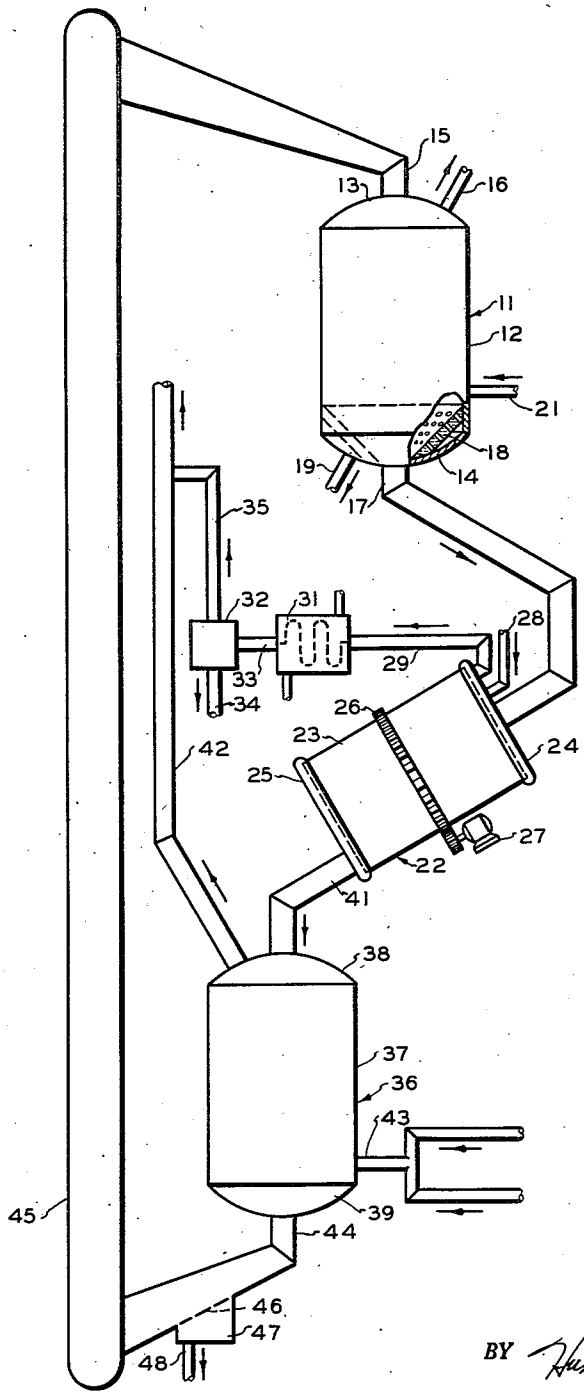
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SYSTEM FOR GASIFYING COAL

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SYSTEM FOR GASIFYING COAL

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5 Claims. (Cl. 48—73)

This invention relates to the gasification of organic solid materials. In one of its more specific aspects it relates to a method and apparatus for the gasification of coking and low ash-fusion-temperature coals.

This application is a division of U. S. application Serial No. 115,209, filed September 12, 1949, now Patent No. 2,659,668.

The gasification of coal can be represented by the reaction between steam and carbon, i. e.,

$$C+H_2O \rightarrow CO+H_2$$

This reaction takes place at temperatures in the neighborhood of approximately 1200° F., but in commercial operation it is ordinarily desirable to use higher temperatures so as to obtain a more rapid rate of reaction. Other reactions also occur in the gasification of coal, such as

$$CO+H_2O \rightarrow H_2+CO_2,\ CO+2H_2 \rightarrow CH_4+\text{etc.}$$

The resulting gas, therefore, is a mixture of hydrogen, carbon monoxide, steam, carbon dioxide, and hydrocarbons. Hydrocarbons are also formed by thermally cracking the coal structure which is composed of complex molecules of primarily carbon and hydrogen. The net gasification reaction is endothermic and most commercial processes vary mainly in their means of introducing heat of reaction for the gasification process. Some conventional processes use internally fired retorts, others provide for periodically blasting the bed of coal with air, and others provide for continually introducing oxygen to make the net reaction exothermic, thus highly superheating steam which is added.

In conventional operation the coal is introduced into a gasification reactor and is heated by one of the above means to the reaction temperature. As the coal is heated, a number of things may happen. At temperatures in the neighborhood of between 400° F. and 500° F., the coal starts to lose its volatile matter, the first released material being mainly loosely bound water. As the temperature is increased, more violent thermal decomposition occurs and hydrocarbon fragments are given off as volatile matter. Larger hydrocarbon fragments, resulting either from cracking or polymerization of smaller hydrocarbon fragments, remain in the coal and exert a solvent action thereon. When this occurs, the coal goes through a plastic or semi-fluid state. The temperature at which the coal is converted to a plastic or semi-fluid state depends upon the particular coal which is being reacted. With a bituminous coal, a plastic or semi-fluid state is encountered at temperatures in the neighborhood of between 800° F. and 1000° F. Certain types of coals, such as lignitic coal and high rank anthracite coal, do not go through the plastic state. Coals which form a plastic state will, upon further heating, further decompose with the evolution of volatile matter and form a resulting solid coke residue.

Commercial gasification processes have heretofore utilized as a feed, coke and coals which do not pass through a plastic or semi-fluid state. Since these materials do not

go through a plastic stage, no difficulty is encountered in the gasification thereof. A great deal of the coal which is available in the United States for gasification is of a coking variety, such as bituminous and sub-bituminous coals. When these coals are supplied to conventional commercial processes, considerable plugging difficulties are encountered in the feed entry and reaction chambers tend to become plugged because of caking on the walls of the chamber where the process utilizes a powdered coal as the feed and the formation of solid clinker-like plugs when the process utilizes a moving solid bed of coal. It has therefore been necessary, heretofore, to convert such coal to coke before supplying the material to a gasification system.

The present invention is defined to overcome the obstacles and difficulties described above which beset conventional gasification processes when utilizing coking and low ash-fusion-temperature coals. Broadly speaking, the invention comprises forming a coating of coke upon the surface of hot, small particles of solid heat exchange material. The coke encrusted solid heat exchange material is then passed to a gasification chamber wherein the coke encrusted solid heat exchange material is contacted with a mixture of steam and oxygen whereby the coke material is gasified. The solid heat exchange material is then removed from the gasification chamber and is heated once again for the purpose of supplying heat to coal which is mixed therewith so as to form a layer of coke on the particles of the solid heat exchange material.

An object of this invention is to provide improved means for gasifying organic solid materials. Another object of the invention is to provide an improved method for gasifying organic solid materials. Another object of the invention is to provide a method for gasifying low ash-fusion-temperature coals. Another object of the invention is to provide a method of gasifying organic solid materials and preventing the accumulation of coke on the walls of gasifying apparatus. Other and further objects and advantages of this invention will be apparent to those skilled in the art upon study of the accompanying disclosure.

Solid heat exchange material which may be utilized in the gasification system of this invention may be generally termed "pebbles." The term "pebbles," as used herein, denotes any substantially solid material of flowable size and form which has sufficient strength to withstand mechanical pressures and the temperatures encountered within the gasification system. These pebbles must be of such structure that they can carry large amounts of heat from one chamber to another without rapid deterioration or substantial breakage. Pebbles which may be satisfactorily used in this gasification system may be substantially spherical in shape and range from about ⅛ inch to about 1 inch in diameter. The size of the pebbles which are used will generally be dependent upon the state of the organic solid material with which they are mixed. When the organic solid material is in a finely powdered state, the pebbles are preferably of a size within the range of from ⅛ inch to ⅝ inch in diameter. Materials which may be used singly or in combination in the formation of such pebbles include among others alumina, silicon carbide, periclase, beryllia, mullite, nickel, cobalt, copper, iron, magnesia, and zirconia.

More complete understanding of the invention will be obtained upon reference to the drawing which is a schematic representation of the device of this invention.

Referring particularly to the drawing, heating chamber **11** comprises a vertically disposed chamber **12** being closed at its upper and lower ends by closure members **13** and **14**, respectively. Pebble inlet conduit **15** and effluent outlet conduit **16** are provided in closure member **13**. Pebble outlet conduit **17** is disposed in closure chamber **14**. Perforate pebble support member **18** extends

upwardly and outwardly from the inlet end of conduit **17** to the walls of shell **12**. Member **18** forms a false bottom in the bottom of chamber **11** and is perforate so as to permit drainage of liquid therethrough, but so as to prevent the passage of pebbles therethrough. Liquid ash outlet conduit **19** is provided in closure member **14** below support member **18**. Fluid heat exchange material inlet conduit **21** is provided in the wall of shell **12**, preferably in the lower portion thereof but above the rim of support member **18**.

Coking chamber **22** is a cylindrical shell **23** which is rotatably mounted at its ends in end closure members **24** and **25**. Closure members **24** and **25** are maintained rigidly in place and permit shell **23** to rotate therein. Traction means, such as toothed member **26**, is provided about the outer surface of shell **23** and is operatively connected to drive means, such as motor **27**. Coking chamber **22** is inclined from the horizontal at an angle of between 1° and 30°. It is preferred that the angle of inclination be between 2° and 15°. Pebble outlet conduit **17** extends from the lower end of chamber **11** to the upper end of chamber **22** and forms a pebble inlet conduit for the latter chamber. Conduit **28** is provided in closure member **24** so as to provide inlet means for finely divided organic solid material.

Effluent outlet conduit **29** extends from closure member **24** to condensation chamber **31**. Separation chamber **32** is connected to condensation chamber **31** by means of conduit **33**. Condensate outlet conduit **34** extends from the bottom of separation chamber **32** and effluent outlet conduit **35** extends from the upper portion of separation chamber **32**. Gasification chamber **36** comprises shell **37** closed at its upper and lower ends by closure members **38** and **39**, respectively. Pebble conduit **41** extends between closure member **25** at the lower end of coking chamber **22** and closure member **38** at the upper end of gasification chamber **36**. Effluent outlet conduit **42** extends upwardly from closure member **38** and is connected to effluent outlet conduit **35** to form a common outlet conduit. The gasifying medium conduit **43** is provided in shell **37** adjacent its lower end. Pebble outlet conduit **44** is provided in closure member **39** and extends to elevator **45**. Elevator **45** is connected at its upper end to pebble inlet conduit **15** of heating chamber **11**. Screen member **46** is provided in the lower wall of a portion of pebble outlet conduit **44** and chamber **47** is provided below screen member **46**. Solid ash outlet conduit **48** is provided in the bottom of chamber **47**.

In the operation of the device disclosed above, solid heat exchange material is introduced to pebble heating chamber **11** and is heated to a temperature of at least 1200° F. The pebbles are preferably heated to a temperature within the range of between 1200° F. and 2000° F. Heat is provided to the flowing bed of pebbles within chamber **11** by passing a fuel which may be a hydrocarbon liquid or gas into the chamber through inlet conduit **21**. The fuel is burned on the surface of the pebbles, providing heat to the pebbles, and the resulting combustion gas is passed upwardly through the pebble bed and is removed from chamber **11** through effluent outlet conduit **16**. This method of operation may be modified by passing a hot gas, such as hot combustion gas, into chamber **11** through inlet conduit **21** rather than supplying a fuel therethrough. The heated pebbles are removed from the lower portion of chamber **11** through pebble outlet conduit **17** and are supplied to the upper portion of coking chamber **22**.

Powdered organic solid material, such as coking or low ash-fusion-temperature coal, is added to coking chamber **22** through inlet conduit **28**. Shell **23** is rotated at a speed within the range of from 1 to 30 revolutions per minute, preferably at a speed of from 1 to 15 revolutions per minute, by the connection between motor **27** and traction member **26**, or any other conventional drive means. The powdered organic solid is mixed with the heated pebbles and receives sufficient sensible heat from the pebbles to convert it to a coke layer upon the surface of the pebbles. Loosely bound water and any hydrocarbon material which is released is removed from chamber **22** through effluent outlet conduit **29**. The effluent material is passed through condensation chamber **31** where it is cooled so as to condense the water. The materials are then passed into separation chamber **32** through conduit **33** and the condensed materials are separated from the uncondensed materials. The uncondensed hydrocarbon materials are removed through conduit **35** and the condensed materials are removed through conduit **34**.

The speed at which shell **23** is rotated will depend generally upon the diameter of the shell. The rotation of shell **23** is supplied only for the purpose of insuring complete mixing of the heated solid heat exchange material and the powdered organic solid material. The inclination of chamber **22** from the horizontal is sufficient to insure flow of the coke covered solid heat exchange material from the lower end of chamber **22** through conduit **41** into gasification chamber **36**. The coated solid heat exchange material forms a flowing bed within chamber **36**.

Oxygen and steam are supplied to the lower portion of chamber **36** through conduit **43** and is passed upwardly countercurrent the flow of the coated solid heat exchange material. The coke is gasified by the reaction with steam and the resulting gaseous materials are removed from chamber **36** through effluent outlet conduit **42**. The hydrocarbons from conduit **35** are added to the gases in conduit **42** so as to enrich the gases therein. The cooled solid heat exchange material is removed from the bottom of chamber **36** through pebble outlet conduit **44** and passes over screen **46** to elevator **45**. Any solid ash which has been separated from the surface of the solid heat exchange material is removed from the flowing mass of solid heat exchange material by allowing it to fall through screen **46** into chamber **47** from which it is removed through outlet conduit **48**. The solid heat exchange material is elevated by elevator **45** to the upper portion of heating chamber **11**. Any ash which remains on the surface of the solid heat exchange material is melted by the application of heat to that solid heat exchange material in heating chamber **11**. The melted ash flows downwardly through the perforate support member **18** and is removed from the bottom of chamber **11** through melted ash outlet conduit **19**.

The description of the method of this invention is clearly applicable to the operation of the apparatus which is shown in the drawing. The scope of the method of gasifying coking variety of coals which is disclosed herein is believed to be broader than the specific apparatus herein disclosed. It should be noted that the device of this invention could be modified by providing another type of tumbler device which would insure complete mixing of the coal and heated pebbles, but the device would not necessarily have to be rotated axially. A separation means, such as screen **46** and chamber **47**, could be provided in pebble outlet conduit **17** and pebble support member **18** would therefore not be required. It is very important, however, that the coke be gasified while coating the solid heat exchange material and that a minimum of grinding be obtained in drum **22**. By passing the pebbles and coke to the gasification chamber without separation, a greater overall heat efficiency is obtainable and a producer gas of higher calorific value is obtained.

The upper surface of support member 18 is preferably formed as an inverted cone, the included angle within said cone being between 60° and 100°. A support member which has such a slope on its upper surface will direct pebbles through its central inlet and substantially prevent the accumulation of stagnant pebbles on its upper surface.

Inert gas, such as steam, may be supplied to pebble conduits **17** and **41** through conduits not shown. The inert gas will act as a choke means and will prevent ef-

fluent gas from passing from one chamber upwardly through conduits 17 and 41 to another chamber.

Various other modifications of the invention will be apparent to those skilled in the art upon study of the above disclosure. It is believed that such modifications are within the spirit and the scope of the disclosure.

I claim:

1. An organic solids gasification system which comprises in combination, a pebble heating chamber; a pebble inlet conduit in the upper portion of said pebble heating chamber; a first effluent outlet in the upper portion of said pebble heating chamber; a first fluid heat exchange material inlet conduit in the lower portion of said pebble heating chamber; an inclined pebble coking chamber rotatable about its axis; a first pebble conduit extending between the lower portion of said pebble heating chamber and the upper portion of said pebble coking chamber; an organic solids inlet conduit in the upper end of said pebble coking chamber; a condensation chamber; a second effluent outlet conduit extending between the upper end of said pebble coking chamber and said condensation chamber; a separation chamber; a third effluent outlet conduit extending between said condensation chamber and said separation chamber; a condensate outlet extending from the lower portion of said separation chamber; a fourth effluent outlet conduit extending from the upper portion of said separation chamber; a gasification chamber; a second pebble conduit extending between the lower end of said pebble coking chamber and the upper portion of said gasification chamber; a fifth effluent outlet extending from the upper end of said gasification chamber and connected to said fourth effluent outlet; gasifying medium inlet means in the lower portion of said gasification chamber; a pebble outlet conduit extending from the lower portion of said gasification chamber; and elevation means extending between said pebble outlet conduit means and said pebble inlet conduit.

2. The gasification system of claim 1, wherein liquid-solid separation grid means are provided in the lower portion of said pebble heater chamber; and a liquid outlet conduit extends from the lower portion of said pebble heater chamber below said liquid-solid separation means.

3. The gasification system of claim 1, wherein said pebble coking chamber is a cylinder rotatably mounted in closure members at its upper and lower ends; traction means on the outer wall of said cylinder; and rotation means operatively connected to said cylinder.

4. The gasification system of claim 3 wherein said pebble coking chamber is inclined from the horizontal at an angle of between 1° and 30° and is adapted to be rotated at a speed within the range of 1 to 30 revolutions per minute.

5. An organic solids gasification system which comprises, in combination, pebble heating means having pebble inlet means and pebble outlet means connected thereto; an inclined pebble coking chamber rotatable about its axis and connected at its upper end portion to said pebble outlet means of said pebble heating means; a gasification chamber; pebble conduit means extending between the lower end portion of said inclined pebble coking chamber and the upper end portion of said gasification chamber; gaseous effluent outlet means extending from the upper end portion of said gasification chamber; pebble outlet means in the lower end portion of said gasification chamber; elevator means extending between said pebble outlet means of said gasification chamber and said pebble inlet means of said pebble heating means; gasifying medium inlet means in the lower portion of said gasification chamber; organic solids inlet means in the upper end portion of said inclined pebble coking chamber, gaseous effluent conduit means extending from the upper end portion of said inclined pebble coking chamber; cooling means operatively connected to said gaseous effluent conduit means from said inclined pebble coking chamber; separation means connected to said gaseous effluent conduit means from said inclined pebble coking chamber downstream of said cooling means; condensate outlet conduit means extending from the lower portion of said separation chamber; and conduit means connecting said separation chamber with said gaseous effluent conduit means from said gasification chamber.

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