of carbonaceous fuel to the decomposing action of superheated gas and steam to generate additional gas, subjecting another portion of the same mass of fuel to the distilling action of the heat of the produced gas to produce other gas, employing the gas mentioned in the first mentioned portion of the fuel as a gas to which this fuel portion is later subjected, and simultaneously burning some of the gas produced in the first mentioned fuel portion and with the resultant heat superheating the gas to which the first mentioned fuel portion is subjected.

6. The method of producing gas which consists in subjecting one portion of a mass of carbonaceous fuel to the action of superheated gas and steam to generate additional gas, subjecting another portion of the same mass of fuel to the distilling action of the heat of the produced gas to produce other gas, employing the gas produced in the first mentioned portion of the fuel as the gas to which this fuel portion is later subjected, simultaneously burning some of the gas produced in the first mentioned fuel portion and with the resultant heat superheating the gas to which the first mentioned fuel portion is subjected in a subsequent cycle.

7. A method of producing combustible gas, which consists in subjecting one portion of a mass of carbonaceous fuel to the action of a superheated mixture of gas and steam to generate additional gas, subjecting another portion of the same mass of fuel to the distilling action of a portion of the gas, removing this distilled portion of the generated gas containing volatile hydrocarbons from a relative cool zone of the fuel without subjecting the volatile hydrocarbons to a fixing temperature, removing a portion of the gas produced in the first mentioned portion of the fuel bed from a relatively hot zone burning some of the gas generated in said hot zone, and with the resultant heat of combustion superheating the gas to which the said first mentioned fuel portion is subsequently subjected.

8. The method of producing gas which consists in subjecting an incandescent portion of a mass of carbonaceous fuel to the decomposing action of a superheated mixture of gas and steam to generate additional gas, subjecting another portion of the same mass of fuel to the distilling action of the heat of the produced gas to produce other gas, employing the gas produced in the first mentioned portion of the fuel as a gas to which this fuel portion is later subjected, simultaneously burning some of the produced gas and with the resultant heat superheating the gas to which the first mentioned fuel portion is subjected in the subsequent cycle and heating water with the hot gases produced in the process to form the steam used in the process.

9. The method of producing a combustible gas which comprises subjecting the incandescent zone of a mass of carbonaceous fuel

to the gas producing reaction of a superheated mixture of gas and steam, whereby additional fixed gas is generated, using a portion of the produced gases for distilling the volatiles from a cooler portion of the same mass of fuel, removing another portion of the fixed gas while still hot and utilizing its heat for generating steam, removing a portion of the cooled gases from the cycle after their heat has been used in said steam generation and passing the remaining gas, together with steam, through a superheater in which the mixture is heated to a temperature sufficient to decompose the steam, and utilizing a portion of the superheated mixture to be burned with air for storing heat for superheating gas and steam in a subsequent cycle.

10. The method of producing a combustible gas which comprises subjecting the incandescent zone of a mass of carbonaceous fuel to the gas producing reaction of a superheated mixture of gas and steam whereby additional fixed gas is generated, using a portion of the produced gases for distilling the volatiles from a cooler portion of the same mass of fuel, removing another portion of the fixed gas while still hot and utilizing its heat for generating steam, removing a portion of the cooled gases from the cycle after their heat has been used in said steam generation and passing the remaining gas, together with steam, through a superheater in which the mixture is heated to white heat sufficient to decompose the steam, introducing a portion of the superheated mixture into the incandescent fuel and diverting another portion thereof to be burned with air for storing heat for superheating gas and steam in a subsequent cycle.

11. The method according to claim 10, which consists in removing the condensible products from that portion of the gas which is passed through the distilling zone of the fuel and mixing the stripped gas with a portion of the gas removed from the gas making cycle after extraction of its heat in generating steam.

12. The method according to claim 10, which consists in adding a small quantity of air with the superheated gas and steam introduced into the incandescent zone of the fuel.

13. The method of producing combustible gas from carbonaceous fuel, which consists in subjecting one portion of the fuel to the action of a superheated mixture of gas and steam to produce other gas, subjecting a relatively cool portion of the fuel to the heat of said produced gases to distil the volatile hydrocarbons from the fuel, removing the resulting rich gas from the fuel bed without subjecting it to cracking temperatures, cooling said rich gas to remove the condensible constituents, removing a portion of the gas produced in the first mentioned portion of the fuel bed, burning a portion of said gas during the gas making operation and with the resulting heat heating a regenerator by means of which gas and steam, for the gas making operation, are superheated in a subsequent cycle.

In witness whereof, I hereunto subscribe my name this tenth day of October, A. D., 1919.

FREDERICK T. SNYDER.