PATENT SPECIFICATION

Application Date: July 9, 1942. No. 9571/42. **578,332**

(Patent of Addition to No. 577,015: dated Sept. 15, 1941.)

Complete Specification Left: March 16, 1943.

Complete Specification Accepted: June 25, 1946.

3632

PROVISIONAL SPECIFICATION

A Process for the Production of Water Gas and like Synthesis Gases

I, MICHAEL STEINSCHLAEGER, of no nationality, formerly of Russian nationality, of 50, Portsea Hall, Connaught Square, London, W.2, do hereby declare the nature of this invention to be as follows:—

This invention relates to a process for

can be utilised for pre-heating the air necessary for a blowing period or for pre-heating secondary air.

In manufacturing carburetted water gas by the process of Specification No. 11810/41 (Serial No. 577,015) it has further ...

ERRATUM

SPECIFICATION No. 578,332.

In the heading on page 1, *for* " March 16, 1943 " *read* " March 26, 1943 "

THE PATENT OFFICE,
14th November, 1946.

... the temperature required for the reaction in the generator.

It has now been found according to this invention that instead of using a mixture of water gas with or without coke oven gas or other gas rich in methane and steam and/or carbon dioxide there may be used a mixture of coke oven gas or other gases or vapours containing or consisting of normally gaseous or liquid hydrocarbons and steam and/or carbon dioxide.

Moreover, in carrying out the process of Specification No. 11810/41 (Serial No. 577,015) or the process of this invention, it has been found to be advantageous in some cases to pre-heat the air used when the generator is subjected to a blowing period.

Furthermore it has been found that if in carrying out the process of Specification No. 11810/41 (Serial No. 577,015) the gases produced in the generator have a sufficiently high temperature, e.g. above 1000° C. then the use of a regenerator can be dispensed with or the regenerator

necessary with the addition of secondary air.

Before the re-cycle gases are brought to the necessary working temperature their sensible heat may be used for pre-heating the blow gases which are to be used for the next blowing period.

The part at which the gases leave the generator may be chosen according to the temperature required. For example, it may be advantageous to remove a part of the gases leaving the generator at places at which the temperatures are higher than at the top or the bottom of the generator. The same applies to the regenerator in respect of regulating the re-cycle gases and air pre-heat temperatures.

In producing synthesis gases it is advantageous in the down gas making period to store as much heat as possible in the ash and clinker, so that in the following up gas making or blow period the heat so stored is utilised in the steam or re-cycle gases and steam or the air required for blowing. As indicated

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PROVISIONAL SPECIFICATION

A Process for the Production of Water Gas and like Synthesis Gases

I, MICHAEL STEINSCHLAEGER, of no nationality, formerly of Russian nationality, of 50, Portsea Hall, Connaught Square, London, W.2, do hereby declare the nature of this invention to be as follows:—

This invention relates to a process for the production of water gas and like synthesis gases, all of which are hereinafter referred to as water gas, and is concerned more particularly with improvements in or modifications of the process of my Specification No. 11810/41 (Serial No. 577,015).

The said Specification describes a process for the manufacture of water gas wherein a regenerator is heated by gas from a producer gas plant or other source, whereafter a mixture of water gas with or without coke oven gas or other gas rich in methane and steam and/or carbon dioxide is passed through the said regenerator and then passed to a water gas generator, the passage of the said mixture through the regenerator heating the mixture to the temperature required for the reaction in the generator.

It has now been found according to this invention that instead of using a mixture of water gas with or without coke oven gas or other gas rich in methane and steam and/or carbon dioxide there may be used a mixture of coke oven gas or other gases or vapours containing or consisting of normally gaseous or liquid hydrocarbons and steam and/or carbon dioxide.

Moreover, in carrying out the process of Specification No. 11810/41 (Serial No. 577,015) or the process of this invention, it has been found to be advantageous in some cases to pre-heat the air used when the generator is subjected to a blowing period.

Furthermore it has been found that if in carrying out the process of Specification No. 11810/41 (Serial No. 577,015) the gases produced in the generator have a sufficiently high temperature, e.g. above 1000° C. then the use of a regenerator can be dispensed with or the regenerator can be utilised for pre-heating the air necessary for a blowing period or for pre-heating secondary air.

In manufacturing carburetted water gas by the process of Specification No. 11810/41 (Serial No. 577,015) it has further been found that the use of a superheater can, in some cases, be dispensed with by introducing the oil into the gases produced using the sensible heat of the gases produced and that of the undecomposed steam.

In the manufacture of carburetted water gas by the process of Specification No. 11810/41 (Serial No. 577,015) and the process of this invention it is advantageous to increase the sensible heat of the gases produced. This may be effected by making gas always in the upward direction, by increasing the excess of steam, removing the gases or part thereof from a relatively hot zone of the generator, charging the coke before the gas making period begins and pre-heating the coke with the blow gases if necessary with the addition of secondary air.

Before the re-cycle gases are brought to the necessary working temperature their sensible heat may be used for pre-heating the blow gases which are to be used for the next blowing period.

The part at which the gases leave the generator may be chosen according to the temperature required. For example, it may be advantageous to remove a part of the gases leaving the generator at places at which the temperatures are higher than at the top or the bottom of the generator. The same applies to the regenerator in respect of regulating the re-cycle gases and air pre-heat temperatures.

In producing synthesis gases it is advantageous in the down gas making period to store as much heat as possible in the ash and clinker, so that in the following up gas making or blow period the heat so stored is utilised in the steam or re-cycle gases and steam or the air required for blowing. As indicated above the coke is advantageously charged before the up gas making period begins so as to pre-heat partly or wholly the coke with the gases leaving the generator. The pre-heating of the coke to still higher temperatures can be effected with the blow gases leaving the reaction zone (if necessary by the addition of secondary air). The ratio between the amount of gases made in the down and up gas making periods can be regulated by the temperatures of the gases leaving the generator. For heating the regenerator the heat in the blow gases is used and as it is not necessary to use so much re-cycle gases this heat is sufficient to heat the regenerator and provide steam for the reaction and surplus steam. The amount of surplus steam available can be regulated by the variation of the pre-heat temperature of the gases leaving the regenerator and, of course, by the composition and amount of the blow gases. The sensible heat of the gas and steam leaving the generator is used for production of steam in the gas making cycle (thus utilising the capacity of the available boiler in the gas making period and saving in cooling water for the cooling of the gases).

The pre-heat temperatures of the re-cycle gases in the down and up gas making periods may advantageously differ (for example, lower in the up gas making period). The motive power for the re-cycle gases is preferably steam or other gases necessary for the reaction used in an injector.

If high reaction temperatures are used in the reaction zone the following operation conditions are advantageous:—

(1). Ash leaving the generator in solid form: All the gases are produced in the up gas making period and as the gases leaving the generator have a very high temperature the re-cycle gases mixed with steam are injected without pre-heating into the generator. In this case it is preferable to use the regenerator for pre-heating the air necessary for the blowing and combustion. The heating of the regenerator is accomplished with the sensible heat of the water gas leaving the generator.

(2). If a generator system is used in which the ash leaves the generator in fluid form it is preferable to pre-heat the re-cycle gases and steam mixture still further and use another regenerator for pre-heating the air or all or a part of the gases can be produced in the down gas making period and the heat stored in the ash and clinker used for pre-heating the air. In this case the pre-heating temperature of the re-cycle gases used in up gas making is practically the same or higher as the highest temperature of the ash and clinker.

In producing carburetted water gas it is possible by using the process of this invention to achieve a considerably higher temperature in the gases leaving the generator than is usually achieved by other processes. The operation of the generator is then as follows: The whole or the greater part of the gases is produced in the up gas making period. This will allow of the injection of the oil and the evaporation of the same in the gas (without using a carburettor).

The following example illustrates the working of the generator in this manner:—

0.5 Cubic metre of re-cycle gases and the necessary amount of steam are pre-heated in the regenerator to the required temperature and injected into the generator (in this case the temperature of the pre-heated gases is about 1050° C. and the gases will be introduced above the grate). The gases leaving the reaction zone have a high temperature (about 1175° C.), this temperature can substantially be the same when the gases are leaving the generator. This is brought about by blowing the generator before the up gas making period and by heating the coke, which was charged between the up gas making and the blowing periods. From this gas leaving the generator (1.0 and 0.5 cubic metres = 1.5 cubic metres) having in this example a temperature of 1000° C., 0.5 cubic metres are re-cycled using an injector the motive power of which is steam necessary for the reaction. This mixture can be brought directly into the generator through the grate (the mixture has in this case a temperature of 500° C.) or if the mixture has a higher temperature before being pre-heated in the regenerator (a regenerator previously heated by blow gases) the gases are brought into the generator above the grate. The 1 cubic metre of the water gas having a temperature of 1000° C. is mixed (by injection of oil or tar) with the oil or tar which evaporates and the average temperature of the gases and oil vapours amounts to 500° C. This mixture is then sent to the superheater where the mixture is heated to the necessary temperature for the complete cracking of the oil and to produce the required carburetted water gas. The amount of the oil used in the above mentioned example is 2 gallons per 1000 cubic feet of carburetted water gas; if 3 gallons are used the temperature of the mixture will be about 420° C. By using pre-heated oils or distillation oil gases or tars or tar gases it is possible to use a still smaller sized superheater or even no superheater at all. The same results can be achieved by increasing the temperature of the gases leaving the generator still higher or by increasing the sensible heat of these gases by using a greater excess of steam than is normally necessary for the reaction or using more re-cycle gases. If the re-cycle gases and steam have been brought into the generator at a temperature of about 500° C. it is not necessary to use the regenerator for pre-heating the latter and the regenerator is preferably used for pre-heating the air necessary for the reaction and for lowering the consumption of coke (if it is desirable to use a blue water gas plant for the production of carburetted water gases the regenerator can be used as superheater). The regenerator is heated by the sensible heat of the carburetted water gases leaving the regenerator is used for steam production in the gas making period.

In certain circumstances it may be advantageous to operate the generator with high reaction temperatures. The operation of the generator is then preferably as follows: The whole of the gas is made in the up gas making period. The gases leaving the generator have a very high temperature and the sensible heat of these gases can be still further increased by increasing the excess of steam above that normally necessary for the reaction. It will then be possible to achieve the evaporation and the cracking of the oil without using a carburettor and superheater. The carburettor and superheater can then be used for pre-heating the re-cycle gases, steam and air necessary for the reaction. The above-mentioned modification can be used for making carburetted water gas without a superheater or with a superheater when very high temperatures are required for cracking the oils, tars, pitch, etc., utilising oils, tars, pitches, etc., which are difficult to crack or require higher cracking temperatures than the oils normally used.

Using a generator in which the ash is leaving the generator in fluid form, an example of a suitable form of operation is as follows:—

a. Gas making period: 0.5 cubic metre of re-cycle gases and 0.9 kg. of steam per cubic metre of gas produced are brought into the generator (average temperature in the reaction zone 1500° C.) with a pre-heat temperature of 1500° C. The sensible heat of the gases leaving the generator is used in the following way: 1.0 cubic metre of gases + 0.383 kgm. of steam are used for evaporation and cracking of the oil (2 gallons per 1000 cubic feet) and the temperature of the mixture is 770° C. 0.5 cubic metre of gases and 0.162 kgm. of steam are used to heat the regenerator (carburettor) (the regenerator is used in the following blowing period for the pre-heating of the air used for blowing to a temperature in this example of 900° C.), after leaving the regenerator this re-cycle gas is mixed with 0.6 kgm. of steam (used in an injector) and brought into the superheater for pre-heating the mixture to 1500° C., and then brought into the generator.

b. Blowing period. Air is blown through the regenerator into the generator. The blow gases leaving the reaction zone pre-heat the coke and are then used for heating the superheater to the temperature required. The coke consumption in using this modification is low in spite of the high temperatures of the gases and the undecomposed steam leaving the generator, and the capacity of the generator is very high.

A part of the reduction gases obtained from a hydrogen plant can be used instead of re-cycle gases. In this case it is not necessary to add steam or other gases necessary for the reaction as sufficient steam and carbon dioxide are available in the reduction gases. As the gases come hot from the plant they can be brought hot into the generator and the regenerator can be used for pre-heating the air for blowing the generator hot. The heating of the regenerator is achieved with the sensible heat of the water gases leaving the generator or if higher temperatures are desirable with a part of a heat in the reduction gases.

It is also possible by using this process to deliver direct to the hydrogen plant a water gas having a high temperature, which is necessary for the reaction.

As it is possible to operate the generator with practically very low temperatures without decreasing the capacity of the generator to a very low level the process is very suitable for production of hydrogen-rich gases. Or, if a high capacity of the generator is desirable it is possible to use high temperatures and a high excess of steam without unduly increasing the coke consumption. In this case a part of the steam not used in the reaction can always be re-cycled back with the gases injected into the generator. If a further conversion plant is used for production of still more hydrogen the gases and undecomposed steam can be sent direct to the conversion plant and the temperature of the mixture can be adjusted by adjusting the operating conditions of the generator.

By using coke oven gas or other methane-containing gases or other gaseous or liquid hydrocarbons particularly residual gases from oil synthesis or other synthesis processes or hydrogenation processes, the decomposed gases and the undecomposed steam (from the decomposing chamber or regenerator) are used instead of re-cycle gases and as it is not necessary to send gases back to the generator (as they are replaced continuously by new gases) the output of synthesis gases from the generator is considerably increased. The amount of the methane containing carbon dioxide, steam or other gases is dependent on the composition of synthesis gases required.

By using the Fischer-Tropsch or similar processes the greater part of the residual gas can be sent through the regenerator for decomposition (the temperature in the regenerator is dependent on the degree of the decomposition required or whether catalysts are used for the decomposing reaction and the composition of the residual gas) and from there to the generator where synthesis gas is produced. The inert content of the synthesis gases can be regulated by taking out a part of the residual gases from the process. The blow gases are used for heating the regenerator to provide the heat necessary for the decomposition reaction and to pre-heat the steam and the gases used in the reaction. The excess of steam for the decomposing reaction is preferably so high that the undecomposed steam leaving the regenerator is for the greater part or wholly sufficient for the later reaction in the generator. If the blow gases are not sufficient to provide the whole heat for the reaction in the regenerator residual gases or other fuels can be added. If the ratio of methane-containing gases, steam or other gases used for the reaction is too high, so that the heat which must be stored in the regenerator is consequently also too high it is preferable, so as to avoid too large sized regenerators, to use two regenerators. The operation when using two regenerators is as follows: Heating of the regenerator. 1. In the blow period with the blow gases and additional fuels. 2. In the gas making period with additional fuels. At the same time the other regenerator is used for pre-heating purposes.

The above mentioned modification for the production of synthesis gases applies to the production of gases with a ratio of $CO:H_2=1:2$ and more of hydrogen and allows of the production of gases with a ratio of $CO:H_2=1:1$ and less of hydrogen (the CO rich gases are used for the production of primary products rich in olefines).

If a high decomposition temperature is used in the regenerator and no such high temperature is desirable in the generator (low fusion temperature of the ash or production of hydrogen-rich gases, etc.) the temperature can be regulated by addition of steam or other gases necessary for the reaction.

The depth of the reaction zone, the coke ash and clinker bed should be varied according to the reaction taking place or the gas composition required, so as to achieve the most advantageous results and conditions.

The re-cycle gases, steam, air and other gases and fuels necessary for the reaction, when having low temperatures are brought into the generator in the same way as in known constructions of generators. By using the gases with high pre-heat temperatures but not so high as the reaction temperature, the gases are introduced into the generator at such places that they can be pre-heated with the heat stored in the ash, clinker, coke, coal or lining of the generator. By using the above mentioned gases with the same or higher temperatures as the reaction temperature the gases should be introduced at places having the same or the highest temperatures in the generator. This is all provided that some other considerations do not require other conditions of operation.

The steam necessary for the reaction and the surplus steam can be produced in the generator plant or if steam is available from other sources the coke consumption can be decreased.

In some cases it may be advantageous to blow the generator up and down, thus using the heat stored in the coke, clinker and ash for pre-heating the air or for further pre-heating of the re-cycle gases and/or steam. The ratio of the air used in down and up blowing is dependent on the amount of the heat which it is desirable to store.

Instead of air in the blow period it is sometimes advantageous to use oxygen in the blow period. The gases leaving the generator in the blow period are, preferably after washing out carbon dioxide, mixed with the gases produced in the gas making period. If the gases produced in the blow period are mixed without washing out carbon dioxide the amount of carbon dioxide in the mixture can be regulated by the ratio between steam or other gas and carbon dioxide used in the blow period. The sensible heat of the gases leaving the generator in the blow period is used for heating the regenerator. The above mentioned gases leaving the generator with a high temperature can be used instead of the re-cycle gases for the production of water gas. In this case the gases leaving one generator are brought into another. It may be advantageous to operate this modification under pressure, choosing the pressure according to the gas to be produced.

In order to use the same connection for both the up and down gas making periods for bringing the re-cycle gases into the bottom or the top of the generator, two injectors working in different directions disposed between the connection pipes are used.

If coal is used for the production of water gas the re-cycle gases favour the carbonisation of the coal. The amount of the re-cycle gases and steam, the pre-heat temperatures of the same, the times and directions of the gas making periods and the time of charging the coal can be chosen according to the quality of the coal used and the quality and composition of the gas required. For example, the temperatures and the conditions of operation in the generator and regenerator are so chosen that the cracking or decomposition of the tar and gases available from the carbonisation is such as not to produce carbon and hydrogen but gaseous hydrocarbons and so to produce gases with higher calorific values, which can be used alone or in admixture with the water gas produced. A part or the whole of the heat necessary for the carbonisation or pre-heating of the coal can be provided by the blow gases leaving the generator.

Carburetted water gas may be conveniently produced from coal according to the present invention by proceeding as follows:

The mixture of re-cycle gases (which are taken from the gases leaving the regenerator or generator) and steam is introduced at the bottom of the generator and the heat in the gases leaving the reaction zone is used for the carbonisation of the coal (which is preferably pre-heated by the blow gases leaving the reaction zone). The mixture leaving the generator (to which has now been added tar and carbonisation gases) is sent through a regenerator (carburettor) the temperature in which is adjusted according to the quality and composition of the gases required. A part of the gases leaving the regenerator is introduced through an injector as recycle gas and the other gas is, after injection and evaporation of the oil, introduced into the superheater for further cracking. The temperature in the regenerator may be higher or lower than in the superheater and the blow gases are sent through the regenerator or superheater before or after secondary air is added to them. The blow gases can be sent first through the regenerator or through the superheater according to the temperatures required in the two vessels and the results to be achieved.

Dated this 9th day of July, 1942.
ELKINGTON & FIFE,
Consulting Chemists and
Chartered Patent Agents,
Bank Chambers, 329, High Holborn,
London, W.C.1,
Agents for the Applicant.

COMPLETE SPECIFICATION

A Process for the Production of Water Gas and like Synthesis Gases

I, MICHAEL STEINSCHLAEGER, of no nationality, formerly of Russian nationality, of 50, Portsea Hall, Connaught Square, London, W.2, 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:—

This invention relates to a process for the production of carburetted water gas and synthesis gases, and is concerned more particularly with improvements in or modifications of the process of my Specification No. 11810/41 (Serial No. 577,015).

The said Specification describes a discontinuous process for the manufacture of water gas wherein the heat necessary for the reaction with the solid fuel in the generator and to compensate for heat losses is obtained partly by using a regenerator which is heated by blow gases or gas from a producer gas plant or other source, whereafter a mixture of water gas with or without coke oven gas or other gas rich in methane and steam and/or carbon dioxide is passed through the said regenerator and then passed to a water gas generator, the passage of the said mixture through the regenerator heating the mixture to a pre-determined temperature, and partly by subjecting the generator to blowing from time to time with oxygen, air or other oxygen containing gases.

The present invention provides a discontinuous process for the manufacture of carburreted water gas wherein the heat necessary for the reaction with the solid fuel in the generator and to compensate for heat losses is obtained partly by using a regenerator which is heated by blow gases or gas from a producer gas plant or other source, whereafter a mixture of water gas and steam and/or carbon dioxide is passed through the said regenerator and then passed to the water gas generator, the passage of the said mixture through the said regenerator heating the mixture to a pre-determined temperature and partly by subjecting the generator to blowing from time to time with oxygen, air or other oxygen-containing gases and wherein oil is introduced into the gases produced in the generator after they have left the same, utilising for the evaporation and/or cracking of the oil a part or the whole of the sensible heat of the gases produced and that of the undecomposed steam and/ or undecomposed carbon dioxide.

If necessary the hot gases may be still further heated before introducing the oil.

The present invention also provides a discontinuous process for the manufacture of synthesis gases comprising blowing, down gas making and up gas making periods wherein the heat necessary for the reaction with the solid fuel in the generator and to compensate for heat losses is obtained partly by using a regenerator which is heated by blow gases or gas from a producer gas plant or other source, whereafter a mixture of a gas or of vapour containing or consisting of hydrocarbons and steam and/or carbon dioxide is passed through the said regenerator and then passed to a water gas generator through which it passes in the downward direction, the passage of the said mixture through the said regenerator heating the mixture to such a temperature that decomposition of a major proportion of the hydrocarbons takes place in the regenerator; and partly by subjecting the generator to blowing from time to time with oxygen, air or other oxygen-containing gases, and wherein a part of the sensible heat of the gases produced and of the undecomposed steam and/or carbon dioxide in the down gas making period is stored in the ash bed and utilised for superheating the steam or pre-heating the gases used in the subsequent up gas making and blowing periods, sufficient steam and/or carbon dioxide being supplied to the regenerator to effect the reaction with the hydrocarbons in the regenerator and to provide an excess at least sufficient for the water gas reaction in the generator, and wherein the gases produced and the undecomposed steam and/or carbon dioxide in the down gas making period are partly or wholly removed from the generator above the grate.

Moreover, in carrying out the process of Specification No. 11810/41 (Serial No. 577,015) or the process of this invention, it has been found to be advantageous in some cases to pre-heat the oxygen, air or other oxygen-containing gas blown into the generator during a blowing period.

Furthermore, it has been found that if in carrying out the process of Specification No. 11810/41 (Serial No. 577,015) for the manufacture of carburetted water gas the gases produced in the generator have a sufficiently high temperature, e.g. above 1000° C., part of the heat necessary for the reaction with the solid fuel in the generator and to compensate for heat losses is obtained by returning a part of the gases leaving the generator to the inlet thereof (re-cycle gases) together with steam and returning the other part to the regenerator, and the other part by subjecting the generator to blowing from time to time with oxygen, air or other oxygen-containing gases.

In the manufacture of carburetted water gas by the process of Specification No. 11810/41 (Serial No. 577,015) and the process of this invention it is advantageous to increase the sensible heat of the gases produced. This may be effected by making the whole or the major part of the gas always in one direction, by increasing the excess of steam, removing the gases or part thereof from a relatively hot zone of the generator, charging the coke before the gas making period begins and pre-heating the coke with the blow gases if necessary with the addition of secondary air. If necessary the gases produced in the generator may be still further heated in the regenerator.

Before the re-cycle gases are brought to the necessary working temperature their sensible heat may be used for pre-heating the air which is to be used for the next blowing period.

The point at which the gases leave the generator may be chosen according to the temperature required. For example, it may be advantageous to remove a part of the gases leaving the generator at places at which the temperatures are higher than at the top or the bottom of the generator. The same applies to the regenerator in respect of regulating the re-cycle gases and air pre-heat temperatures.

In producing synthesis gases it is advantageous in the down gas making period to store as much heat as possible in the ash and clinker, so that in the following up gas making or blow period the heat so stored is utilised in the steam or re-cycle gases and steam or the air required for blowing. The coke is advantageously charged before the up gas making period begins so as to pre-heat partly or wholly the coke with the gases leaving the generator. The pre-heating of the coke to still higher temperatures can be effected with the blow gases leaving the reaction zone (if necessary by the addition of secondary air). The temperature of the gases leaving the generator can be regulated by the ratio between the amount of gases made in the down and up gas making periods. For heating the regenerator the heat in the blow gases is used and as it is not necessary to use so much re-cycle gases this heat is sufficient to heat the regenerator and provide steam for the reaction and surplus steam. The amount of surplus steam available can be regulated by the variation of the pre-heat temperature of the gases leaving the regenerator and, of course, by the composition and amount of the blow gases. The sensible heat of the gas produced and steam leaving the generator is used for production of steam in the gas making cycle (thus utilising the capacity of the available boiler in the gas making period and saving in cooling water for the cooling of the gases).

The pre-heat temperatures of the re-cycle gases in the down and up gas making periods may advantageously differ (for example, lower in the up gas making period). The motive power for the re-cycle gases is preferably steam or other gases necessary for the reaction used in an injector.

In producing carburetted water gas it is possible by using the process of this invention to achieve a considerably higher temperature in the gases leaving the generator than is usually achieved by other processes. The operation of the generator is preferably as follows: The whole or the greater part of the gases is produced in the up gas making period. This will allow of the injection of the oil into the gases produced which have left the generator and the evaporation and cracking of the same in the gas.

The following example and Figs. 1 and 2 of the accompanying diagrammatic drawings illustrate the working of the generator in this manner:

In the accompanying drawings, Figs. 1 and 2 are diagrammatic flow sheets in which like parts are indicated throughout by like reference characters, and in which:

Fig. 1 shows the blow cycle when using a superheater;

Fig. 2 shows the up gas making cycle.

Referring to Fig. 1 of the drawings, the generator is indicated by 1, the reaction zone thereof by 1a, the superheater by 2 and the regenerator by 3. In carrying out the blow cycle air is admitted through line 4 and passes in succession through the generator 1, superheater 2 and regenerator 3 by the line 5 as shown. Secondary air may be admitted through the line 6 and the passage of the blow gas heats the superheater 2 and the regenerator 3 to the desired temperatures.

Referring to Fig. 2 of the drawings, 0.5 cubic metre of re-cycle gases supplied through line 7 and the necessary amount of steam admitted through line 8 are pre-heated in the regenerator 3 to the required temperature and injected into the generator 1 (in this case the temperature of the pre-heated gases is about 1050° C. and the gases will be introduced above the grate through line 10). If the gases leave the generator at the level of the reaction zone they have a high temperature (about 1175° C.), but this temperature can be substantially attained when the gases leave the generator above the reaction zone through line 11 if the coke is pre-heated. This is brought about by blowing the generator before the up gas making period (as described above) and by heating the coke, which was charged between the up gas making and the blowing periods. From this gas leaving the generator (1.0 and 0.5 cubic metres = 1.5 cubic metres) having in this example a temperature of 1000° C., 0.5 cubic metres are re-cycled through line 7 using an injector the motive power of which is steam necessary for the reaction admitted through line 8. This mixture can be brought directly into the generator through the grate (the mixture has in this case a temperature of 500° C.) or if the mixture has a higher temperature before being pre-heated in the regenerator (a regenerator previously heated by blow gases) the gases are brought into the generator above the grate. The 1 cubic metre of the water gas having a temperature of 1000° C. is mixed with oil or tar (by injection thereof through line 12) which evaporates and the average temperature of the gases and oil vapours amounts to 500° C. This mixture is then sent to the superheater 2 via line 13 where the mixture is heated to the necessary temperature for the complete cracking of the oil or tar and to produce the required carburetted water gas. The amount of the oil used in the above mentioned example is 2.6 gallons per 1000 cubic feet of carburetted water gas; if 3 gallons are used the temperature of the mixture will be about 440° C. By using pre-heated oils or oil distillation gases or tars or tar gases it is possible to use a still smaller sized superheater or even to dispense with a superheater. The same results can be achieved by increasing the temperature of the gases leaving the generator still higher in the reaction zone or in a regenerator or by increasing the sensible heat of these gases by using a greater excess of steam than is normally necessary for the reaction or using more re-cycle gases.

In certain circumstances it may be advantageous to operate the generator with high reaction temperatures. The operation of the generator is then preferably as follows: The whole of the gas is made in the up gas making period. The gases leaving the generator have a very high temperature and the sensible heat of these gases can be still further increased by increasing the excess of steam above that normally necessary for the reaction. It will then be possible to achieve the evaporation and the cracking of the oil without using a carburettor and superheater. The carburettor and superheater can then be used for pre-heating the re-cycle gases, steam and air necessary for the reaction. The above-mentioned modification can be used for making carburetted water gas without a superheater or with a superheater when very high temperatures are required for cracking the oils, tars, pitch, etc., using oils, tars, pitches, etc., which are difficut to crack or require higher cracking temperatures than the oils normally used when gases with high calorific values or other desired properties are required.

Using a generator in which the ash is leaving the generator in fluid form, an example of a suitable form of operation is as follows:

a. GAS MAKING PERIOD: 0.5 cubic metre of re-cycle gases and 0.99 kg. of steam per cubic metre of gas produced are brought into the generator (average temperature in the reaction zone 1500° C.) with a pre-heat temperature of 1500° C. The sensible heat of the gases leaving the generator is used in the following way: 1.0 cubic metre of gases + 0.333 kgm. of steam are used for evaporation and cracking of the oil (5 gallons per 1000 cubic feet) and the temperature of the mixture is 770° C. 0.5 cubic metre of gases and 0.166 kgm. of steam are used to heat the regenerator (carburettor) (the regenerator is used in the following blowing period for the pre-heating of the air used for blowing to a temperature in this example of 900° C.), after leaving the regenerator this re-cycle gas is mixed with 0.6 kgm. of steam (used in an injector) and brought into the superheater for pre-heating the mixture to 1500° C., and then brought into the generator.

b. BLOWING PERIOD: Air is blown through the regenerator into the generator. The blow gases leaving the reaction zone pre-heat the coke and are then used for heating the superheater (if used) to the temperature required. The coke consumption in using this modification is low in spite of the high temperatures of the gases and the undecomposed steam leaving the generator, and the capacity of the generator is very high.

By using coke oven gas or other methane-containing gases or other gases or vapour containing gaseous or liquid hydrocarbons particularly residual gases from oil synthesis or other synthesis processes or hydrogenation processes or mixtures of these gases, the decomposed gases and the undecomposed steam (from the decomposing chamber or regenerator) are used instead of re-cycle gases and as it is not necessary to send gases back to the generator (as they are replaced continuously by new gases) the output of synthesis gases from the generator plant is considerably increased. The amount of the methane-containing gases, carbon dioxide, steam or other gases required for the reaction is dependent on the composition of synthesis gases required.

By using the Fischer-Tropsch or similar processes which also use gases containing carbon monoxide and hydrogen as the initial material the greater part of the residual gas can be sent through the regenerator for decomposition (the temperature in the regenerator is dependent on the degree of decomposition required or whether catalysts are used for the decomposing reaction and the composition of the residual gas) and from there to the generator where synthesis gas is produced. The inert content of the synthesis gases can be regulated by bleeding off continuously a part of the residual gases from the process. The blow gases are used for heating the regenerator to provide the heat necessary for the decomposition reaction and to preheat the steam and the gases used in the reaction. The excess of steam for the decomposing reaction is preferably so high that the undecomposed steam leaving the regenerator is for the greater part or wholly sufficient for the later reaction in the generator. If the blow gases are not sufficient to provide the whole heat for the reaction in the generator residual gases or other fuels can be added. If the ratio of methane-containing gases, steam or other gases used for the reaction is too high, so that the heat which must be stored in the regenerator is consequently also too high it is preferable, so as to avoid too large sized regenerators, to use two regenerators. The operation when using two regenerators may be as follows: Heating of the regenerator: 1. In the blow period with the blow gases and additional fuels. 2. In the gas making period with additional fuels. At the same time the other regenerator is used for pre-heating purposes.

In the accompanying drawings Figs. 3 to 5 are diagrammatic flow sheets illustrating the manufacture of synthesis gases according to the invention, in which like parts are indicated throughout by like reference characters, and in which:

Fig. 3 shows the blow cycle,

Fig. 4 shows the down gas making cycle, and

Fig. 5 shows the up gas making cycle.

Referring to Fig. 3 of the drawings, the generator is indicated by 14, the reaction zone thereof by 14*a* and the regenerator by 15. In carrying out the blow cycle air is admitted through line 16 and passes through the generator to the regenerator 15 by line 17, addition fuel being admitted through line 18 and secondary air through line 19. The passage of the blow gases heats the regenerator 15 to the desired temperature.

Referring now to Fig. 4 of the drawings, steam and/or carbon dioxide admitted through line 20 and hydrocarbon-containing gases admitted through line 21 are passed through the heated regenerator 15 in which the reaction between the hydrocarbons and steam and/or carbon dioxide takes place. The gases leaving the regenerator, which contain carbon monoxide and hydrogen, pass through line 17 to the generator 14 wherein further carbon monoxide and hydrogen are produced from the steam and/or carbon dioxide remaining in the mixture coming from the regenerator. The gases leave the generator 14 above the grate through lines 22 and 23.

Referring to Fig. 5 of the drawings, steam and/or carbon dioxide is introduced through lines 24 and 16 into the generator 14 wherein the steam and/or carbon dioxide after pre-heating by the heat stored in the ash reacts with the solid fuel to produce a gas containing carbon monoxide and hydrogen which leave through line 25. If desired, at the same time hydrocarbons and steam and/or carbon dioxide may be passed through the regenerator 15 as described in connection with Fig. 4 above, the products being mixed with the products leaving the generator through line 25.

The above mentioned modification for the production of synthesis gases applies to the production of gases with a ratio of $CO:H_2=1:2$ and more of hydrogen and allows of the production of gases with a ratio of $CO:H_2=1:1$ and less of hydrogen (the CO rich gases are used for the production of primary products rich in olefines).

If a high decomposition temperature is used in the regenerator and no such high temperature is desirable in the generator (low fusion temperature of the ash or production of hydrogen-rich gases, etc.) the temperature can be regulated by addition of steam or other gases necessary for the reaction.

The depth of the reaction zone, the coke ash and clinker bed should be varied according to the reaction taking place or the gas composition required, so as to achieve the most advantageous results and conditions.

The re-cycle gases, steam, air and other gases and fuels necessary for the reaction, when having low temperatures are brought into the generator in the same way as in known constructions of generators. By using the gases with high pre-heat temperatures but not so high as the reaction temperature, the gases are introduced into the generator at such places that they can be pre-heated with the heat stored in the ash, clinker, coke, coal or lining of the generator. By using the above mentioned gases with the same or higher temperatures as the reaction temperature the gases should be introduced at places having the same or the highest temperatures in the generator. This is all provided that some other considerations do not require other conditions of operation.

The steam necessary for the reaction and the surplus steam can be produced in the generator plant or if steam is available from other sources the coke consumption can be decreased.

In some cases, it may be advantageous to blow the generator up and down, thus using the heat stored in the coke, clinker and ash for pre-heating the air or for further pre-heating of the re-cycle gases and/or steam. The ratio of the air used in down and up blowing is dependent on the amount of the heat which it is desirable to store.

Instead of air in the blow period it is sometimes advantageous to use oxygen alone or with steam in the blow period. The gases leaving the generator in the blow period are, preferably after washing out carbon dioxide, mixed with the gases produced in the gas making period. If the gases produced in the blow period are mixed without washing out carbon dioxide the amount of carbon dioxide in the mixture can be regulated by the ratio between steam or other gas and oxygen used in the blow period. The sensible heat of the gases leaving the generator in the blow period is used for heating the regenerator. The above menioned gases leaving the generator with a high temperature can be used instead of the re-cycle gases for the production of water gas. In this case the gases leaving one generator are brought into another. It may be advantageous to operate this modification under pressure, when it is desired to produce gases rich in methane.

In order to use the same connection for both the up and down gas making periods for bringing the re-cycle gases into the bottom or the top of the generator, two injectors working in different directions disposed between the connection pipes are used.

If coal is used for the production of water gas the re-cycle gases favour the carbonisation of the coal. The amount of the re-cycle gases and steam, the pre-heat temperatures of the same, the times and directions of the gas making periods and the time of charging the coal can be chosen according to the quality of the coal used and the quality and composition of the gas required. For example, the temperatures and the conditions of operation in the generator and regenerator are so chosen that the cracking or decomposition of the tar and gases available from the carbonisation is such as not to produce carbon or carbon monoxide and hydrogen but gaseous hydrocarbons and so to produce gases with higher calorific values, which can be used alone or in admixture with the water gas produced. A part or the whole of the heat necessary for the carbonisation or pre-heating of the coal can be provided by the blow gases leaving the generator.

Carburetted water gas may be conveniently produced from coal according to the present invention by proceeding as follows:

The mixture of re-cycle gases (which are taken from the gases leaving the regenerator or generator) and steam is introduced at the bottom of the generator and the heat in the gases leaving the reaction zone is used for the carbonisation of the coal (which is preferably pre-heated by the blow gases leaving the reaction zone). The mixture leaving the generator (to which has now been added tar and carbonisation gases) is sent through a regenerator (carburettor) the temperature in which is adjusted according to the quality and composition of the gases required. A part of the gases leaving the regenerator is introduced through an injector as re-cycle gas and the other gas is, after injection and evaporation of the oil, introduced, if necessary, into the superheater for further cracking. The temperature in the regenerator may be higher or lower than in the superheater and the blow gases are sent through the regenerator or superheater before or after secondary air is added to them. The blow gases can be sent first through the regenerator or through the superheater according to the temperatures required in the two vesesls and the results to be achieved.

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

1. A discontinuous process for the manufacure of carburetted water gas wherein the heat necessary for the reaction with the solid fuel in the generator and to compensate for heat losses is obtained partly by using a regenerator which is heated by blow gases or gas from a producer gas plant or other source, whereafter a mixture of water gas and steam and/or carbon dioxide is passed through the said generator and then passed to a water gas generator, the passage of the said mixture through the said regenerator heating the mixture to a predetermined temperature and partly by subjecting the generator to blowing from time to time with oxygen, air or other oxygen-containing gases, and wherein oil is introduced into the gases produced in the generator after they have left the same, utilising for the evaporation and/or cracking of the oil a part or the whole of the sensible heat of the gases produced and that of the undecomposed steam and/or undecomposed carbon dioxide.

2. A discontinuous process for the manufacture of synthesis gases comprising blowing, down gas making and up gas making periods wherein the heat necessary for the reaction with the solid fuel in the generator and to compensate for heat losses is obtained partly by using a regenerator which is heated by blow gases or gas from a producer gas plant or other source, whereafter a mixture of a gas or of vapour containing or consisting of hydrocarbons and steam and/or carbon dioxide is passed through the said regenerator and then passed to the water gas generator through which it passes in the downward direction, the passage of the said mixture through the said regenerator heating the mixture to

such a temperature that decomposition of a major proportion of the hydrocarbons takes place in the regenerator; and partly by subjecting the generator to blowing from time to time with oxygen, air or other oxygen-containing gases, and wherein a part of the sensible heat of the gases produced and of the undecomposed steam and/or carbon dioxide in the down gas making period is stored in the ash bed and utilised for superheating the steam or pre-heating the gases used in the subsequent up gas making and blowing periods, sufficient steam and/or carbon dioxide being supplied to the regenerator to effect the reaction with the hydrocarbons in the regenerator and to provide an excess at least sufficient for the water gas reaction in the generator, and wherein the gases produced and the undecomposed steam and/or carbon dioxide in the down gas making period are partly or wholly removed from the generator above the grate.

3. A process as claimed in Specification No. 11810/41 (Serial No. 577,015) or in claim 1 or 2 herein wherein the oxygen air or other oxygen-containing gas blown into the generator during a blowing period is pre-heated.

4. A modification of the process for manufacturing carburetted water gas claimed in Specification No. 11810/41 (Serial No. 577,015) or in claim 1 or 3 herein, wherein the sensible heat of the gases produced is increased by making the whole or a major part of the gas always in one direction, by increasing the excess of steam, removing the gases or part thereof from a relatively hot zone of the generator, further heating the gases, charging the coke before the gas making period begins and pre-heating the coke with the blow gases if necessary with the addition of secondary air.

5. A modification of the process for the manufacture of carburetted water gas as claimed in Specification No. 11810/41 (Serial No. 577,015) or in any one of claims 1, 3 or 4 herein, wherein the heat necessary for the reaction with the solid fuel in the generator and to compensate for heat losses is obtained partly by returning a part of the gases leaving the generator to the inlet thereof together with steam and returning the other part to the regenerator and partly by subjecting the generator to blowing from time to time with oxygen, air, or other oxygen-containing gases.

6. Carburetted water gas when manufactured by the process claimed in any one of the preceding claims 1, 3, 4 or 5.

7. Synthesis gas when manufactured by the process claimed in claim 2 or 3 herein.

Dated the 26th day of March, 1943.
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