PATENT SPECIFICATION

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3366

COMPLETE SPECIFICATION

Method and Apparatus for the Production of Gas Suitable for Chemical Syntheses

We, S. A. FORNI ED IMPIANTI INDUSTRIALI INGG. DE BARTOLOMEIS, of Via Settembrini 7, Milan, Italy, an Italian company, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The invention relates to the production of a gas suitable for chemical syntheses starting from coals rich in volatile matter, such for example as long flame gas coal, pitchy lignite, etc.

The invention has for its object a method by the application of which conditions are obtained suitable both for the gasification of the coal and for a complete decomposition of the products of distillation into hydrogen and carbon monoxide; the invention comprises also an apparatus which facilitates the performance of the method and ensures maximum output.

It has already been suggested to carry out the gasification of solid fuel rich in volatile matters by means of steam and oxygen in two producers, the steam being introduced alternately at the top end of each producer, which makes it necessary to effect at intervals the vaporization of the tar.

For the distillation of fuels such as peat and saw-dust, and the production of water gas it has been suggested to introduce the gas formed in one producer at the top of the other producer in which said gas traverses from above downwards the layer of fuel. When utilizing fuels rich in volatile matter it has also been suggested to connect two producers at the top of the chambers and introduce the gasification agents below the fuel in one producer to provide an upward flow preceding the downward flow through the other.

The invention relates to the production of gas starting from fuel rich in volatile matters by making use of steam and oxygen, or steam, oxygen and air, and has for its object a process in which the gasification agents are injected underneath the layer of fuel and caused to traverse it from below upwards, whereupon the temperature of the gas so obtained is raised and the gas is caused to traverse from above downwards a layer of fuel brought to incandescence by the foregoing injection from below, the conditions in the two chambers being periodically inverted, in known manner, in order to have the fuel layer serve alternately for gasifying the coal and for decomposing the hydrocarbons.

In this manner the most favourable conditions are obtained both for the gasification of the coal and for the cracking of the products of distillation.

For carrying out the process according to this invention, use is made of two gas producers (of the most suitable type for gasification of fuel rich in volatile matters) which are connected to each other in the upper part and work in alternate phases. In one phase, the first producer works on the updraught principle and the second producer on the downdraught principle. In such phase, a mixture of oxygen and steam is introduced at the bottom of the first producer, while the final gas is taken off, at the bottom of the second producer.

In the connecting duct between the two producers a certain quantity of oxygen may be introduced so as to obtain a partial combustion of the gases made in the first producer. In the subsequent phase the producers will work in the reverse direction.

This inversion takes place at a right time so as to realize the best conditions for working of the apparatus allowing to the desired result.

Considering the phase in which oxygen and steam are introduced at the bottom of the first producer and final gas is taken off at the bottom of the second producer, the mixture of oxygen and steam is admitted to the first producer at the centre of the grate and immediately meets the hot ash layer and superheats itself.

Later, this gas meets the coal layer and exothermic reactions take place with formation of CO_2 and development of an intense heat, building a zone of high temperature of the order of 1200°C. and above. Over this zone, endothermic reaction then takes place with reduction of CO_2 to CO and decomposition of the steam.

Therefore a region of less high temperatures builds up in the first producer as a consequence of the equilibrium of the various reactions, while over this region there is the region of lower temperature where coal gazifies and lastly the region of still lower temperature where the moisture contents of the coal vaporizes.

The gas leaves the first producer at a temperature of the order of 500°C.

In the connection between the first and the second producer a further introduction of oxygen may be caused to occur, and this oxygen partially burns the gas made in the first producer decomposing the hydrocarbons and raising the temperature to about 1000°C.

In the second producer, in which the gas admitted at the top flows downwards, the gas made in the first producer meets the coal layers at the temperature which is increasing from top to bottom, such distribution of the temperature being a consequence of the preceding phase of working in which the second producer worked as therefore described with reference to the first producer.

In this manner, there first takes place a gasification of the volatile substances contained in the coal at the expense of the sensible heat of the gas, and then, when the very hot region is reached, (the region of the exothermic reactions of the foregoing phase), there takes place a decomposition of the hydrocarbon and a reduction to CO of CO_2 produced by the partial combustion in the duct connecting the two producers.

Finally the gas, before leaving the second producer, is caused to pass through a thick ash layer to which it delivers its own sensible heat thus leaving the producer at a temperature of about 500°C.

The inversion of the cycle is caused to occur at suitable intervals so as to maintain the desired temperatures in the various zones of the two producers.

The admission of the mixture of oxygen and steam to the first producer and the offtake of the final gas from the second producer occur in the central zone, so that both the mixture of oxygen and the final gas are forced to go through the two layers of ash and coal respectively whereby the reactions are carried out in the most complete manner.

The process according to the invention will be described in such a form in relation to the installation diagram shown in Fig. 1 of the annexed drawing.

In this figure, A and B indicate two producers which, in the example in question, are of known type for gasification long flaming coals and which comprise, at the lower part, a boiler 1a, 1b and, at the upper part, a chamber 2a, 2b with the walls and arch of refractory and insulating materials. 3a and 3b indicate the rotating grates, which may be of any suitable type, provided with vessels 4a, 4b for hydraulic sealing. The chambers 2a, 2b of the two producers are put into communication with one another by a passage 5 of refractory and insulating material and into which extends a conduit 6 controlled by a valve 7 preceded by a regulating member (not shown), the said conduit 6 extending opposite a plate 8 of refractory material disposed inside the passage 5.

For charging with coal each producer has, at its upper end, a double hopper 9a, 9b which, for the coal used in this example, may be replaced by any charging apparatus, capable of distributing the coal in continuous manner to the inside of the producer. For other fuels, for example lignite, the charging hopper may be followed by the usual cylindrical conduit which exists inside the producer, this conduit remaining filled with fuel.

In Figure 1 h indicates the upper plane of the fuel and h^1 the level of the ash in each of the two producers A and B.

For supplying steam and oxygen or a mixture of air and oxygen, beneath the grate of one of the producers and for extracting the final gas at the base of the other producer, a group of conduits and cocks is provided which permit of providing in turn the necessary connections.

In figure 1, two conduits 10a, 10b extend beneath grates 3a, 3b of the two producers from conduits 11a, 11b in which are interposed cocks 12a, 12b and which branch from a single conduit 13. Between the cocks 12a, 12b, and the conduits 10a, 10b the conduits 11a, 11b communicate with the conduits 14a, 14b in which are interposed stop cocks 15a, 15b and which branch from a steam pipe 16; a transverse conduit 17 communicates at its two ends, with the conduits 14a, 14b at points

between the stop cocks 15a, 15b and the conduits 11a, 11b and has stop cocks 18a, 18b between which the conduit 17 is connected to a conduit 19 for the introduction of oxygen or a mixture of air and oxygen. The stop cocks 15a, 15b, 16a, 16b are preceded by regulating members (slides, gauges or the like) not shown.

In practice other means for forming the mixture of gasification agents, such as injectors, rotary mixers, and so on as also other devices suitable for these purposes may be used.

The manipulation of the different cocks permits of sending the steam from the pipe 16 and the oxygen or mixture of air and oxygen from the conduit 19, beneath the grate of one or other producer, while at the base of the producer without a supply of steam and through the grid, will be obtained the gases which have been subjected to cracking inside the producer and are collected and fed through the conduit 13.

Alternation of the operations may be obtained by effecting by hand the necessary changes of the different cocks or by making use of an automatic reversing device of known type.

Starting from the position in which the stop cock 12a is closed and the cock 12b open and the cocks 15b, 18b, 15a, 18a closed, by opening the cock 15a there is first effected, by means of steam, the washing of all the conduits to beneath the grate 3a; then the cock 18a is opened for the oxygen or for the mixture of air and oxygen as a result of which gasification commences in the producer A, the mixture of vapour, oxygen and air being regulated by the regulating means referred to but not shown.

In passing, in the producer A, through the layer of ash to which the gases have yielded their heat in the preceding period, the steam and the oxygen are heated and they reach under the best conditions the layer of fuel which they traverse upwards producing water gas.

Meanwhile fresh coal descends from the hopper 9a on the upper plane h in the chamber 2a and the coal is distilled, the products of the distillation, with the water gas and the steam not decomposed, rising towards the arch of the producer A in order to pass through the conduit 5, into the upper region of the producer B.

Into the conduit 5 is introduced, through the conduit 6, a jet of oxygen which, according to the known principle of the inverted flame, burns in the atmosphere of gas and heats the plate 8 which serves to render the combustion stable; in consequence of this combustion, a part of the gas, mainly hydrogen, burns raising the temperature of the gas and of the distillation products coming from the producer A to the desired degree, while the rapid distillation of the fresh coal charged into the producer B will be facilitated and a partial decomposition of the tar and hydrocarbons is produced.

The raising of the temperature in the upper region of the two producers due to the combustion of a part of the gas in the conduit 5 facilitates the subsequent cracking of this gas, since the combustion of the hydrogen produces water vapour and hydroxides which during their passage through the layer of incandescent coal, with the water vapour not decomposed, favourably affects hydrogenation of the hydrocarbons. Moreover the raising of the temperature of the gas raises the temperature of the layer of fuel and consequently of the surrounding atmosphere in which cracking of the tar and of the hydrocarbons takes place.

All the gases which reach the upper region of the producer B are then forced to pass downwards through the layer of fuel contained in the producer B meeting temperatures which are still higher until the level h^1 where the temperature is a maximum.

The cracking decomposition of the tar and of the hydrocarbons as well as their hydrogenation is thus produced in the producer B. The resulting gas free from the tar gives up its heat to the layer of ash which is of considerable height and it leaves the base of the producer relatively cold reaching the conduit 13 through the conduits 10b, 11b and the cock 12b.

After a certain time the cock 18a is closed in order to permit of washing of the conduits beneath the grate 3a by means of steam, after which the operation of the apparatus will be reversed by closing the cocks 12b and 15a and opening the cocks 12a and 15b, in such manner that in the producer B the conduits will be cleaned as far as the grate 3b; then the cock 18b is opened, and gasification is carried out in the producer B, at the base of which water vapour and oxygen is introduced while the final gas leaves the base of the producer A, this gas reaching the conduit 13 through the conduits 10a and 11a and the cock 12a.

Figure 2 shows another arrangement of the group of conduits and cocks which permits alternate operation of the two producers with a quite particular ease of operation.

In this figure the different parts are indicated by the same references as employed in Figure 1; thus 10a and 10b indicate the conduits leading beneath the

grates extending from the conduits 11a and 11b provided with cocks 12a and 12b and reuniting in the single conduit 13; 19 indicates the conduit which supplies the oxygen or the mixture of air and oxygen and 16 the conduit for the steam.

In this form the cocks 15a and 15b for intercepting the steam are replaced by a single cock 15 preceded by a regulating member (such as a gauge) not shown. Similarly, the cocks 18a and 18b for the oxygen are replaced by a single cock 18, also preceded by a regulating member.

The group comprises finally an injector 20 into which the conduit 19 for the oxygen and the conduit 16 for the steam open, the oxygen being drawn in by the steam and mixed with it. From the injector 20 extends a conduit 21 which forms two branches one of which, provided with a stop cock 22a, leads to the conduit 11a of the producer A and the other, provided with a stop cock 22b, leads to the conduit 11b of the producer B.

This group of conduits and cocks permits the operation as the cock 15 for the steam is always open and the steam jet, regulated by the regulating member which precedes the cock 15, passes always to the injector 20 and, consequently, to one or other producer.

The alternate operation is obtained by the manipulation of the cocks 12a, 12b and 22a, 22b (by means of which the outlet of the gases and the inlet of the mixture of steam and oxygen are respectively controlled, and by the operation of the cock 18 for the oxygen.

Assuming that one starts from the condition in which the cock 12a is closed and that 12b open and the cocks 22b and 18 are closed, while that 22a is open, the steam which flows continuously through the cock 15 blows down the conduits 14a, 11a and 10a. After these conduits are cleaned, the cock 18 is opened for the oxygen (or for the mixture of air and oxygen) and the oxygen (or the mixture) drawn in by the injector and mixed with the steam, reaches the grate 3a and initiates the period of gasification in the producer A; after a certain time the cock 18 is closed and the steam is permitted to clean the conduits up to the grate 3a. Then, the operation will be reversed by closing the cocks 12b and 22a and opening those 12a and 22b.

The steam which flows continuously through the cock 15 cleans the conduits 14b, 11b and 10b and when cock 18 is opened the period of gasification in the producer B is initiated.

The admission of oxygen into the conduit 5 through the conduit 6 will be suitably regulated in the different periods and in particular it will be reduced for example during the discharge periods.

The jet through the conduit 6 into the conduit 5 may be replaced or completed by one or more other jets obtained by means of connections disposed in the arch or in the upper region of the producers A and B.

As is obvious from the preceding, the apparatus described provides several means of obtaining the best gasification and decomposition of the tar and of the hydrocarbons.

In particular it is possible to modify the proportion of steam and oxygen and one may thus reduce the ratio between steam and oxygen to the minimum value compatible with good condition of the ash, which presents the advantage of having the highest possible temperature in the incandescent layer of coal.

Moreover the height of the layer of ash on the grate may be modified and one of the features of this invention resides in this that the said layer is kept relatively high with the object of accumulating therein the heat contained in the hot gases which, in the period of decomposition of the tar and of the hydrocarbons flow downwards through the producer and of recovering the said heat in the following period in which the layer is traversed upwards by the gasification agents.

Finally the height of the layer of fuel may be modified, and also the height of the layer of fresh coal and the quantity of oxygen which is introduced in the upper region of the producers for the combustion of a part of the gases.

By regulating these different conditions of operation in relation to the characteristics of the fuel employed, it is thus always possible to obtain the gas of the desired type and suitable for the purpose in view.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A method for the production of a gas suitable for chemical synthesis starting from coal rich in volatile matters and producing the gasification of the fuel by means of injection of steam and oxygen or steam and a mixture of air and oxygen whereupon the gas so obtained, which comprises also the products of distillation, is caused to pass through a layer of incandescent coal to produce the cracking and hydrogenation of the tar and hydrocarbons, characterized in that the gasification agents are injected underneath the layer of fuel and forced therethrough

from below upwards, the temperature of the gas so obtained is raised and this gas is caused to pass from above downwards through a layer of coal brought to incandescence by a foregoing injection of gasification agents from below, the conditions in both chambers being periodically inverted in known manner whereby the layer of fuel serves alternately for gasification of the coal and decomposition of the hydrocarbons.

2. A method as claimed in Claim 1 characterised in this that in the layer of fuel traversed by the final gas is maintained a high layer of ash in order to recover the heat contained in the issuing gas.

3. A method as claimed in Claim 2 characterised in this that the elevation of the temperature is obtained by burning part of the gases by introducing oxygen.

4. Apparatus for carrying out the method claimed in Claim 1 characterised in this that it comprises two producers (A and B) of a type suited to the gasification of the fuel to be employed, in communication with one another at their upper region through a conduit, said conduit and/or the upper region of said producers comprising means for raising the temperature of the gas, said producers being provided with means for rendering possible their alternate operation, one for the gasification when steam and oxygen or steam, air and oxygen are introduced from below, which is to pass upwards through the layer of incandescent fuel, and the other for the cracking and hydrogenation of the tar and of the hydrocarbons when it is traversed downwards by the gases which have to traverse the incandescent fuel contained in the said producer in order to be discharged through the grate.

5. Apparatus as claimed in Claim 4 characterised in this that conduits (6) for the introduction of oxygen intended to burn a part of the gas generated and thus raise the temperature extend into the communicating conduit (5) between the two producers (A and B) or into the upper region of the latter.

6. Apparatus as claimed in Claim 5 characterised in this that a plate (8) of refractory material for stabilizing the combustion is disposed in front of the pipe for the introduction of oxygen.

Dated this 18th day of February, 1947.
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[This Drawing is a reproduction of the Original on a reduced scale.]

Fig.1

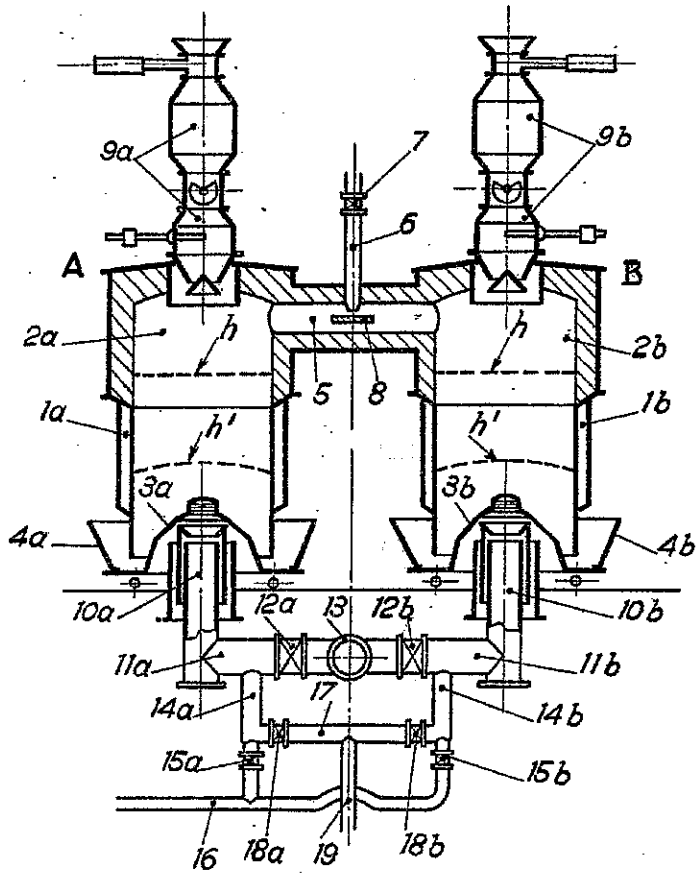
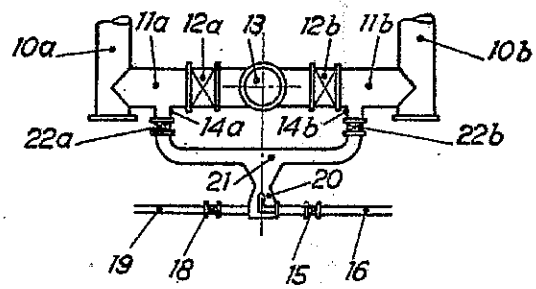


Fig. 2



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