

[54] **PROCESS FOR COAL GASIFICATION**

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[58] Field of Search **48/202, 203, 204, 206, 207, 48/210, 63, 64, 73, 76, 77, 78, 99, 197 R**

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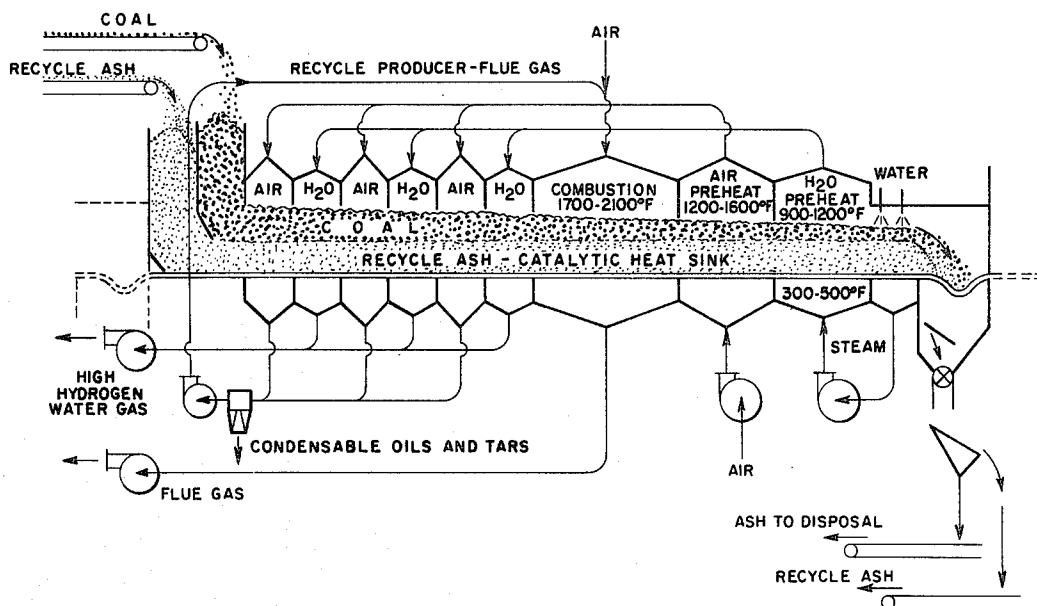
Primary Examiner—Joseph Scovronek

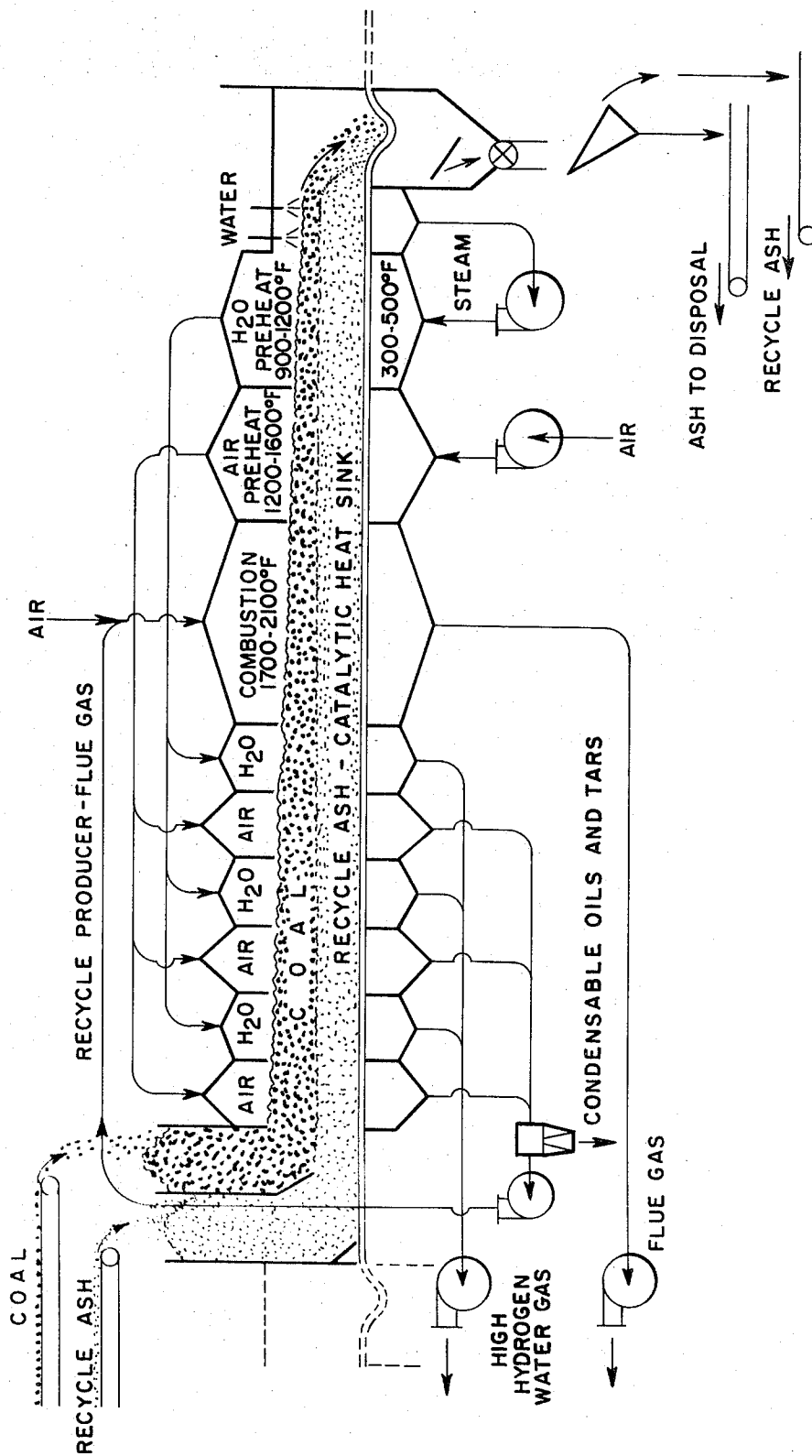
Attorney, Agent, or Firm—McNenney, Farrington, Pearne & Gordon

[57] **ABSTRACT**

There is provided a process for producing water gas containing a large quantity of hydrogen and involving the formation of a moving quiescent gas-permeable bed composed of both particles of coal and particles of spent coal or ash. The bed is passed through a series of zones in which, in a succession of cycles, the bed is permeated with an oxygen-containing gas preheated to a predetermined temperature and then a moisture-laden gas also preheated to a predetermined temperature. These gases are collected separately after they traverse the moving quiescent bed. The water gas may be used as an industrial gas, and the producer-flue gas resulting from the portions treated with oxygen-containing gas may be recycled through the bed at a point downstream. The process provides a continuous economic procedure for gasification of coal.

10 Claims, 1 Drawing Figure



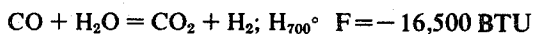
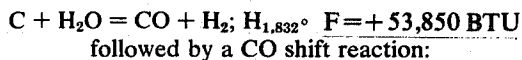


PROCESS FOR COAL GASIFICATION

BACKGROUND OF THE INVENTION AND PRIOR ART

Coal is recognized as a hydrogen-deficient fuel and requires an improved hydrogen:carbon ratio before it can be upgraded into high quality liquid or gaseous hydrocarbons. In general, processes for synthesis of pipeline gas from coal require either a hydrogenation step for hydrogen addition, or a decarbonization step for improvement of the hydrogen:carbon ratio. Efficient coal conversion processes contemplate hydrogen production from surplus carbon or coal and reintroduction of the manufactured hydrogen to the coal by hydrogenation processes.

Hydrogen is an expensive gas to manufacture. Normal petroleum refinery systems usually generate hydrogen by reforming natural gas. Depletion of natural gas supplies has caused greater incentive to steam-coal reactions for production of hydrogen. Essentially, this can be brought about by the well-known water gas reaction:



This in turn is followed by means to absorb carbon dioxide such as carbonate-forming systems or ethanolamine absorbents.

The water gas reaction is normally carried out at from 1,500° to 2,000° F. and is highly endothermic. This reaction may be supported by (1) cyclic air combustion operation of the water-gas producer; (2) use of oxygen for partial combustion to avoid nitrogen diluent present in air; (3) electrothermal reactions; and (4) high temperature heat transfer by solids such as used in the CO₂ acceptor process.

The carbon monoxide shift reaction is favored by lower temperatures generally on the order of 700° to 900° F. and is exothermic. Catalysts such as iron, iron compounds (iron oxides) and chromium or chromium compounds tend to accelerate the rate of conversion.

The use of oxygen in the production of water gas is extremely expensive inasmuch as the oxygen requirement is practically as high as the coal requirement. Electrothermal methods are expensive, and solid heat transfer systems are associated with materials handling and degradation problems.

The present invention contemplates a new and improved method of producing high hydrogen water gas directly from coal and water through the use of a traveling grate firing operation which overcomes many disadvantages of the old cyclic generators and does not require the use of oxygen gas. The traveling grate operations are readily scaled to massive handling of materials at minimum risks and costs. The present improved process makes use of a recycle catalytic heat sink as a hearth layer or co-blended with the coal. The present process depends upon alternate air and moist gas injections through a relatively thin moving quiescent bed of coal particles. By "moving quiescent" is meant that once the bed is formed and is moving along a predetermined path, there is minimal relative movement between adjacent particles. Some settling will occur as the bed shrinks in the course of gasification. The opera-

tions of the present invention are readily adapted to a straight line traveling grate or to a circular traveling grate such as that described in U. S. Pat. No. 3,302,936 dated Feb. 7, 1967.

BRIEF STATEMENT OF THE INVENTION

Briefly stated, the present invention is in a process for producing from coal water gas having an enhanced hydrogen content and which comprises the steps of:

- a. continuously forming a quiescent gas permeable bed of coal particles and spent coal particles. The bed may be composed of an interspersed of spent material from the process among raw coal particles or the raw coal particles may be layered upon a hearth layer of spent particles or ash. The bed is then moved (generally horizontally) through a series of zones wherein in a succession of cycles it is permeated first with an oxygen-containing gas preheated to a temperature of from 1000° to 1,800° F. to raise the temperature in the bed along a heat front to from 2,200° to 2,500° F. and to effect carbonization of the coal and to yield a producer flue gas; and
- b. a moisture laden gas or steam at a temperature of from 800° to 1,400° F. to yield high hydrogen water gas. The flue gas and the high hydrogen water gas issuing from the burden, usually the lower surface thereof, are separately collected. The water gas may be sent to storage, and the producer flue gas recycled for further combustion of the coal in the process. Steam may be produced from the application of water at a terminal portion of the travel of the bed, and an oxygen-containing gas, e.g., air, to be used in the initial portion of the operation may be preheated by passage through the bed from an ambient source, for example, prior to the quenching step.

BRIEF DESCRIPTION OF THE DRAWING

The present invention may be better understood by having reference to the annexed drawing which illustrates in diagrammatic and schematic form a development of a circular traveling grate machine and illustrating the various zones through which the moving quiescent gas-permeable bed of coal particles and spent coal particles flows in the course of treatment pursuant to a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE PROCESS

With reference to the annexed drawing, the operations occur in the following sequence:

- Recycle ash is applied as a hearth layer, the depth thereof being regulated to from 18 to 36 inches by suitable gating means in a known manner. This hearth layer is used not only as a heat sink to trap and retain heat resulting in the process but also to provide catalytic elements or compounds useful in improving the conversion as previously indicated. The hearth layer is charged directly upon the traveling grate as a relatively thick layer of crushed graded recycle material. The ash is graded approximately -2 inches plus 1/4 inch and is applied continually as a bed approximately 24 inches deep. A continuous bed of crushed coal is applied directly over the hearth layer. The coal is graded to approximately -2 inches plus 1/4 inch and is applied as a bed depth of approximately 12 - 24 inches.

The moving bed is initially permeated by a downdraft of preheated oxygen-containing gas, for example air, which brings about carbonization and preheating of the

coal to a temperature of 2,500° F. The temperature of the oxygen-containing gas as it enters the bed is from 1,200° to 1,600° F.

In the next zone horizontally traversed by the moving quiescent gas-permeable bed, it encounters preheated steam which is reacted with the hot coal in the bed and brings about the endothermic water gas reaction. In the presence of the catalytic material, residual carbon monoxide reacts in a second reaction with surplus steam to bring about the shift reaction which is operable at the lower temperatures. The shift reaction is also influenced by the metallic iron and iron oxide of the hearth layer composed of coal ash as well as the scale, metallic iron, and chromic constituents of the alloy grate bars and pallets of the traveling grate machine. The treatment with the oxygen-containing gas followed by the treatment with moisture-laden gas or steam constitute a single cycle. A plurality of such cycles in sequence is undergone by the coal. In the embodiment shown, three such cycles are contemplated. A larger number of cycles may be used if desired.

Within the lower windboxes, the products of combustion from the injection of oxygen-containing gas are collected in respective alternate windboxes. The products containing water gas are also collected in alternate windboxes adjacent those previously mentioned. The windboxes collecting the products of combustion, identified herein as producer-flue gas, are maintained at a vacuum slightly higher than those of the adjacent windboxes containing and collecting the water gas. This minimizes infiltration of nitrogen diluent into the water gas windboxes. Such windboxes may also be provided with steam flooded seals at deadplate areas to prevent excessive water gas infiltration as well as to prevent dilution of the water gas with nitrogen.

The products of combustion are largely a blend of producer gas and flue gas in combination inasmuch as a considerable amount of carbon monoxide is generated by the reaction of air with the hot coal-char bed. The gases are preferably cleaned of condensable oils and tars inherent in the process of carbonizing coal. The producer flue gas is conveniently recycled to a combustion zone downstream of the final water gas production zone and serves to complete the burning of the coal and to preheat the spent coal ash and the catalytic heat sink, thus restoring latent and sensible heat to the system. Exhaust gas from windboxes of the combustion zone is then directed to a stack or suitable exhaust gas treating apparatus for further utilization or discharge to the atmosphere. It is apparent, however, that the heat of the gas from the windboxes may be exchanged, if desired, with incoming updraft air in the next following cooling zone. The resulting heated air may then be used for the combustion cycles. When the incoming air from an ambient source becomes preheated, the catalytic heat sink becomes cooled. This preliminary cooling stage is then followed by a steam preheating stage where the temperature of the moisture-laden gas is elevated to lower than that of the combustion air. There then follows a final cooling stage for the bed wherein a water quench is conveniently applied. The quenching operation produces steam downwardly drawn through the bed which is then preheated by passage upwardly through the moving quiescent gas-permeable bed to provide preheated steam at a temperature of from about 800° to 1,400° F. for coal gasifica-

tion. Additional or make-up steam may be supplied by an auxiliary service.

The total clinker discharge is comprised of the hearth layer or mixed layer and spent coal ash which is dumped from the machine, crushed, and graded. A graded portion of the ash is directed back to the process, and the balance directed to disposal.

It is contemplated for the foregoing gasification reactions that there may be used a liquid sealed circular traveling grate such as described in the aforesaid U.S. Pat. No. 3,302,936. It is apparent, however, that any conventional traveling grate machine whether of the straight line or circular variety may be equipped with adequate seals.

The system which is illustrated in the annexed drawing is particularly efficient wherein the air and moisture move counter to the direction of movement of the moving quiescent gas-permeable bed. It has been observed that the presence of iron or iron compounds and chromium alloy in the grate bars contributes to an unexpected high yield of hydrogen in this system. Catalysis is apparently brought about by the downdraft of the gases, causing the shift reaction to occur in the lower temperatures of the lower reaches of the hearth layer. As an alternative technique, the catalytic heat sink may be preliminarily blended with the coal, thereby providing a longer residence time for enabling the gases to co-react in the presence of the catalyst. It has also been found that a co-blend of the recycle ash and the coal brings about improvement in the gas solid reactions when using soft plastic coals such as those of the coking and semicoking types. The blend of ash and coal provides isolated coal particles and prevents the caking which ordinarily impedes gas-solid reactions.

What is claimed is:

1. A process for producing water gas having a high hydrogen content from coal which comprises the steps of:

- a. continuously forming a generally horizontally moving quiescent gas-permeable bed comprising a layer of coal particles superposed upon an underlying layer of recycled spent coal particles;
 - b. passing said bed through a series of zones wherein, in a succession of cycles, said bed is downwardly permeated with:
 1. an oxygen-containing gas preheated to a temperature of from 1,000° to 1,800° F. to raise the temperature in the bed along a heat front to from 2,200° to 2,500° F. and to effect carbonization of the coal to yield a producer flue gas; and
 2. a moisture-laden gas at a temperature of from 800° to 1,400° F. to yield high hydrogen water gas;
 - c. separately collecting the producer flue gas, and
 - d. separately collecting the high hydrogen water gas.
2. A process in accordance with claim 1 in which the oxygen-containing gas is air.
3. A process in accordance with claim 1 in which at least a portion of the producer flue gas is recycled through the burden in a separate zone following said series in zones.
4. A process in accordance with claim 3 in which the producer flue gas is mixed with fresh air prior to recycling through the bed.
5. A process in accordance with claim 1 in which the oxygen-containing gas is preheated by passage through

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the bed in a recuperating zone downstream of said series of zones.

6. A process in accordance with claim 5 in which the oxygen-containing gas is ambient air.

7. A process in accordance with claim 1 in which the moisture-laden gas is steam.

8. A process in accordance with claim 1 in which the moisture-laden gas is preheated by passage through the bed in a recuperating zone downstream of said series of zones.

9. A process in accordance with claim 1 in which the

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moisture-laden gas is produced in a bed quenching zone wherein water is directed onto the upper surface of said bed and the resulting gas drawn downwardly through said bed.

10. A process in accordance with claim 9 in which the moisture-laden gas is directed upwardly through the bed in a zone next preceding said quenching zone to elevate the temperature thereof to from 800° to 1,400° F.

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