

I. Q.



Industria y Comercio
SUPERINTENDENCIA



SOLICITUD

PATENTE DE INVENCION

21 EXPEDIENTE N°

04-2782

54 TITULO Método para producir energía limpia a partir del
carbón

51 CLASIFICACIÓN INTERNACIONAL C10J 3/08

71 SOLICITANTE Caldem Syngas Company

DOMICILIO Ohio, Estados Unidos

74 APODERADO Dilia Rodriguez D'Aleuón

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1) SOLICITUD DE			
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2) SOLICITANTE (71)	Nombre CALDERON SYNGAS COMPANY Direccion 500 Lehman Avenue, Bowling Green, Ohio 43402, Estados Unidos Nacionalidad o domicilio Ohio, Estados Unidos Lugar de constitucion Estados Unidos		IDENTIFICACIÓN C C ☐ NIT ☐ C E ☐ OTRO ☐ Cual _____ NUMERO _____
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3) REPRESENTANTE O APODERADO	Nombre DILIA MARIA RODRIGUEZ D ALEMAN Direccion Carrera 11 N° 93-43 Of 404 Santafé de Bogota D C Teléfono 6350835 Fax 6350824 E Mail clarkemodet@clarkemodet.com.co		IDENTIFICACIÓN C C ☒ NIT ☐ C E ☐ OTRO ☐ NUMERO 41 654 882 TP 20824 CSJ
4) INVENTOR (ES) (72)	Nombre (1) CALDERON, Albert, (2) LAUBIS, Terry, James Dirección (1) 1065 Melrose, Bowling Green, OH 43402 (Estados Unidos), (2) 14377 Powell Road, Portage, OH 43451 (Estados Unidos) Nacionalidad o Domicilio Estados Unidos		
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ANEXOS

☒ Comprobante de pago de la tasa de presentación de la solicitud

☐ Comprobante de pago por reivindicación de prioridad

☐ Documento que acredite la existencia y representación legal cuando el solicitante sea persona Jurídica

☐ Poderes si fuera el caso

☐ Documento de cesión del inventor al solicitante o a su causante

☐ Declaraciones

☒ Copia de la solicitud Internacional (Resumen descripción reivindicación Dibujos)

☒ Traducción de la solicitud internacional al castellano (Resumen descripción reivindicación Dibujos)

☒ Copia del examen preliminar efectuado por la IPEA sin anexos

☐ De ser el caso copia del contrato de arrendamiento

☐ De ser el caso documento que acredite la licencia o autorización de uso de conocimientos tradicionales de las comunidades indígenas

☐ De ser el caso certificado de depósito del material biológico

☐ Arte final 12 x 12 y 6 x 6 cm

☐ De ser el caso información sobre otras solicitudes de patente o títulos obtenidos en el extranjero por el mismo titular o su causante relacionados parcial o totalmente con la invención de esta solicitud

☒ Otros

1 Copia del PCT Request

2 Reporte de Búsqueda Internacional con copia de los documentos citados

3 Notificación de transmisión del reporte de búsqueda internacional

4 Notificación de recibo de la solicitud por la autoridad de examen preliminar internacional

5 Notificación de transmisión del examen preliminar internacional

6 Copia simple de la cesión de la solicitud de patente No PCT/US02-21099 de CALDERON ENERGY COMPANY OF BOWLING GREEN INC a CALDERON SYNGAS COMPANY

7 Copia de la carta de solicitud de registro de cambio de solicitante bajo la Regla No 92bis

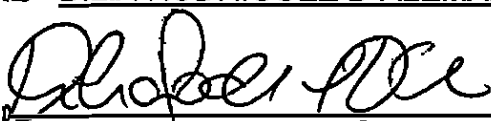
11) FIGURA CARACTERISTICA

12) Solicitud concesion de la patente,

NOMBRE

DILIA RODRÍGUEZ D ALEMAN

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(71) Applicant CALDERON ENERGY COMPANY OF
BOWLING GREEN INC [US/US] 500 Lehman Av
enue Bowling Green OH 43402 (US)
(72) Inventors CALDERON Albert 1065 Melrose Bowling
Green OH 43402 (US) LAUBIS Terry James 14377
Powell Road Portage OH 43451 (US)

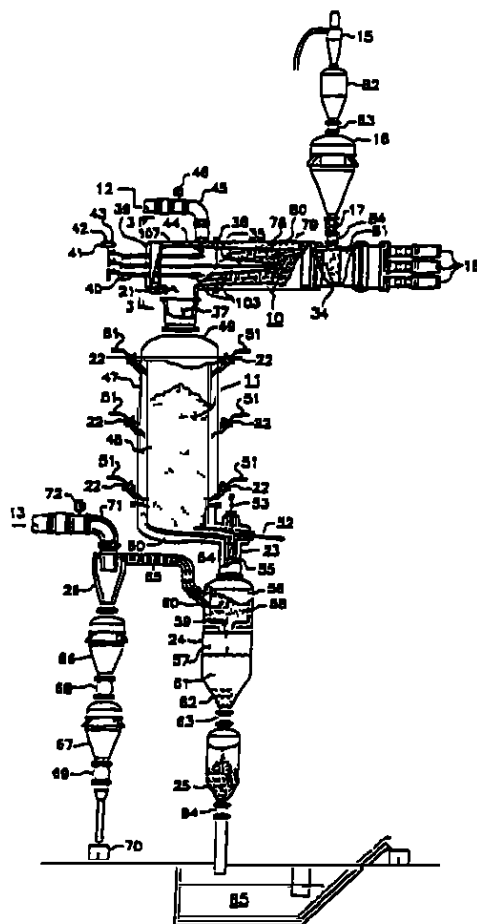
(74) Agents SCHURR, Donald A et al Marshall & Mel
horn LLC Four SeaGate 8th floor Toledo OH 43604
(US)

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(54) Title METHOD FOR PRODUCING CLEAN ENERGY FROM COAL



(57) Abstract A method for producing clean energy from coal by feeding the coal in a reactor (10) which is sealed to atmosphere and moving the coal in the reactor (10) while injecting oxygen (40) to combust a portion of the coal to yield a pressurized hydrogen rich raw gas and hot char. Said hydrogen rich gas is cracked in cracking compartment (21) to remove distillates and hydrocarbons and desulfurized to produce synthesis gas. The hot char is gasified in an air blown gasifier (11) to produce a fuel gas and a molten slag which are jointly directed out of the gasifier through a common port (23). The fuel gas and the molten slag are separated in a separator (24). After separation the fuel gas is desulfurized to produce gas which will produce very low Nox emission while combusted.

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METHOD FOR PRODUCING CLEAN ENERGY FROM COAL

Background of the Invention

This application is a further development of the applicant's issued patent No 5 063,732 which discloses a method for repowering existing electric power plants while co-producing a clean liquid fuel, it also discloses that coal is first pyrolyzed to produce a rich gas which is cleaned and then synthesized to a liquid and a char which is gasified to make a low Btu gas that is also cleaned and then used to generate electricity, this development resides in improving the referenced method as follows

- Reduction of the great number of process tubes (reactors) which reduces capital investment to make it economically viable
- Elimination of the complex charging system which comprises a revolving means to make it easy to maintain
- Improving the heating of the charge to increase efficiency
- Insuring that the gases produced in the process reactor flow in the proper direction to cause the cracking of undesirable cancer causing constituents of the coal
- Blowing the char gasifier in a down draft direction to overcome the excessive entrainment of particulate matter in the low Btu gas
- Preventing the plugging of the slagging port of the gasifier to obtain the free flow of slag out of the gasifier
- Mitigating the cooling effect of the slag quench to prevent the premature solidification of the molten slag before it is quenched

Introduction

Of the three major fossil energy resources found in Nature, which consist of oil, natural gas and coal, 90% is coal, yet, we are unable to use coal in an environmentally acceptable manner. This invention which is environmentally closed, operated at pressure and devoid of coal derived cancer causing agents, makes possible the use of coal in a clean, efficient and economical manner. Since coal is essentially an energy ore, it has impurities the same as any other ore. These

impurities comprise ash, sulfur and cancer causing distillates and hydrocarbons which are chemically bound in the volatile matter of the coal

Objectives of the Invention

The main object of the present invention resides in the processing of coal which is considered to be a dirty fuel, to produce clean energy from it and enable mankind to utilize this abundant and affordable natural resource

Another object of the present invention is to process the coal under pressure to increase efficiency and minimize capital investment by providing a module that is large enough in size and yet easy to heat under reducing conditions

Still another object of the invention is to produce thermal energy in the form of clean gases from coal

Yet another object of this invention is to apply it to existing coal burning electric power plants to render them clean and efficient and give them a new lease on life thus saving capital investment of major proportions

Therefore another object of the present invention resides in the recovery of hydrogen rich gas from the coal that can be converted to value added liquid fuels via synthesis as alternate to petroleum for transportation and heating

Further another object of the present invention is to produce from coal a clean low Btu gas (lean gas) that produces low NO_x , when combusted, which is capable of generating power more efficiently while flowing through a gas turbine by virtue of its large mass

Also another object of the present invention is to co-produce in a closed system a rich gas from the volatile matter of the coal which is high in hydrogen content for synthesis into liquids and chemicals, and a lean gas from the residual char for use as a fuel for generating electric power or for heating purposes

Further yet another object of the present invention is to produce carbon from coal which can be used as a coke or activated carbon

These and other objects of the present invention will become more apparent to those skilled in the art to which this invention pertains and from the following description and appended claims. Reference is now made to the accompanying drawings forming a part of this specification. It is to be noted that the embodiments shown herein are for the purpose of description and not limitation

Brief Description of Drawings

Figure 1 illustrates the method by means of a process flow diagram which by way of example is applied for co-production

Figure 2 shows equipment to carry out the method

Figure 3 is a section taken at 3-3 of Figure 2

Figure 4 is an illustration showing another variation of the equipment shown in Figure 2 which relates to heating of the coal and the discharging of the lean gas and molten slag

Figure 5 is a section taken at 5-5 of Figure 4

Figure 6 is an enlargement of a portion of Figure 4 showing an alternate approach for the separation of the gas from the molten slag than that shown in Figure 2

Before proceeding with the detailed description of the invention by making use of the drawings it is to be noted that for the sake of clarity, reference will be made with numerals to represent various components

Detailed Description of the Drawings

Reference is made to Figure 1 which is a process flow diagram that illustrates the processing of coal to coproduce - (i) a rich gas which is cleaned and synthesized to a liquid fuel such as methanol, diesel fuel, gasoline or a chemical, and (ii) a lean gas which is cleaned and used as fuel to generate electric power or provide thermal energy for heating. Numeral 10 represents a reactor chamber in which the coal is heated to produce a raw rich gas and a hot char. Numeral 11 represents the gasifier which converts the hot char to a raw lean gas. Numeral 12 represents the cleanup for the raw rich gas and numeral 13 the cleanup for the raw lean gas. Numeral 14 represents the coal dryer which receives coal from bunker 19, it is followed by surge hopper 15 and lockhopper 16. Beneath lockhopper 16, feeder 17 is disposed for flow control of the coal. A coal charger denoted by numeral 18 force feeds the coal into reactor 10. Burner 20 is used for start-up and may be used as an auxiliary source of heat. Oxygen and steam are injected from a gas cracking compartment at the discharging end of reactor 10, which is denoted by numeral 21. Cracking compartment 21 possesses a radiant zone in order to radiate thermal energy against the coal and char emerging from the discharging end of reactor 10.

Gasifier 11 is equipped with inlet port 22 and exit port 23. Inlet port 22 serves for the injection of an oxidant which preferably is preheated air and exit port 23 serves for the discharge of the raw lean gas and molten slag. Beneath port 23 separator 24 is disposed which serves the dual purpose for the disengagement of the raw lean gas from the molten slag produced in gasifier 11, and for the quenching of the slag. Lockhopper 25 is used to remove the quenched slag without loss of system pressure. A first cyclone denoted by numeral 26 is provided to remove dust from the raw lean gas.

Downstream of rich gas cleanup 12, cooler 27 is provided prior to feeding the cleaned rich gas to the synthesis plant for making a chemical or a liquid fuel such as methanol, gasoline or diesel and the like as an alternate to petroleum, which is represented by numeral 28. Downstream of lean gas cleanup 13 a second cyclone denoted by numeral 29, is provided as a polishing bed and downstream of cyclone 29, air pre-heater 30 and cooler 31 are situated. Beyond cooler 31 an activated carbon bed/pressurized baghouse denoted by numeral 32, is disposed. The raw lean gas after having been cleaned is directed as a cleaned lean gas, to a station such as an electric power house, a heating plant, an industrial furnace facility, etc., which is represented by numeral 33.

Referring to Figure 2, numeral 10 is the reactor for processing the coal and numeral 11 is the gasifier for converting the char into gas and the ash into slag. Reactor 10 possesses a charging end denoted by numeral 34 and a discharging end denoted by numeral 35. Extending beyond discharging end 35 a gas cracking compartment denoted by numeral 21, is provided, it is equipped with a downcomer denoted by numeral 37 which serves to interconnect reactor 10 to gasifier 11. One end of cracking compartment 21 is open and connects to discharging end 35 of reactor 10 by means of flange connection 38, and the other end of compartment 21 is closed and serves as the radiation wall, denoted by numeral 39, through which the penetration of lance 40 takes place. Lance 40 which can be advanced or retracted serves for the injection of oxidant such as air or oxygen, and possibly steam when producing rich gas relatively pure oxygen is injected. Lance 40 may also be equipped to inject an oxygen fuel combination to increase the energy input into compartment 21. To raise the H_2 content of the gas some steam may be added to the oxygen, this being done when making syngas for the production of liquid fuels. 4

plurality of lances such as lance 40, may be used for a large diameter reactor and in so doing, a manifold denoted by numeral 41 is provided with inlet port 42 for the oxygen and inlet port 43 for the steam. By way of example penetration points into wall 39 by lances 40 are shown in Figure 3. An exit port denoted by numeral 44 is provided to cracking compartment 21 for the exhaust of the cracked rich gas, which communicates with gas pipe 45, a pressure valve denoted by numeral 46 is disposed to pipe 45 to control the back pressure in cracking compartment 21. The continuation of pipe 45 (not shown, but indicated by the directional arrow) ties to rich gas cleanup 12 shown in Figure 1.

Gasifier 11 which is connected via downcomer 37 to compartment 21 is a shaft type vessel made up of pressure shell 47, lining 48, top 49 and bottom 50. Penetrations through shell 47 and lining 48 are provided to accommodate inlet ports 22 for the introduction of an oxidant preferably in the form of pre-heated air for the conversion of the hot char to a raw lean gas and the ash in the char to a molten vitreous slag. Relatively pure oxygen and steam may replace the air if the carbon content of the hot char is to be converted to a syngas. Flow control means, denoted by numeral 51 are provided for the control of the air into gasifier 11. Air may be introduced at different levels of gasifier 11. Bottom 50 of gasifier 11 is configured in such a way to preferably slope towards exit port 23 which is equipped with piercing lances 52 and 53 that are adapted to use a gas such as oxygen to keep horizontal passage 54 and vertical passage 55 of exit port 23 open to insure the free flow of gas and molten slag out of gasifier 11.

Separator 24 located below exit port 23, is a pressure vessel divided into two parts - An upper part denoted by numeral 56 and a lower part denoted by numeral 57. Upper part 56 comprises disengagement zone 58 which is equipped with a discharge slag nozzle 59 and gas exit port 60. Lower part 57 comprises slag quenching pool 61 which is supplied with water, and surge hopper 62. Isolation valve 63 connects surge hopper 62 to lockhopper 25 which is equipped at the bottom with valve 64 in order to remove the quenched slag from the process without losing system pressure by maintaining valve 63 closed and valve 64 open during the discharge of the quenched slag into sump 85.

Gas exit port 60 communicates with cyclone 26 via header 65 which directs the separated gas to cyclone 26. Cyclone 26 is equipped at the bottom with surge

hopper 66 which in turn is connected to lockhopper 67 isolation valves 68 and 69 permit lockhopper 67 to discharge particulate matter into collection box 70 which is open to the atmosphere without loss of system pressure Cyclone 26 is equipped with exit gas main 71 to direct the lean gas for further treatment Pressure control valve 72 serves to control the back pressure in gasifier 11 The continuation of gas main 71 (not shown but indicated by the directional arrow) ties to lean gas cleanup 13 shown in Figure 1

Referring to Figure 4 and supported by Figure 5 for additional detail, reactor 10 is similar to reactor 10 shown in Figure 2 with certain modifications Reactor 10 in Figure 4 possesses burner 20 leading to inlet port 73 via duct 74 for the flow of hot flue gases to a heating element denoted by numeral 75 which partially heats the coal indirectly and circumferentially by conduction, with the flue gases flowing through flues 76 (shown in Figure 5) and exiting from outlet port 77 An insulating material denoted by numeral 78 is disposed between heating element 75 and pressure shell 79, the coal mass within reactor 10 being shown by numeral 80 Both reactors shown in Figures 2 and 4, are provided with a taper to diverge from charging end 34 to discharging end 35 to facilitate the movement of the coal within reactor 10 as it is force fed by means of ram 81 actuated by coal charger 18 (shown in Figure 1)

Referring again to Figure 4, beneath gasifier 11, a receiver denoted by numeral 36 is provided, receiver 36 which is shown enlarged in Figure 6, comprises shell 86, lining 87 and ports 88, 89 and 90 The lower part of receiver 36 is furnished with a crucible which is denoted by numeral 91, crucible 91 is adapted to be heated such as with induction coil 92 A snorkel denoted by numeral 93 extends downwardly from port 88 into receiver 36 for directing the gas and the molten slag into receiver 36 in a submerged manner and in such a way as to have the gas bubble through the molten slag and flow out of receiver 36 via port 89 Port 90 is provided for the molten slag to flow out of receiver 36 when the level of the molten slag reaches the spilling level denoted by numeral 102, as shown more clearly in Figure 6 Receiver 36 is provided with a bottom discharge 108 when conditions arise that necessitate the emptying of the contents of receiver 36 Downstream of gas exit port 89, gas main 101 is furnished to connect receiver 36 with gas cleanup 13

Downstream of port 90 slag quenching vessel 57 is provided with downcomer 94 connecting receiver 36 to quenching vessel 57 Lancing means 95 and 96 are also

provided in order to maintain downcomer 94 open by injection of an oxidant this insures the free flow of the molten slag. Quenching vessel 57 possesses three ports 97, 98 and 99, port 97 is for the entry of the molten slag from downcomer 94, port 98 is for the exit of the steam generated when the molten slag drops into the water bath denoted by numeral 61, and port 99 is for the discharge of the quenched slag. Particulate matter from the steam is removed by any known method as for example cyclone 26, which was described earlier by making reference to Figure 2. A control valve denoted by numeral 100 is provided for pressure balancing at the exit of cyclone 26. Control valve 100 insures that steam generated from the quench does not back into receiver 36 by keeping the pressure in receiver 36 higher than the pressure in quenching vessel 57 to prevent premature solidification of the slag caused by the cooling effect of the steam.

Operation

In describing the operation of the instant invention as stated above, coal is essentially an energy ore with the following constituents: ^xcarbon, ash, sulfur and volatile matter (gas). In order to be able to use coal in a clean manner the unpurities which consist of the ash, sulfur, and the cancer causing portions in the gas must be removed and converted to useful products. The ash must be vitrified to become non-leaching, the sulfur must be removed as elemental sulfur, and the cancer causing distillates such as tars and light oils which include benzene must be destroyed by cracking. Various configurations will be described in order to respond to the need to which the invention is applied. The configuration which relates to the co-production of syngas for synthesis into liquid fuel(s) for transportation or heating, and of fuel gas for the generation of electric power will be described in detail and the others will be described by reference to the co-production while pointing out the differences.

Reference is now made to Figure 1, which configuration relates to co-production. Coal is fed from bunker 19 into drier 14 thence to lockhopper 16 via surge hopper 15. The coal may have other material(s) with it such as biomass and/or waste to be processed with the coal. Once lockhopper 16 is full it is locked and feeder 17 controls coal from lockhopper 16 into charging end 34. Coal charger 18 force feeds the coal into reactor 10 in such a way as to compact the coal and make it dense and essentially impervious to gas flow at the charging end to force pressurized

raw gases generated during the combination of a portion of the coal to flow co-current with the movement of the coal in reactor 10 and towards discharging end of reactor 10. Assuming that start-up burner 20 has ignited the coal at the discharging end of reactor 10 and the process is already at steady state the coal is advanced in reactor 10 while oxygen (and possibly steam) are injected via lance(s) 40 into the coal preferably from cracking compartment 21 to devolatilize the coal and produce a raw rich gas while the environment is kept under reducing conditions by operating sub-stoichiometrically. The temperature of compartment 21 is maintained above the cracking temperature of coal tar, oils, hydrocarbons, etc. to crack these cancer causing compounds to result in a hydrogen rich cracked gas which is directed via conduit 104 to gas cleanup 12 for further treatment such as desulfurization to thus yield an ideal synthesis gas of $2H_2$ and $1CO$. In the event that not enough fuel exists in compartment 21 by virtue of using low volatile coal, supplemental fuel may be added with the oxygen in order to attain cracking temperatures. Cracking compartment 21 which serves to separate the rich gas from the hot char is also used to pretreat the raw rich gas by cracking the cancer causing liquids and hydrocarbons from the coal by means of elevated temperature in cracking compartment 21 through the injection of sufficient oxidant via ports 103 (shown in Figure 2) of lance 40 and combusting some of the volatile matter from the coal to yield a cracked gas which is devoid of coal liquids and hydrocarbons and whose composition is mainly H_2 and CO with H_2 being the dominant gas. Within compartment 21, radiant zone 107 provides efficient thermal energy transfer to the coal emerging from discharging end 35. The coal/char is pushed out of chamber 80 progressively in a pulsating mode in order to provide a fresh new face of coal/char which is heated frontally by radiation from compartment 21. Depending upon the coal used it is possible to obtain a cracked gas of $2H_2$ and $1CO$ from the process without the need for a shift converter which is known in the art. If inadequate volatile matter is contained in the coal, steam is added in order to increase the H_2 content of the gas. Subsequent to cleanup the synthesis gas thus produced is comprised of the essential proportions of $2H_2$ to $1CO$. This gas when cooled in heat exchanger 27 and directed to plant 28 via duct 105 is ideal for synthesizing it into a liquid. Plant 28 may be a Fischer Tropsch or a methanol plant which in turn may be followed by a methanol-to-gasoline train, such as the one developed by Mobil Oil. These processes for conversion of the synthesis

gas to various liquids are known in the art and are not part of this invention. Since the major cost of making an alternate to petroleum liquid fuel from synthesis gas is the cost of producing the synthesis gas, the cracking of the volatile matter of the coal as described herein, is an elegant and economical approach for making the feedstock for the synthesis plant(s).

The hot char which is quite porous and highly reactive resulting from the devolatilization of the coal, drops into gasifier 11 and is gasified with air which may be preheated. The air is preferably injected into gasifier 11 in the downdraft mode which tends to equilibrate the temperature of the char, the air may be injected at several points as shown in Figures 2 and 4. The air reacts with the carbon in the char to make a producer gas which is also known as "lean gas" by virtue of its low Btu content. This lean gas is fed to hot gas cleanup 13 via duct 106 for sulfur removal. In the event the lean gas is not up to temperature for the hot gas cleanup, an oxidant is added as denoted by numeral 9 prior to entry into cleanup vessel 13. After exiting from cleanup 13, the lean gas is directed to cyclone 29 for particulate removal and thence to air preheater 30. The lean gas after exiting from preheater 30, is directed to heat exchanger 31 to raise steam which is used in the process for H_2 generation, for moderating temperatures, for steam tracing, etc. The lean gas is then introduced to filter/baghouse 32 for mercury and alkali control and thence the gas is directed to station 33 which may represent an electric power plant. This lean gas is an excellent fuel for use in a combustion turbine by virtue of its mass to generate electric power more efficiently and by virtue of its low formation of NO_x when combusted, since it burns cool. The combustion turbine may be followed by a steam turbine to provide a combined cycle arrangement, an efficient manner of producing electricity, which is in common practice.

In addition to the lean gas made in the gasifier, the ash in the coal is converted to a molten slag, and both the lean gas and molten slag are discharged from gasifier 11 via exit port 23 into separator 24 wherein the gas is directed to cyclone 26 and the slag after having been quenched is fed into lockhopper 25 for discharge into the atmosphere without loss of system pressure. The slag so produced is vitreous and inert which passes the non-leachability test.

The sulfur in both the raw rich gas and the raw fuel gas leaves the process in the form of H_2S which is removed by any one of known systems including the

applicant's own system described in the referenced patent. The H_2S is absorbed by a sorbent contained in cleanup 12 and 13 shown in Figure 1. The sorbent which is recycled and regenerated in vessel 7 extracts the sulfur in elemental form as a vapor and is condensed in a condenser which is denoted by numeral 8. The off-gas from condenser 8 which is used for recycling the sorbent, is boosted in pressure in compressor 109. A side stream from cleanup vessel 12, is diverted by means of valve feeder 110 for regeneration in regenerator 7. Valve feeder 111 recycles the sorbent to cleanup vessel 13. A cyclone above regenerator 7, denoted by numeral 112 removes particulate matter from the recycling off-gas.

In utilizing this invention for the exclusive manufacture of synthesis gas, the air in gasifier 11 is substituted by oxygen and steam to react with the char and thus produce additional H_2 rich gas which after cleanup can be synthesized to a liquid and/or chemical the same as the H_2 rich gas derived from the cracked gas after it undergoes a shift reaction which is known in the art of gasification.

In utilizing this invention for the exclusive manufacture of fuel gas, the oxygen injected through the cracking reactor is diluted with air to produce a lean gas which after cleanup can be used as a fuel gas the same as that produced from gasifier 11 when blown with air. The fuel gas can be used as a fuel for various heating applications including electric power generation.

It is also the purpose of this invention to repower existing power plants in order to give them a new lease on life as more than 50% of the electric power is still produced in polluting pulverized coal boilers in the United States.

Another application of the invention is to process the coal in reactor 10 to make coke or char and not gasifying it, such coke being useable in the field of metallurgy. The char while incandescent is treated with steam to make it into activated carbon for utilization in filtering systems including the removal of mercury.

It is submitted that the presentation made herein discloses a method which can process coal for producing abundant clean energy efficiently and in an environmentally closed manner for heating, transportation, electric power, chemicals and the like, as an alternate to petroleum and natural gas, including the capability to make coke and activated carbon.

I claim

- 1 A method for producing clean energy from coal comprising
- feeding coal into a chamber which is sealed to the atmosphere and
- which possesses a charging end and a discharging end
- moving the coal within said chamber towards the discharging end
- injecting oxygen which is essentially pure in such a way as to
- combust a portion of the coal while maintaining a pressurized reducing
- atmosphere to
- (i) cause the release of high levels of thermal energy to devolatilize the coal, and
 - (ii) yield a pressurized hydrogen rich raw gas containing coal derived cancer causing distillates and hydrocarbons together with a hot char,
- cracking the coal-derived cancer causing distillates and hydrocarbons contained in the hydrogen rich raw gas to make a hydrogen rich cracked gas which after desulfurization becomes a clean hydrogen rich synthesis gas
- directing the hot char to a gasifier which is sealed to the atmosphere,
- gasifying the hot char with air in said gasifier to yield a raw fuel gas and a molten slag,
- flowing the raw fuel gas together with the molten slag through a common port out of said gasifier to maintain said port open for the free flow of the raw fuel gas and the molten slag,
- separating the raw fuel gas from the molten slag after exiting from said common port,
- directing the raw fuel gas to a cleanup system to clean it and thus yield a clean fuel gas suitable for combustion with low NO_x formation and quenching the molten slag to convert it to a non-leaching solid

2 The method set forth in claim 1 further comprising the synthesizing of said clean hydrogen rich synthesis gas into a liquid fuel or chemical

3 The method set forth in claim 1 further comprising the utilizing of said clean fuel gas for the generation of electric power

4 The method set forth in claim 1 wherein the step of gasifying the hot char with air in said gasifier to yield a raw fuel gas is further characterized by the step of substituting the air with essentially pure oxygen and steam in order to make a hydrogen rich raw gas instead of a fuel gas from the char, which after cleanup a clean synthesis gas is obtained which can be synthesized into a liquid fuel for heating or transportation

5 The method set forth in claim 1 wherein the step of injecting oxygen which is essentially pure in such a way as to combust a portion of the coal is further characterized by the step of substituting air for the pure oxygen in order to make a raw fuel gas which after cleanup, a clean fuel gas is obtained which can be utilized for heating or electric power generation

6 The method set forth in claim 1 includes the using of preheated air

7 The method set forth in claim 1 includes the using of oxygen enriched air

8 The method set forth in claim 1 wherein the step of gasifying the hot char with air in said gasifier comprises the injection of the air in the downdraft mode

9 The method set forth in claim 8 further comprising the injection of the air at a plurality of penetrations into said gasifier

10 The method set forth in claim 1 includes the step of compacting the coal against the wall of the chamber at the charging end to such an extent as to densify the coal to essentially make it impervious to gas flow at the charging end in order to force pressurized raw gases generated during the heating of the coal to flow out of the discharging end of said chamber

11 The method set forth in claim 1 wherein the step of flowing the raw fuel gas together with the molten slag through a common port of said gasifier includes the step of providing supplementary thermal energy to prevent solidification of the molten slag in said port

12 The method set forth in claim 11 includes the step of providing oxidant injection means to combust a portion of said raw fuel gas to create said supplementary thermal energy

13 The method set forth in claim 11 wherein said supplementary thermal energy is derived from electric induction means

14 The method set forth in claim 1 wherein the step of flowing the raw fuel gas together with the molten slag through a common port out of said gasifier includes the collecting of the molten slag in a receiver to serve as a molten bath

15 The method set forth in claim 14 includes the step of directing the raw fuel gas together with the molten slag to the receiver in a submerged fashion to cause the raw fuel gas to bubble through said molten bath in order to separate the entrained slag from the raw fuel gas and to essentially scrub the fuel gas by making use of the molten slag in said receiver

16 The method set forth in claim 14 includes the step of providing a gas exit port above the bath for the discharge of the scrubbed fuel gas

17 The method set forth in claim 14 includes the step of providing a spillway for the molten slag to flow out of said receiver

18 The method set forth in claim 17 includes the step of providing downstream of said spillway a water quenching chamber to cool the molten slag to a non-leaching solid

19 The method set forth in claim 1 wherein the method is conducted under pressure

20 The method set forth in claim 1 wherein the step of injecting oxygen which is essentially pure in such a way as to combust a portion of the coal is further characterized by the step of injecting the oxygen from a compartment located downstream of the discharging end of said chamber

21 The method set forth in claim 20 further comprising a hot radiant zone disposed to said compartment to reflect intense thermal energy against the coal in the discharging end of said chamber to expedite devolatilization of the coal and crack coal distillates and hydrocarbons which are cancer causing

22 The method set forth in claim 1 including the passing of hot gases through flues disposed in the wall of said chamber

23 The method set forth in claim 1 wherein the step of moving the coal within the chamber towards the discharging end is further characterized by moving the coal progressively with pauses in order to create successive new frontal faces of coal at the discharging end of said chamber for the efficient exposure of the coal to radiant heat

24 The method set forth in claim 1 being further characterized by balancing the pressure between the step of injecting oxygen to combust a portion of the coal and the step of gasifying the char with air so as to essentially prevent the contamination of the hydrogen rich gas by the fuel gas

25 The method set forth in claim 14 includes the step of heating the receiver

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26 The method set forth in claim 25 wherein the heating of the receiver is derived from electric induction means

27 The method set forth in claim 1 further comprising the injection of oxygen which is essentially pure in such a way as to combust a portion of the coal at a plurality of points to more efficiently combust coal while maintaining a reducing atmosphere

28 The method set forth in claim 1 wherein an oxidant is added to raise the temperature of the hydrogen rich cracked gas prior to its desulfurization

29 The method set forth in claim 1 wherein an oxidant is added to raise the temperature of the fuel gas prior to its desulfurization

30 The method set forth in claim 28 includes the desulfurization in a cleanup system which is regenerative

31 The method set forth in claim 29 includes the desulfurization in a cleanup system which is regenerative

32 The method set forth in claim 1 further includes the tapering of the reactor chamber in such a way as to diverge towards the discharging end to facilitate the movement of the coal within the chamber

33 The method set forth in claim 1 includes the passing of gases in flues provided to the chamber of said reactor

34 The method set forth in claim 1 includes the addition of biomass to the coal for processing them in unison

35 The method set forth in claim 1 includes the addition of waste to the coal for processing them in unison

36 The method set forth in claim 1 wherein the step of gasifying the hot char is obviated to limit the conversion of the coal to a coke or a char

37 The method set forth in claim 36 wherein the coke or char are converted to activated carbon

38 The method set forth in claim 1 being further characterized by balancing the pressures between the step of injecting oxygen and the step of gasifying the char, and the step of gasifying the char and the quenching of the molten slag in order to control the various flows of the gases in the process

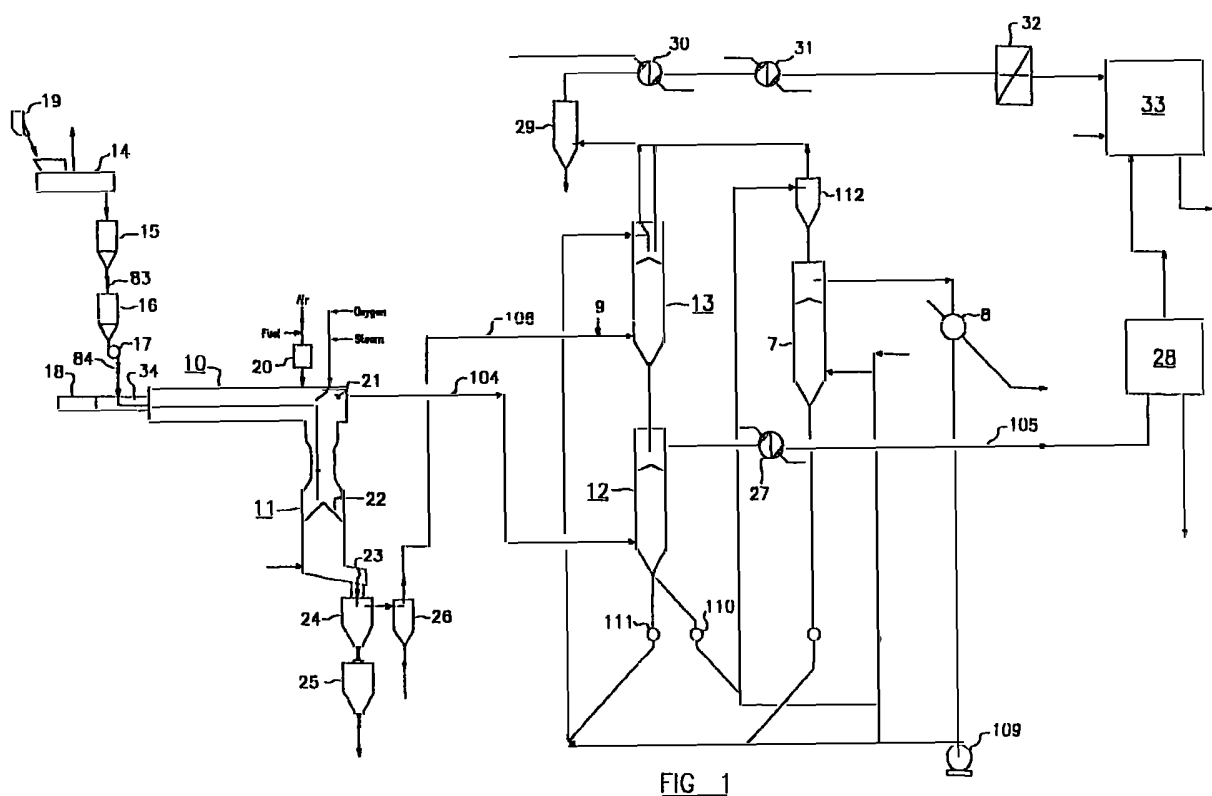


FIG 1

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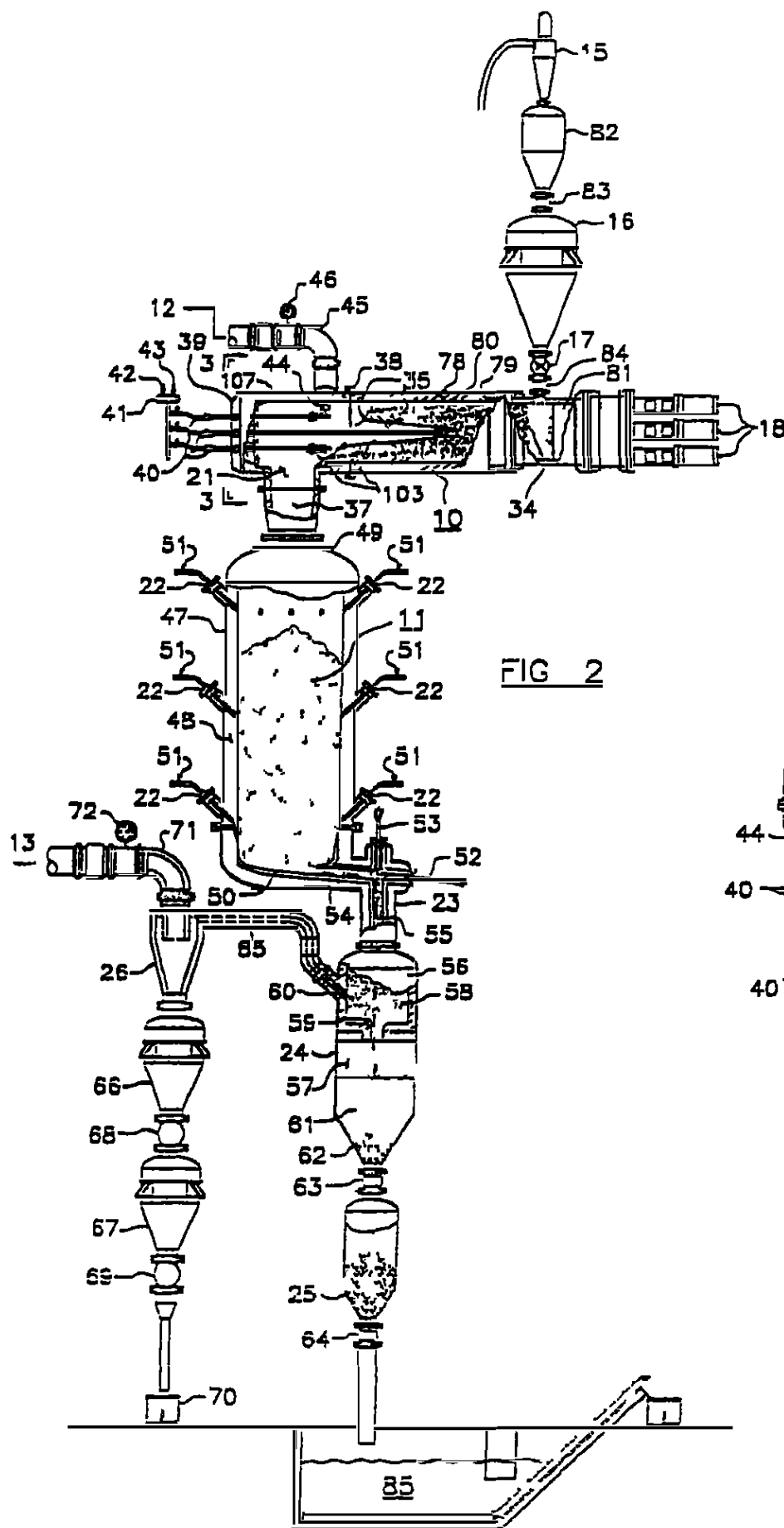


FIG 2

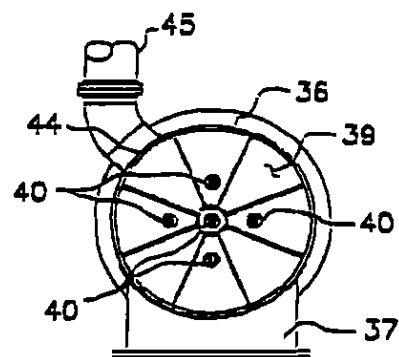
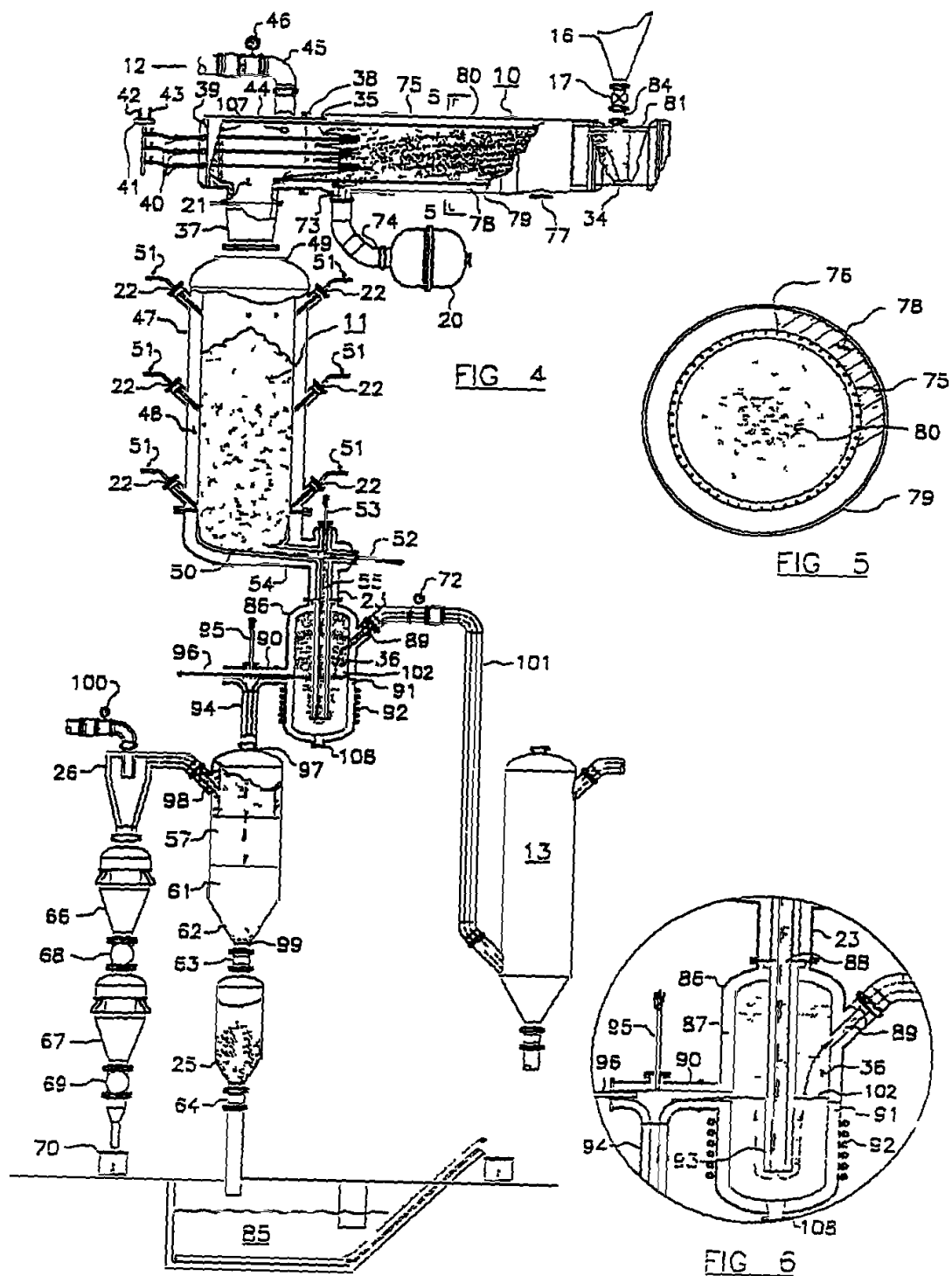


FIG 3

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National Phase Claims

Claim 1 A method for producing clean energy from coal comprising

feeding coal into a chamber which is sealed to the atmosphere and which possesses a charging end and a discharging end

moving the coal within said chamber towards the discharging end

injecting oxygen which is essentially pure in such a way as to combust a portion of the coal while maintaining a pressurized reducing atmosphere to

(i) cause the release of thermal energy to devolatilize the coal and

(ii) yield a pressurized hydrogen rich raw gas containing coal derived cancer causing distillates and hydrocarbons together with a hot char

cracking the coal derived cancer causing distillates and hydrocarbons contained in the hydrogen rich raw gas to make a hydrogen rich cracked gas which after desulfurization becomes a clean hydrogen rich synthesis gas

directing the hot char to a gasifier which is sealed to the atmosphere

gasifying the hot char with an oxidant in said gasifier to yield a raw second gas and a molten slag

flowing the raw second gas together with the molten slag through a common port out of said gasifier to maintain said port open for the free flow of the raw second gas and the molten slag

separating the raw second gas from the molten slag after exiting from said common

port

directing the raw second gas to a cleanup system to clean it and thus yield a

clean second gas and

quenching the molten slag to convert it to a non-leaching solid

Claim 2 The method set forth in claim 1 further comprising the synthesizing of said clean hydrogen rich synthesis gas into a liquid fuel or chemical

Claim 3 The method set forth in claim 1 further comprising the utilizing of said clean fuel gas for the generation of electric power

Claim 4 The method set forth in claim 1 wherein the hot char is gasified with essentially pure oxygen and steam in order to make a hydrogen rich raw gas from the char which, after cleanup, a clean synthesis gas is obtained which can be synthesized into a hydrogen rich gaseous or liquid fuel

Claim 5 The method set forth in claim 1 wherein the step of injecting oxygen which is essentially pure in such a way as to combust a portion of the coal is further characterized by the step of substituting air for the pure oxygen in order to make a raw fuel gas which after cleanup a clean fuel gas is obtained which can be utilized for heating or electric power generation

Claim 6 The method set forth in claim 1 includes the using of preheated air

Claim 7 The method set forth in claim 1 includes the using of oxygen enriched air

Claim 8 The method set forth in claim 1 wherein the step of gasifying the hot char with air in said gasifier comprises the injection of the air in the downward mode

Claim 9 The method set forth in claim 8 further comprising the injection of the air at a plurality of penetrations into said gasifier

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Claim 10 The method set forth in claim 1 includes the step of compacting the coal against the wall of the chamber at the charging end to such an extent as to densify the coal to essentially make it impervious to gas flow at the charging end in order to force pressurized raw gases generated during the heating of the coal to flow out of the discharging end of said chamber

Claim 11 The method set forth in claim 1 wherein the step of flowing the raw fuel gas together with the molten slag through a common port of said gasifier includes the step of providing supplementary thermal energy to prevent solidification of the molten slag in said port

Claim 12 The method set forth in claim 11 includes the step of providing oxidant injection means to combust a portion of said raw fuel gas to create said supplementary thermal energy

Claim 13 The method set forth in claim 11 wherein said supplementary thermal energy is derived from electric induction means

Claim 14 The method set forth in claim 1 wherein the step of flowing the raw fuel gas together with the molten slag through a common port out of said gasifier includes the collecting of the molten slag in a receiver to serve as a molten bath

Claim 15 The method set forth in claim 14 includes the step of directing the raw fuel gas together with the molten slag to the receiver in a submerged fashion to cause the raw fuel gas to bubble through said molten bath in order to separate the entrained slag from the raw fuel gas and to essentially scrub the fuel gas by making use of the molten slag in said receiver

Claim 16 The method set forth in claim 14 includes the step of providing a gas exit port above the bath for the discharge of the scrubbed fuel gas

Claim 17 The method set forth in claim 14 includes the step of providing a spillway for the molten slag to flow out of said receiver

Claim 18 The method set forth in claim 17 includes the step of providing downstream of said spillway a water quenching chamber to cool the molten slag to a non leaching solid

Claim 19 The method set forth in claim 1 wherein the method is conducted under pressure

Claim 20 The method set forth in claim 1 wherein the step of injecting oxygen which is essentially pure in such a way as to combust a portion of the coal is further characterized by the step of injecting the oxygen from a compartment located downstream of the discharging end of said chamber

Claim 21 The method set forth in claim 20 further comprising a hot radiant zone disposed to said compartment to reflect intense thermal energy against the coal in the discharging end of said chamber to expedite devolatilization of the coal and crack coal distillates and hydrocarbons which are cancer causing

Claim 22 The method set forth in claim 1 including the passing of hot gases through flues disposed in the wall of said chamber

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Claim 23 The method set forth in claim 1 wherein the step of moving the coal within the chamber towards the discharging end is further characterized by moving the coal progressively with pauses in order to create successive new frontal faces of coal at the discharging end of said chamber for the efficient exposure of the coal to radiant heat

Claim 24 The method set forth in claim 1 being further characterized by balancing the pressure between the step of injecting oxygen to combust a portion of the coal and the step of gasifying the char with air so as to essentially prevent the contamination of the hydrogen rich gas by the fuel gas

Claim 25 The method set forth in claim 14 includes the step of heating the receiver

Claim 26 The method set forth in claim 25 wherein the heating of the receiver is derived from electric induction means

Claim 27 The method set forth in claim 1 further comprising the injection of oxygen which is essentially pure in such a way as to combust a portion of the coal at a plurality of points to more efficiently combust coal while maintaining a reducing atmosphere

Claim 28 The method set forth in claim 1 wherein an oxidant is added to raise the temperature of the hydrogen rich cracked gas prior to its desulfurization

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Claim 29 The method set forth in claim 1 wherein an oxidant is added to raise the temperature of the fuel gas prior to its desulfurization

Claim 30 The method set forth in claim 28 includes the desulfurization in a cleanup system which is regenerative

Claim 31 The method set forth in claim 29 includes the desulfurization in a cleanup system which is regenerative

Claim 32 The method set forth in claim 1 further includes the tapering of the reactor chamber in such a way as to diverge towards the discharging end to facilitate the movement of the coal within the chamber

Claim 33 The method set forth in claim 1 includes the passing of gases in flues provided to the chamber of said reactor

Claim 34 The method set forth in claim 1 includes the addition of biomass to the coal for processing them in unison

Claim 35 The method set forth in claim 1 includes the addition of waste to the coal for processing them in unison

Claim 36 The method set forth in claim 1 wherein the step of gasifying the hot char is obviated to limit the conversion of the coal to a coke or a char

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Claim 37 The method set forth in claim 36 wherein the coke or char is converted to activated carbon

Claim 38 The method set forth in claim 1 being further characterized by balancing the pressures between the step of injecting oxygen and the step of gasifying the char and the step of gasifying the char and the quenching of the molten slag in order to control the various flows of the gases in the process

Claim 39 The method set forth in claim 1 wherein the hot char is gasified with air to yield a raw fuel gas which after cleanup yields a clean fuel gas suitable for combustion with low NO_x formation

Claim 40 A method for producing clean energy from coal comprising
feeding coal into a chamber which is sealed to the atmosphere and which
possesses a charging end and a discharging end
moving the coal within said chamber towards the discharging end
injecting oxygen in such a way as to combust a portion of the coal while
maintaining a pressurized reducing atmosphere to
(i) cause the release of thermal energy to devolatilize the coal and
(ii) yield a pressurized hydrogen rich raw gas containing coal
derived cancer causing distillates and hydrocarbons together with
a hot char,
directing the pressurized hydrogen rich raw gas in such a way as to emerge from
the discharging end of said chamber

cracking the coal derived cracker crusing distillates and hydrocarbons contained in
the hydrogen rich raw gas to make a first hydrogen rich cracked gas
directing the hot char to a slagging gasifier which is sealed to the atmosphere and
gasifying same to make a second gas and a molten slag
removing said slag from the system and
cleaning said first gas and said second gas to provide clean gases for useful
applications

Claim 41 The method set forth in claim 40 further comprising the injection of steam
with said oxygen

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MÉTODO PARA PRODUCIR ENERGÍA

LIMPIA A PARTIR DE CARBÓN

ANTECEDENTES DE LA INVENCION

Esta solicitud es un desarrollo adicional de la patente otorgada al presente solicitante No 5,063,732 que describe un método para repotenciar las plantas de energía eléctrica existentes mientras que se coproduce un combustible líquido limpio, también describe que el carbón es primero pirolizado para producir un gas rico el cual es limpiado y luego sintetizado en líquido, y un carbón que es gasificado para formar un gas de bajo Btu que también es limpiado y luego utilizado para generar electricidad, este desarrollo reside en una mejora del método referenciado como sigue

- Reducción del gran número de tubos de proceso (reactores) que reduce la inversión de capital para hacerlo económicamente viable

- Eliminación del sistema de carga complejo que comprende medios para hacerlo más fácil de mantener
- Mejorar el calentamiento de la carga para incrementar la eficiencia
- Asegurar que los gases producidos en el reactor del proceso fluyen en la dirección adecuada para causar el craqueo de constituyentes no deseados que producen cáncer del carbón
- Soplar el gasificador de carbón en una dirección hacia abajo para superar el llevar material particular excesiva en el gas de bajo Btu
- Impedir el taponamiento de las puertas de salida del gasificador para obtener un flujo libre de remanentes del gasificador
- Mitigar el efecto de enfriamiento de los productos calmados para impedir la solidificación prematura de la escoria fundida antes de ser calmada

INTRODUCCIÓN

De las tres fuentes mayores de energía fósil encontradas en la naturaleza que consisten de aceite, gas natural y carbón, 90% es carbón, todavía así, somos incapaces de usar el carbón de una manera aceptable desde el punto de vista ambiental. Esta invención que es operada a presión ambientalmente cerrada y dedicada a eliminar los agentes derivados del carbón que causan cáncer, hace posible el uso del carbón de una manera limpia eficiente y económica. Ya que el carbón es esencialmente una mina de energía, este tiene impurezas al igual que otras minas. Estas impurezas comprenden cenizas, azufre y destilados que causan cáncer e hidrocarburos que están ligados químicamente en la materia volátil del carbón.

OBJETIVOS DE LA INVENCION

El objetivo principal de la presente invención reside en el procesamiento del carbón que es considerado como un combustible sucio para producir energía limpia de este y permitir

que el hombre o la humanidad utiliza este recurso natural abundante y costeable

Otro objeto de la presente invención es procesar el carbón bajo presión para incrementar la eficiencia y minimizar la inversión de capital suministrando un módulo que es suficientemente grande en tamaño y todavía fácil de calentar bajo condiciones de reducción

Todavía otro objetivo de la invención es producir energía térmica en la forma de gases limpios a partir del carbón

Todavía otro objeto de esta invención es aplicarlo a plantas de generación de energía eléctrica existentes que queman carbón para convertirlas en eficientes y limpias, y darles una nueva una oportunidad de vida ahorrando Inversiones de capital de mayores proporciones

Por lo tanto otro objetivo de la presente invención reside en la recuperación del gas rico en hidrógeno a partir del carbón que puede ser convertido en combustibles líquidos de valor agregado

por medio de síntesis como alternativa al petróleo para el transporte y calentamiento

Todavía otro objetivo de la presente invención es producir a partir del carbón un gas limpio de bajos Btu (gas pobre) que produce bajo NO_x , cuando se pone bajo combustión el cuál es capaz de generar potencia más eficientemente aunque fluye a través de una turbina de gas en virtud de su masa grande

Otro objetivo también de la presente invención es coproducir en un sistema cerrado un gas rico a partir de materia volátil del carbón, que tiene un alto contenido en hidrógeno para sintetizarlo en líquidos y químicos, y un gas pobre a partir de carbonizados residuales para uso en un combustible para generar potencia eléctrica o para propósitos de calentamiento

Todavía otro objetivo de la presente invención es producir carbón a partir de el carbón que pueda ser usado como un coque o un carbón activado

Estos y otros objetivos de la presente invención serán más evidentes para aquellos versados en la técnica a lo cuales esta

Invención pertenece, y desde la siguiente descripción y de las reivindicaciones adjuntas. La referencia se hace ahora a los dibujos adjuntos que hacen parte de esta especificación. Debe notarse que las modalidades mostradas aquí tienen el propósito de describir y no de limitar.

BREVE DESCRIPCIÓN DE LOS DIBUJOS

La figura 1, ilustra el método por medio de un diagrama de flujo de proceso, el cual por vía de ejemplo se aplica para la coproducción.

La figura 2, muestra el equipo para llevar a cabo el método.

La figura 3 es una sección tomada en 3-3 de la figura de la figura 2.

La figura 4 es una ilustración que muestra otra variante de el equipo mostrado en la figura 2 que se refiere con el calentamiento del carbón y la descarga del gas pobre y de la escoria fundida.

La figura 5 es una sección tomada de 5-5 de la figura 4.

La figura 6 es una magnificación de una porción de la figura 4 mostrando una enseñanza alternativa para la separación del gas de la escoria fundida que se muestra en la figura 2

Antes de proceder con la descripción detallada de la invención haciendo uso de los dibujos, debe notarse por cuestión de claridad, que la referencia hecha con los numerales para representar varios componentes

DESCRIPCIÓN DETALLADA DE LOS DIBUJOS

Se hace referencia a la figura 1, que es un diagrama de flujo de proceso que ilustra el procesamiento del carbón para coproducir - (i) un gas rico que es limpiado y sintetizado a un combustible líquido tal como metanol, combustible diesel, gasolina un químico, y (ii) un gas pobre que es limpiado y usado como combustible para generar potencia eléctrica o energía eléctrica o suministrar energía térmica para calentamiento El numeral 10 representa una cámara de reactor en la cual el carbón es calentado para producir un gas rico de materia prima y un carbón caliente El numeral 11 representa el gasificador que convierte el carbón caliente en un gas pobre de partida El numeral 12

representa la limpieza para el gas rico de partida y el numeral 13 la limpieza del gas pobre de partida. El numeral 14 representa el secador de carbón el cual recibe el carbón desde la carbonera 19, es seguido por la tolva 15 y la compuerta 16. Debajo de la compuerta 16 el alimentador 17 está dispuesto para el control del flujo del carbón. Un cargador de carbón con el numeral 18 fuerza la alimentación del carbón dentro del reactor 10, el quemador 20 es usado para iniciar y puede ser usado como una fuente auxiliar de calor. El oxígeno y el vapor son inyectados desde un compartimento de craqueo de gas en el extremo de descarga del reactor 10, que se numera con 21. El compartimento de craqueo 21 posee una zona radiante para poder radiar energía térmica contra el carbón y el carbonizado que emerge del extremo de descarga del reactor 10.

El gasificador 11 está equipado con una puerta de entrada 22 y una puerta de salida 23. La puerta de entrada 22 sirve para la inyección de un oxidante que preferiblemente es aire precalentado, y la puerta de salida 23 sirve para la descarga del gas pobre de partida y la escoria fundida. Por debajo de la puerta 23, el separador 24 está dispuesto el cuál tiene el propósito doble para el desenganche del gas pobre de partida de la escoria

fundida producida en el gasificador 11, y para calmar la escoria La compuerta 25 se usa para remover la escoria calmada sin perdida de la presión del sistema Un primer ciclón numerado con 26 se suministra para remover el polvo del gas pobre de partida

Aguas abajo del limpiador de gas rico 12 el enfriador 27 esta provista antes de alimentar el gas rico limpiado en la planta de síntesis para hacer un químico o un combustible líquido tal como metanol, gasolina, diesel y similares como una alternativa al petróleo, que es representado por el numeral 28

Aguas abajo del limpiador de gas pobre 13 un segundo ciclón numerado con 29, se suministra como una cama abrillantadora, y aguas abajo del ciclón 29 un precalentador de aire 30 y un enfriador 31 se sitúan Mas allá del enfriador 31, una cámara de bolsa de cama de carbón /presurizada numerada con 32, se dispone El gas pobre de partida después de haber sido limpiado es dirigido como un gas pobre limpiado, a una estación tal como una central de potencia eléctrica, una planta de calentamiento, una fabrica de hornos industriales, etc , que es representada por el numeral 33

Haciendo referencia a la figura 2, el numeral 1º es el reactor para procesar el carbón y el numeral 11 es el gasificador para convertir el carbonizado en gas y las cenizas en escoria. El reactor 10 posee un extremo de carga numerado con 34 y un extremo de descarga numerado con 35. Extendiéndose mas allá de el extremo de descarga 35 un compartimento de craqueo de gas numerado con 21, se ha suministrado, este esta equipado con un bajante numerado con 37 que sirve para interconectar el reactor 10 con el gasificador 11. Un extremo del compartimento de craqueo 21 esta abierto y se conecta con el extremo de descarga 35 del reactor 10 por medio de una conexión de reborde 38, y el otro extremo del compartimento 21 esta cerrado y sirve como pared de radiación, marcada con el número 39, a través de la cuál penetración de la lanza 40 toma lugar. La lanza 40 que puede avanzar o retraerse sirve para la inyección del oxidante tal como aire u oxígeno, y posiblemente vapor, cuando se produce el gas rico relativamente puro se inyecta oxígeno. La lanza 40 puede también estar equipada para inyectar una combinación de combustible y oxígeno para incrementar la entrada de energía en el compartimento 21. Para elevar el contenido de H_2 del gas algún vapor puede ser agregado al oxígeno, esto se hace cuando se esta

haciendo síntesis de gas para la producción de combustibles líquidos. Una pluralidad de lanzas tales como la lanza 40, pueden ser usadas para un reactor de diámetro grande y al hacer esto, un múltiple de salida numerado con 41 suministra con una puerta de entrada 42 para el oxígeno y una puerta de salida 43 para el vapor como vía de ejemplo en los puntos de penetración en la pared 39 por lanzas 40 se muestran en la figura 3. Una puerta de salida o de escape numerado con 44 esta provista para el compartimento de craqueo 21 para que salga el gas rico craqueado, el cual se comunica con la tubería de gas 45, una válvula de presión numerado con 46, esta dispuesta en la tubería 45 para controlar la presión inversa en el compartimento de craqueo 21. A continuación del tubo 45 (no mostrado, pero indicado por la flecha direccional) se amarra al limpiador de gas rico 12 mostrado en la figura 1.

El gasificador que esta conectado a través de la bajante 37 al compartimento 21, es un recipiente tipo eje hecho de una concha de presión 47, un refuerzo 48, una tapa 49 y un fondo 50. Las penetraciones a través de la concha 47 y el refuerzo 48 están provistas para acomodar puertas de entrada 22 para la introducción de un oxidante, preferiblemente en la forma de aire

precalentado para la conversión del carbonizado caliente en gas pobre de partida y las cenizas en el carbonizado en escoria fundida vitrosa. Oxígeno relativamente puro y vapor pueden remplazar el aire si el contenido de carbón del carbonizado caliente va a ser convertido a una síntesis de gas. Los medios de control de flujo, marcados con el numeral 51 están provistos para el control del aire en el gasificador 11. El aire puede ser introducido en los niveles diferentes del gasificador 11. El fondo 50 del gasificador 11 está configurado de tal manera que se inclina preferiblemente hacia la puerta de salida 23 que está equipada con lanzas de punción 52 y 53 que están adaptadas para usar un gas tal como oxígeno para mantener el pasaje horizontal 54 y el pasaje vertical 55 de la puerta de salida 23 abiertos para asegurar el flujo libre del gas y de la escoria fundida fuera del gasificador 11.

El separador 24 localizado por debajo de la puerta de salida 23 es un recipiente de presión dividido en dos partes - una parte superior numerado con 56 una parte inferior numerado con 57. La parte superior comprende una zona de desenganche 58 que está equipada con una boquilla de descarga de escoria 59 y una puerta de salida de gas 60. La parte inferior 57 comprende la

pliscina de calmado de la escoria 61 que esta suministrada con agua, y la tolva de descarga 62 La válvula de aislamiento 63 conecta la tolva de descarga 62 con la compuerta 25 que esta equipada en el fondo con la válvula 64 para poder remover la escoria calmada del proceso sin la perdida de la presión del sistema por medio de mantener la válvula 63 cerrada y la válvula 64 abierta durante la descarga de la escoria calmada en el sumidero 85

La puerta de salida gas 60 se comunica con el ciclón 26 por el cabezal 65 el cuál dirige el gas separado al ciclón 26 El ciclón 26 esta equipado en el fondo con la tolva de descarga 66 la cuál a su vez esta conectada con la compuerta 67, las válvulas de aislamiento 68 y 69 permiten a la compuerta 67 descargar el material particulada en la caja de recolección 70 que esta abierta ala atmósfera, sin perdida de la presión del sistema El ciclón 26 esta equipado con una puerta de salida de gas principal 71 para dirigir el gas pobre para su tratamiento adicional La válvula de control de presión 72 sirve par controlar la presión inversa en el gasificador 11 A continuación del principal de gas 71 (no mostrado pero indicado por la flecha direccional) se amarra al limpiador de gas pobre 13 mostrado en la figura 1

Con referencia a la figura 4 y soportado por la figura 5 para detalles adicionales el reactor 10 es similar al reactor 10 mostrado en la figura 2 con ciertas modificaciones. El reactor 10 en la figura 4 posee el quemador 20 dirigido hacia la puerta de entrada 73 por medio del ducto 74 para el flujo de los gases de flujo calientes a un elemento de calefacción denotado por el numeral 75, el cual calienta parcialmente el carbón indirectamente y circunferencialmente por conducción con los gases del humero fluyendo por las chimeneas 76 (mostradas en la figura 5) y salen de la puerta de salida 77. Un material de aislamiento marcado con el numeral 78 está dispuesto entre el elemento de calefacción 75 y la concha de presión 79, la masa de carbón dentro del reactor 10 está mostrada con el numeral 80. Ambos reactores mostrados en las figuras 2 y 4 están provistos con una inclinación para divergir del extremo de carga 34 al extremo de descarga 35 para facilitar el movimiento del carbón dentro del reactor 10 a medida que es forzado en la alimentación por medio del ariete 81 actuando por el cargador de carbón 18 (mostrado en la figura 1).

Haciendo referencia nuevamente a la figura 4, debajo del gasificador 11, un receptor marcado con el numeral 36 se ha

provisto, el receptor 36 que esta mostrado de manera magnificada en la figura 6, comprende la concha 86, el refuerzo 87 y las puertas 88, 89 y 90. La parte inferior del receptor 36 esta suministrada con un crisol que se marca con el numeral 91, el crisol 91 esta adaptado para ser calentado de modo que tal como con una bobina de inducción 92. Un esnorkel marcado con 93 se extiende hacia abajo desde la puerta 88 hacia dentro del receptor 36 para dirigir el gas y la escoria fundida dentro del receptor 36 de una manera sumergida y de tal manera como para tener burbujas de gas en la escoria fundida y hacerla fluir del receptor 36 por la puerta 89. La puerta 90 esta provista para que la escoria fundida fluya hacia fuera del receptor 36 cuando el nivel de la escoria fundida alcanza el nivel de derrame marcado por el numeral 102, como se muestra más claramente en la figura 6. El receptor 36 esta provisto con una descarga de fondo 108 cuando las condiciones surgen en al cuales se necesita vaciar los contenidos del receptor 36. Aguas debajo de la puerta de salida de la puerta de salida de gas 89, un principal de gas 101 se ha suministrada para conectar el receptor 36 con el limpiador de gas

Aguas debajo de la puerta 90 el recipiente de calmado de escoria 57 se ha provisto con un bajante 94 que conecta el receptor 36 con el recipiente de calmado 57. Medios de lanza 95 y 96 también se han suministrado para poder mantener la bajante 94 abierta para la inyección de un oxidante, esto asegura el flujo libre de la escoria fundida. El recipiente de calmado 57 posee tres puertas 97, 98 y 99, la puerta 97 es para la entrada de la escoria fundida desde la bajante 94, la puerta 98 es para la salida del vapor generado cuando la escoria fundida cae dentro del baño de agua marcado con el numeral 61 y la puerta 99 es para la descarga de la escoria calmada. Materia particulada del vapor es removida por cualquier método conocido como por ejemplo un ciclón 26, el cuál fue descrito anteriormente con referencia a la figura 2. Una válvula de control marcada con el numeral 100 esta provista para balancear la presión en la salida del ciclón 26. La válvula de control 100 asegura que el vapor generado del calmado no se devuelva hacia dentro del receptor 36 manteniendo la presión 36 más alta que la presión en el recipiente de calmado 57 para impedir la solidificación prematura de la escoria causada por el efecto de enfriamiento del vapor.

OPERACIÓN

En la descripción de la operación⁷ de la presente invención, como se estableció anteriormente, el carbón es esencialmente una mina de energía con los siguientes constituyentes - carbón, cenizas, azufre y materia volátil (gas). Para poder ser capaz de usar el carbón de una manera limpia, las impurezas que consisten de las cenizas, azufre, y las porciones causantes de cáncer en el gas deben ser removidas y convertidas en productos útiles. Las cenizas pueden ser vitrificadas para volverse en no lixiviadas, el azufre puede removerse como azufre elemental y los destilados causantes de cáncer tales como los alquitranes y aceites livianos que incluyen el benceno, deben ser destruidos por craqueo. Varias configuraciones serán descritas para poder responder a la necesidad a la cuál la invención esta dirigida. La configuración que se relaciona con la coproducción de gas de síntesis para la síntesis en combustibles líquidos para transporte o calefacción, o de gas de combustible para la generación de potencia eléctrica serán descritos en detalle y los otros serán descritos por referencia a la coproducción aunque apuntando las diferencias.

Las referencias se hace ahora a la Figura 1, dicha configuración se relaciona a la co-producción. El carbón es alimentado desde la carbonera 19 hacia el secador 14 y luego a la compuerta 16 por medio de la tolva de descarga 15. El carbón puede tener otros materiales con el tales como la biomasa y/o el desecho que va hacer procesado con el carbón. Una vez que la compuerta 16 esta llena, se sierra y el alimentador 17 controla el carbón desde la compuerta 16 hacia el extremo de carga 34. El cargador de carbón 18 fuerza la alimentación de carbón hacia el reactor 10 de tal manera que compacta el carbón y lo hace denso y esencialmente impermeable al flujo de gas en el extremo de descarga para forzar los gases de partida presurizados generados durante la combinación de una porción del carbón, para que fluyan concurrentes con el movimiento del carbón en el reactor 10 y hacia el extremo de descarga del reactor 10. Asumiendo que el quemador de partida 20 ha prendido el carbón en el extremo de descarga del reactor 10 y el proceso ya esta en un estado estable el carbón es avanzado en el reactor 10 mientras que se inyecta oxígeno (y posiblemente vapor) por medio de las lanzas 40 en el carbón preferiblemente desde el compartimento de craqueo 21 para desvolatilizar el carbón y producir un gas de partida rico mientras el ambiente se mantiene bajo condiciones

de reducción por medio de operarlo sub-estequiométricamente. La temperatura del compartimento 21 es mantenida por encima de la temperatura de craqueo del alquitrán de carbón, aceites, hidrocarburos, etc para craquear estos compuestos causantes de cáncer lo que resulta en un gas de craqueo rico en hidrógeno que es dirigido por medio del conducto 104 a un limpiador de gas 12 para su tratamiento adicional tal como la desulfurización y por lo tanto producir un gas de síntesis ideal de $2H_2$ y $1CO$ en el evento de que no haya suficiente combustible en el compartimento 21 por virtud de usar carbón de baja volatilidad, el combustible complementario puede ser agregado con el oxígeno para poder lograr las temperaturas de craqueo. El compartimento de craqueo 21 que sirve para separar el gas rico del carbonizado caliente es también usado para el pretratamiento del gas rico de partida por craqueo de los líquidos que causan cáncer y de los hidrocarburos del carbón por medio de la temperatura elevada en el compartimento de craqueo 21 a través de la inyección de suficiente oxidante por las puertas 103 (mostrada en la Figura 2) de la lanza 40 y hacer combustiones algunas de las materias volátiles del carbón para producir un gas de craqueo que esta ausente del líquidos de carbón e hidrocarburos y cuya composición es principalmente H_2 y CO con H_2 siendo el gas dominante. Dentro

del compartimento 21, la zona radiante 107 suministra una transferencia de energía térmica eficiente al carbón que emerge del extremo de descarga 35. El carbón/carbonizado es empujado hacia fuera de la cámara 80 progresivamente en un modo pulsante para poder suministrar una cara fresca nueva de carbón/carbonizado que es calentada frontalmente por la radiación del compartimento 21. Dependiendo del carbón usado es posible obtener un gas craqueado de $2H_2$ y $1CO$ del proceso sin la necesidad de un convertidor de cambios que es conocido en la técnica. Si las materias volátiles son inadecuadas están contenidas en el carbón, se agrega vapor para poder incrementar el contenido de H_2 del gas. Subsecuentemente a la limpieza del gas de síntesis así producido, se incluye proporciones esenciales de $2H_2$ a $1CO$ este gas cuando es enfriado en el intercambiador de calor 27 y dirigido a la planta 28 por medio del ducto 105 es ideal para sintetizarlo en líquido. La planta 28 puede ser una Fischer Tropsch o una planta de metanol que a su vez puede estar seguida por un tren de metanol a gasolina, tal como aquel desarrollado por la Mobil Oil. Estos procesos para la conversión del gas de síntesis en varios líquidos son conocidos en la técnica y no son parte de esta invención. Ya que el mayor costo de fabricación de una alternativa al combustible líquido de petróleo a partir del gas

de síntesis es el costo de producir el gas de síntesis, el craqueo de la materia volátil del carbón como se describió aquí, es una enseñanza elegante y económica para hacer un material de partida para las plantas de síntesis

El carbonizado caliente es algo poroso y altamente reactivo resultante de la desvolatilización del carbón, y cae en el gasificador 11 y es gasificado con aire el cual puede estar precalentado. El aire es inyectado preferiblemente dentro del gasificador 11 en el modo de caída hacia abajo lo cual tiende a equilibrar la temperatura del carbonizado, el aire puede ser inyectado en diversos puntos como se muestra en las Figuras 2 y 4. El aire reacciona con el carbón en el carbonizado para hacer un gas de producción el cual también es conocido como "gas pobre" por virtud de su bajo contenido en Btu. Este gas pobre es alimentado en un limpiador de gas caliente 13 por medio del ducto 106 para la remoción del azufre, en el evento de que el gas pobre no este a la temperatura para el limpiador de gas caliente se agrega un oxidante como se mencionó por el numeral 9 antes de éntralo en el recipiente de limpieza 13. Después de salir del limpiador 13, el gas pobre es dirigido al ciclón 29 para la remoción del participado y de ahí al precalentado de aire 30. El gas pobre

después de salir del precalentado 30 , es dirigido al intercambiador de calor 31 para elevar el vapor que es usado en el proceso para la generación de H_2 , a temperaturas moderadas, para el seguimiento del vapor, etc El gas pobre es entonces introducido en un filtro/caja de bolsa 32 para el control de mercurio y álcalis y de ahí el gas es dirigidos a la estación 33 que puede representar una planta de generación de potencia eléctrica Este gas pobre es un excelente combustible para uso en una turbina de combustión por virtud de su masa para generar potencia eléctrica mas eficientemente y por virtud de su baja formación de NO_x cuando es quemado, ya que este quema suavemente La turbina de combustión puede estar seguida por una turbina de vapor para suministrar una disposición de ciclo combinada, de una manera eficiente para producir electricidad, que es una practica común

Adicionalmente al gas pobre hecho en el gasificador, la ceniza en el carbón es convertida en una escoria fundida, y tanto el gas pobre como la escoria fundida son descargados desde el gasificador 11 por medio de la puerta de salida 23 hacia el separador 24 en donde el gas es dirigido al ciclón 26 y la escoria después de haber sido calmada es alimentada en la tolva 25 para

la descarga en la atmósfera sin pérdida de la presión del sistema
La escoria así producida es vítreo e inerte la cual pasa el ensayo de
no-lixiviación

El azufre tanto en el gas rico de partida como el gas combustible de partida deja el proceso en la forma de H_2S el cual es removido por cualquiera de los sistemas conocidos incluyendo el sistema propio del solicitante descrito en la patente que se menciono al principio El H_2S es absorbido por una solvante contenido en los limpiadores 12 y 13 mostrador en la Figura 1 El absorbente que un producto reciclado y regenerado en el recipiente 7, extrae el azufre en forma elemental como un vapor y es condensado en un condensador el cual se marca con el numeral 8 El gas desviado del condensador 8 que es usado para reciclar el absorbente es empujado en compresión al compresor 109 Una corriente lateral del recipiente de limpieza 12, es desviada por medio del alimentador de válvula 110 para la regeneración en el regenerador 7 El alimentador de válvula 111 recicla el absorbente para el recipiente de limpieza 13 Un ciclón arriba del generador 7, marcado con el numeral 112 remueva la materia particulada del gas desviado reciclado

Al utilizar esta invención para la fabricación exclusiva de gas de síntesis, el aire en el gasificador 11 es sustituido por oxígeno y vapor para hacerlo reaccionar con el carbonizado y así producir gas rico en H_2 adicional el cual después de limpieza puede ser sintetizado en productos líquidos y/o químicos al igual que el gas rico en H_2 derivado del gas de craqueo después de que este es sometido a una reacción de cambio la cual es conocida en la técnica de la gasificación

Al utilizar esta invención para la fabricación exclusiva de gas combustible, el oxígeno inyectado a través del reactor de craqueo es diluido con aire para producir un gas pobre el cual después de limpieza puede ser usado como un gas combustible igual que el producido del gasificador 11 cuando se sopla con aire. El gas combustible puede ser usado como un combustible para diversas aplicaciones de calentamiento incluyendo la generación de potencia eléctrica

Este también es el propósito de esta invención de repotenciar las plantas de potencias existentes para poder darles una nueva facilidad de sobrevivir en más del 50% de la potencia

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eléctrica que todavía es producida por calderas de carbón pulverizado contaminantes en los estados unidos

Otra aplicación de la invención es procesar el carbón en el reactor 10 para hacer Coque o carbonizado y no gasificarlo, tal coque es utilizable en el campo de la metalurgia El carbonizado aunque esta incandescente es tratado con vapor para convertirlo en carbón activado para la utilización en sistemas de filtro Incluyendo la remoción de mercurio

Se ha mencionado que la presentación hecha aquí describe un método el cual puede procesar carbón para producir abundante energía limpia de manera muy eficiente y en un ambiente totalmente cerrado para calentamiento, transporte, potencia eléctrica, químicos y similares, como una alternativa al petróleo y al gas natural, incluyendo la capacidad para fabricar coque y carbón activado

REIVINDICACIONES.

1 Un método para producir energía limpia a partir de carbón comprende

Alimentar carbón a una cámara la cual esta sellada a la atmósfera y que posee un extremo de carga y un extremo de descarga,

Mover el carbón dentro de dicha cámara hacia el extremo de descarga,

Injectar oxígeno el cual es esencialmente puro de tal manera que se quema una porción del carbón aunque se mantiene una atmósfera presurizada de reducción a

- (i) Causar la liberación de niveles altos de energía térmicas para desvolatilizar el carbón, y
- (ii) producir un gas de partida rico en hidrógeno presurizado que contiene destilados derivados del carbón causantes de cáncer e

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hidrocarburos junto con un carbonizado caliente,

craquear los destilados derivados del carbón causantes de cáncer y lo hidrocarburos contenidos en el gas de partida rico en hidrógeno para fabricar un gas craqueado rico en hidrógeno que después de la desulfurización se convierte en un gas de síntesis rico en hidrógeno limpio,

dirigir el carbonizado caliente a un gasificador el cual esta sellado a la atmósfera,

gasificar el carbonizado caliente con aire en dicho gasificador para producir un segundo gas combustible de partida y una escoria fundida,

Hacer fluir el segundo gas combustible de partida junto con la escoria fundida por una puerta común hacia fuera de dicho gasificador para mantener dicha puerta abierta para el libre flujo del segundo gas combustible de partida y de la escoria fundida,

Separa el segundo gas combustible de partida de la escoria fundida después de salir de dicha puerta común,

Dirigir el segundo gas de partida a un sistema de limpieza para limpiarlo y así producir un segundo gas combustible limpio adecuado para la combustión con la formación baja de NO_x , y

Calmar la escoria fundida para convertirla en un sólido no-lixiviado

- 2 El método de acuerdo con la reivindicación 1 que comprende adicionalmente el sintetizar dicho gas de síntesis rico en hidrógeno limpio en un combustible líquido o un químico
- 3 El método según la reivindicación 1 que comprende adicionalmente utilizar dicho gas combustible limpio para la generación de potencia eléctrica

- 4 El método según la reivindicación 1 en donde la etapa de gasificar el carbonizado caliente con aire en dicho gasificador para producir un gas combustible de partida esta caracterizado adicionalmente por la etapa de sustituir el aire con oxígeno esencialmente puro y vapor para poder hacer un gas de partida rico en hidrógeno en lugar de un gas combustible a partir del carbonizado, que después de ser limpiado, un gas de síntesis limpio es obtenido el cual puede ser sintetizado en un combustible liquido para el calentamiento o el transporte
- 5 El método según la reivindicación 1 en donde la etapa de inyectar oxígeno que es esencialmente puro de tal manera que se quema una porción del carbón esta caracterizado adicionalmente por la etapa de sustituir el aire por oxígeno puro para poder hacer un gas combustible de partida que después de limpieza, un gas de combustible limpio es obtenido el cual puede ser utilizado para calentamiento o generación de potencia eléctrica

- 6 El método de acuerdo con la reivindicación 1 que incluye el uso de aire precalentado
- 7 El método según la reivindicación 1 que incluye el uso de aire enriquecido con oxígeno
- 8 El método según la reivindicación 1 en donde la etapa de gasificar el carbonizado caliente con aire en dicho gasificador comprende la inyección de aire en el modo de caída hacia abajo
- 9 El método según se establece en la reivindicación 8 que comprende adicionalmente la inyección de aire en una pluralidad de penetraciones dentro de dicho gasificador
- 10 El método según la reivindicación 1 que incluye la etapa de compactar el carbón contra la pared de la cámara en el extremo de carga a tal grado como para densificar el carbón y hacerlo esencialmente impermeable al flujo de gas en el extremo de carga para poder forzar los gases de partida presurizados

generados durante el calentamiento del carbón para que fluyan hacia el extremo de descarga de dicha cámara

- 11 El método establecido en la reivindicación 1 en donde la etapa de hacer fluir el gas combustible de partida junto con la escoria fundida por una puerta común de dicho gasificador incluye la etapa de suministrar una energía térmica suplementaria para impedir la solidificación de la escoria fundida en dicha puerta
- 12 El método establecido en la reivindicación 11 que incluye la etapa de suministrar medios para inyección de oxígeno para quemar una porción de dicho gas combustible de partida para crear dicha energía térmica suplementaria
- 13 El método establecido en la reivindicación 11 en donde dicha energía térmica suplementaria es derivada de medios de inducción eléctrica

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- 14 El método establecido en la reivindicación 1 en donde la etapa de hacer fluir el gas combustible de partida junto con la escoria fundida por una puerta común hacia fuera del gasificador incluye la recolección de la escoria fundida en un receptor que servir como baño de fusión
- 15 El método establecido en la reivindicación 14 que incluye la etapa de dirigir el gas combustible de partida junto con la escoria fundida al receptor de una manera sumergida para causar que el gas combustible de partida burbujee dentro del baño fundido para poder separar la escoria del gas combustible de partida y esencialmente retirar el gas combustible haciendo uso de la bolsa fundida en dicho receptor
- 16 El método establecido en la reivindicación 14 que incluye la etapa de suministrar una puerta de salida de gas por encima del baño para la descarga del gas combustible separado

- 17 El método establecido en la reivindicación 14 que incluye la etapa de suministrar un vertedero para que la escoria fundida fluya fuera de dicho receptor
- 18 El método establecido en la reivindicación 17 que incluye la etapa de suministrar aguas debajo de dicho vertedero una cámara de calmado con agua para enfriar la escoria fundida y volverla un sólido no-lixiviado
- 19 El método según la reivindicación 1 en donde el método es conducido bajo presión
- 20 El método de acuerdo con la reivindicación 1 en donde la etapa de inyectar oxígeno que es esencialmente puro de tal manera que se quema una porción del carbón esta caracterizada adicionalmente por la etapa de inyectar el oxígeno desde un comportamiento localizado aguas abajo del extremo de descarga de dicha cámara

- 21 El método de acuerdo con la reivindicación 20 que comprende adicionalmente una zona radiante caliente dispuesta en dicho compartimento para reflejar energía térmica intensa contra el carbón en el extremo de descarga de dicha cámara para agilizar la desvolatilización del carbón y los destilados del carbón de craqueo e hidrocarburos que son causantes de cáncer
- 22 El método establecido en la reivindicación 1 en que incluye pasar los gases calientes por chimeneas dispuestas en la pared de dicha cámara
- 23 El método establecido en la reivindicación 1 en donde la etapa de mover el carbón dentro de la cámara hacia el extremo de descarga esta caracterizado adicionalmente por hacer mover el carbón progresivamente con pausas para poder crear caras frontales nuevas sucesivas de carbón en el extremo de descarga de dicha cámara para la exposición eficiente del carbón al calor radiante

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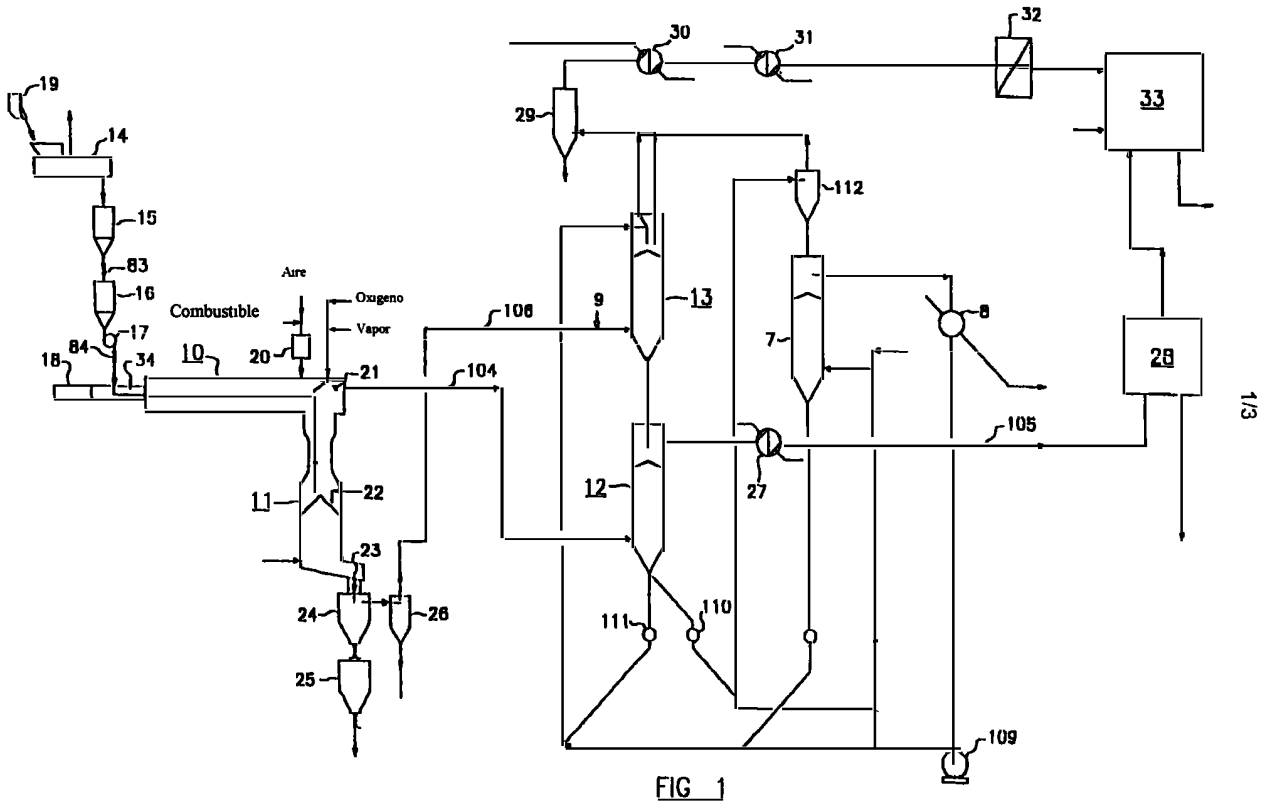
- 24 El método según se establecido en la reivindicación 1 caracterizado adicionalmente por balancear la presión entre la etapa de inyección de oxígeno para quemar una porción del carbón y la etapa de gasificar el carbonizado con aire de modo que se impide esencialmente la contaminación del gas rico en hidrógeno por el gas combustible
- 25 El método según la reivindicación 14 que incluye la etapa de calentar el receptor
- 26 El método según la reivindicación 25 en donde el calentamiento del receptor se deriva de medios de inducción eléctricos
- 27 El método establecido en la reivindicación 1 que comprende adicionalmente la inyección de oxígeno el cual es esencialmente puro de tal manera que se quema una porción del carbón en una pluralidad de puntos de modo que se quema más eficientemente el carbón mientras se mantiene una atmósfera de reducción

- 28 El método según la reivindicación 1 en donde el oxidante es agregado para elevar la temperatura del gas craqueado rico en hidrógeno antes de su desulfurización
- 29 El método según la reivindicación 1 en donde un oxidante es agregado para elevar la temperatura del gas combustible antes de su desulfurización
- 30 El método según la reivindicación 28 que incluye la desulfurización en un sistema de limpieza que es degenerativo
- 31 El método según la reivindicación 29 que incluye la desulfurización en un sistema de limpieza que es degenerativo
- 32 El método según la reivindicación 1 que incluye adicionalmente la inclinación de la cámara del reactor de tal manera que se dirige hacia el extremo de

descarga para facilitar el movimiento del carbón dentro de dicha cámara

- 33 El método según la reivindicación 1 que incluye el paso de los gases en chimeneas suministradas a la cámara de dicho reactor
- 34 El método según la reivindicación 1 que incluye la adición de biomasa al carbón para procesarlos en unidad
- 35 El método establecido en la reivindicación 1 que incluye la adición de desechos al carbón para procesarlos en unidad
- 36 El método de acuerdo con la reivindicación 1 en donde la etapa de gasificar el carbonizado caliente se elimina para limitar la conversión del carbón en coque o carbonizado

- 37 El método de acuerdo con la reivindicación 36 en donde el coque o el carbonizado son convertidos en carbón activado
- 38 El método establecido en la reivindicación 1 caracterizado adicionalmente por balancear las expresiones entre la etapa de inyectar oxígeno y la etapa de gasificar el carbonizado, y la etapa de gasificar el carbonizado y calmar de la escoria fundida para poder controlar los diversos flujos de los gases en el proceso



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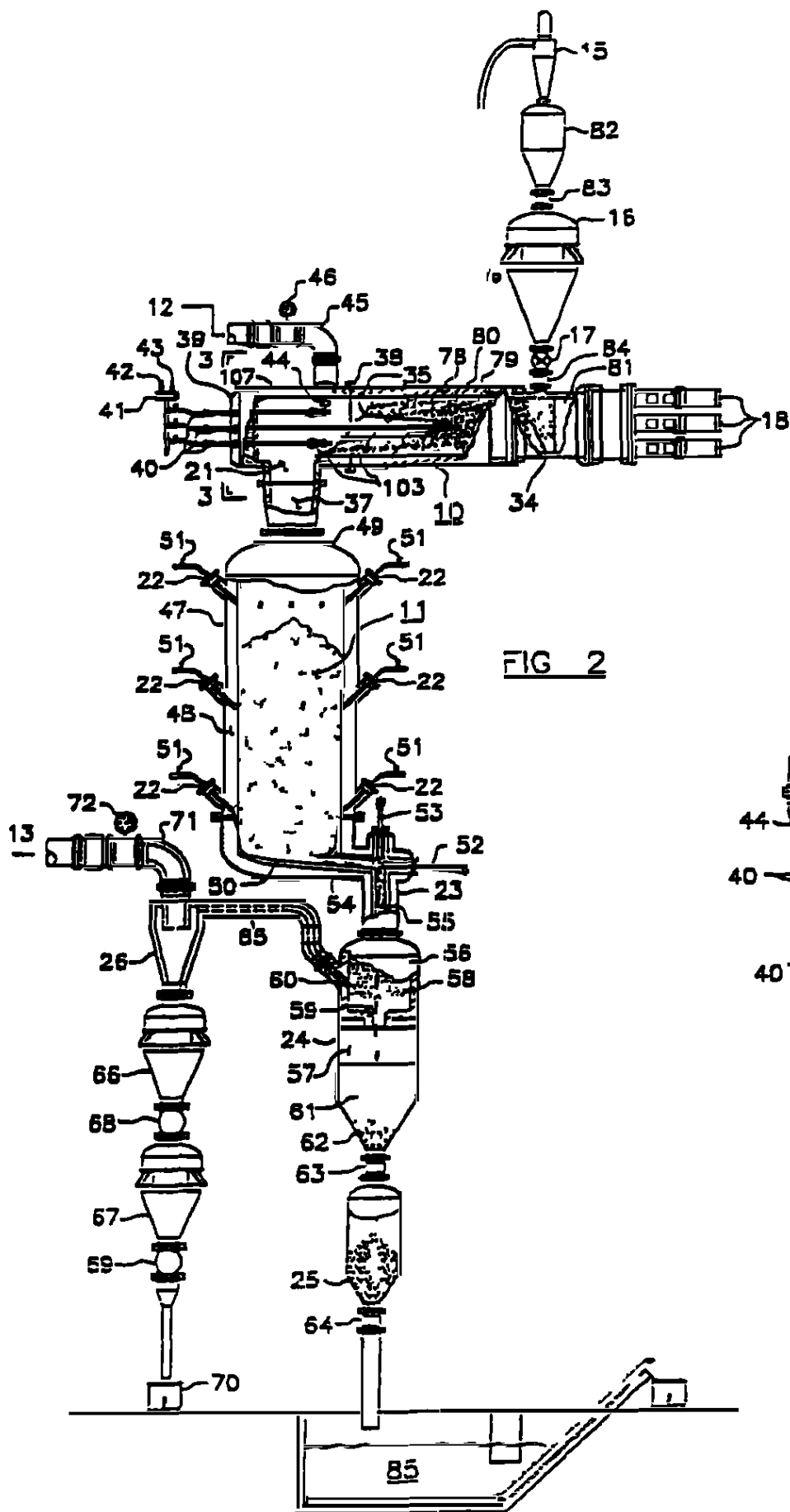


FIG 2

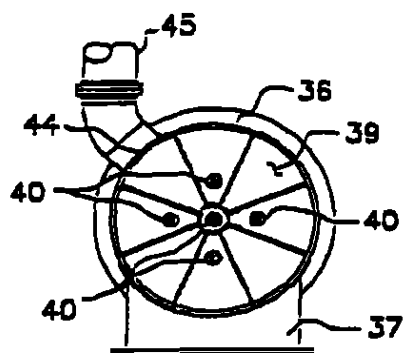


FIG 3

3/3

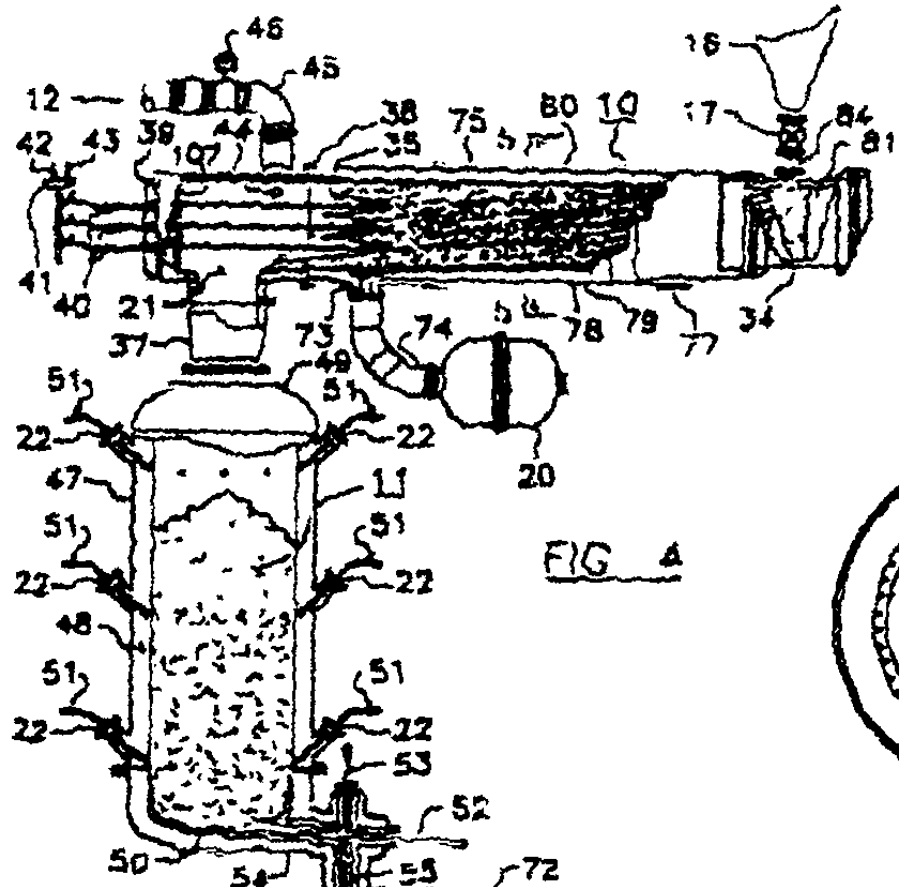


FIG 4

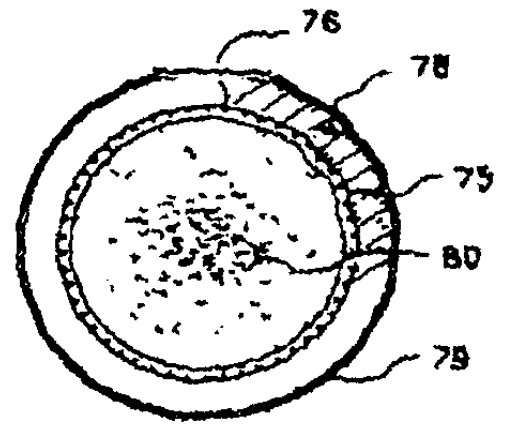


FIG 5

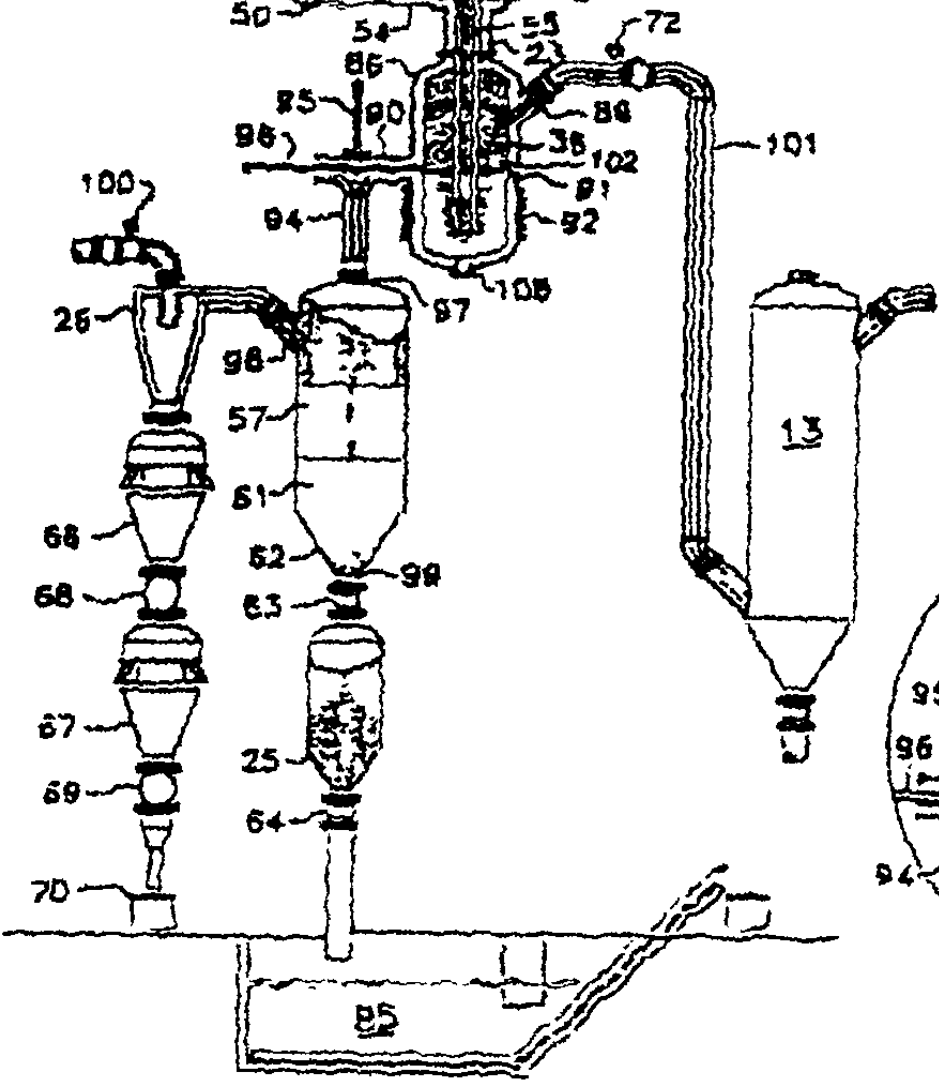


FIG 6

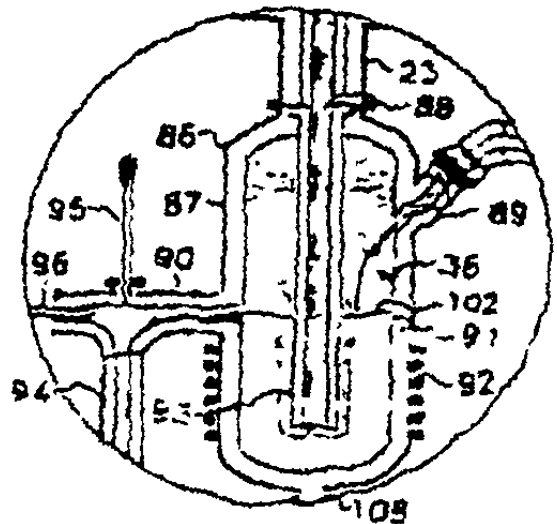


FIG 7

REIVINDICACIONES DE LA FASE NACIONAL.

Reivindicación 1. Un método para producir energía limpia a partir de carbón comprende

Alimentar el carbón en una cámara que esta sellada a la atmósfera y la cual posee un extremo de carga y un extremo de descarga,

Mover el carbón dentro de dicha cámara hacia la puerta de descarga,

Inyectar oxígeno el cual es esencialmente puro de tal manera que se quema una porción del carbón mientras se mantiene una atmósfera presurizada de reducción para

- (i) Causar la liberación de la energía térmica para desvolatilizar el carbón, y
- (ii) producir un gas de partida rico en hidrógeno presurizado que contiene destilados e hidrocarburos derivados del carbón

causantes de cáncer junto con un carbonizado caliente,

craquear los destilados e hidrocarburos derivados del carbón causantes de cáncer contenidos en el gas de partida rico en hidrógeno para hacer un gas craqueado rico en hidrógeno que después de la desulfurización se convierte en un gas de síntesis rico en hidrógeno limpio,

Dirigir el carbonizado caliente a un gasificador el cual esta sellado a la atmósfera,

Gasificar el carbonizado caliente con un oxidante en dicho gasificador para producir un segundo gas de partida y una escoria fundida,

Hacer fluir el segundo gas de partida junto con la escoria fundida por una puerta común hacia fuera del gasificador para mantener dicha puerta abierta para el libre flujo del segundo gas de partida y de la escoria fundida,

Separar el segundo gas de partida de la escoria fundida después de salir de dicha puerta común,

Dirigir el segundo gas de partida a un sistema de limpieza para limpiarlo y así producir un segundo gas limpio, y

calmar la escoria fundida para convertirla en un sólido no-lixiviado

Reivindicación 2 El método de acuerdo con la reivindicación 1 que comprende adicionalmente sintetizar dicho gas de síntesis rico en hidrógeno limpio en combustible o químico líquido

Reivindicación 3. El método según la reivindicación 1 que comprende adicionalmente utilizar dicho gas combustible limpio para la generación de potencia eléctrica

Reivindicación 4 El método establecido en la reivindicación 1 en donde el carbonizado caliente es

gasificado con oxígeno esencialmente puro y vapor para poder hacer un gas de partida rico en hidrógeno a partir del carbonizado el cual, después de la limpieza, se produce un gas de síntesis limpio que puede ser sintetizado en combustible líquido o gaseoso rico en hidrógeno

Reivindicación 5. El método según se establece en la reivindicación 1 en donde la etapa de inyectar oxígeno que es esencialmente puro de tal manera que se quema una porción del carbón esta caracterizada adicionalmente por la etapa de sustituir el aire por oxígeno puro para hacer un gas combustible de partida que después de limpiado, se obtiene un gas combustible limpio el cual puede ser utilizado para calentamiento o generación de potencia eléctrica

Reivindicación 6 El método de acuerdo con la reivindicación 1 que incluye el uso de aire precalentado

Reivindicación 7. El método de acuerdo con la reivindicación 1 que incluye el uso de aire enriquecido con oxígeno

Reivindicación 8. El método establecido en la reivindicación 1 en donde la etapa de gasificar el carbonizado caliente con aire en dicho gasificador comprende la inyección de aire en el modo de descarga hacia abajo

Reivindicación 9. El método establecido en la reivindicación 8 que comprende adicionalmente la inyección de aire en una pluralidad de penetraciones dentro de dicho gasificador

Reivindicación 10. El método establecido la reivindicación 1 que incluye la etapa de compactar el carbón contra la pared de la cámara en el extremo de carga a tal grado que se densifica el carbón para esencialmente hacerlo impermeable al flujo de gas en el extremo de carga para poder forzar los gases de partida presurizados generados durante el calentamiento del carbón para que fluyan hacia la puerta de descarga de dicha cámara

Reivindicación 11. El método establecido en la reivindicación 1 en donde la etapa de hacer fluir el gas

combustible de partida junto con la escoria fundida por una puerta común de dicho gasificador incluye la etapa de suministrar una energía térmica suplementaria para impedir la solidificación de la escoria fundida en dicha puerta

Reivindicación 12. El método de acuerdo con la reivindicación 11 que incluye la etapa de suministrar medios para inyección de oxidante para quemar una porción de dicho gas combustible de partida para crear dicha energía térmica suplementaria

Reivindicación 13. El método establecido en la reivindicación 11 en donde dicha energía térmica suplementaria es derivada de medios de Inducción eléctrica

Reivindicación 14. El método establecido en la reivindicación 1 en donde la etapa de hacer fluir el gas combustible de partida junto con la escoria fundida por una puerta común hacia fuera del gasificador incluye la recolección de la escoria fundida en un receptor que servir como baño fundido

Reivindicación 15 El método establecido en la reivindicación 14 que incluye la etapa de dirigir el gas combustible de partida junto con la escoria fundida al receptor de una manera sumergida para causar que el gas combustible de partida burbujee a través de dicho baño fundido para poder separar la escoria portada del gas combustible de partida y esencialmente limpiar el gas combustible haciendo uso de la escoria fundida en dicho receptor

Reivindicación 16 El método según se establece en la reivindicación 14 que incluye la etapa de suministrar una puerta de salida de gas por encima del baño para la descarga del gas combustible limpiado

Reivindicación 17. El método establecido en la reivindicación 14 que incluye la etapa de suministrar un vertedero para que la escoria fundida fluya hacia fuera de dicho receptor

Reivindicación 18. El método establecido en la reivindicación 17 que incluye la etapa de suministrar aguas

abajo de dicho vertedero una cámara de calmado con agua para enfriar la escoria fundida y volverla un sólido no-lixiviado

Reivindicación 19. El método establecido en la reivindicación 1 en donde el método es conducido bajo presión

Reivindicación 20. El método de establecido en la reivindicación 1 en donde la etapa de inyectar oxígeno que es esencialmente puro de tal manera que se quema una porción del carbón esta caracterizada adicionalmente por la etapa de inyectar el oxígeno desde un comportamiento localizado aguas abajo del extremo de descarga de dicha cámara

Reivindicación 21. El método establecido en la reivindicación 20 que comprende adicionalmente una zona radiante caliente dispuesta en dicho compartimento para reflejar energía térmica intensa contra el carbón en el extremo de descarga de dicha cámara para agilizar la

desvolatilización del carbón y los destilados del carbón de craqueo e hidrocarburos que son causantes de cáncer

Reivindicación 22. El método establecido en la reivindicación 1 en que incluye pasar los gases calientes por chimeneas dispuestas en la pared de dicha cámara

Reivindicación 23 El método según la reivindicación 1 en donde la etapa de mover el carbón dentro de la cámara hacia el extremo de descarga esta caracterizado adicionalmente por hacer mover el carbón progresivamente con pausas para poder crear caras frontales nuevas sucesivas de carbón en el extremo de descarga de dicha cámara para la exposición eficiente del carbón al calor radiante

Reivindicación 24 El método establecido en la reivindicación 1 caracterizado adicionalmente por balancear la presión entre la etapa de inyección de oxígeno para quemar una porción del carbón y la etapa de gasificar el carbonizado con aire de modo que se impide esencialmente la contaminación del gas rico en hidrógeno por el gas combustible

Reivindicación 25 El método de acuerdo con la reivindicación 14 que incluye la etapa de calentar el receptor

Reivindicación 26. El método de acuerdo con la reivindicación 25 en donde el calentar del receptor se deriva de medios de inducción eléctricas

Reivindicación 27. El método según la reivindicación 1 que comprende adicionalmente inyectar el oxígeno que es esencialmente puro de tal manera que se quema una porción del carbón en una pluralidad de puntos para quemar mas eficientemente el carbón mientras se mantiene una atmósfera de reducción

Reivindicación 28. El método según la reivindicación 1 en donde un oxidante es agregado para elevar la temperatura del gas craqueado rico en hidrógeno antes de su desulfurización

Reivindicación 29 El método establecido en la reivindicación 1 en donde un oxidante es agregado para elevar la temperatura del gas combustible antes de su desulfurización

Reivindicación 30. El método establecido en la reivindicación 28 que incluye la desulfurización en un sistema de limpieza que es degenerativo

Reivindicación 31 El método según se establece la reivindicación 29 que incluye la desulfurización en un sistema de limpieza que es degenerativo

Reivindicación 32. El método establecido en la reivindicación 1 que incluye adicionalmente la inclinación de la cámara del reactor de tal manera que se dirige hacia el extremo de descarga para facilitar el movimiento del carbón dentro de la cámara

Reivindicación 33 El método establecido en la reivindicación 1 que incluye pasar de los gases por chimeneas suministradas a la cámara de dicho reactor

Reivindicación 34. El método según se establece la reivindicación 1 que incluye la adición de biomasa al carbón para procesarlos en unidad

Reivindicación 35. El método según se establece la reivindicación 1 que incluye la adición de desechos al carbón para procesarlos en unidad

Reivindicación 36. El método establecido en la reivindicación 1 en donde la etapa de gasificar el carbonizado caliente es eliminada para limitar la conversión del carbón en coque o carbonizado

Reivindicación 37 El método de según la reivindicación 36 en donde el coque o el carbonizado son convertidos en carbón activado

Reivindicación 38 El método de acuerdo con la reivindicación 1 caracterizado adicionalmente por balancear las expresiones entre la etapa de inyectar oxígeno y la etapa de gasificar el carbonizado, y la etapa de gasificar el

carbonizado, y el calmado de la escoria fundida para poder controlar los diversos flujos de los gases en el proceso

Reivindicación 39. El método según la reivindicación 1 en donde el carbonizado caliente es gasificado con aire para producir un gas combustible de partida que después de la limpieza produce un gas combustible limpio adecuado para la combustión con baja formación de NO_x

Reivindicación 40 Un método para producir energía limpia a partir de carbón que comprende

Alimentar carbón a una cámara la cual esta sellada a la atmósfera y la cual que posee un extremo de carga y un extremo de descarga,

Mover el carbón dentro de dicha cámara hacia el extremo de descarga,

inyectar oxígeno de tal manera que se quema una porción del carbón aunque se mantiene una atmósfera de reducción presurizada para

- (i) Causar la liberación de energía térmica para desvolatilizar el carbón, y
- (ii) Producir un gas de partida rico en hidrógeno presurizado que contiene destilados e hidrocarburos derivados del carbón causantes de cáncer junto con un carbonizado caliente,

Dirigir el gas de partida rico en hidrógeno presurizado de tal manera que emerge del extremo de descarga de dicha cámara,

Craquear los destilados e hidrocarburos derivados del carbón causantes de cáncer contenidos en el gas de partida rico en hidrógeno para hacer un primer gas de craqueo rico hidrógeno,

Dirigir el carbonizado caliente a un gasificador de separación el cual esta sellado a la atmósfera y gasificar ahí para producir un segundo gas y una escoria fundida,

Remover dicha escoria del sistema, y

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Limpiar dicho primer gas y dicho segundo gas para producir gases limpios para aplicaciones útiles

Reivindicación 41 El método establecido en la reivindicación 40 que comprende adicionalmente la inyección de vapor con dicho oxígeno

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To
DONALD A. SCHURR
MARSHALL & MELORN LLC
FOUR SEAGATE 8TH FLOOR
TOLEDO OH 43604

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference 53 15755	Date of Mailing (day/month/year) 12 SEP 2002
International application No PCT/US02/21099	International filing date (day/month/year) 08 July 2002 (08.07.2002)
Applicant CALDERON ENERGY COMPANY OF BOWLING GREEN INC	

1 ☒ The applicant is hereby notified that the international search report has been established and is transmitted herewith
 Filing of amendments and statement under Article 19
 The applicant is entitled if he so wishes to amend the claims of the international application (see Rule 46)
 When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report
 Where? Directly to the International Bureau of WIPO 34 chemin des Colombettes
 1211 Geneva 20 Switzerland Facsimile No (41 22) 740 14 35
 For more detailed instructions see the notes on the accompanying sheet

2 ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith

3 ☐ With regard to the protest against payment of (an) additional fee(s) under Rule 40.2 the applicant is notified that
☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices
☐ no decision has been made yet on the protest the applicant will be notified as soon as a decision is made

4 Reminders
 Shortly after 18 months from the priority date the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication a notice of withdrawal of the international application or of the priority claim must reach the International Bureau as provided in Rules 90 bis 1 and 90 bis 3 respectively before the completion of the technical preparations for international publication
 Within 19 months from the priority date but only in respect of some designated Offices a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later) otherwise the applicant must within 20 months from the priority date perform the prescribed acts for entry into the national phase before those designated Offices
 In respect of other designated Offices the time limit of 30 months (or later) will apply even if no demand is filed within 19 months
 See the Annex to Form PCT/IB/301 and for details about the applicable time limits Office by Office see the *PCT Applicant's Guide* Volume II National Chapters and the WIPO Internet site

Name and mailing address of the ISA/US Commissioner for Patents Box PCT Washington D.C. 20231 Facsimile No (703)305-3230	Authorized officer Basia Ridley <i>Basia Ridley</i> Telephone No (703) 308-0661
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Form PCT/ISA/220 (April 2002)

(See notes on accompanying sheet)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 53 15755	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as where applicable item 5 below
International application No PCT/US02/21099	International filing date (day/month/year) 08 July 2002 (08 07 2002)	(Earliest) Priority Date (day/month/year) 09 July 2001 (09 07 2001)
Applicant CALDERON ENERGY COMPANY OF BOWLING GREEN INC		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the Report

a. With regard to the language the international search was carried out on the basis of the international application in the language in which it was filed unless otherwise indicated under this item:

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any nucleotide and/or amino acid sequence disclosed in the international application the international search was carried out on the basis of the sequence listing:

☐ contained in the international application in written form

☐ filed together with the international application in computer readable form

☐ furnished subsequently to this Authority in written form

☐ furnished subsequently to this Authority in computer readable form

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ Certain claims were found unsearchable (See Box I)

3. ☐ Unity of invention is lacking (See Box II)

4. With regard to the title:

☒ the text is approved as submitted by the applicant

☐ the text has been established by this Authority to read as follows:

5. With regard to the abstract:

☐ the text is approved as submitted by the applicant

☒ the text has been established according to Rule 38.2(b) by this Authority as it appears in Box III. The applicant may within one month from the date of mailing of this international search report submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is Figure No. 2:

☐ as suggested by the applicant ☐ None of the figures

☒ because the applicant failed to suggest a figure

☐ because this figure better characterizes the invention

Form PCT/ISA/210 (first sheet) (July 1998)

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US02/21099

Box III TEXT OF THE ABSTRACT (Continuation of Item 5 of the first sheet)

The technical features mentioned in the abstract do not include a reference sign between parentheses (PCT Rule 8 1(d))

The abstract is too long (PCT Rule 8 1(b)) The abstract must be less than 150 words or 200 words when no figure is to be published

NEW ABSTRACT

A method for producing clean energy from coal by feeding the coal into a reactor (10) which is sealed to atmosphere and moving the coal in the reactor (10) while injecting oxygen (40) to combust a portion of the coal to yield a pressurized hydrogen rich gas and hot char. Said hydrogen rich gas is cracked in cracking compartment (21) to remove distillates and hydrocarbons and desulfurized to produce synthesis gas. The hot char is gasified in an air blown gasifier (11) to produce a fuel gas and a molten slag which are jointly directed out of the gasifier through a common port (23). The fuel gas and the molten slag are separated in a separator (24). After separation the fuel gas is desulfurized to produce gas which will produce very low NOx emission while combusted.

INTERNATIONAL SEARCH REPORT

International application No

PCT/US02/21099

A CLASSIFICATION OF SUBJECT MATTERIPC(7) C10J 3/08
US CL 48/210

According to International Patent Classification (IPC) or to both national classification and IPC

B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U S 48/210 101 107 119 202 203 422/232 236 60/39 01 39 12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and where practicable search terms used)

C DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document with indication, where appropriate of the relevant passages	Relevant to claim No
Y	US 4 261 167 A (PAULL et al) 14 April 1981 (14 04 1981) Fig 1	1 38
Y	US 4 852 996 A (KNOP et al) 1 August 1989 (01 08 1989) column 1	1 38
Y	US 5 063 732 A (CALDERON) 12 November 1991 (12 11 1991) Fig 4	1 38
Y	US 5 469 699 A (DAMAN) 28 November 1995 (28 11 1995) columns 2-4	1 38

☐ Further documents are listed in the continuation of Box C☐ See patent family annex

Special categories of cited documents	
A document defining the general state of the art which is not considered to be of particular relevance	T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
E earlier application or patent published on or after the international filing date	X document of particular relevance the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	Y document of particular relevance the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents such combination being obvious to a person skilled in the art
O document referring to an oral disclosure use exhibition or other means	
P document published prior to the international filing date but later than the priority date claimed	& document member of the same patent family

Date of the actual completion of the international search

23 August 2002 (23 08 2002)

Date of mailing of the international search report

12 SEP 2002

Name and mailing address of the ISA/US

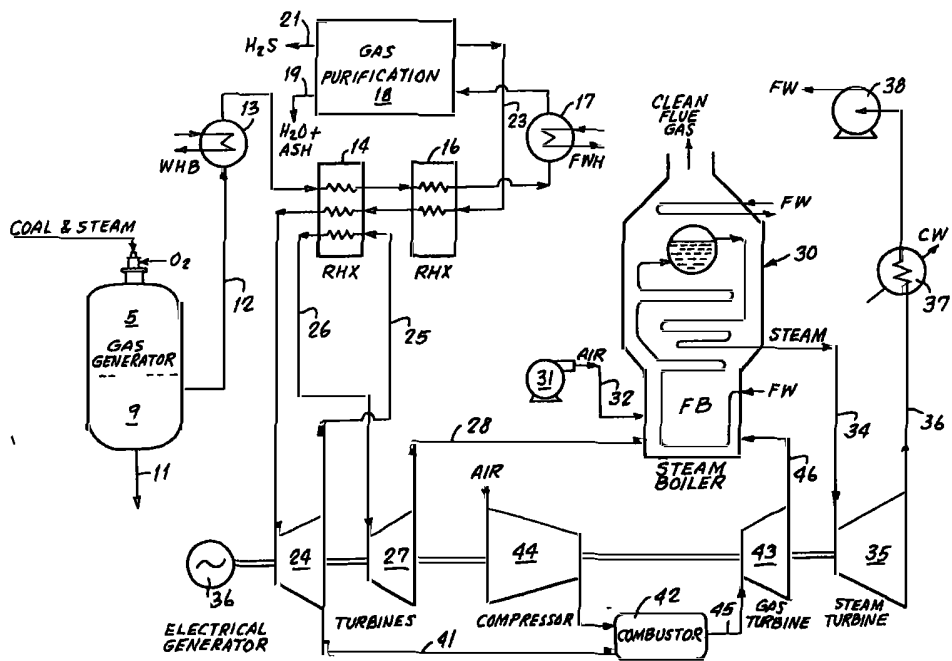
Commissioner of Patents and Trademarks
Box PCT
Washington D C 20231

Facsimile No (703)305 3230

Authorized officer

Basia Ridley

Telephone No (703) 308-0661



US Patent

Apr 14, 1981

4,261,167

PROCESS FOR THE GENERATION OF POWER FROM SOLID CARBONACEOUS FUELS

This invention relates to a method for the operation of gas fired heaters and power plants with a non gaseous carbonaceous fuel such as coal or heavy fuel oil as fuel for the plant with minimal conversion problems and minimal atmospheric pollution. The process provides a means for the economical conversion of existing facilities, for example industrial boilers heaters furnaces and power plants from gas to coal or heavy fuel oil. By the process of this invention the capacity of a given boiler or gas-fired steam generation facility may be increased without any substantial modification of the boiler.

The shortage of petroleum products in various parts of the world including the United States of America has resulted in governmental regulations to conserve the dwindling supply of natural gas which often require conversion of existing gas-fired heaters and boilers to other forms of fossil fuels. At the same time, environmental regulations in many places restrict the relative amounts of sulfur compounds and oxides of nitrogen which may be discharged into the atmosphere. A number of industrial heater and boilers, including those owned and operated by large public utilities in their electrical generation plants were designed for the combustion of gaseous fuels such as natural gas are not readily adaptable to direct conversion to other fuels. Basic design factors used in the design and construction of gas fired heaters and boilers mitigate against their use as oil fired or coal fired boilers and heaters.

It has been proposed heretofore to convert coal and other solid carbonaceous fuels to fuel gases of various qualities ranging from low heating value fuel gas to gases of high calorific value which may be substituted for natural gas. In a co-pending patent application Ser. No. 976 950 filed Feb. 13, 1978 and having a common assignee with this patent application, there is disclosed a process for the generation of power from solid carbonaceous fuel with minimal atmospheric pollution wherein the fuel is subjected to a series of partial oxidation steps followed by complete combustion with the recovery of power from the gaseous products following each of the oxidation stages. The process provides also for the removal of sulfur-containing gases from the fuel gas produced by the partial oxidation of solid fuel so that waste gases from the process are substantially free from sulfur compounds.

The process of this invention provides a method of producing power efficiently from various solid fuels, including low grade high-sulfur content fuels using existing boilers heaters, and steam generation facilities designed for gaseous fuels while at the same time minimizing air pollution problems.

By the process of this invention for example, it is possible to convert gas fired steam boiler power plants to plants utilizing coal as fuel with no loss of power producing capacity or steam generation ability and in fact it is possible to increase the power output from any given boiler installation utilizing the process of this invention. In the process of this invention carbonaceous fuel is subjected to partial oxidation with relatively pure oxygen at a pressure in the range of 35 to 170 bars (500 to 2500 psi) preferably 70 to 105 bars (1000 to 1500 psi) at a temperature in the range of 980 to 1650 C (1800 to 3000 F) effecting conversion of the carbonaceous fuel to a high pressure gaseous fuel stream comprising carbon monoxide hydrogen and methane and having a higher heating value in the range of 5 to 11 MJ/m³ (150 to 300 Btu s/ft³). The partial oxidation of solid carbonaceous fuels to gases containing carbon monoxide hydrogen and methane is fairly well known and is described for example in U.S. Pat. No. 3 544 291 to W. G. Schlinger et al which disclosure is incorporated herein by reference.

The drawing is a schematic representation of a preferred embodiment of the process of this invention. With reference to the drawing a gasifier or gas generator of the type described in the above mentioned U.S. Pat. No. 3 544 291 is designated by reference numeral 5. Carbonaceous fuel which may comprise pulverized coal coke or solvent refined coal residue or a heavy petroleum residuum is supplied to a gas generator through supply line 6. Oxygen containing gas, preferably commercially pure oxygen containing 98% or more free oxygen is supplied into admixture with the fuel to the gas generator through supply line 7. Steam or water is supplied in admixture with the fuel through supply line 8. The feedstreams to the reaction zone preferably comprise oxygen at a temperature in the range of ambient to 150 C (300 F) carbonaceous fuel at a temperature in the range of 300 to 400 C (572 to 752 F) and steam supplied to the gas generator at generator pressure and at a temperature in the range of 260 to 650 C (500 to 1200 F). The reaction is carried out in the high pressure partial oxidation reactor 5 at a pressure in the range of 35 to 170 bar (500 to 2500 psi) at an autogenous temperature in the range of 980 to 1650 C (1800 to 3000 F) with substantially complete consumption of the combustible portions of the solid fuel to oxides of carbon to produce a high pressure fuel gas comprising carbon monoxide hydrogen and methane together with smaller amounts of carbon dioxide, nitrogen and gaseous sulfur-containing compounds principally hydrogen sulfide and carbonyl sulfide.

The high pressure raw fuel gas product stream discharged from the gas generator 4 is passed to a slag trap 9 or sump to permit molten slag and large solid particles to separate from the gas stream. The slag or other solids may be discharged from the slag trap through line 11. Hot gases containing fly ash and soot are passed through line 12 successively to a waste heat boiler 13 for the generation of steam and then to regenerative heat exchangers 14 and 16 and a feed water heater 17 wherein the gases are cooled. The cooled gases are supplied to a purification system 18 for the removal of fly ash soot, and sulfur compounds from the fuel gas stream as well as water and part of the carbon dioxide contained in the raw fuel gas to produce a clean fuel gas. Water ash, and unconsumed carbon or soot removed from the fuel gas in the gas purification system are discharged through line 19. Hydrogen sulfide, together with more or less carbon dioxide separated from the fuel gas stream is withdrawn through line 21 for disposal as by chemical processing for example, conversion to elemental sulfur sulfuric acid or ammonium sulfate.

The removal of acid gases from the fuel gas stream in the purification system 18 may be effected by any of the standard gas purification processes, for example, by scrubbing the gas stream with molten alkali salts or with an aqueous solution of hot potassium carbonate or with an aqueous solution of an amine such as ethanolamine.

The removal of acid gases from the fuel gas stream in the purification system 18 may be effected by any of the standard gas purification processes, for example, by scrubbing the gas stream with molten alkali salts or with an aqueous solution of hot potassium carbonate or with an aqueous solution of an amine such as ethanolamine.

The removal of acid gases from the fuel gas stream in the purification system 18 may be effected by any of the standard gas purification processes, for example, by scrubbing the gas stream with molten alkali salts or with an aqueous solution of hot potassium carbonate or with an aqueous solution of an amine such as ethanolamine.

The clean fuel gas so produced having a higher heating value in the range of 9 to 13 MJ/m³ (250 to 350 Btu/ft³) is passed through line 23 serially through regenerative heat exchangers 16 and 14 to a first pressure let-down turbine 24 where the pressure is reduced by expansion of the gases through the turbine with the generation of power and simultaneous cooling of the gas stream.

The gas stream discharged from the first turbine 24, suitably at a pressure in the range of 7 to 10 bar (100 to 150 psig) is passed through line 25 to regenerative heat exchanger 14 where it is reheated and then passed through line 26 to a second pressure let-down turbine 27. In the second gas turbine 27 the fuel gas stream is expanded with the production of power and simultaneous cooling of the gas stream, to a pressure in the range of atmospheric to near-atmospheric pressure 1.02 to 1.4 bar (15 to 20 psia). The resulting low pressure fuel gas is supplied to the firebox (FB) of a steam boiler 30 designed for firing with gas. Air for complete combustion of the fuel is supplied to the firebox of the boiler by blower 31 through line 32 into admixture with the fuel.

The steam boiler illustrated diagrammatically represents a relatively standard design commercial utility power plant boiler having a vaporizing section in the lower part of the boiler, a steam superheater above the vaporizing section and economizer sections in the upper portion of the boiler including a feed water (FW) heating section and a second steam generating section above the steam super heater section. The boiler, per se, forms no part of the present invention and may be of standard design. Steam from the boiler is discharged through line 34 conventional steam turbine 35 for the generation of power. Power in the form of electrical energy is generated in generator 36 of conventional design. As illustrated, all of the turbines are connected with and supply power to a single generator 36. It will be evident that any number of turbines and generators may be employed separately or in combination.

Exhaust steam from the steam turbine 35 is discharged through line 36 to a condenser 37 supplied with cooling water and if desired a water leg condenser. Condensate is pumped by pump 38 to the feed water system and may be recirculated to the boiler after heating in feed water heater 17, the feed water (FW) heater section of boiler 30 or both.

In an alternate preferred embodiment of the process of this invention, a portion of the clean fuel gas after expansion in the first let down turbine 24 is passed through line 41 to burner 42 of a combustion gas turbine 43 wherein it is completely burned with a large excess of air supplied to the combustor section 42 of the turbine from an air compressor 44 preferably driven by the combustion gas turbine. The exhaust gas from combustion gas turbine 43 contains unreacted oxygen in a preheated condition which when supplied to the boiler in admixture with fuel from line 28 serves as a source of preheated oxygen containing gas for combustion of fuel in the boiler. It will be understood that combustor 42 of the combustion gas turbine may be arranged in a conventional manner for example as in aircraft jet engines to bypass a portion of the air from air compressor 44 to exhaust line 45. In this way any desired amount of air may be passed through combustion gas turbine 43 and line 46 to the boiler. In one embodiment of this invention, illustrated in one of the following examples, all of the air required for combustion is supplied to the steam boiler from compressor 44 so that blower 31 is not

needed. It should be understood that either blower 31 or air compressor 44 may be used to supply all of the air required for the boiler or that both may be used simultaneously with part of the air supplied by blower 31 and part supplied by compressor 44.

EXAMPLE 1

An Itsudan 1 coal analyzing 0.87 weight percent nitrogen 1.78 percent sulfur 64.32 percent carbon 4.92 percent hydrogen 14.97 percent oxygen and 13.14 percent ash and having a lower heating value of 26.77 MJ/Kg (11,510 Btu/lb) is charged at the rate of 41,116 Kg/hr (90,645 lb/hr) to a flow type gas generator or gasifier of the type disclosed in U.S. Pat. No. 3,544,291.

In the gas generator coal is subjected to a disperse phase, non-catalytic partial oxidation reaction with oxygen of 98 volume percent purity supplied to the reactor at the rate of 27,205 Kg/hr (59,976 lb/hr) and steam supplied to the reactor with the coal at the rate of 27,686 Kg/hr (61,038 lb/hr). The oxygen is supplied to the gas generator at 38° C. (100° F) while the coal and steam in admixture with one another are supplied to the gas generator at 300° C. (575° F). The reaction is carried out in a high pressure reaction zone of gas generator 5 at a pressure of 83.8 bar (1215 psia) and at an autogenous temperature of 1200° C. (2200° F) in a fly ash mode, producing a raw fuel gas of the following composition:

Raw Fuel Gas	
Component	Volume %
Carbon monoxide	33.81
Carbon dioxide	9.52
Steam	24.02
Hydrogen sulfide	0.48
Carbonyl sulfide	0.02
Hydrogen	29.27
Nitrogen	0.24
Argon	0.04
Methane	0.60

The raw fuel gas leaving the generator at 1200° C. and 83.8 bar is cooled to 93° C. (200° F) and passed to the gas purification system 18 at the rate of 87,532 Kg/hr (192,929 lb/hr). The gas stream from the generator carries with it ash and unconsumed carbon amounting to 2098 Kg/hr (4626 lb/hr) of ash and 1486 Kg/hr (3275 lb/hr) of unconverted carbon.

The purification system removes approximately 98 percent of the sulfur-containing compounds, all of the particulate ash and soot carried over from the generator and substantially all of the water as well as approximately 20 percent of the carbon dioxide from the fuel gas stream. The purified fuel gas is discharged from the gas purification system 18 through line 23 at a pressure of 82.1 bar (1190 psia) and 38° C. (100° F) at the rate of 61,723 Kg/hr (136,075 lb/hr). The purified fuel gas has the following composition:

Purified Fuel Gas	
Component	Volume %
Carbon monoxide	47.19
Carbon dioxide	10.64
Water vapor	0.08
Hydrogen sulfide	0.01
Carbonyl sulfide	0.01
Hydrogen	40.85

-continued

Purified Fuel Gas	
Component	Volume %
Nitrogen	0.33
Argon	0.06
Methane	0.84

The purified gas stream from the gas purification zone is passed through line 23 and reversing heat exchangers 16 and 14 where it is heated to a temperature of 871 C (1600 F) and supplied at the rate of 61 723 kg/hr (136 075 lb/hr) to the inlet of a first gas turbine 24 where it is expanded to a pressure of 9.77 bar (141.7 psia) with the production of power and the simultaneous reduction of its temperature to 447 C (837 F).

In this example all of the exhaust gas from turbine 24 is passed through line 25 to regenerative heat exchanger 14 wherein it is reheated to 871 C (1600 F) and delivered to turbine 27 at a pressure of 9.48 bar (137.4 psia) wherein its pressure is further reduced to 1.14 bar (16.5 psia) with the production of power and simultaneous reduction of its temperature to 447 C (837 F). Exhaust gas from turbine 27 is passed at a rate of 61 723 kg/hr (136 075 lb/hr) through line 28 to the fire box of gas fired steam boiler 30 as fuel for the boiler. Air is supplied to the boiler from blower 31 through line 32 at a pressure of 1.14 bar (16.5 psia) at a temperature of 38 C (100 F) and at the rate of 214 140 Kg/hr (472 097 lb/hr). The clean fuel gas supplied to the boiler has a lower heating value of 10.09 MJ/m³ (270.75 Btu/ft³).

In this example 839 720 MJ/hr (795 943 × 10³ Btu/hr) of heat are recovered in the boilers and feed water heater for the production of steam. Of this amount 72 238 MJ/hr (68 472 × 10³ Btu/hr) are required to produce steam for the gas generator 5. The balance of the steam is converted to 306 990 MJ/hr (290 988 × 10³ Btu/hr) of power in the steam turbine 35. An additional 94 040 MJ/hr (89 138 × 10³ Btu/hr) of power are recovered from the pressure let down turbines 24 and 27 for a total system net power output of 401 030 MJ/hr (380 016 × 10³ Btu/hr).

In this example, the plant delivers 111.4 thousand kilowatts of electrical energy with an overall plant efficiency of 36.4 percent. Plant efficiency is defined as the amount of energy delivered by the plant in the form of electric power divided by the amount of heat energy supplied to the plant as fuel neglecting the energy requirements of the oxygen plant needed to supply pure oxygen to the system.

EXAMPLE 2

In a second specific example of a preferred embodiment of the present invention oxygen, coal and steam are reacted in the same proportions and under the same conditions of pressure, temperature and flow rates as in Example 1. In this specific embodiment, a portion of the clean fuel gas is withdrawn from the discharge of the first turbine 24 through line 41 at a rate of 12,918 Kg/hr (28 480 lb/hr) and at a pressure of 9.77 bar (141.7 psia) and a temperature of 447 C (837 F) and supplied to the burner 42 of a combustion gas turbine 43. Air is compressed by an air compressor 44 driven by the combustion gas turbine 43 and supplied to the burner 42 at a pressure of 10.78 bar (141.7 psia) and a temperature of 352 C (665 F) at a rate of 212,111 kg/hr (467 624

lb/hr). The combustion gas turbine generates power in excess of that required to drive the air compressor.

Exhaust gas from combustion gas turbine 43 has the following composition:

Component	Volume %
Carbon dioxide	5.16
Steam	3.74
Oxygen	15.95
Nitrogen	75.15

Exhaust gas from the combustion gas turbine 43 is passed through line 46 to the steam boiler 30 at the rate of 225 029 Kg/hr (496 104 lb/hr) at a pressure of 1.14 bar (16.5 psia) and a temperature of 532 C (989 F) for complete combustion of the fuel gas supplied to the boiler.

The remaining portion of the clean fuel gas discharged from the first turbine 24 is passed through line 25 at the rate of 48 804 Kg/hr (107 595 lb/hr) and at a pressure of 9.77 bar (141.7 psia) and a temperature of 447 C (837 F) to regenerative heat exchanger 14 wherein it is heated to a temperature of 871 C (1600 F) and passed through line 26 to the second turbine 27 wherein its pressure is reduced from 9.48 bar to 1.14 bar (137.4 psia to 16.5 psia) with the generation of power and simultaneous reduction in temperature of 447 C (837 F). The exhaust gas from turbine 27 is passed through line 28 to the firebox of the steam boiler 30 where it is completely burned with the oxygen-containing gas supplied to the boiler from combustion gas turbine 43 through line 46. In this example no air is supplied by blower 31.

In this example, the first gas turbine recovers 47 020 MJ/hr (44 569 × 10³ Btu/hr) and the second gas turbine recovers 37 179 MJ/hr (35 241 × 10³ Btu/hr) as power. An additional 51 056 MJ/hr (48 394 × 10³ Btu/hr) are recovered in the combustion gas turbine as power. In this instance, 797 950 MJ/hr (756 352 × 10³ Btu/hr) of heat are recovered in the boilers and feedwater heater for the production of steam. Of this amount 72 238 MJ/hr (68 472 × 10³ Btu/hr) are required for the steam supplied to the gas generator. The balance is converted to 290,285 MJ/hr (275 152 × 10³ Btu/hr) of power in the steam turbine. When added to the power recovered by the two let down gas turbines and the combustion gas turbine, a total system net power output of 425 540 MJ/hr (403 356 × 10³ Btu/hr) is obtained. The plant is capable of delivering 118.2 thousand kilowatts of electricity with an overall plant efficiency of 38.7 percent.

The process of the present invention provides an effective means for converting gas fired power plants to coal while retaining comparable overall plant efficiencies. Moreover, significant augmentation in overall plant capacity is achieved by the addition of the gas turbines and the various heat exchange units. In the first example, the power generation capacity is increased by 26.2 percent as compared with the same power plant operating with natural gas under equivalent boiler conditions. In the case of the second example the power generation capacity of the plant is increased by 43.3 percent by the process of this invention.

We claim:

1. A process for the generation of power from a carbonaceous fuel wherein said fuel is subjected to partial

oxidation with oxygen at a pressure above 500 psia and a temperature above 1800° F effecting conversion of said carbonaceous fuel to a fuel gas stream having a higher heating value in the range of 150 to 300 BTU/ft³ comprising carbon monoxide, hydrogen, and methane and containing ash and soot, which comprises cooling said gas stream and separating unconverted carbon and ash therefrom to produce a clean fuel gas stream reheating said clean fuel gas stream, expanding said reheated clean fuel gas stream in an engine to produce a first expanded fuel gas with the production of power reheating a portion of said first expanded fuel gas and expanding same in a second engine with the production of power subjecting the expanded fuel gas from said second engine to substantially complete combustion with air in a boiler for the generation of steam, and expanding the resulting steam in a steam turbine with the generation of power

2. A process according to claim 1 wherein said carbonaceous fuel contains sulfur and gaseous sulfur compounds are separated from said fuel gas stream in a gas purification step.

3. A process according to claim 1 wherein said carbonaceous fuel is coal

4. A process according to claim 1 wherein said carbonaceous fuel is a petroleum residuum.

5. A process according claim 1 wherein said carbonaceous fuel is a residue from solvent refined oil

6. A process for the generation of power from a carbonaceous fuel wherein said fuel is subjected to partial oxidation with oxygen at a pressure above 35 bars (500 psia) and a temperature in the range of 980 to 1650° C

(1800 to 300° F) effecting conversion of said carbonaceous fuel to a high pressure fuel gas stream comprising carbon monoxide, hydrogen and methane having a higher heating value in the range of 5 to 11 MJ/m³ (150 to 300 BTU/ft³) which comprises expanding said fuel gas stream in an engine to an intermediate pressure within the range of 2 to 14 bars (30 to 500 psia) effecting simultaneous cooling of said fuel gas stream and production of power subjecting a portion of said fuel gas at said pressure of 2 to 14 bars to substantially complete combustion with excess air producing a gas stream containing oxygen, nitrogen, and products of combustion, expanding said oxygen-containing gas in an engine to substantially atmospheric pressure with the production of power, expanding a second portion of said fuel gas from said pressure of 2 to 14 bars to substantially atmospheric pressure in an engine with the generation of power combining said expanded second portion of said fuel gas with said expanded oxygen-containing gas and subjecting said expanded fuel gas to substantially complete combustion with said oxygen-containing gas with the production of steam and expanding said steam in an engine with the production of power, said oxygen containing gas supplying the oxygen necessary for the combustion of said expanded fuel gas.

7. A process as defined in claim 6 wherein said intermediate pressure fuel gas is reheated by indirect heat exchange with said high pressure fuel gas prior to expansion to substantially atmospheric pressure in said engine.

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United States Patent [19]
Knop et al

[11] **Patent Number** 4,852,996
[45] **Date of Patent** Aug. 1, 1989

- [54] **PROCESS FOR GASIFYING COAL**
[75] **Inventors** Klaus Knop, Geldern, Gunter
Wolters, Dusseldorf Helmut Kubiak,
Herne, all of Fed. Rep. of Germany
[73] **Assignee** Man Gutehoffnungshuette GmbH,
Fed. Rep. of Germany
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48/210-60/39 04, 60/39 12 252/373 423/359
421/545
[58] **Field of Search** 48/197 R, 202 206
48/210, 204 99 60/39 02, 39 12, 39 04 122/7
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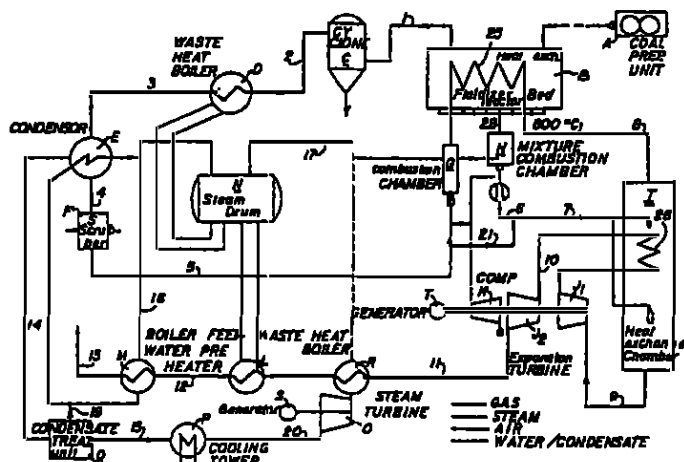
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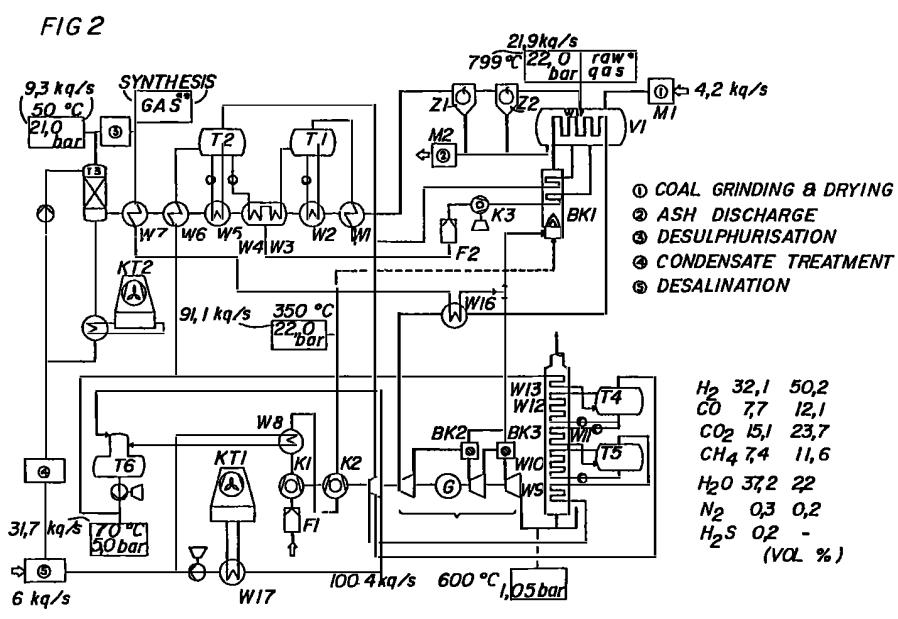
Primary Examiner—Joyce Woodard
Attorney, Agent, or Firm—McGlew & Tuttle

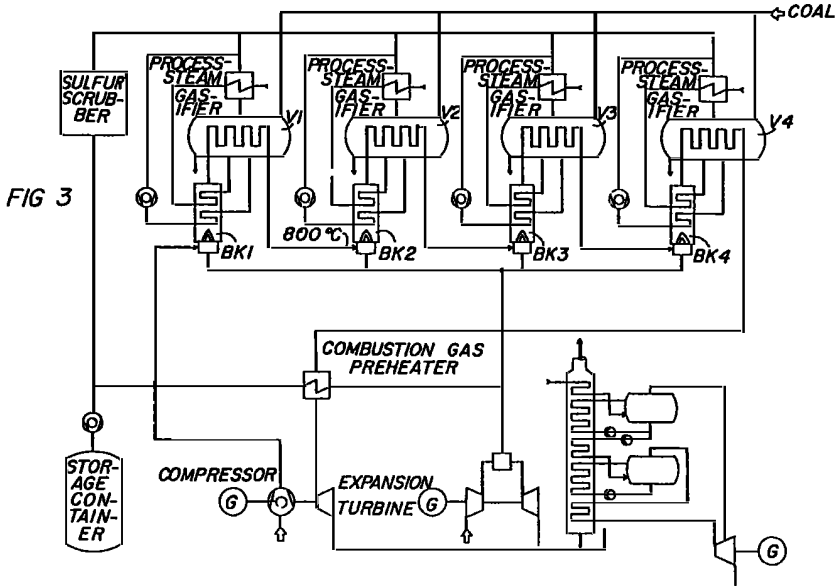
[57] **ABSTRACT**

Part of the synthesis gas produced by coal gasification in an allothermically heated fluidized bed reactor is burned after removal of dust and sulfur and serves as a source of energy to heat the reactor by indirect heat exchange and to produce the steam required for the gasification process. The flue gas exiting from the heat exchanger of the reactor can be used to perform work in expansion turbines. The rest of the synthesis gas is available for use in downstream processes such as iron ore reduction or can be burned and used to perform work in turbines to produce electric current. The result is a process that is environmentally safer and operates with a better yield than direct coal burning or autothermal coal gasification, but requires no outside source of energy such as nuclear power as prior art allothermal coal gasification processes do.

15 Claims 4 Drawing Sheets







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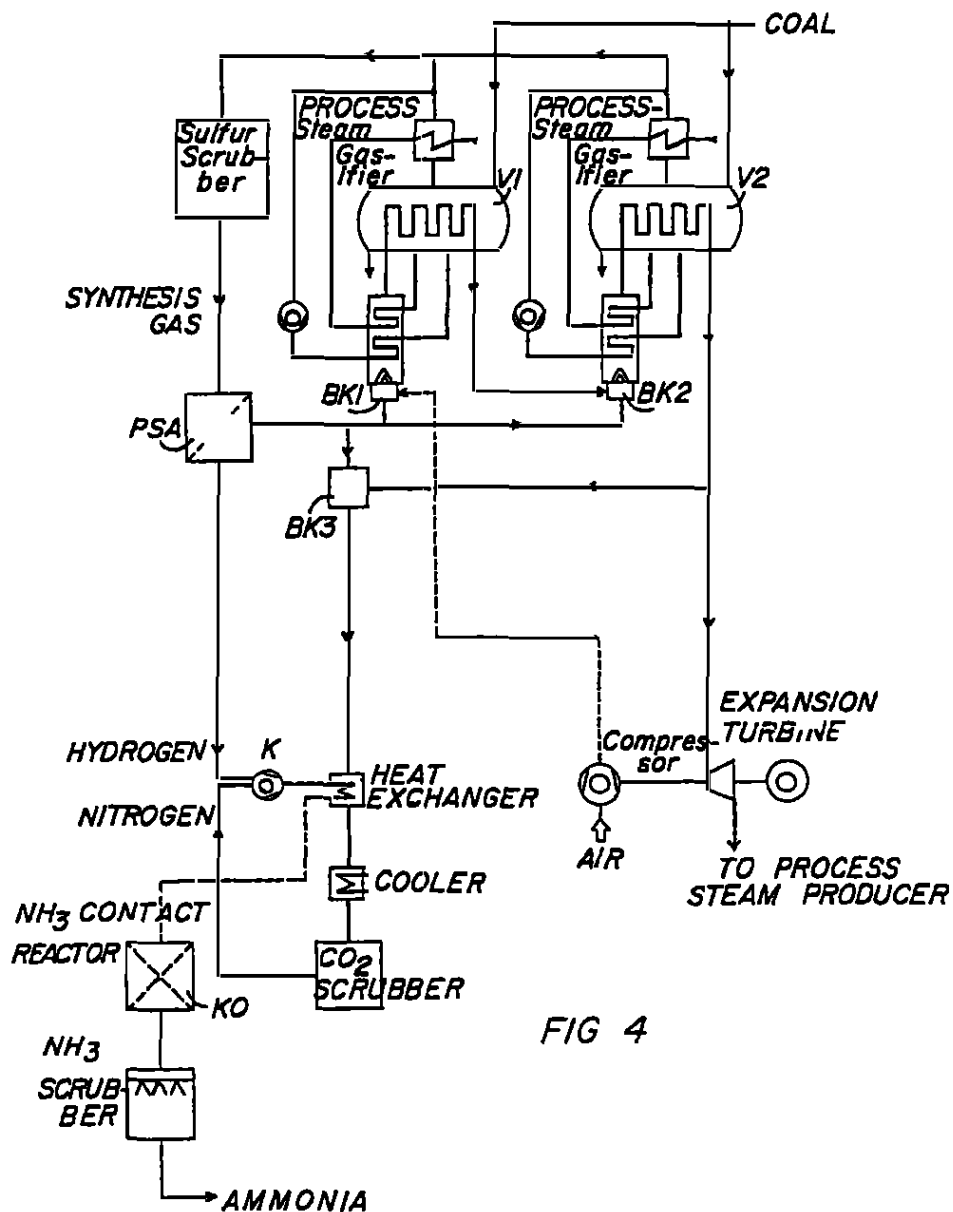


FIG 4

PROCESS FOR GASIFYING COAL

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates in general to the field of gasification for carbon-containing fuel, and in particular to a new and useful process and device for gasifying carbon-containing fuel in particular coal whereby a portion of the produced synthesis gas is burned to heat a fluidized bed reactor in which the fuel is gasified.

In coal gasification, a distinction is made between "autothermal" and "allothermal" processes. In autothermal gasification, the heat needed to sustain the gas-forming reactions is produced by combustion reactions that take place in the reactor itself. Not just coal and steam, but air and/or oxygen as well are fed into the reactor so that incomplete or sub-stoichiometric combustion of the coal occurs as synthesis gas is produced. In practice, this means that a considerable portion, typically about 30-40% of the coal is lost in the production of heat and only the remainder is converted into available product gas. Another disadvantage is that the available gas is loaded with combustion products and, unless pure oxygen is used for processing, the gas is also loaded with a large proportion of ballast material in the form of nitrogen, which diminishes its usefulness and means that the downstream purification and desulfurizing units must be built correspondingly larger in size. Finally the relatively high temperature produced in the reactor by the combustion reaction is also disadvantageous, because it makes it more difficult to maintain the fluidized bed and may favor the formation of nitrogen oxides (NO_x) harmful to the environment. Also known to the art are autothermal coal gasification processes wherein a portion of the gas produced is recycled to the reactor and again takes part in the reaction (e.g. German Pat. No. 32 23 702).

In allothermal gasification, heat is supplied from an outside source. Apart from the coal dust, essentially only steam is introduced into the reactor to act as a reaction medium and to sustain the fluidized bed while the reaction heat required for gasification is essentially provided by an exchange of heat by the reactor with a hot heat exchange medium fed in from the outside. In this process, the coal can be converted essentially completely into available gas, and the produced gas is largely free of combustion residues, nitrogen ballast, etc. Furthermore, the temperature in the reactor can be kept at a lower or optimal level for the gas forming reaction. The problem there, however is that to heat the heat exchange medium to be fed into the reactor an additional source of heat and hence a corresponding demand for primary energy is required. The allothermal process is most advantageous if a nuclear reactor is available to act as such an additional source of energy. In such case, a secondary helium cooling circuit heated by the primary helium cooling circuit of the nuclear reactor can serve both as a heat exchange medium for heating up the reactor and also for the production of the steam required in the reactor (see van Heek and Kirchhoff in "HdT Vortragsveröffentlichungen (Haus der Technik Lecture Publications) 453 1982, p. 59).

SUMMARY OF THE INVENTION

The present invention provides a process of the kind indicated that makes use of the advantages of allothermal gasification of the coal or fuel but requires no outside sources of heat, as well as a device with which to perform the process.

Accordingly an object of the present invention is to provide a process for gasifying a carbon containing fuel, in particular coal, with subsequent use of a product gas therefrom comprising supplying finely ground or atomized carbon-containing fuel to a fluidized bed reactor gasifying the fuel in the reactor by means of an essentially allothermal gasification reaction and by feeding in steam to the reactor heating the reactor by indirect heat exchange with a heat exchange medium with synthesis gas being produced in the reactor from the fuel removing dust and sulfur from the synthesis gas to form purified synthesis gas, burning at least a portion of the purified synthesis gas to form hot flue gas, and using the resulting hot flue as the heat exchange medium to heat the reactor.

A further object of the present invention is to provide a device for performing this process which includes a fluidized bed reactor with a heat exchanger therein feed means for feeding ground coal or other carbon containing fuel to the reactor purifying means for purifying gas produced by the reactor to remove dust and sulfur from the gas, steam producer means connected to the reactor for producing steam and for supplying steam to the reactor, and heating means for heating up a heat exchange medium to be fed to the heat exchanger the heating means comprising a combustion chamber for receiving the purified synthesis gas to burn the gas and form the heat exchange medium.

The process of the invention makes it possible to run an allothermal gasification reactor without the aid of an additional heat source, because the requisite heat is obtained by burning a portion of the available product gas. In this process to be sure, as is the case with the autothermal process only part of the coal is ultimately converted into available gas, but the other disadvantages described above of the autothermal process are avoided.

The process pursuant to the invention is particularly advantageous when the flue gas obtained by burning the product synthesis gas is used for power production, and is preferably used in one or more expansion gas turbines. In such case, the product of the process as a whole is not available product gas but electrical power and the system as a whole constitutes a power plant. Customarily in coal fired power plants the coal is burned and the flue gas used to run the gas turbines or produce steam is obtained directly from that. In comparison the process pursuant to the invention whereby the coal is first degasified and the gas is then burned would seem at first glance to involve unnecessary extra expense. The process pursuant to the invention, however does offer substantial advantages over direct coal burning. Since the synthesis gas produced by degasification is already purified and desulfurized, the flue gases deriving from the subsequent burning of the gas do not require further purification. Since the volume of the synthesis gas is substantially smaller than that of the flue gases, the expense involved in removing dust and sulfur is correspondingly less. While the direct coal burning flue gas with a high NO_x content is produced with coal gasification because of the substantially lower temperatures in

the gasification reactor the formation of nitrogen oxides is largely eliminated and even the subsequent burning of the synthesis gas can be controlled in such a way that nitrogen oxide formation is substantially lower than with coal burning.

The process pursuant to the invention thus proves to be particularly sound from an environmental standpoint. A power plant operating with such a process can thus be run in whole or in part even on fuels that contain heavy amounts of pollutants. In particular solid household or industrial refuse, waste oil or the like, if necessary with an appropriate admixture of coal, can be fed into the reactor. The pollutants contained in them remain for the most part in the solid slag removed from the reactor. To the extent that they are transferred to the product gas they are separated by gas purification before the burning step so that flue gas purification is no longer necessary. Such a power plant can therefore be built in or near residential areas, which is advantageous with respect to the power heat connection.

Accordingly a further object of the invention is to provide a process which efficiently gasifies carbon-containing fuel and a device for performing that process which is simple in design rugged in construction and economical to manufacture.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific object attained by its uses reference is made to the accompanying drawings and descriptive matter in which preferred embodiments of the invention are illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings

FIG. 1 is a flow chart of the process pursuant to the invention where the synthesis gas is used for power production,

FIG. 2 is a similar flow chart to that of FIG. 1, but for a different embodiment of the invention.

FIG. 3 is a flow chart of a different embodiment of the process with several gasification reactors connected in series, and

FIG. 4 is a flow chart for another embodiment of the process pursuant to the invention where the synthesis gas is used to produce ammonia.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings in particular the invention embodied therein comprises a process and device for the gasification of carbon-containing fuel, in particular coal.

Coal ground in a coal mill A is conveyed via an appropriate system of locks (with the aid of a propellant gas) to a fluidized bed reactor B. The coal is gasified allothermically in the reactor by means of a steam/flue gas mixture (primarily steam) produced in a combustion chamber H and conveyed to the reactor B via line 22. The required reaction heat is supplied by indirect heat exchange with flue gas, which flows through a heating coil or heat exchanger 25.

The synthesis gas leaving the reactor B via line 1 is freed of dust in a cyclone separator C and corresponding filter devices. Via line 2 the gas (at 800-900 °C.) enters a wasteheat boiler D and leaves it via line 3 in

order to be cooled in a condenser E to the point that it can enter a suitable sulfur scrubber F over a line 4.

The desulfurized gas leaving the sulfur scrubber F goes via line 5 to a combustion chamber G where it is burned super stoichiometrically to the point where the resulting flue gas is at a temperature of about 850-1000 °C. This flue gas enters the heat exchanger 25 of the reactor B.

In reactor B the amount of heat required for the gasification reaction is taken from the flue gas (a portion of the heat supply also comes from the steam/flue gas mixture from H). The flue gas leaving the reactor via line 8 at, for instance, 750-850 °C enters another heat exchanger chamber I where it serves to reheat the flue gas proceeding via line 10 from the first step J₁ to the second step J₂ of an expansion turbine. The flue gas leaving the heat exchanger chamber I via line 9 enters the first step J₁ of the expansion turbine at a pressure of for example 40 bar. The flue gas leaving the second step J₂ via line 11 at, for example, a final pressure of 1.2 bar and a temperature of 250 °C is first fed into a heat exchanger R to superheat the steam and then cooled in a waste-heat boiler L and fed to a boiler feed water preheater M after a line 12 and subsequently to a chimney via line 13.

The steam produced in the waste-heat boilers L and D is collected in a steam collecting drum N and superheated in R. The steam is then expanded through a steam turbine O which drives a generator S. The condensation heat of the expanded steam is conveyed to a cooling tower P over a line 20 and and via line 15 to a condensate treatment unit Q. As is the condensate from E via line 14. The treated condensate is then fed back into the process via line 19. The feed water conveyed via line 16 from the preheater M is used for steam production.

A portion of the steam leaving the steam collecting drum N is conveyed via line 17 to the combustion chamber H, where the steam is directly mixed and thereby superheated, with hot flue gas that is derived from the combustion of a portion of the synthesis gas that comes from line 5 is conveyed via line 6 to the combustion chamber and is burned with combustion air from compressor K.

Combustion in H should preferably be stoichiometric but can also be super stoichiometric. If the operating method is super-stoichiometric the free oxygen serves to provide additional heat by the combustion of C or CO in the reactor B via the coal feed line (by using air as the propellant gas).

The quantity of free oxygen that should be supplied to the reactor B with the air must be optimized in any case (e.g. the greater the quantity of oxygen that is brought into the process in the air the greater the quantity of N₂ in the synthesis gas and hence the greater must be the design capacity of units C, D, E, and F conversely however the heat exchanger in B can be designed smaller).

In such cases therefore, a certain amount of autothermal heat production takes place in the reactor B which can also affect the composition of the gas. This amount however is so small in any case that the process does not lose its overall allothermal character.

A further portion of the synthesis gas from line 5 can be fed to the heat exchanger chamber I via line 7 where it is burned and produces extra hot flue gas which is mixed with the flue gas from 8 so that the temperature of the flue gas fed into the gas turbine J₁ can be raised.

again to for example, 900–1000° C. Higher temperatures than that are generally inappropriate because of the heat stress on the turbine blades.

The expansion turbines J_1 and J_2 that admit the flue gas drive a generator T to produce electric current. In addition, the turbines may drive compressor K that compresses the combustion air that is fed to combustion chambers G and H via line 21 to, for example, 40 bar whereby the air is simultaneously heated to a temperature of over 600° C. for example.

The flue gas produced in combustion chamber G is involved only in an indirect heat exchange with the reactor B. It is advantageous to have the combustion in the combustion chamber G carried out under heavily superstoichiometric conditions so that, first of all the volume of the gas is greater and the energy release in the expansion turbines J_1 , J_2 is correspondingly increased and secondly the gas exiting the heat exchanger 25 via line 8 still carries surplus air for the combustion of the additional synthesis gas fed to the heat exchange chamber I via line 7.

With the system described which is used for power production, efficiencies (terminal output) of 42–45% can be achieved, depending on the application.

The advantages of this combined power plant in comparison with conventional coal fired systems with the flue gas desulfurization can be summarized as follows:

- (a) better efficiencies,
- (b) lower cost of producing electric current,
- (c) substantially lower water requirements
- (d) reduced heat losses, and
- (e) possibility of locating the plant in the vicinity of environmentally protected districts.

If gasification in the reactor B is performed at temperatures of between 700 and 800° C. and at pressures of around 40 bar one can obtain per ton of coal about 3,200 m³ of product gas with approximately the following composition (% by volume): 58% H₂, 2% CO, 30% CO₂, 10% CH₄. The CO₂ content can be eliminated by a CO₂ scrubber and the proportions of H₂ and CH₄ increased to 83% and 14% by volume, respectively which means that a conversion step can be eliminated that is necessary as a rule with gas obtained by autothermal gasification. The fact that no oxygen is required for the gasification is another considerable advantage over autothermal processes. For combustion in the combustion chambers approximately 1/3 of the quantity of gas is required so that about 2,000 m³ of gas per ton of coal are available for combustion in the heat exchanger chamber I or for other purposes.

In the embodiment shown in FIG. 2, which differs in some details, the process works as follows:

After milling and drying (M1) the prepared coal is blown into the gasifier (V1), where it is up to 97% gasified in a fluidized bed with the aid of steam. The steam enters the gasifier at a temperature of 850° C., after it has passed through the heat exchanger W14 in the combustion chamber BK1. The heat required for gasification is fed to the reaction chamber via the heat exchanger W17. The ashes and the residual carbon (ungasified coal) are discharged via a cellular wheel sluice and a system of locks (M2).

The raw gas leaving the gasifier V1 via a double cyclone (Z1/Z2) is cooled by passing through the raw gas cooling train W1 to W7 and in the quencher T3 whereby the water vapor is condensed out of the raw gas and the evaporation heat is thus utilized. The condensate is fed to a water treatment unit and is returned

to the process via a boiler feed water treatment. The use of process water is thereby reduced to a minimum. The cooling train W1 to W6 is used to produce intermediate pressure steam at drum T1 (25 bar) or low pressure steam at drum T2 (3.6 bar). The cooled raw gas is fed to a sulfur scrubber. This scrubber operates according to an oxidative process. The H₂S contained in the raw gas is converted directly into S by means of air (LO-CAT process). The sulfur can be removed in solid form.

Via the heat exchangers W7 and W16 a portion of the now purified raw gas (synthesis gas) goes to the burner of the combustion chamber BK1. In this combustion chamber the synthesis gas is burned with air coming from the compressor K1/2 in order to enter the heat exchanger W17 of the gasifier V1 at a temperature of 950° C. after raw gas (F2/K3) or steam (from T1) recirculated in the heat exchangers W15 or W16 has been heated to 850° C.

The air/flue gas mixture leaves reactor W17/V1 at a temperature of 800° C. After passing through heat exchanger W16 it enters the first step GT1 of the expansion turbine GT at 760° C. In GT1 pressure is reduced from 20 bar to 7.5 bar. The off gas from GT1 goes to a combustion chamber BK2, which is hooked up upstream of the second step GT2 and heated with another portion of the synthesis gas and the off gas is again heated up (reheating). In the turbine or turbine step GT2, pressure is reduced to 3 bar. In combustion chamber BK3 the rest of the synthesis gas is burned with the residual oxygen in the flue gas from GT2 (2nd reheating). In turbine GT3 pressure is dropped to 1.05 bar.

The flue gas leaving the expansion step GT3 at approximately 600° C. enters a flue gas cooler WR with heat exchangers W9 to W13. In drum and heat exchanger combination T5/W10 high pressure steam (45 bar) is produced that is superheated in W9 to 480° C. In combination T4/W12 low pressure steam (3.6 bar) is produced. The flue gas leaves WR after an economizer W13 at 105° C.

Both the high-pressure and the low pressure steam from T2 or T4 are fed into a steam turbine DT1. Both steam turbine and the GT1 as well drive the compressor K/2. Both gas turbine steps GT2 and GT3 are coupled with a generator G. The condensate from the steam turbine DT1 is cooled by means of a cooling tower KTL and pumped back into the cycle.

For structural and operational reasons, the size and hence the capacity of the gasification reactor B or V1 in the embodiments pursuant to FIGS. 1 and 2 are necessarily limited, which means that the quantity of energy produced or the output of the power plant is limited as well. The process, however, can readily be expanded for greater capacity by using several gasifiers. An example of such an embodiment is shown in FIG. 3.

The mixture of air and flue gas exiting the first gas producer V1 enters the combustion chamber BK2 of the second gas producer V2 at 800° C. There the air/flue gas mixture is reheated by combustion of a portion of the synthesis gas. The flue gas and steam are heated to 880° C. and the flue gas which still has a high oxygen content, is fed to the heat exchanger of the second gasifier V2 at 950° C. This process can be repeated with additional gasifiers V3 and V4 and burners BK3 and BK4, i.e. repeated four times, for example using as a basis the data given in FIG. 1. The four gasifiers are thus hooked up in parallel with respect to fuel feed and synthesis gas discharge but in series with respect to flue gas feed to the heat exchangers.

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The flue gas (with an O₂ content of 6%) exiting the last heat exchanger is fed to an expansion turbine. This expansion turbine drives the air compressor. The surplus power of 12 MW can be given out (to the network). The flue gas, which still has a temperature of approximately 350 C is used to produce steam.

The synthesis gas produced is fed into the combustion chamber of a gas turbine unit (after desulfurization). Electric power production by means of this combined power plant is similar to that shown in FIG. 2.

If the plant shown in FIGS. 1, 2 or 3 is run with less output, surplus synthesis gas can be produced which is put under pressure of, for example, 200 bar via another compressor and conveyed to a storage container (FIG. 3). If electric current production must be increased suddenly, the synthesis gas is expanded out of the storage container into the combustion chamber of the gas turbine. The gas turbine can thus be brought up very quickly. The storage capacity must be great enough that the gasifier can be brought up to full capacity within that space of time.

The invention is not limited to the embodiments described, which are used only for power production. The synthesis gas produced by the coal gasification can also be used as process gas for downstream processes to the extent that it is not burned up in heating the reactor. If the process is altered in this way, the combustion shown in FIG. 1 of the surplus synthesis gas conveyed via line 7 in the heat exchanger I would be eliminated and instead of that the process gas line of a downstream processing step would be hooked up to line 7. One would continue, however, to use the flue gases leaving the heat exchanger coil of the reactor B via line 8 to perform work in expansion turbines J₁, J₂, which could also serve for power production, but at the least for driving the compressor K.

As examples of other uses for the unburned surplus of synthesis gas, we might mention

Use as Town Gas

After the CO₂ is removed by scrubbing, the product gas produced in the reactor B already meets the specifications for town gas in terms of its calorific value. Conversion and methanation are not necessary.

Production of Sponge Iron

After removal of the CO₂ by scrubbing, the product gas can be fed into the reducing gas circuit of a reduction reactor for sponge iron. Another hook up with the process schema depicted in the drawing is possible and consists of having the reducing gas circuit flow through a heat exchanger coil placed in the heat exchanger chamber I and by thereby heated in an indirect exchange of heat by the flue gases exiting the reactor B.

Production of Steel

Again in this instance, the product gas is fed via line 7 to a reduction reactor, which it passes through only once. The furnace gas that results in the reduction reactor can be fed to the heat exchanger chamber I and there burned, so that extra hot flue gas is obtained to be admitted into the expansion turbines J₁, J₂. With the current produced in generators S and T, the sponge iron can be melted together with scrap iron in an electric arc furnace. The result is a mini steel plant, which is suitable for regions with poor quality scrap and poor electric power supply and is particularly safe for the environment.

In addition, the product gas produced in the reactor B is particularly suitable to be methanized for production of SNG or to be converted directly into methanol.

Another example of the use of the synthesis gas is shown in FIG. 4. Here the synthesis gas is used to produce ammonia. In this case, two gasifiers V1, V2 are provided, which are hooked up in series in the same way as described for FIG. 3. Part of the synthesis gas discharged from each gasifier V1, V2 is recycled in order to use the water vapor contained in it as process steam. The rest of the synthesis gas is subjected to a sulfur scrubbing and then to a molecular sieve PSA process, in which the H₂ hydrogen is separated out of the synthesis gas. The remainder of the synthesis gas, consisting primarily of CO₂, is conveyed to the combustion chambers BK1 and BK2 in order to produce the flue gas for the indirect heating of the gasifiers V1, V2.

From the total flue gas discharged from the second gasifier V2, a portion is diverted and conveyed to a combustion chamber BK3, where it is after burned stoichiometrically with a portion of the synthesis gas coming from the molecular sieve PSA process, so that the resulting flue gas now contains essentially only N₂ and CO₂. After cooling, the CO₂ is removed by a CO scrubber. The remaining nitrogen is mixed with the hydrogen from the molecular sieve PSA process and condensed by a compressor K to 200 bar, heated and fed to an NH₃ contact reactor KO, where the reaction between hydrogen and nitrogen results in the formation of ammonia, which is then washed out by a NH₃ scrubber.

The process may be taken further by causing the produced ammonia to react with the sulfur derived from the desulfurization of the synthesis gas in order to produce ammonium sulfate. The result is an environmentally safe artificial fertilizer plant that can also produce process steam and perhaps power as well.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. Process for producing electricity from carbonaceous fuel comprising the steps of supplying finely atomized carbon-containing fuel to a fluidized bed reactor, gasifying the fuel in the reactor by means of an essentially allothermal gasification reaction to produce synthesis gas, withdrawing the synthesis gas from said reactor and purifying the synthesis gas so as to remove dust and sulfur from the synthesis gas, combusting a first portion of the purified synthesis gas and producing a first portion of flue gas, heating the reactor by indirect heat exchange by conveying the first portion of flue gas through a heat exchanger in said reactor for production of synthesis gas allothermally, burning a second portion of the purified synthesis gas to produce a second portion of flue gas, mixing the first portion of flue gas with the second portion of flue gas to form a combined flue gas stream, directing said combined flue gas stream into an expansion turbine for rotation upon expansion of said combined flue gas stream, and, driving an electric generator with the expansion turbine.

2. A process according to claim 1 wherein steam is introduced into the fluidized bed reactor and a third portion of the purified synthesis gas is combusted to produce a third portion of flue gas and is mixed with the steam and introduced together with the steam into the reactor.

3 A process according to claim 2, wherein the steam introduced into the reactor is produced by means of heat obtained from cooling the synthesis gas produced in the reactor

4 A process according to claim 1, wherein the first portion of flue gas is produced by superstoichiometric combustion of the first portion of the purified synthesis gas, a third portion of the purified synthesis gas is burned in a mixture combustion chamber to form a third portion of flue gas which is mixed with steam and introduced into the fluidized bed reactor and the second portion of the purified synthesis gas is directed to a superheating combustion chamber and is burned in admixture with the first portion of flue gas having surplus air said second portion of purified synthesis gas being burned by means of the surplus air

5 A process according to claim 1 wherein the expanded combined flue gas stream exits the expansion turbine and is reheated by at least one of an indirect exchange of heat with the first portion of flue gas employed in the heat exchanger prior to being introduced into the expansion turbine and the second portion of flue gas produced by combustion of the second portion of the purified synthesis gas and feeding the reheated flue gas coming from the expansion turbine into a second turbine

6 A process according to claim 1 wherein the first portion of flue gas employed in the heat exchanger is conveyed to the reactor at a temperature of about 850° to 1000° C. and leaves at a temperature of about 750° to 850° C.

7 A process according to claim 6 wherein the first portion of flue gas employed in the heat exchanger is heated to a temperature of about 900 to 1000 C before entering the expansion turbine by the admixture thereto of the second portion of flue gas

8 A process according to claim 2 wherein at least one of the first portion of flue gas employed in the heat

exchanger and the third portion of flue gas mixed with the steam is produced by combustion with compressed air

9 A process according to claim 2, including using the heat of the expanded flue gas stream after exiting the expansion turbine to at least one of superheat the steam, to produce the steam and to preheat feed water of a steam producing unit to produce the steam

10 A process according to claim 1, wherein the produced synthesis gas includes steam as a component and a portion of the produced synthesis gas leaving the reactor is diverted prior to purification and before cooling below the condensation point of the steam and introduced into the reactor so that the steam contained therein can be used for the reaction with the fuel.

11 A process according to claim 10 wherein a third portion of the purified synthesis gas that is temporarily not needed in the process is stored in a container under pressure.

12 A process according to claim 1 wherein the reactor and the purified synthesis gas is kept under pressure of about 40 bar

13 A process according to claim 1 including using at least one of combustible solid wastes liquid wastes and a mixture of wastes with coal as the carbon containing fuel

14 A process according to claim 1 wherein hydrogen contained in the purified synthesis gas is partially separated out of the purified synthesis gas and a portion of the combined flue gas stream is diverted prior to expansion and directed to a carbon dioxide scrubber for producing a nitrogen rich gas stream which is reacted with the hydrogen to produce ammonia.

15 A process according to claim 14 wherein the ammonia is converted into ammonium sulfate by reaction with sulfur obtained from purification of the synthesis gas withdrawn from the reactor

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[54] METHOD FOR REPOWERING EXISTING ELECTRIC POWER PLANT

[75] Inventor Albert Calderon Bowling Green Ohio

[73] Assignee Calderon Automation Inc Bowling Green Ohio

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Related U.S. Application Data

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[58] Field of Search 18/197 R 60/39 02

60/39 12 39 182

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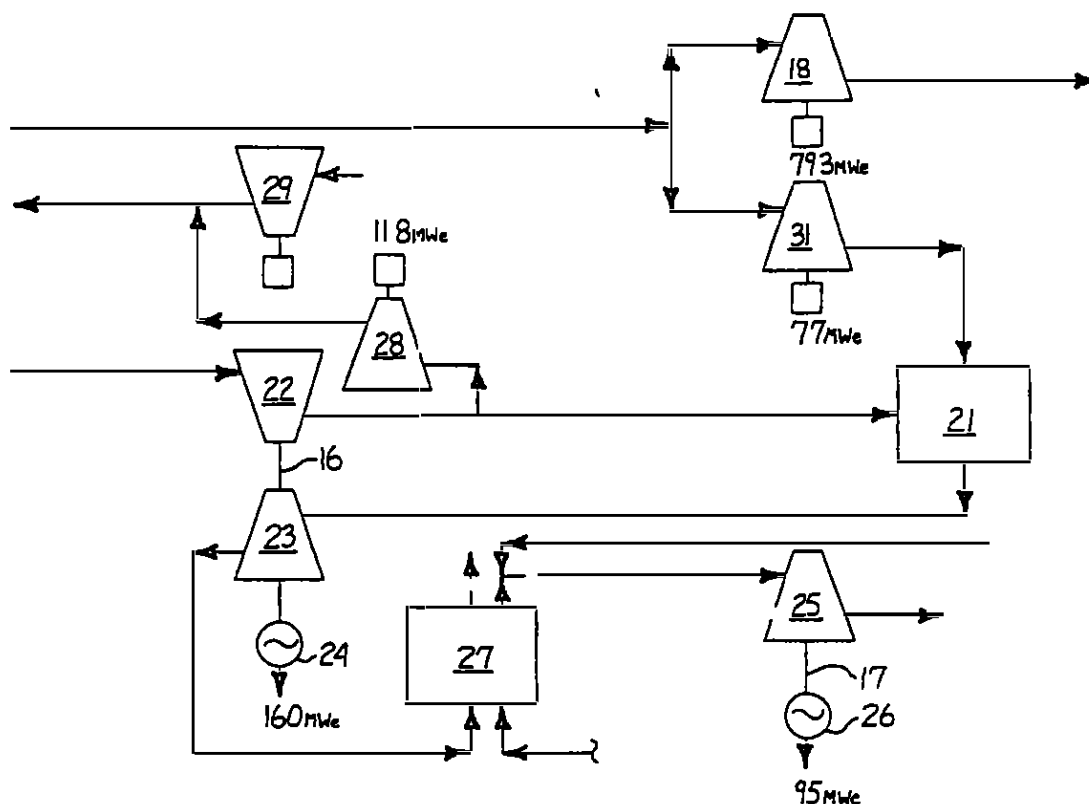
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Primary Examiner—Louis J Casaregola
Assistant Examiner—John A Savio III

[57] ABSTRACT

A method for the repowering of an existing coal fired facility used in the generation of electric power which makes the facility more efficient while reducing its emissions in a cost-effective manner using the following steps a) processing the coal in use to co produce a clean liquid fuel and a clean low Btu gas b) replacing the pulverized coal burners of the boiler contained in the facility with burners adapted to burn low Btu gas c) burning clean low Btu gas in the boiler instead of coal d) making up the derate of the boiler by the addition of efficient combined cycle power generation and e) crediting the revenue derived from the sale of the liquid fuel co-produced to the existing facility to render such repowering commercially viable

20 Claims 4 Drawing Sheets



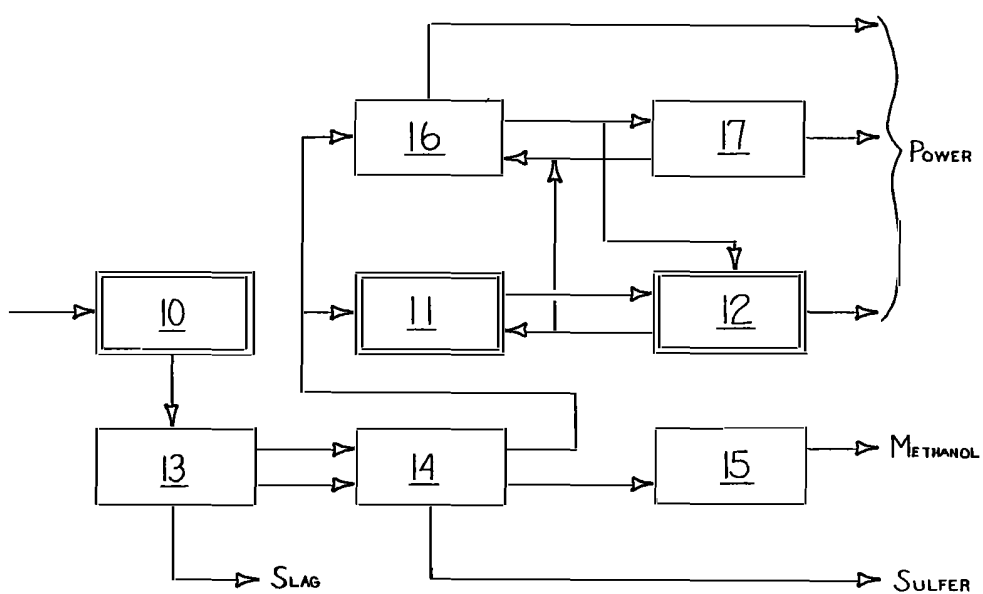
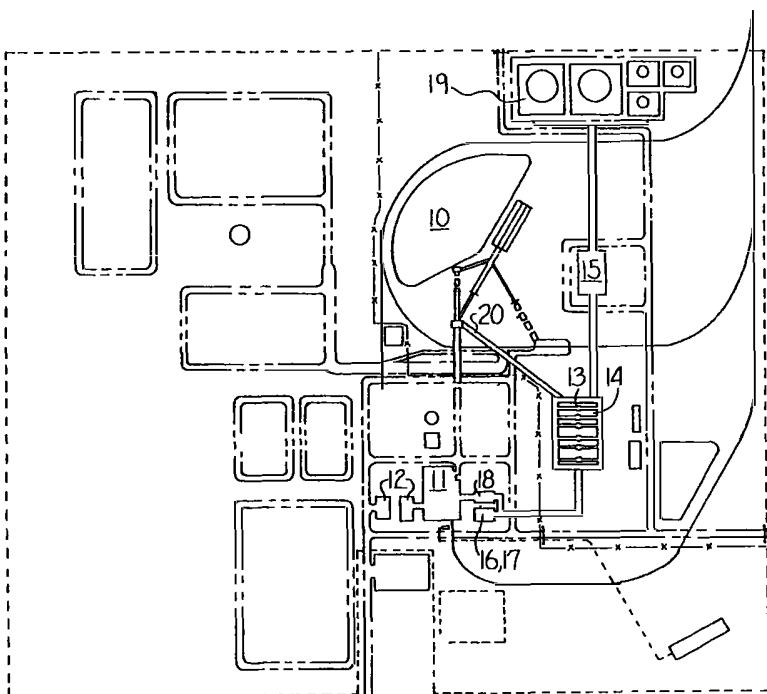


FIGURE 1

EXISTING

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FIGURE 2



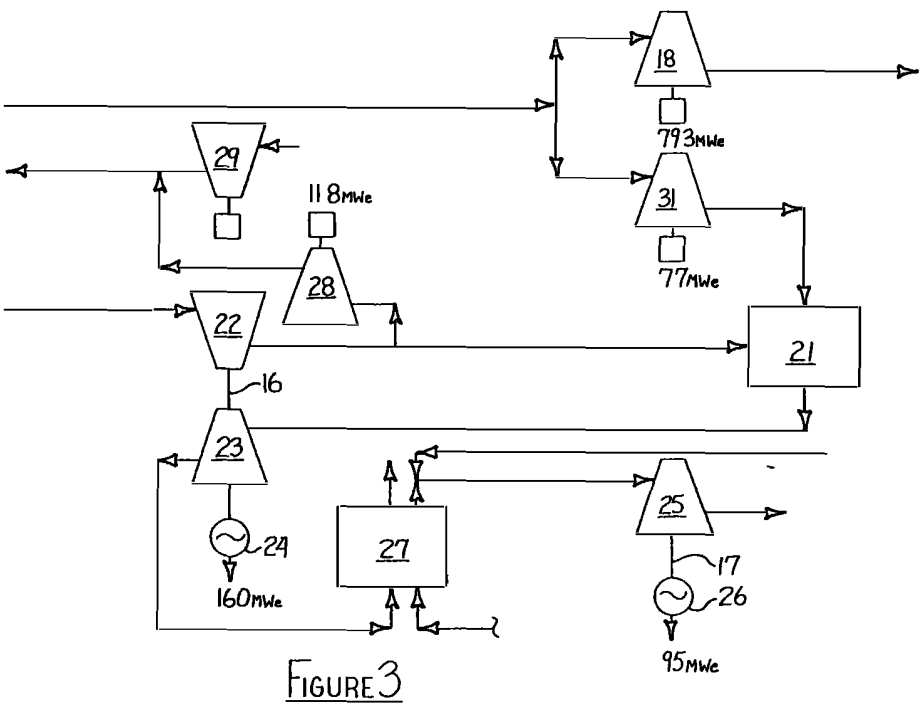
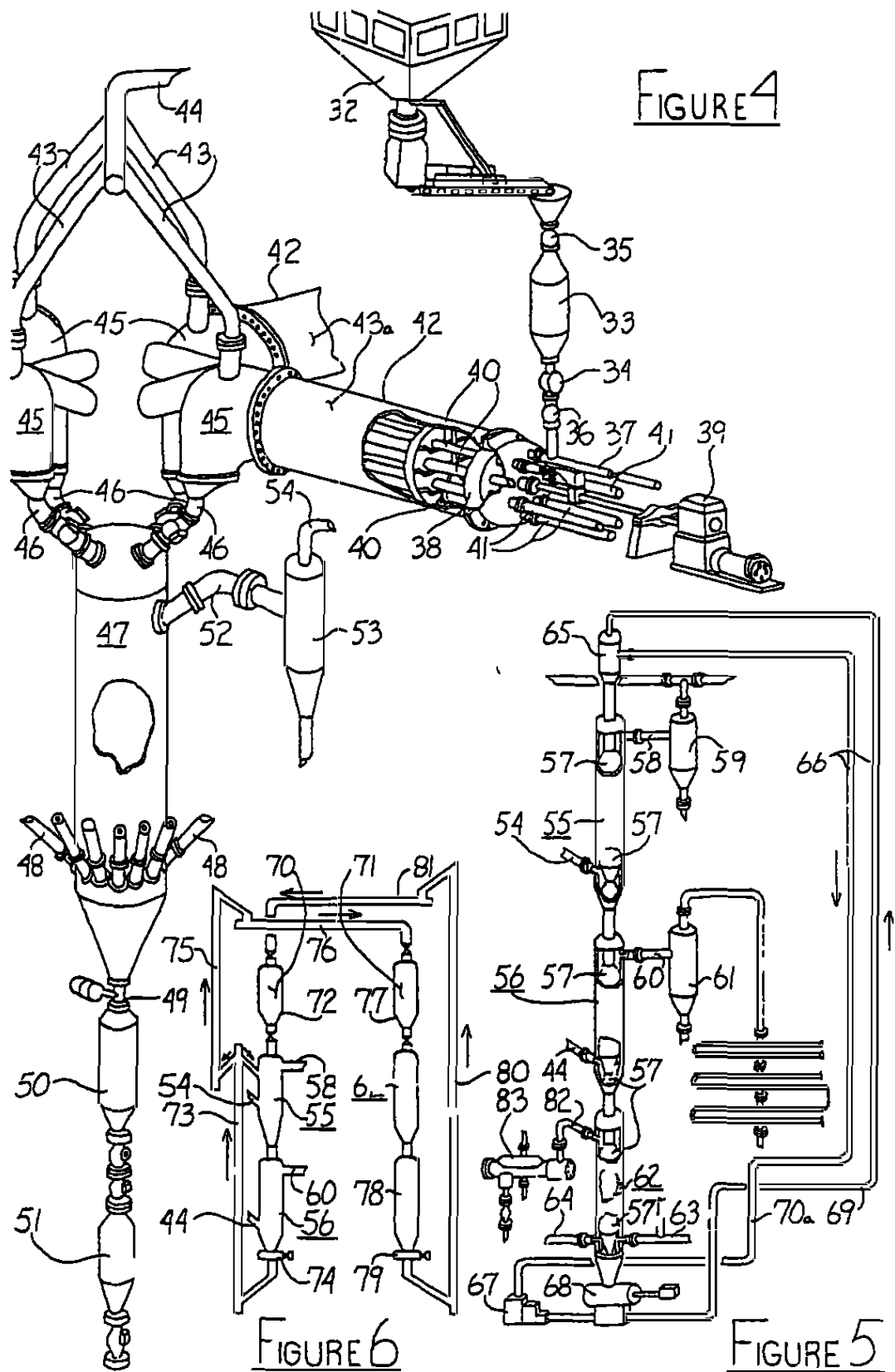


FIGURE 3

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METHOD FOR REPOWERING EXISTING ELECTRIC POWER PLANT

BACKGROUND

This invention is a division of the now pending application of the applicant bearing Ser. No. 07/198,862 filed on May 26, 1988 U.S. Pat. No. 4,609,541.

This pending application, among other inventions also discloses the repowering of an existing coal burning electric power generating facility wherein the co-production of clean fuel and electric power results in cost effective benefits which not only provide acceptable pollution controls for such facility but also in cash flows which are large enough to pay for the repowering of the existing coal burning facility.

The disclosure in said pending application covers the pressurized pyrolyzation of coal to produce a rich gas made up of gases and vapors, and a residue in the form of a char which is gasified under pressure with air to produce a lean gas. The rich gas and the lean gas are segregated and are cleaned while hot in a hot gas cleanup system to co-produce a clean rich gas (syngas) suitable for use as a feedstock for the making of chemicals including fuel grade methanol and a clean lean gas which after expansion is suitable as a very clean fuel for burning in the existing boiler which conventionally burns coal. This boiler comprising the major component of the existing power generation facility. This invention therefore makes use of the coal handling system, the boiler, the generator and the main services of the existing facility and replaces the pulverized coal burners by low Btu burners in order to burn the said lean gas instead of pulverized coal.

Since 85% of the transboundary SO_2 emissions which cause acid rain originate from coal burning utility boilers it is essential to drastically curtail the emissions from these boilers and yet do this in an environmentally and cost effective manner. Currently legislation is being enacted in Congress to control the SO_2 emissions from 107 power plants. One method for the control of such emissions consists in the installation of scrubbers. Another solution is the use of compliance coal whose content of sulfur must be quite low. The installation of scrubbers is a very costly program, produces solid waste, adds to maintenance costs, and reduces the efficiency of the plant. The use of compliance coal adds to the cost of the fuel and eliminates mining jobs in the high sulfur coal fields causing unemployment.

OBJECTIVES OF THE INVENTION

The instant invention solves the above disadvantages and yet uses high sulfur coal in an economically and environmentally acceptable manner thereby salvaging the existing coal burning facilities.

Therefore the main object of the present invention is to repower the existing coal burning facilities used in the generation of electric power while providing pollution control for such facilities with minimum change to the facilities themselves.

Another object of the present invention is to repower the existing coal burning facilities used in the generation of electric power at no out-of-pocket expenditure for such repowering.

Still another object of the present invention is to repower the existing coal burning facilities used in the generation of electric power in such a way as to yield

economic incentives to make such repowering commercially viable.

Yet another object of the present invention is to repower the existing coal burning facilities used in the generation of electric power in such a way as to demand the minimum shut-down of said facilities during such repowering.

It is therefore another object of the instant invention to repower the existing coal burning facilities used in the generation of electric power in such a way as to increase the capacity of said facilities.

It is still another object of the present invention to repower the existing coal burning facilities used in the generation of electric power in such a way as to make said facilities more efficient.

It is yet another object of the present invention to repower the existing coal burning facilities used in the generation of electric power in such a way as to reduce the maintenance of said facilities as well as extend the useful life of said facilities.

These and other objects of the instant invention will become more apparent to those skilled in the art to which this invention pertains and particularly from the following description and appended claims.

SUMMARY OF THE INVENTION

The instant invention repowers the existing coal burning facilities used in the generation of electric power in the manner illustrated in the following description of a facility whose capacity is, by way of example, a 509 MW Plant. This plant mainly possesses coal receipt storage and supply, a steam boiler equipped with pulverization mills, pulverized coal burners and bottom ash handling, a precipitator for particulate removal, and a steam turbine attached to a turbogenerator. The repowering consists of the installation of a coal gasification plant of a unique design to co-produce liquid transport fuel and a lean gas under pressure. The lean gas after cleanup is divided into two streams: the first stream is directed through an expander and into the boiler where this lean gas is burned instead of pulverized coal and the second stream while still under pressure is directed to a newly installed gas turbine which is accompanied by a waste heat boiler followed by a steam turbine. The gas turbine, waste heat boiler and steam turbine configuration is commonly known as combined cycle. Since the burning of lean gas in a boiler which is designed to burn coal, causes a derate of the boiler by as much as 40%, the loss of this rating is made up by the added capacity from an expander preceeding the boiler and by the combined cycle.

By burning clean gas in the boiler the following advantages ensue:

- 1) Elimination of ash from the boiler
- 2) Elimination of the pulverization mills
- 3) Elimination of the precipitator and
- 4) Increase in the availability of the boiler

These advantages plus an increase in capacity together with the credits derived from the sale of the transport fuel makes the repowering a very profitable venture in addition to solving the problem of pollution from power generation facilities caused by the oxides of sulfur and nitrogen.

Reference is now made to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the various views. It is to be noted that the embodiment

ments shown herein are for the purpose of description and not limitation

BRIEF DESCRIPTION OF DRAWINGS

FIG 1 is a general process flow diagram in which the boxes marked by double border lines represent existing facilities and in which the boxes marked by single border lines represent the newly added facilities

FIG 2 is a plan view of the repowered power plant in which the facilities shown in phantom are the facilities which exist and which are left intact the facilities shown in solid lines are the facilities that are added and the boiler which is slightly modified

FIG 3 is a flow diagram showing the various electric power generation units of the repowered plant

FIG 4 is the gasification system used for the co-production of a rich gas for the making of liquid fuel and of a lean gas used in the repowering of the facility for the efficient generation of electric power

FIG 5 is the hot gas cleanup system for treating the lean gas and treating and cracking of the rich gas to make it suitable as a feed stock for liquid fuel production used in the repowering

FIG 6 is an alternate arrangement for the hot gas cleanup system for treating the gases

Before proceeding with the detailed description of the invention by means of the drawings it is to be noted that for the sake of clarity reference will be made with numerals to represent the various components of the invention

DETAILED DESCRIPTION OF THE DRAWINGS

In FIG 1 reference numeral 10 is the receipt storage and supply of the coal to the plant and reference numeral 11 is the existing boiler in which the pulverized coal burners have been replaced by lean gas burners. Reference numeral 12 represents the steam cycle and the turbo-generator. The equipment represented by numerals 10 11 and 12 are existing components of the plant

Reference numeral 13 is the part of the plant used to make a rich gas from coal via pyrolysis and a lean gas from the residual char of the coal via gasification using air as the oxidant. Reference numeral 14 is the hot gas cleanup for both the rich gas and the lean gas. The rich gas is cracked and treated for sulfur removal and the lean gas is treated for sulfur removal in the component of the repowered plant represented by numeral 14. Reference numeral 15 represents the synthesis plant for making liquid fuel such as methanol from the rich gas. Synthesis plant 15 may be used to make other chemicals such as synthetic natural gas gasoline hydrogen ammonia, etc instead of methanol. Reference numeral 16 is the combustion gas turbine integrated to a waste heat boiler and reference numeral 17 is the steam cycle which is operated with steam from the waste heat boiler which in turn raises steam with flue gas from the gas turbine

Referring to FIG 2 10 is the receipt storage and supply of the coal to the plant 11 is the existing boiler and 12 is the existing steam cycle tied to the turbo generator. Reference numeral 13 is the pyrolysis and gasification components of the plant and 14 is the hot gas cleanup. Reference numeral 15 is the methanol plant and numerals 16 and 17 represent the combined cycle configuration for the generation of power to make up for the derate. Reference numeral 18 is an expander for

the lean gas prior to its combustion in boiler 11. A liquid fuel storage is provided in tanks as represented by numeral 19. A conveyor represented by numeral 20 is added to direct coal from storage 10 to pyrolysis/gasification 13

Referring to FIG 3 for a more detailed description of the power generation combined cycle complex numeral 16 is the gas turbine cycle and numeral 17 is the steam cycle. numeral 18 represents the expander for the existing boiler. Gas turbine cycle 16 is made up mainly of four (4) components a combustion chamber represented by numeral 21 a compressor represented by numeral 22 an expander represented by numeral 23 and a generator represented by numeral 24. Steam turbine cycle 17 is made up mainly of steam turbine 25 and generator 26. A waste heat boiler also known as a heat recovery steam generator represented by numeral 27 is interposed between expander 23 and steam turbine 25. This waste heat boiler recovers thermal energy from the flue gas which leaves the gas turbine to generate steam which steam is used to drive steam turbine 25 thus increasing the efficiency of the entire system. Air from compressor 22 is divided into two portions. One portion is directed to combustion chamber 21 and the second portion to a booster-compressor represented by numeral 28. An auxiliary compressor denoted by numeral 29 is also provided. Both booster compressor 28 and auxiliary compressor 29 are required to supply the air for the gasifier which is shown in FIG 4 which shall be described hereinafter. To balance the system a secondary expander for the gas turbine is provided and denoted by numeral 31

Referring to FIG 4 for the detailed description of the coal processing into gases and their cleanup coal is delivered from a bunker represented by numeral 32 to a lockhopper which is represented by reference numeral 33. Lockhopper 33 is equipped with feeder 34 and upper isolation valve 35 and lower isolation valve 36. A packing ram represented by numeral 37 pushes the coal into an accumulator which is represented by numeral 38. Accumulator 38 preferably takes the shape of a revolving wheel having multi holes which is rotated by means of drive 39. As coal is packed into each one of the plurality of holes in accumulator 38 the accumulator is indexed so as to align the packed holes with pyrolysis tubes which are denoted by reference numeral 40. Each pyrolysis tube is individually charged with coal by means of individual pushing rams which are represented by numeral 41

Pyrolysis tubes 40 which preferably are substantially horizontal are grouped together in a bundle such as bundle 42 and each bundle may be enveloped in a pressure shell as denoted by numeral 43a. Pyrolysis tubes 40 are heated individually and indirectly in order to heat the coal uniformly as the coal is pushed along the length of each tube. As such heating of the coal takes place the volatile matter is driven out of the coal. A manifold system is provided to collect the volatile matter such manifold is represented by numeral 43. The volatile matter which is also called rich gas leaves via a duct which is represented by numeral 44. The residual char remaining after the pyrolysis of the coal is discharged through elbows 45 via duct 46 into the gasification vessel which is represented by reference numeral 47. Gasification vessel 47 is an elongated vertical shaft equipped with tuyeres 48 for the injection of an oxidant such as air or pure oxygen. A slag discharge nozzle 49 a slag quenching hopper 50 and a slag lockhopper 51

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Compressed air from booster-compressor 28 and auxiliary compressor 29 shown in FIG. 3 supply the air to tuyeres 48. At the top of gasification vessel 47 a duct denoted by numeral 52 is provided to collect the gas produced from the gasification of the char. This gas which is also known as lean gas is passed through a cyclone denoted by reference numeral 53 which serves to remove particulate matter from the lean gas prior to its cleanup in the hot gas system shown in FIG. 5 or FIG. 6. This lean gas leaves the top of cyclone 53 via duct 54.

Referring to FIG. 5 the lean gas from duct 54 (extension of duct 54 FIG. 4) enters a contactor represented by numeral 55 which serves to clean the lean gas, the rich gas from duct 44 (extension of duct 44 FIG. 4) enters a cracker represented by numeral 56 which serves to simultaneously crack and desulfurize the rich gas. Both contactor 55 and cracker 56 contain a sorbent 57 such as lime (CaO) which is used as a desulfurizing agent and as a catalyst for cracking hydrocarbons contained in the gases. The lean gas leaving the top of gasification vessel 47 is quite hot around 1900° F.-2000° F. and this hot lean gas heats sorbent 57 in contactor 55 as it filters through and exits contactor 55 via duct 58. Any particulate matter entrained in the lean gas is removed in a cyclone which is denoted by numeral 59. The heated sorbent 57 in contactor 55 flows downward by gravity into cracker 56 where it is used to desulfurize the rich gas which rich gas enters the bottom of cracker 56 through duct 44 and exits cracker 56 through duct 60. The thermal energy for the endothermic reaction of cracking the hydrocarbons in the rich gas is provided by the hot sorbent 57 which was preheated by direct contact in contactor 55 by means of the lean gas prior to the descent of sorbent 57 from contactor 55 to cracker 56. A cyclone denoted by numeral 61 is provided to remove any particulate from the hot rich gas which now is in the form of a syngas leaving cracker 56. Cracker 56 serves to desulfurize the rich gas and crack all of the hydrocarbons to yield a clean syngas essentially made-up of H₂ and CO.

Sorbent 57 descends from cracker 56 to a sorbent regenerator which is represented by reference numeral 62. Regenerator 62 is equipped with means for the injection of air through duct 63 and steam through duct 64 to regenerate sorbent 57. The exit regeneration gas leaves regenerator 62 via duct 82 and enters a sulfur condenser for the precipitation of elemental sulfur which is denoted by numeral 83. Sorbent 57 recirculates from the bottom of regenerator 62 to the top of classifier 65 which feeds sorbent 57 to contactor 55. The recirculating means may be any one of known systems such as a pneumatic system which is represented by numeral 66 which mainly comprises compressor 67, feeder 68 and conveying ducting 69 and 70a.

Referring to FIG. 6, to describe the alternate system for the hot gas cleanup two columns are provided: column 70 to be used for absorption and column 71 to be used for regeneration. Column 70 comprises a lock hopper denoted by a numeral 72 and contactor 55 and cracker 56 which have been described above. Column 70 also possesses sorbent recirculating conveyor (bucket elevator) represented by numeral 73 and feeder 74 in order to recirculate the sorbent between cracker 56 and contactor 55 until the sorbent is spent at which time conveyor 73 discharges the spent sorbent to an elevating conveyor which is denoted by numeral 75 which in turn feeds the spent sorbent to horizontal con-

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veyor 76. Conveyor 76 is used to transfer the spent sorbent to regeneration column 71.

Column 71 comprises a lockhopper above regenerator 62 which is denoted by numeral 77 and a surge hopper below regenerator 62 which is denoted by numeral 78. Using feeder 79 which is located at the bottom of surge hopper 78 in conjunction with elevator conveyor denoted by numeral 80 and horizontal conveyor 81 the sorbent is after regeneration transferred from regeneration column 71 to absorption column 70.

Operation

In repowering the power plant referred to above whose current capacity is 509 MWe and shown in FIG. 2 in plan view the complex for gasification represented by numerals 13 and 14 the methanol plant represented by numeral 15 and the combined cycle represented by numerals 16 and 17 are first constructed in a period of about 2 years without disturbing the generation of power from the coal burning boiler which is represented by numeral 11. Once the new complex is shaken down, the combined cycle takes over while boiler 11 is shut down for the installation of the low Btu (lean) gas fuel burners into the existing auxiliary air compartments, after the removal of the pulverized coal burners. By boiler 11 using the low Btu gas for fuel it is estimated that the boiler will be derated from 509 MWe to 310 MWe. It is for this reason that the combined cycle is added to make-up this derate. The combined cycle capability as shown in FIG. 3 is as follows:

Expander 18	79.3 MWe
Expander 31	7.7 MWe
Gas Turbine 23	1160.0 MWe
Steam Turbine 25	94.0 MWe
Sub-total	342.0 MWe
<u>Less:</u>	
Compressor Booster 28	11.8 MWe
Auxiliary Compressor 29	77.2 MWe
Net Combined Cycle	253.0 MWe
<u>Total Capacity of Plant</u>	
Boiler 11 on Lean Gas	310 MWe
Combined Cycle Net	253 MWe
Total New Capacity	563 MWe
Net gain by repowering	54 MWe
	34 MWe
Net Gain in Percent	34 x 100/509 = 10.6%

Since the only change to boiler 11 consists of replacement of the pulverized coal burners by lean gas burner nozzles the cost for such conversion is minimal and would take around 90 days, during which time the boiler will not be available. By repowering boiler 11 to burn lean gas instead of pulverized coal sulfur emissions would be drastically reduced and the oxides of nitrogen (NO_x) will be at a minimum (20 parts/million) by virtue that low-Btu (lean) gas produces very little NO_x because it burns cooler.

The procedure for repowering disclosed herein which consists of the co-production of electric power and methanol will result in increasing the availability of boiler 11 from 75% to 90% (historically gas fired boilers have better than 90% capacity factor) the decrease in maintenance because of the elimination of the pulverizers, the precipitators and the ash from boiler 11, methanol is used as a backup fuel for both boiler 11 and combined cycle 16 to augment reliability and the decrease in operating costs because of the cash credits derived from the sale of the methanol.

Besides making repowering of existing coal burning electric power plants a profitable venture while at the same time drastically reducing emissions from them at no out-of-pocket costs the co-production of methanol or other liquid fuels to substitute petroleum liquids would be of great importance to the economy and security of the United States. When methanol is converted to gasoline as in the process of Mobile Oil (MTG process) the quantity of imported petroleum liquids could be drastically curtailed.

1 claim

1 A method of increasing the efficiency of an existing coal burning facility while reducing emissions from same in a cost effective manner comprising the following steps

- a) Installing a coal processing means capable of pyrolyzing coal under pressure to produce a raw rich gas and a hot char and said processing means being also capable of gasifying the hot char to produce a raw lean gas
- b) Installing a hot gas processing means capable of desulfurizing and cracking said raw rich gas under pressure to yield a syngas which is substantially made up of H_2 and CO in composition
- c) Installing facilities that are capable of converting said syngas into a marketable chemical
- d) Installing a hot gas processing means capable of desulfurizing said hot lean gas under pressure to yield a clean hot low Btu gas
- e) Replacing the pulverized coal burners of the boiler contained in said facility with burners adapted to the burning of low Btu gas in order to burn low Btu gas instead of pulverized coal in said boiler
- f) Splitting said clean hot low Btu gas into a first stream and a second stream
- g) Expanding the low Btu gas in said first stream to accommodate the pressure requirement of said boiler
- h) Combusting the expanded low Btu gas in said boiler to produce steam which in turn generates electricity by turning the steam turbine tied to the generator which exist in said facility
- i) Combusting the low Btu gas in said second stream in a newly installed gas combustion turbine to generate additional electric power to make up for the derate sustained by said boiler when low Btu gas is burned instead of coal in said boiler

2 The method as set forth in claim 1 wherein said step of combusting the low Btu gas in said second stream in a newly installed gas combustion turbine to generate additional electric power is further characterized by the step of directing the products of combustion from said gas combustion turbine to a heat recovery steam generator to raise steam which is in turn directed to a steam turbine tied to a generator in order to generate still more electric power via the combined cycle mode

3 The method as set forth in claim 1 wherein the step of installing a coal processing means capable of pyrolyzing coal under pressure to produce a raw rich gas is further characterized by the step of providing multi tubes grouped in a bundle wherein each tube is individually charged with coal and is individually heated in order to result in uniform pyrolyzation of the coal

4 The method as set forth in claim 3 wherein the step of providing multi tubes grouped in a bundle wherein each tube is individually charged with coal and is individually heated is further characterized by the step of

carrying out the charging of the coal and the heating thereof under pressure

5 The method as set forth in claim 1 wherein said step of installing a coal processing means capable of gasifying the hot char with air to produce a hot raw lean gas is further characterized by the step of carrying out the gasification of said char under such pressure as to accommodate the pressure required by a gas combustion turbine

6 The method as set forth in claim 1 wherein the step of installing a hot gas processing means capable of desulfurizing and cracking said rich gas under pressure and the step of installing a hot gas processing means capable of desulfurizing said hot lean gas under pressure are further characterized by the step of lifting a sorbent which serves as a desulfurizing agent from said means capable of desulfurizing and cracking said rich gas to said means capable of desulfurizing said hot lean gas and by the step of gravitationally feeding said sorbent from said means capable of desulfurizing said hot lean gas to said means capable of desulfurizing and cracking said rich gas in order to provide a recirculating pattern to said sorbent

7 The method as set forth in claim 6 wherein said step of lifting said sorbent from said means capable of desulfurizing and cracking said rich gas to said means capable of desulfurizing said hot lean gas is further characterized by the step of heating said sorbent by means of said hot lean gas in said means capable of desulfurizing said hot lean gas to such an extent as to have the sorbent at such an elevated temperature sufficient to crack hydrocarbons

8 The method as set forth in claim 7 wherein said step of heating said sorbent by means of said hot lean gas in said means capable of desulfurizing said hot lean gas to such an extent as to have the heated sorbent at such temperature sufficient to crack hydrocarbons is further characterized by the step of employing the thermal energy contained in said sorbent to crack the hydrocarbons contained in the rich gas passed through said means capable of desulfurizing and cracking said rich gas

9 The method as set forth in claim 7 wherein said step of heating said sorbent by means of said hot lean gas in said means capable of desulfurizing said hot lean gas to such an extent as to have the heated sorbent at such an elevated temperature sufficient to crack hydrocarbons is further characterized by the step of gravitationally feeding said heated sorbent from said means capable of desulfurizing said hot lean gas to said means capable of desulfurizing and cracking said rich gas

10 The method as set forth in claim 6 wherein said step of lifting said sorbent which serves as a desulfurizing agent from said means capable of desulfurizing and cracking said rich gas to said means capable of desulfurizing said hot lean gas is further characterized by the step of directing said sorbent to a sorbent regeneration means from said means capable of desulfurizing and cracking said rich gas when said sorbent becomes spent

11 The method as set forth in claim 10 wherein said step of directing said sorbent to a sorbent regeneration means is further characterized by the step of returning said sorbent after its regeneration to said means capable of desulfurizing said hot lean gas

12 The method as set forth in claim 3 wherein said step of providing multi tubes grouped in a bundle wherein each tube is individually charged with coal and is individually heated in order to result in uniform

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pyrolyzation of the coal is further characterized by the step of indirectly heating the coal in each individual tube

13 The method as set forth in claim 1 wherein the step of installing facilities that are capable of converting said syngas into a marketable chemical is further characterized by the step of converting said syngas to a fuel

14 The method as set forth in claim 1 wherein the step of installing facilities that are capable of converting said syngas into a marketable chemical is further characterized by the step of converting said syngas to synthetic natural gas

15 The method as set forth in claim 1 wherein the step of installing facilities that are capable of converting said syngas into a marketable chemical is further characterized by the step of converting said syngas to methanol

16 The method as set forth in claim 1 wherein the step of installing facilities that are capable of converting said syngas into a marketable chemical is further characterized by the step of converting said syngas to gasoline

17 The method as set forth in claim 1 wherein the step of installing facilities that are capable of converting

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said syngas into a marketable chemical is further characterized by the step of converting said syngas to hydrogen

18 The method as set forth in claim 1 wherein the step of installing facilities that are capable of converting said syngas into a marketable chemical is further characterized by the step of converting said syngas to ammonia

19 The method as set forth in claim 3 wherein the step of providing multi tubes grouped in a bundle wherein each tube is individually charged with coal is further characterized by the step of providing a revolving means adapted to take coal and having indexing features for alignment with each individual tube to be charged

20 The method as set forth in claim 1 wherein the step of providing a revolving means adapted to take coal and having indexing features for alignment with each individual tube to be charged is further characterized by the step of turning said revolving means for alignment being performed without loss of pressure from the vessel within which said revolving means is contained

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United States Patent [19]

[11] Patent Number 5,469,699

Daman

[45] Date of Patent Nov 28, 1995

[54] METHOD AND APPARATUS FOR
GENERATING ELECTRICAL ENERGY
UTILIZING A BOILER AND A GAS TURBINE
POWERED BY A CARBONIZER

[75] Inventor Ernest L. Daman, Mountainside N.J.

[73] Assignee Foster Wheeler Development
Corporation Livingston, N.J.

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[51] Int. Cl.⁶ F02C 3/28

[52] U.S. CL. 60/39.02 60/39.12

[58] Field of Search 60/39.02 39.12,
60/39.182, 39.464 110/230 201/17

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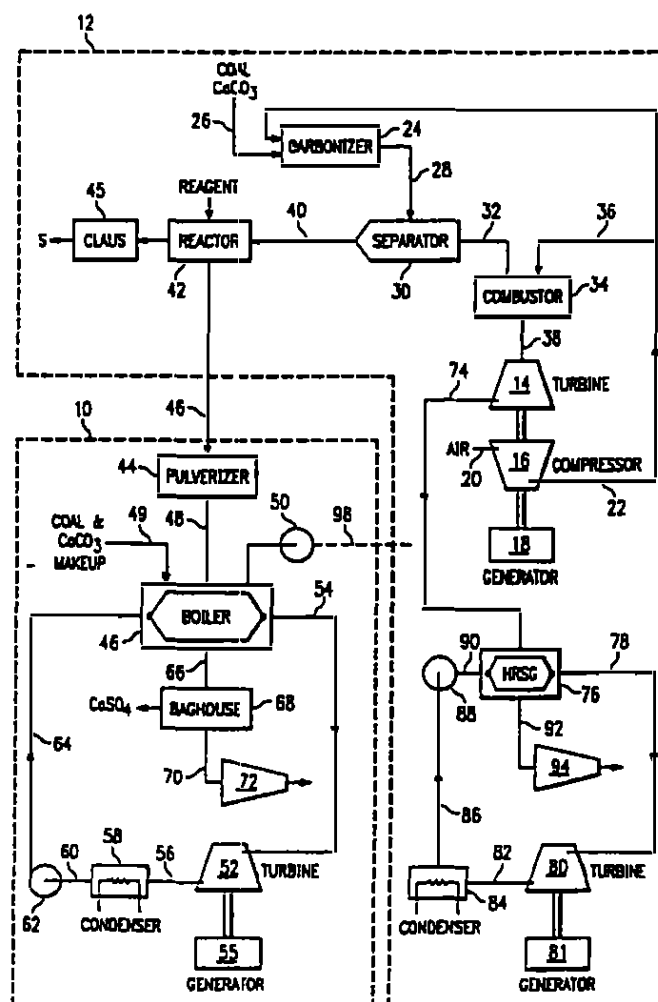
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Primary Examiner—Louis J. Casaregola
Attorney Agent or Firm—Marvin A. Naugur

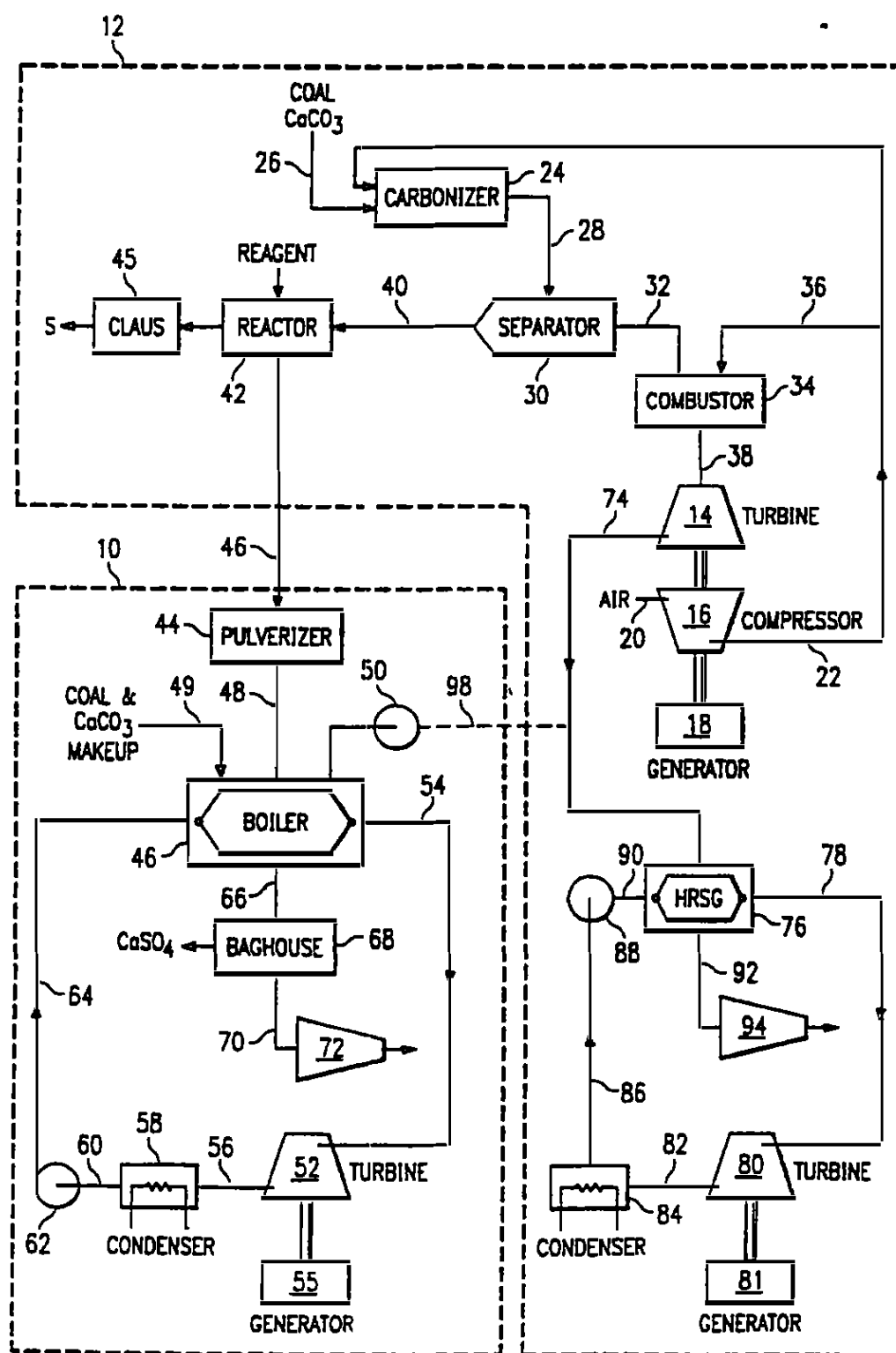
[57] ABSTRACT

An apparatus and method for generating electrical energy utilizing a boiler and a gas turbine powered by a carbonizer. A carbonizer is provided which produces low Btu gases which are passed to a gas turbine for driving the turbine and a char which is passed to a boiler for powering the boiler. The turbine utilizes the low Btu gases as its sole source of power and is operated independently of the boiler.

12 Claims, 1 Drawing Sheet



2580
108



METHOD AND APPARATUS FOR GENERATING ELECTRICAL ENERGY UTILIZING A BOILER AND A GAS TURBINE POWERED BY A CARBONIZER

BACKGROUND OF THE INVENTION

This invention relates to an apparatus and method for repowering a coal fired steam generator and, more particularly to such an apparatus and method in which the combustion or boiler is repowered by incorporating a partial gasifier or carbonizer that produces a low Btu fuel gas to power a gas turbine and a partially desulfurized char to be fired in the boiler.

Although coal fired boilers have enjoyed considerable success in supplying heat energy to steam turbines in utility plants for producing electrical energy it has always been difficult to keep them in compliance with federal and state emissions standards. This is especially true with respect to the introduction of sulfur products into the air especially when certain coals having high sulfur contents are used.

Since gas turbines are fairly efficient even when driven by a relatively low Btu gas they also lend themselves to the production of electrical energy. In these arrangements the coal is initially introduced to a partial gasifier or carbonizer which produces a relatively low Btu gas which is passed to the gas turbine and a char which is passed elsewhere in the plant. However one disadvantage of carbonizers is that, with some coals, only a fraction of the thermal energy in the coal can be extracted in the form of gas while the remaining percentage leaves the carbonizer in the form of char.

The present invention is a result of the recognition that the char obtained from the carbonizer under the above-described conditions can, when properly treated, be utilized to drive the above-described boilers in a manner to considerably reduce the production of sulfur emissions. Most importantly this invention allows repowering of an existing steam generator increasing the total plant output of electric energy while raising the plant efficiency and reducing sulfur emissions to the atmosphere.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an apparatus and method which incorporates a carbonizer to provide a low Btu gas which is used to power a gas turbine and a partially desulfurized char which is fired in a boiler.

It is further a further object to provide a method and apparatus of the above type in which the gas turbine is decoupled from the boiler and utilizes the low Btu gas from the carbonizer as its only source of fuel.

It is further object of the present invention to provide an apparatus and method of the above type in which the char passing from the carbonizer to the boiler is treated in a manner so that the levels of sulfur released into the atmosphere by the boiler are relatively low.

It is a further object of the present invention to provide an apparatus and method of the above type in which a relatively high efficiency is obtained.

Toward the fulfillment of these and other objects, according to the apparatus and method of the present invention a carbonizer is utilized for the generation of low Btu gas and solid char. The low Btu gases are passed to a combustion chamber where they are mixed with compressed air to raise the temperature of the gases before they are passed to a gas turbine for driving same. The char is passed to a boiler which

operates to produce hot gases that are passed in a heat exchange relation with water to produce steam. The gas turbine utilizes the low Btu gases as its sole source of power and is operated independently of the boiler.

BRIEF DESCRIPTION OF THE DRAWINGS

The above brief description as well as further objects, features and advantages of the present invention will be more fully appreciated by reference to the following detailed description of the presently preferred but nonetheless illustrative embodiment in accordance with the present invention when taken in conjunction with the drawing which is a schematic diagram of the system of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the drawing the reference numerals 10 and 12 refer in general to a boiler system and a carbonizer system, respectively. The carbonizer system 12 is comprised of a gas turbine 14 that is drivingly connected to an air compressor 16 and to an electrical generator 18 to drive same in a conventional manner. The air compressor 16 receives ambient air from an inlet conduit 20 and operates to compress the air which is passed through a conduit 22 extending from the outlet of the air compressor 16 to a carbonizer 24.

A feeder 26 introduces particulate fuel, such as coal into the carbonizer 24. It being understood that other feeders can be associated with the carbonizer 24 for distributing limestone or other particulate adsorbent material into the carbonizer 24 as needed. The carbonizer 24 functions in a conventional manner to partially gasify the fuel material and convert it into fuel gas and a char and to enable the limestone to absorb the sulfur generated in the gasification process.

A conduit 28 registers with an outlet formed in the carbonizer 24 to communicate it with a cyclone separator 30 disposed adjacent the carbonizer 24. The separator 30 thus receives the low Btu gas generated in the carbonizer and entrained solids, namely the solid char and reacted limestone from the carbonizer 24 and operates in a conventional manner to disengage the solids from the low Btu gas due to the centrifugal forces created in the separator 30. As cyclone separators are well known in the art, the separator 30 will not be described in any further detail.

The separated low Btu gases which are substantially free of char enter a conduit 32 projecting upwardly through the upper portion of the separator 30 for passage into a topping combustor 34. A conduit 36 connects the conduit 22 to the topping combustor 34 which operates in a conventional manner to combust the low Btu gases in the presence of the compressed air received from the conduit 22. The gas outlet of the combustor 34 is connected, by a conduit 38, to the inlet of the gas turbine 14 for passing the heated gases to the turbine to drive the turbine.

The separated solids including the char and the reacted limestone drain by gravity from the separator 30 into a conduit 40 which extends into a reactor 42 disposed adjacent the separator 30. In the reactor the solids are mixed with a reagent which is introduced into the reactor 42 for the purpose of removing sulfur from the reacted limestone by chemical extraction. A conduit 46 connects the combustion system 10 to the carbonizer system 12 and, more particularly the reactor 42 to a pulverizer (if required) 44 to pass the treated char and treated limestone to the pulverizer. The removed sulfur which is in the form of H_2S is passed to a Claus unit 45 or equivalent, which converts the H_2S into elemental sulfur.

A conduit 48 extends from the pulverizer 44 and registers with an opening formed in a boiler 46 to pass the treated char which has a significant Btu content, to the boiler 46. A conduit 49 extends into the boiler 46 for introducing a makeup fuel such as coal into the boiler along with an adsorbent, such as raw limestone (CaCO_3) for adsorbing sulfur products by the combustion of the fuel. Ambient air is introduced into the boiler 46 via a fan 50 or the like to support the burning or combustion of the mixture of char and coal reacted limestone and makeup limestone if required. The boiler 46 includes a water/steam flow circuit which passes the water/steam in an absorbing relation with the heat generated in the boiler as a result of the above combustion. This circuit includes a steam turbine 52 which receives steam from the boiler via a conduit 54 and which drives an electrical generator 55 in a conventional manner. A conduit 56 passes the exhaust steam from the turbine 52 to a condenser 58 and the water from the condenser is returned to the boiler 46 via a conduit 60, a pump 62, and a conduit 64 respectively. Since these type of boilers are well known in the industry the boiler 46 will not be described in further detail.

The exhaust gases from the boiler 46 pass via a conduit 66 to a baghouse 68 which operates to separate any solids such as coal ashes, or the like, from the gases before the gases are passed, via a conduit 70 to a stack 72 for exhaustion to the atmosphere.

The hot exhaust gases from the outlet of the turbine 14 are passed, by a conduit 74 to a heat recovery steam generator 76. The heat recovery steam generator 76 transfers heat from these gases to water flowing through the generator 76 in a conventional manner to produce steam. A conduit 78 passes the steam generated in the generator 76 to a steam turbine 80 which operates in a conventional manner to drive a generator 81. The outlet of the steam turbine 80 is connected by a conduit 82 to a condenser 84 where the steam is converted to water. The converted water is then passed to the heat recovery steam generator 76 via a conduit 86, a pump 88, and a conduit 90. The remaining exhaust gases from the turbine 80 and the heat recovery steam generator 76 are vented from the system via a conduit 92 and a stack 94.

In operation, ambient air is introduced into the air compressor 16 which is driven by the gas turbine 14 to compress the air in order to raise its pressure. A portion of the compressed air is passed from the compressor 16 to the combustor 34 while the remaining air is passed to the carbonizer 24.

In the carbonizer 24 the particulate fuel is carbonized to produce low Btu fuel gases and char while the limestone reacts with the sulfur generated during the process and adsorbs the sulfur. The low Btu gases and the entrained solids from the carbonizer 24 are passed to the separator 30 which operates in a conventional manner to separate the solids from the gases with the solids being introduced to the reactor 42 and the gases to the combustor 34.

In the combustor 34 the gases are mixed with a portion of the air from the compressor 16 and combusted to raise the temperature of the low Btu gas to the temperature required for maximum efficiency of the turbine 14. The gases are then introduced to the gas turbine 14 to drive same with an increased mass and volume to enable the gas turbine 14 to drive the air compressor 16 and the electrical generator 18.

The exhaust gases from the gas turbine 14 are directed to the generator 76. In the generator 76 the heat from the exhaust gases is transferred to water in the manner described above thereby producing steam which drives the steam

turbine 80 which, in turn, drives the generator 81 all in a conventional manner. The cooled exhaust gases from the heat recovery steam generator are vented from the system via the stack 94.

Sulfur is removed from the separated limestone in the reactor 42 by the reagent before the mixture of char and limestone is pulverized in the pulverizer 44 and introduced into the boiler 46 where it is mixed with ambient air along with makeup coal and limestone from the feeder 49 as needed. The char is combusted in the boiler 46 in a conventional manner to heat the water/steam mixture circulating through the boiler. The steam is passed to the turbine 52 for driving the turbine which in turn drives the electrical generator 55. The exhaust steam from the turbine 52 is passed in a heat exchange relationship with water in the condenser 58 and converted to water before it is passed back to the boiler 46. The exhaust gases from the boiler 46 are passed through the baghouse 68 which operates to separate any solids from the gases before the latter are passed to the stack 72.

The system and method of the present invention thus have several advantages over the prior art. By adding the carbonizer/gas turbine system to the boiler the char from the carbonizer (along with some makeup coal and raw limestone as needed) can be used to power the boiler while a relatively large amount of sulfur can be captured by the limestone in the carbonizer 24 and removed at the reactor 42, thus considerably reducing the sulfur emissions by the boiler. Also the low Btu gas from the carbonizer is the sole source of fuel for the turbine 14 and thus allows the turbine, and its associated combustor to be decoupled from the boiler and operate independently.

In addition, the exhaust gases from the turbine 14 can be supplied to the heat recovery steam generator 76 for the production of steam to drive the steam turbine 80 resulting in the recovery of the thermal energy stored in the exhaust gases thereby efficiently using the exhaust from the gas turbine by not venting the exhaust to the atmosphere.

Although not specifically illustrated in the drawing it is understood that additional necessary equipment will be provided and that these and all components described above are arranged in an appropriate fashion to form a complete and operative system.

It is understood that variations may be made in the method of the present invention without departing from the scope of the invention. For example, the heat recovery system generator 76 could be eliminated, and a conduit 98 provided to pass the gases discharged from the gas turbine 14 to the boiler 46. Since the latter gases are relatively high in oxygen content, they could be used in place of the ambient air normally supplied to the boiler 46 by the fan 50. Additionally a heat exchanger may be added between the carbonizer 24 and the separator 30 to cool the gas/solids stream, thereby allowing the condensation of alkalis. Furthermore a barrier filter may be added downstream of the separator 30 to remove fine particulates that escape the separator. Also a scrubber can be disposed between the baghouse 68 and the stack 72 for removing sulfur products from the gases before they are exhausted to the atmosphere.

It should be noted that the amount of char produced in the carbonizer 24 will depend on the size or rating of the gas turbine which uses the fuel gas from the carbonizer as its sole source of fuel. Therefore in some cases the char produced may only represent a small portion of the total fuel input to the existing boiler. In other cases it may represent a larger percentage of the total fuel to the boiler.



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Other modifications changes and substitutions are intended in the foregoing disclosure and in some instances some features of the invention will be employed without a corresponding use of other features. Accordingly it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

What is claimed is:

1. Apparatus for generating energy said apparatus comprising:

means for carbonizing fuel in the presence of limestone to generate fuel gas and char including limestone containing sulfur generated during said carbonizing

a separator for receiving said fuel gas and char from said carbonizing means and for separating said char from said fuel gas

a gas turbine

means for passing said fuel gas to said gas turbine for driving same

means operatively connected to said gas turbine for generating electrical energy

a reactor

means for passing said char to said reactor for removing said sulfur from said limestone,

a boiler

means for passing said char from said reactor to said boiler for powering said boiler and,

means operatively connected to said boiler for generating electrical energy

2. The apparatus of claim 1 further comprising means for passing the exhaust gases from said turbine to said boiler

3. The apparatus of claim 1 further comprising a steam generator and means for passing the exhaust gases from said turbine to said steam generator to generate steam.

4. The apparatus of claim 2 further comprising means for receiving the steam from said steam generator and generating additional electrical energy

5. The apparatus of claim 1 further comprising a combustor for receiving said fuel gas from said separator and

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combusting said fuel gas to increase the temperature of said fuel gas before said fuel gas is passed to said gas turbine

6. The apparatus of claim 5 further comprising an air compressor for receiving and compressing ambient air means for passing a portion of said compressed air from said compressor to said carbonizing means to support the generation of said fuel gas and means for passing another portion of said compressed air to said combustor so that said fuel gas is combusted in the presence of said air

7. A method of generating energy comprising the steps of carbonizing fuel in the presence of limestone to generate fuel gas and char including limestone containing sulfur generated during said carbonizing.

separating said char from said fuel gas

passing said fuel gas to a gas turbine for driving same and generating electrical energy

passing said char to a reactor for removing said sulfur from said limestone, and

passing said char from said reactor to a boiler for powering said boiler and generating additional electrical energy

8. The method of claim 7 further comprising the step of passing the exhaust gases from said turbine to said boiler

9. The method of claim 7 further comprising the step of passing the exhaust gases from said turbine to a steam generator to generate steam.

10. The method of claim 9 further comprising the step of utilizing said steam to generate additional electrical energy

11. The method of claim 7 further comprising the step of combusting said fuel gas to increase the temperature of said fuel gas before said fuel gas is passed to said gas turbine

12. The method of claim 11 further comprising the steps of compressing ambient air utilizing a portion of said compressed air in said step of carbonizing and utilizing another portion of said compressed air in said step of combusting

* * * * *

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING
SUBMISSION OR TRANSMITTAL
OF PRIORITY DOCUMENT

(PCT Administrative Instructions Section 411)

To

SCHURR Donald A
Marshall & Melhorn LLC
Four SeaGate 8th floor
Toledo OH 43604
United States of America

Date of mailing (day/month/year) 21 September 2002 (21 09 02)	
Applicant s or agent s file reference 53 15755	IMPORTANT NOTIFICATION
International application No PCT/US02/21099	International filing date (day/month/year) 08 July 2002 (08 07 02)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 09 July 2001 (09 07 01)
Applicant CALDERON ENERGY COMPANY OF BOWLING GREEN INC	

1 The applicant is hereby notified of the date of receipt (except where the letters NR appear in the right hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below Unless otherwise indicated by an asterisk appearing next to a date of receipt or by the letters NR in the right hand column the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17 1(a) or (b)

2 This updates and replaces any previously issued notification concerning submission or transmittal of priority documents

3 An asterisk(*) appearing next to a date of receipt in the right hand column denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17 1(a) or (b) In such a case the attention of the applicant is directed to Rule 17 1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity upon entry into the national phase to furnish the priority document within a time limit which is reasonable under the circumstances

4 The letters NR appearing in the right hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau as provided by Rule 17 1(a) or (b) respectively In such a case the attention of the applicant is directed to Rule 17 1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity upon entry into the national phase to furnish the priority document within a time limit which is reasonable under the circumstances

<u>Priority date</u>	<u>Priority application No</u>	<u>Country or regional Office or PCT receiving Office</u>	<u>Date of receipt of priority document</u>
09 July 2001 (09 07 01)	09/901 554	US	23 Augu 2002 (23 08 02)

The International Bureau of WIPO 34 chemin des Colombettes 1211 Geneva 20 Switzerland Facsimile No (41 22) 740 14 35	Authorized officer SEYMAN Y Malathib Telephone No (41 22) 338 83 38
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PCT

NOTIFICATION OF THE INTERNATIONAL
APPLICATION NUMBER AND OF THE
INTERNATIONAL FILING DATE

Date of mailing (day month year)	02 Aug 2002
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IMPORTANT NOTIFICATION

Priority date (day/month/year)
09 Jul 2001

Title of the invention **METOD FOR PRODUCING CLEAN ENERGY FROM COAL**

- * The International Bureau monitors the transmittal of the record copy by the receiving Office and will notify the applicant (with Form PCT/IB/301) of its receipt. Should the record copy not have been received by the expiration of 14 months from the priority date, the International Bureau will notify the applicant (Rule 22.1(c)).

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- ☐ License for foreign transmittal not required. 37 CFR 5.11(c)(1) or 37 CFR 5.11(c)(2). However, a license may be required for additional subject matter. See 37 CFR 5.13(b).
- ☒ Foreign transmittal license granted. 35 U.S.C. 184, 37 CFR 5.11 on 30 Jul 2002 (date).
- ☐ 37 CFR 5.13(a) ☒ 37 CFR 5.13(b)

Telephone No 703-305 3639

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PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty

For receiving Office use only

International Application No

International Filing Date

Name of receiving Office and PCT International Application

Applicant's or agent's file reference
(if desired) (12 characters maximum)

53-15755

Box No I TITLE OF INVENTION	
METHOD FOR PRODUCING CLEAN ENERGY FROM COAL	
Box No II APPLICANT ☐ This person is also inventor	
Name and address (Family name followed by given name for a legal entity full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is country) of residence if no State of residence is indicated below.)	
CALDERON ENERGY COMPANY OF BOWLING GREEN, INC., an Ohio corporation 500 Lehman Avenue Bowling Green, Ohio 43402 United States of America	
Telephone No (419) 354-4632	
Facsimile No (419) 353-6293	
Teleprinter No	
Applicant's registration No. with the Office	
State (that is country) of nationality US	
State (that is country) of residence US	
This person is applicant for the purposes of ☒ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
Box No III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
Name and address (Family name followed by given name for a legal entity full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is country) of residence if no State of residence is indicated below.)	
CALDERON, ALBERT 1065 Melrose Bowling Green, Ohio 43402 United States of America	
This person is ☐ applicant only ☐ applicant and inventor ☒ inventor only (If this check box is marked, do not fill in below)	
Applicant's registration No. with the Office	
State (that is country) of nationality	
State (that is country) of residence	
This person is applicant for the purposes of ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.	
Box No IV AGENT OR COMMON REPRESENTATIVE OR ADDRESS FOR CORRESPONDENCE	
The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as ☒ agent ☐ common representative	
Name and address (Family name followed by given name for a legal entity full official designation. The address must include postal code and name of country.)	
MARSHALL & MELHORN, LLC SCHURR, Donald A, DOLGORUKOV, D Edward, OBERLIN, Phillip S, HIXON, Mark A, EVANS, Stephen P, and COLWELL, Angelica M Four SeaGate - 8th Floor Toledo, Ohio 43604 United States of America	
Telephone No (419) 249-7145	
Facsimile No (419) 249-7151	
Teleprinter No	
Agent's registration No. with the Office 34,247, 26,266, 19,066, 44,766, 47,281, 46,637	
☐ Address for correspondence Mark this check box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent	

115

Continuation of Box No III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
<i>If none of the following sub boxes is used, this sheet should not be included in the request</i>	
Name and address (Family name followed by given name for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is country) of residence (if no State of residence is indicated below.) LAUBIS, TERRY JAMES 14377 Powell Road Portage, Ohio 43451 United States of America	This person is ☐ applicant only ☐ applicant and inventor ☒ inventor only (If this check box is marked do not fill in below) Applicant's registration No with the Office
State (that is country) of nationality	State (that is country) of residence
This person is applicant for the purposes of ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address (Family name followed by given name for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is country) of residence (if no State of residence is indicated below.) 	This person is ☐ applicant only ☐ applicant and inventor ☐ inventor only (If this check box is marked do not fill in below) Applicant's registration No with the Office
State (that is country) of nationality	State (that is country) of residence
This person is applicant for the purposes of ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address (Family name followed by given name for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is country) of residence (if no State of residence is indicated below.) 	This person is ☐ applicant only ☐ applicant and inventor ☐ inventor only (If this check box is marked do not fill in below) Applicant's registration No with the Office
State (that is country) of nationality	State (that is country) of residence
This person is applicant for the purposes of ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address (Family name followed by given name for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is country) of residence (if no State of residence is indicated below.) 	This person is ☐ applicant only ☐ applicant and inventor ☐ inventor only (If this check box is marked do not fill in below) Applicant's registration No with the Office
State (that is country) of nationality	State (that is country) of residence
This person is applicant for the purposes of ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
☐ Further applicants and/or (further) inventors are indicated on another continuation sheet	

Box No V DESIGNATION OF STATES Mark the applicable check boxes below at least one must be marked

The following designations are hereby made under Rule 4 9(a)

Regional Patent

- ☒ AP ARIPO Patent GH Ghana GM Gambia KE Kenya LS Lesotho MW Malawi MZ Mozambique SD Sudan SL Sierra Leone SZ Swaziland TZ United Republic of Tanzania, UG Uganda, ZM Zambia, ZW Zimbabwe and any other State which is a Contracting State of the Harare Protocol and of the PCT (if other kind of protection or treatment desired specify on dotted line)
- ☒ EA Eurasian Patent AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ EP European Patent AT Austria, BE Belgium, BG Bulgaria, CH & LI Switzerland and Liechtenstein, CY Cyprus, CZ Czech Republic, DE Germany, DK Denmark, EE Estonia, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, SK Slovakia, TR Turkey and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ OA OAPI Patent BF Burkina Faso, BI Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GQ Equatorial Guinea, GW Guinea Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired specify on dotted line)

National Patent (if other kind of protection or treatment desired specify on dotted line)

- | | | |
|---|--|--|
| ☒ AE United Arab Emirates | ☒ GM Gambia | ☒ NZ New Zealand |
| ☒ AG Antigua and Barbuda | ☒ HR Croatia | ☒ OM Oman |
| ☒ AL Albania | ☒ HU Hungary | ☒ PH Philippines |
| ☒ AM Armenia | ☒ ID Indonesia | ☒ PL Poland |
| ☒ AT Austria | ☒ IL Israel | ☒ PT Portugal |
| ☒ AU Australia | ☒ IN India | ☒ RO Romania |
| ☒ AZ Azerbaijan | ☒ IS Iceland | ☒ RU Russian Federation |
| ☒ BA Bosnia and Herzegovina | ☒ JP Japan | |
| ☒ BB Barbados | ☒ KE Kenya | ☒ SD Sudan |
| ☒ BG Bulgaria | ☒ KG Kyrgyzstan | ☒ SE Sweden |
| ☒ BR Brazil | ☒ KP Democratic People's Republic of Korea | ☒ SG Singapore |
| ☒ BY Belarus | ☒ KR Republic of Korea | ☒ SI Slovenia |
| ☒ BZ Belize | ☒ KZ Kazakhstan | ☒ SK Slovakia |
| ☒ CA Canada | ☒ LC Saint Lucia | ☒ SL Sierra Leone |
| ☒ CH & LI Switzerland and Liechtenstein | ☒ LK Sri Lanka | ☒ TJ Tajikistan |
| ☒ CN China | ☒ LR Liberia | ☒ TM Turkmenistan |
| ☒ CO Colombia | ☒ LS Lesotho | ☒ TN Tunisia |
| ☒ CR Costa Rica | ☒ LT Lithuania | ☒ TR Turkey |
| ☒ CU Cuba | ☒ LU Luxembourg | ☒ TT Trinidad and Tobago |
| ☒ CZ Czech Republic | ☒ LV Latvia | ☒ TZ United Republic of Tanzania |
| ☒ DE Germany | ☒ MA Morocco | ☒ UA Ukraine |
| ☒ DK Denmark | ☒ MD Republic of Moldova | ☒ UG Uganda |
| ☒ DM Dominica | | ☐ US United States of America |
| ☒ DZ Algeria | ☒ MG Madagascar | |
| ☒ EC Ecuador | ☒ MK The former Yugoslav Republic of Macedonia | ☒ UZ Uzbekistan |
| ☒ EE Estonia | ☒ MN Mongolia | ☒ VN Viet Nam |
| ☒ ES Spain | ☒ MW Malawi | ☒ YU Yugoslavia |
| ☒ FI Finland | ☒ MX Mexico | ☒ ZA South Africa |
| ☒ GB United Kingdom | ☒ MZ Mozambique | ☒ ZM Zambia |
| ☒ GD Grenada | ☒ NO Norway | ☒ ZW Zimbabwe |
| ☒ GE Georgia | | |
| ☒ GH Ghana | | |

Check boxes below reserved for designating States which have become party to the PCT after issuance of this sheet

- | | | |
|--------------------------|--------------------------|--------------------------|
| ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ |

Precautionary Designation Statement In addition to the designations made above the applicant also makes under Rule 4 9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation (including fees) must reach the receiving Office within the 15 month time limit.)

Box No VI PRIORITY CLAIM

The priority of the following earlier application() is hereby claimed

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is		
		national application country or Member of WTO	regional application * regional Office	international application receiving Office
item (1) (09 07 01) 09 July 2001	09/901,55 +	US		
item (2)				
item (3)				
item (4)				
item (5)				

☐ Further priority claims are indicated in the Supplemental Box

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office) identified above as

☐ all items ☒ item (1) ☐ item (2) ☐ item (3) ☐ item (4) ☐ item (5) ☐ other see Supplemental Box

* Where the earlier application is an ARIPO application indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4 10(b)(ii))

Box No VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search indicate the Authority chosen the two letter code may be used)

ISA / US

Request to use results of earlier search reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority)

Date (day/month/year) Number Country (or regional Office)

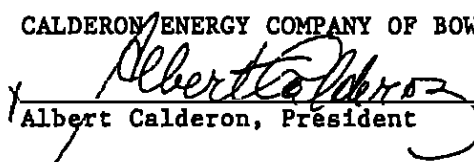
Box No VIII DECLARATIONS

The following declarations are contained in Boxes Nos VIII (i) to (v) (mark the applicable check boxes below and indicate in the right column the number of each type of declaration)

Number of declarations

- ☐ Box No VIII (i) Declaration as to the identity of the inventor
- ☐ Box No VIII (ii) Declaration as to the applicant's entitlement, as at the international filing date to apply for and be granted a patent
- ☐ Box No VIII (iii) Declaration as to the applicant's entitlement as at the international filing date to claim the priority of the earlier application
- ☐ Box No VIII (iv) Declaration of inventorship (only for the purposes of the designation of the United States of America)
- ☐ Box No VIII (v) Declaration as to non prejudicial disclosures or exceptions to lack of novelty

Box No IX CHECK LIST LANGUAGE OF FILING		
This international application contains (a) the following number of sheets in paper form request (including declaration sheets) 5 description (excluding sequence listing part) 10 claims 6 abstract 1 drawings 3 Sub-total number of sheets 25 sequence listing part of description (actual number of sheets if filed in paper form whether or not also filed in computer readable form see (b) below) 25 Total number of sheets 25 (b) sequence listing part of description filed in computer readable form (i) ☐ only (under Section 801(a)(i)) (ii) ☐ in addition to being filed in paper form (under Section 801(a)(ii)) Type and number of carriers (diskette CD ROM, CD R or other) on which the sequence listing part is contained (additional copies to be indicated under item 9(ii) in right column)	This international application is accompanied by the following item(s) (mark the applicable check boxes below and indicate in right column the number of each item) 1 ☒ fee calculation sheet 1 2 ☐ original separate power of attorney 3 ☒ original general power of attorney 1 4 ☐ copy of general power of attorney reference number if any 5 ☐ statement explaining lack of signature 6 ☐ priority document(s) identified in Box No VI as item(s) 7 ☐ translation of international application into (language) 8 ☐ separate indications concerning deposited microorganism or other biological material 9 ☐ sequence listing in computer readable form (indicate also type and number of carriers (diskette CD ROM CD R or other)) (i) ☐ copy submitted for the purposes of international search under Rule 13ter only (and not as part of the international application) (ii) ☐ (only where check box (b)(i) or (b)(ii) is marked in left column) additional copies including where applicable the copy for the purposes of international search under Rule 13ter (iii) ☐ together with relevant statement as to the identity of the copy or copies with the sequence listing part mentioned in left column return card, 2 10 ☒ other (specify) Express mail certificate	Number of items
Figure of the drawings which should accompany the abstract	Language of filing of the international application English	

Box No X SIGNATURE OF APPLICANT AGENT OR COMMON REPRESENTATIVE	
Next to each signature indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request)	
CALDERON ENERGY COMPANY OF BOWLING GREEN, INC  Albert Calderon, President	

For receiving Office use only	
1 Date of actual receipt of the purported international application	2 Drawings ☐ received ☐ not received
3 Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application	
4 Date of timely receipt of the required corrections under PCT Article 11(2)	
5 International Searching Authority (if two or more are competent) ISA /	6 ☐ Transmittal of search copy delayed until search fee is paid
For International Bureau use only	
Date of receipt of the record copy by the International Bureau	

POWER OF ATTORNEY
(for an international application filed under the Patent Cooperation Treaty)
(PCT Rule 90.4)

The undersigned applicant(s) (Names should be indicated as they appear in the request)

CALDERON ENERGY COMPANY OF BOWLING GREEN, INC
An Ohio corporation
500 Lehman Avenue
Bowling Green, Ohio 43402
United States of America

hereby appoints (appoint) the following person as ☒ agent ☐ common representative

Name and address

(Family name followed by given name for a legal entity full official designation The address must include postal code and name of country)

SCHURR Donald A Reg No 34 247 COLGORUKOV D Edward Reg No 26 266 OBERLIN
Phillip S Reg No 19 066 HIXON Mark A Reg No 44 766 EVANS Stephen P Reg No 47 281
and COLWELL Angelica M Reg No 46 637 all of the law firm of
MARSHALL & MELHORN LLC
Four SeaGate 8th Floor
Toledo Ohio 43604
United States of America

to represent the undersigned before

- ☒ all the competent International Authorities
☐ the International Searching Authority only
☐ the International Preliminary Examining Authority only

in connection with the international application identified below

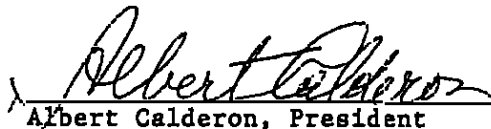
Title of the invention METHOD FOR PRODUCING CLEAN ENERGY FROM COAL

Applicant s or agent s file reference 53-15755

International application number (if already available)

filed with the following Office UNITED STATES PATENT AND TRADEMARK OFFICE as receiving Office
and to make or receive payments on behalf of the undersigned

Signature of the applicant(s) (where there are several applicants each of them must sign next to each signature indicate the name of the person signing and the capacity in which the person signs if such capacity is not obvious from reading the request or this power)


Albert Calderon, President

Date April 18, 2002



PCT

FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International Application No

Date stamp of the receiving Office

Applicant's or agent's
file reference

53-15755

Applicant

CALDERON ENERGY COMPANY OF BOWLING GREEN, INC

CALCULATION OF PRESCRIBED FEES

1 TRANSMITTAL FEE

240 00

T

2 SEARCH FEE

450 00

S

International search to be carried out by ISA/US

(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search)

3 INTERNATIONAL FEE

Basic Fee

Where item (b) of Box No IX applies enter Sub total number of sheets

25

Where item (b) of Box No IX does not apply enter Total number of sheets

b1 first 30 sheets

407 00

b1

b2 0

\$ 9 00

= 0 00

b2

number of sheets
in excess of 30

fee per sheet

b3 additional component (only if sequence listing part of description
is filed in computer readable form under Section 801(a)(i) or
both in that form and on paper under Section 801(a)(ii))

400 x =

b3

fee per sheet

Add amounts entered at b1 b2 and b3 and enter total at B

407 00

B

Designation Fees

The international application contains 92 designations

5

\$ 88 00

440 00

D

number of designation fees
payable (maximum 5)

amount of designation fee

Add amounts entered at B and D and enter total at I

847 00

I

(Applicants from certain States are entitled to a reduction of 75% of the
international fee. Where the applicant is (or all applicants are) so entitled the total
to be entered at I is 25% of the sum of the amounts entered at B and D)

15 00

P

4 FEE FOR PRIORITY DOCUMENT (if applicable)

5 TOTAL FEES PAYABLE

\$ 1,552 00

Add amounts entered at T S I and P and enter total in the TOTAL box

TOTAL

☐ The designation fees are not paid at this time

MODE OF PAYMENT

☒ authorization to charge
deposit account (see below)☐ postal money order☐ cash☐ coupons☒ cheque☐ bank draft☐ revenue stamps☐ other (specify)

AUTHORIZATION TO CHARGE (OR CREDIT) DEPOSIT ACCOUNT

(This mode of payment may not be available at all receiving Offices)

Receiving Office RO/US

Deposit Account No 13-1816

Date July 8 2002

Name Donald A. Schurr

Signature

☐ Authorization to charge the total fees indicated above☒ (This check box may be marked only if the conditions for deposit accounts
of the receiving Office so permit) Authorization to charge any deficiency
or credit any overpayment in the total fees indicated above☐ Authorization to charge the fee for priority document.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

NOTIFICATION OF RECEIPT
OF DEMAND BY COMPETENT INTERNATIONAL
PRELIMINARY EXAMINING AUTHORITY

(PCT Rules 59 3(e) and 61 1(b) first sentence
and Administrative Instructions Section 601(a))

To
DONALD A SCHURR
MARSHALL & MELHORN LLC
FOUR SEAGATE 8TH FLOOR
TOLEDO OHIO 43604

Date of mailing
(day/month/year) 05 MAR 2003

Applicant's or agent's file reference
53 15755

IMPORTANT NOTIFICATION

International application No
PCT/US02/21099

International filing date (day/month/year)
08 Jul 2002

Priority date (day/month/year)
09 Jul 2001

Applicant
CALDERON ENERGY COMPANY OF BOWLING GREEN INC AN OHIO CORPORATION

1 The applicant is hereby notified that this International Preliminary Examining Authority considers the following date as the date of receipt of the demand for international preliminary examination of the international application

03 Feb 2003

2 That date of receipt is

- ☒ the actual date of receipt of the demand by this Authority (Rule 61 1(b))
- ☐ the actual date of receipt of the demand on behalf of this Authority (Rule 59 3(e))
- ☐ the date on which this Authority has in response to the invitation to correct defects in the demand (Form PCT/IPEA/404) received the required corrections

3 ☐ **ATTENTION** That date of receipt is AFTER the expiration of 19 months from the priority date. Consequently the election(s) made in the demand does (do) not have the effect of postponing the entry into the national phase until 30 months from the priority date (or later in some Offices) (Article 39(1)). Therefore the acts for entry into the national phase must be performed within 20 months from the priority date (or later in some Offices) (Article 22). For details see the PCT Applicant's Guide Volume II

☐ (If applicable) This notification confirms the information given by telephone, facsimile transmission or in person on

4 Only where paragraph 3 applies a copy of this notification has been sent to the International Bureau

Name and mailing address of the IPEA/
Assistant Commissioner for Patent Box PCT
Washington DC 20231 Attn RO/US

Authorized officer
Jeryl McDowell

Facsimile No 703 305 3230
Form PCT/IPEA/402 (July 1998)

Telephone No 703 305 3639

RECEIVED

MAR 10 2003

MARSHALL & MELHORN

The demand must be filed directly with the competent International Preliminary Examining Authority or, if two or more Authorities are competent with the one chosen by the applicant. The full name or two-letter code of that Authority may be indicated by the applicant on the line below.
IPEA/ US

PCT

CHAPTER II

DEMAND

under Article 31 of the Patent Cooperation Treaty
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States (except where otherwise indicated)

For International Preliminary Examining Authority use only		
Identification of IPEA		Date of receipt of DEMAND
Box No I IDENTIFICATION OF THE INTERNATIONAL APPLICATION		Applicant's or agent's file reference 53-15755
International application No PCT/US02/21099	International filing date (day/month/year) 08 July 2002 (08 07 02)	(Earliest) Priority date (day/month/year) 09 July 2001 (09 07 01)
Title of invention METHOD FOR PRODUCING CLEAN ENERGY FROM COAL		
Box No II APPLICANT(S)		
Name and address (Family name followed by given name for a legal entity full official designation. The address must include postal code and name of country.) CALDERON ENERGY COMPANY OF BOWLING GREEN INC an Ohio corporation 500 Lehman Avenue Bowling Green Ohio 43402 United States of America		Telephone No (419) 354-4632
		Facsimile No (419) 353 6293
		Teleprinter No
		Applicant's registration No with the Office
State (that is country) of nationality US		State (that is country) of residence US
Name and address (Family name followed by given name for a legal entity full official designation. The address must include postal code and name of country.)		
State (that is country) of nationality		State (that is country) of residence
Name and address (Family name followed by given name for a legal entity full official designation. The address must include postal code and name of country.)		
State (that is country) of nationality		State (that is country) of residence
☐ Further applicants are indicated on a continuation sheet		

Box No III AGENT OR COMMON REPRESENTATIVE OR ADDRESS FOR CORRESPONDENCE

The following person is ☒ agent ☐ common representativeand ☒ has been appointed earlier and represents the applicant(s) also for international preliminary examination☐ is hereby appointed and any earlier appointment of (an) agent(s)/common representative is hereby revoked☐ is hereby appointed specifically for the procedure before the International Preliminary Examining Authority in addition to the agent(s)/common representative appointed earlierName and address (Family name followed by given name for a legal entity full official designation
The address must include postal code and name of country)MARSHALL & MELHORN, LLC
SCHURR, Donald A , DOLGORUKOV, D Edward, OBERLIN,
Phillip S , HIXON, Mark A , EVANS, Stephen P , and
COLWELL, Angelica M
Four SeaGate - 8th Floor
Toledo, Ohio 43604
United States of America

Telephone No

(419) 249-7145

Facsimile No

(419) 249-7151

Teleprinter No

Agent's registration No. with the Office
34,247, 26,266, 19,066,
44,766, 47,281, 46,637☐ Address for correspondence Mark this check box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent

Box No IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION

Statement concerning amendments

1 The applicant wishes the international preliminary examination to start on the basis of

☒ the international application as originally filedthe description ☒ as originally filed☐ as amended under Article 34the claims ☒ as originally filed☐ as amended under Article 19 (together with any accompanying statement)☐ as amended under Article 34the drawings ☒ as originally filed☐ as amended under Article 342 ☐ The applicant wishes any amendment to the claims under Article 19 to be considered as reversed3 ☐ The applicant wishes the start of the international preliminary examination to be postponed until the expiration of 20 months from the priority date unless the International Preliminary Examining Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69 1(d)) (This check box may be marked only where the time limit under Article 19 has not yet expired)

Where no check box is marked international preliminary examination will start on the basis of the international application as originally filed or where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report as so amended

Language for the purposes of international preliminary examination English

☒ which is the language in which the international application was filed☐ which is the language of a translation furnished for the purposes of international search☐ which is the language of publication of the international application☐ which is the language of the translation (to be) furnished for the purposes of international preliminary examination

Box No V ELECTION OF STATES

The applicant hereby elects all eligible States (that is all States which have been designated and which are bound by Chapter II of the PCT)

excluding the following States which the applicant wishes not to elect

Box No VI CHECK LIST

The demand is accompanied by the following elements in the language referred to in Box No IV for the purposes of international preliminary examination

- | | |
|---|--------|
| 1 translation of international application | sheets |
| 2 amendments under Article 34 | sheets |
| 3 copy (or where required translation) of amendments under Article 19 | sheets |
| 4 copy (or where required translation) of statement under Article 19 | sheets |
| 5 letter | sheets |
| 6 other (specify) | sheets |

For International Preliminary
Examining Authority use only

received not received

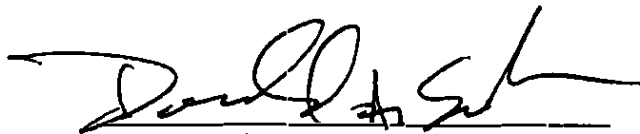
- | | |
|--------------------------|--------------------------|
| ☐ | ☐ |
| ☐ | ☐ |
| ☐ | ☐ |
| ☐ | ☐ |
| ☐ | ☐ |
| ☐ | ☐ |

The demand is also accompanied by the item(s) marked below

- | | |
|--|--|
| 1 ☒ fee calculation sheet | 5 ☐ statement explaining lack of signature |
| 2 ☐ original separate power of attorney | 6 ☐ sequence listings in computer readable form |
| 3 ☐ original general power of attorney | 7 ☐ tables in computer readable form related to sequence listings |
| 4 ☐ copy of general power of attorney reference number if any | 8 ☒ other (specify) Express mail certificate |

Box No VII SIGNATURE OF APPLICANT AGENT OR COMMON REPRESENTATIVE

Next to each signature indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand)

Donald A. Schurr Reg No 34 247
Attorney for Applicant

For International Preliminary Examining Authority use only

- 1 Date of actual receipt of DEMAND

- 2 Adjusted date of receipt of demand due to CORRECTIONS under Rule 60 1(b)

- 3
- ☐
- The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5 below does not apply
- ☐
- The applicant has been informed accordingly

- 4
- ☐
- The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80 5

- 5
- ☐
- Although the date of receipt of the demand is after the expiration of 19 months from the priority date the delay in arrival is EXCUSED pursuant to Rule 82

For International Bureau use only

Demand received from IPEA on

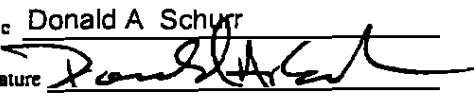
125

CHAPTER II

PCT

FEE CALCULATION SHEET

Annex to the Demand

International application No	PCT/US02/21099	For International Preliminary Examining Authority use only	
Applicant's or agent's file reference	53-15755	Date stamp of the IPEA	
Applicant CALDERON ENERGY COMPANY OF BOWLING GREEN INC			
CALCULATION OF PRESCRIBED FEES			
1 Preliminary examination fee	490 00	P	
2 Handling fee (<i>Applicants from certain States are entitled to a reduction of 75% of the handling fee Where the applicant is (or all applicants are) so entitled the amount to be entered at H is 25% of the handling fee</i>)	146 00	H	
3 Total of prescribed fees Add the amounts entered at P and H and enter total in the TOTAL box	636 00		
		TOTAL	
MODE OF PAYMENT			
☒ authorization to charge deposit account with the IPEA (see below)	☐ cash		
☒ cheque	☐ revenue stamps		
☐ postal money order	☐ coupons		
☐ bank draft	☐ other (<i>specify</i>)		
AUTHORIZATION TO CHARGE (OR CREDIT) DEPOSIT ACCOUNT (<i>This mode of payment may not be available at all IPEAs,</i>			
☐ Authorization to charge the total fees indicated above	IPEA/ <u>US</u>		
☐ (<i>This check box may be marked only if the conditions for deposit accounts of the IPEA so permit</i>) Authorization to charge any deficiency or credit any overpayment in the total fees indicated above	Deposit Account No <u>13 1816</u>		
	Date <u>03 February 2003</u>		
	Name <u>Donald A Schurr</u>		
	Signature 		

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To
DONALD A SCHURR
MARSHALL & MELORN LLC
FOUR SEAGATE 8TH FLOOR
TOLEDO OH 43604

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of Mailing
(day/month/year)

07 APR 2003

Applicant's or agent's file reference

53 15755

IMPORTANT NOTIFICATION

International application No

International filing date (day/month/year)

Priority date (day/month/year)

PCT/US02/21099

08 July 2002 (08 07 2002)

09 July 2001 (09 07 2001)

Applicant

CALDERON ENERGY COMPANY OF BOWLING GREEN INC

- 1 The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes if any established on the international application
- 2 A copy of the report and its annexes if any is being transmitted to the International Bureau for communication to all the elected Offices
- 3 Where required by any of the elected Offices the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices
- 4 REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301)

Where a translation of the international application must be furnished to an elected Office that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices see Volume II of the PCT Applicant's Guide

RECEIVED
APR 11 2003
MARSHALL & MELORN LLC

Name and mailing address of the IPEA/US

Commissioner of Patents and Trademarks
Box PCT
Washington D C 20231

Facsimile No (703) 305 3230

Authorized officer

Rasia Ridley

Telephone No (703) 308-0661

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 53 15755	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No PCT/US02/21099	International filing date (day/month/year) 08 July 2002 (08 07 2002)	Priority date (day/month/year) 09 July 2001 (09 07 2001)
International Patent Classification (IPC) or national classification and IPC IPC(7) C10J 3/08 and US Cl. 48/210 101 107 119 202 203 422/232 236 60/39 01 39 12		
Applicant CALDERON ENERGY COMPANY OF BOWLING GREEN INC		

1 This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36

2 This REPORT consists of a total of 3 sheets including this cover sheet

☐ This report is also accompanied by ANNEXES i.e. sheets of the description claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT)

These annexes consist of a total of 0 sheets

3 This report contains indications relating to the following items

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non establishment of report with regard to novelty inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(1) with regard to novelty inventive step or industrial applicability citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 03 February 2003 (03 02 2003)	Date of completion of this report 21 March 2003 (21 03 2003)
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington D.C. 20231 Facsimile No. (703) 305 3230	Authorized officer Asia Ridley Telephone No. (703) 308 0661

Form PCT/IPEA/409 (cover sheet) (July 1998)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No

PCT/US02/21099

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I Basis of the report**1 With regard to the elements of the international application**

- ☒ the international application as originally filed
- ☒ the description
pages 1 10 as originally filed
pages NONE filed with the demand
pages NONE filed with the letter of _____
- ☒ the claims
pages 11 16 as originally filed
pages NONE as amended (together with any statement) under Article 19
pages NONE filed with the demand
pages NONE filed with the letter of _____
- ☒ the drawings
pages 1 3 as originally filed
pages NONE filed with the demand
pages NONE filed with the letter of _____
- ☐ the sequence listing part of the description
pages NONE as originally filed
pages NONE filed with the demand
pages NONE filed with the letter of _____

2 With regard to the language all the elements marked above were available or furnished to this Authority in the language in which the international application was filed unless otherwise indicated under this item
These elements were available or furnished to this Authority in the following language _____ which is

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23 1(b))
- ☐ the language of publication of the international application (under Rule 48 3(b))
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55 2 and/or 55 3)

3 With regard to any nucleotide and/or amino acid sequence disclosed in the international application the international preliminary examination was carried out on the basis of the sequence listing

- ☐ contained in the international application in printed form
- ☐ filed together with the international application in computer readable form
- ☐ furnished subsequently to this Authority in written form
- ☐ furnished subsequently to this Authority in computer readable form
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

4 The amendments have resulted in the cancellation of

- ☐ the description pages NONE
- ☐ the claims Nos NONE
- ☐ the drawings sheets/fig NONE

5 This report has been established as if (some of) the amendments had not been made since they have been considered to go beyond the disclosure as filed as indicated in the Supplemental Box (Rule 70 2(c)) **

* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as originally filed and are not annexed to this report since they do not contain amendments (Rules 70 16 and 70 17)

** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No
PCT/US02/21099

V Reasoned statement under Rule 66 2(a)(u) with regard to novelty, inventive step or industrial applicability, citations and explanations supporting such statement

1 STATEMENT

Novelty (N)	Claims 1 38	YES
	Claims NONE	NO
Inventive Step (IS)	Claims 1 38	YES
	Claims NONE	NO
Industrial Applicability (IA)	Claims 1 38	YES
	Claims NONE	NO

2 CITATIONS AND EXPLANATIONS

Claims 1 38 meet the criteria set out in PCT Article 33(2) (3) because the prior art does not teach or fairly suggest a method comprising feeding coal into a chamber which is sealed to the atmosphere moving the coal within said chamber towards discharging end injecting essentially pure oxygen in such a way as to combust a portion of the coal while maintaining a pressurized reduced atmosphere to cause release of high levels of thermal energy to devolatilize the coal and to yield a pressurized hydrogen rich raw gas containing coal derived cancer causing distillates and hydrocarbons together with hot char cracking the coal derived cancer causing distillates and hydrocarbons contained in the hydrogen rich raw gas to make a hydrogen rich cracked gas which after desulfurization becomes clean hydrogen rich synthesis gas directing the hot char to a gasifier which is sealed to the atmosphere gasifying the hot char with air in said gasifier to yield a raw fuel gas and molten slag flowing the raw fuel gas together with the molten slag through a common port out of said gasifier to maintain said port open for the free flow of the raw fuel gas and the molten slag separating the raw fuel gas from the molten slag after exiting from said common port directing the raw fuel gas to cleanup system to clean it and thus yield clean fuel gas suitable for combustion with low NOx formation and quenching the molten slag to convert it to a non leaching solid

Claims 1 38 meet criteria of industrial applicability under PCT Article 33(4) because claimed system can be used to provide fuel for fuel cell and therefore for electric power production

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LAW OFFICES OF
MARSHALL & MELHORN LLC

FOUR SEAGATE

EIGHTH FLOOR

TOLEDO OHIO 43604

(419) 249-7100

TELECOPIER (419) 249-7151

FIRM E MAIL attorneys@marshall-melhorn.com

<http://www.marshall-melhorn.com>

EDWIN J. MARSHALL 11873 1946
DONALD F. MELHORN 11889 1974

EDWIN E.
DONALD F. MELHORN JR.
PAUL M. KRAUS
PHILLIP S. OBERLIN

MICHIGAN OFFICE
204 SOUTH MACOMB STREET
MONROE MICHIGAN 48151
(734) 457-2444

JUSTICE G. JOHNSON JR. A
THOMAS W. PALMER
KENNETH J. WHITE
THOMAS P. KILLAM
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KRISTEN A. CONNELLY
JOHN A. BORELL JR.
JANICE K. YOON

ADMITTED TO PRACTICE IN OHIO
THE PATENT AND TRADEMARK OFFICE
ALSO ADMITTED IN MICHIGAN

December 10, 2003

The International Bureau of WIPO
34 chemin des Colombettes
1211 Geneva 20, Switzerland

VIA FEDERAL EXPRESS
8428 2988 2376

Re International Application No. PCT/US02/21099 filed 08 July 2002
Request For Recording Of Change of Applicant Under Rule 92^{bis}
Title Method for Producing Clean Energy From Coal
Applicant Calderon Energy Company of Bowling Green, Inc.
(Our File 53-15755)

Dear Sir/Madam

Pursuant to Rule 92^{bis}, Applicant requests The International Bureau of WIPO to record a Change of Applicant from that appearing in the Request as originally filed. The Applicant Calderon Energy Company of Bowling Green, Inc. has assigned their entire rights to Calderon Syngas Company as noted below.

New Applicant Calderon Syngas Company, an Ohio corporation
500 Lehman Avenue
Bowling Green, Ohio 43402
United States of America

State of Nationality US
State of Residence US

Phone (419) 354-4632 Fax (419) 353-6293

This Request under Rule 92^{bis} is being filed prior to the 30-month deadline date of January 9, 2004, and due to the upcoming national phase filing, Applicant respectfully requests an expeditious recording of change of Applicant and issuance of PCT/IB/306.

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The International Bureau of WIPO
December 10 2003
Page 2

A copy of the Assignment from Calderon Energy Company of Bowling Green, Inc the Applicant in the subject international application to Calderon Syngas Company is attached hereto, along with a newly executed PCT Power of Attorney document for the new Applicant Calderon Syngas Company

Please record the change of Applicant identified above to ensure it is on record with the International Bureau of WIPO in respect of the above captioned international application

Respectfully yours,

MARSHALL & MELHORN LLC



Donald A. Schurr

Attorney for Applicant, Reg No 34 247

DAS/km
Attachments

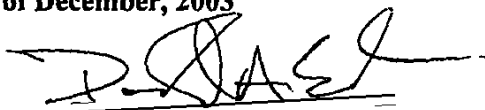
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H
Belle Mead

132

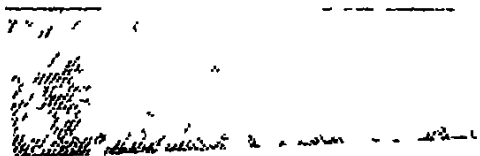
State of Ohio)
) ss
County of Lucas)

I, Donald A Schurr, a Notary Public in and of the State of Ohio, maintaining my office at Four SeaGate - 8th Floor, Toledo, Ohio, USA, do hereby certify that the attached is a true and correct copy of the Assignment document dated December 5, 2003, whereby CALDERON ENERGY COMPANY OF BOWLING GREEN, INC , a corporation of the State of Ohio, sold, assigned and transferred their entire right, title and interest in, to and under the invention found in U S Application No 09/901,554 filed July 9, 2001, and PCT International Application No PCT/US02/21099 filed July 8, 2002, entitled "Method For Producing Clean Energy From Coal", to CALDERON SYNGAS COMPANY, a corporation of the State of Ohio, residing at 500 Lehman Avenue, Bowling Green, Ohio 43402 USA, for the United States and its territorial possessions and in all foreign countries, including all rights to claim priority, and any legal equivalent thereof in a foreign country

Signed in Toledo, Ohio, this 22nd day of December, 2003


Notary Public

 DONALD A. SCHURR
Notary Public - State of Ohio
My commission has no expiration date.
Section 147.03 R.C.



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Attorney's Docket Nos. 1 15755 & 53-15755

PATENT

For ☒ U S and/or ☒ Foreign Rights
 For ☒ U S Application or
 ☐ U S Provisional Application
 For ☐ U S Patent
 For ☒ PCT Application
 By ☐ Inventor(s) or ☒ Present Owner

ASSIGNMENT OF INVENTION

In consideration of the payment by ASSIGNEE to ASSIGNORS of the sum of One Dollar (\$1.00) the receipt of which is hereby acknowledged and for other good and valuable consideration,

ASSIGNORS

Inventors or persons or entities who own the invention

CALDERON ENERGY COMPANY OF BOWLING GREEN, INC.
500 LEHMAN AVENUE
BOWLING GREEN OHIO 43402

AN OHIO CORPORATION U S A
 Nationality

by virtue of an assignment recorded on May 2 2003 at Reel 012869 and Frame 0564 hereby
 sells assigns and transfers to

ASSIGNEE CALDERON SYNGAS COMPANY
500 LEHMAN AVENUE
BOWLING GREEN, OHIO 43402

AN OHIO CORPORATION, U S A
 Nationality

and the successors, assigns and legal representatives of the ASSIGNEE

the entire right title and interest, and in all foreign countries, including all rights to claim priority
 in and to any and all improvements which are disclosed in the invention entitled

METHOD FOR PRODUCING CLEAN ENERGY FROM COAL

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Attorney's Docket No. 1 15755 & 53-15755Name of inventors ALBERT CALDERON and TERRY JAMES LAUBIS

and which is found in U.S. Serial No. 09/901,554 filed July 9, 2001, and in PCT application No. PCT/US02/21090 filed July 8, 2003, and any legal equivalent thereof in a foreign country including the right to claim priority, and, in and to, all Letters Patent to be obtained for said invention by the above application or any continuation, division, renewal or substitute thereof and as to letters patent any reissue or re-examination thereof

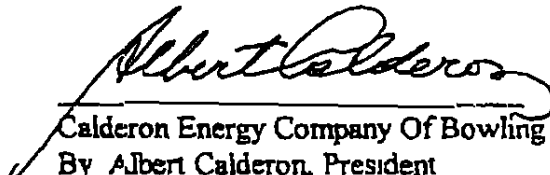
ASSIGNOR hereby covenants that no assignment, sale, agreement or encumbrance has been or will be made or entered into which would conflict with this assignment

ASSIGNOR further covenants that ASSIGNEE will, upon its request, be provided promptly with all pertinent facts and documents relating to said invention and said Letters Patent and legal equivalents as may be known and accessible to ASSIGNOR and will testify as to the same in any interference, litigation or proceeding related thereto and will promptly execute and deliver to ASSIGNEE or its legal representatives any and all papers, instrument or affidavits required to apply for, obtain, maintain, issue and enforce said application, said invention and said Letters Patent and said equivalents thereof which may be necessary or desirable to carry out the purposes thereof

ASSIGNOR

Date

12/5/2003


Calderon Energy Company Of Bowling Green, Inc.
By Albert Calderon, President

PCT

POWER OF ATTORNEY

(for an international application filed under the Patent Cooperation Treaty)

(PCT Rule 90.4)

The undersigned applicant(s) (Names should be indicated as they appear in the request)

Calderon Syngas Company an Ohio corporation
500 Lenman Avenue
Bowling Green Ohio 43402
United States of America

hereby appoint (appoint) the following person as



agent



common representative

Name and address

(Family name followed by given name for a legal entity full official designation. The address must include postal code and name of country.)

SCHURR Donald A Reg No 34 247 DOLGORUKOV D Edward Reg No 26,266 OBERLIN Phillip
S Reg No 19 066 HIXON Mark A Reg No 44 766 EVANS, Stephen P Reg No 47 281 COLWELL
Angelica M Reg No 46 637 and KIMMET Stephen G Reg No 52 488 all of the law firm of
MARSHALL & MELHORN LLC
Four SeaGate 8th Floor
Toledo Ohio 43604
United States of America

to represent the undersigned before



all the competent International Authorities



the International Searching Authority only



the International Preliminary Examining Authority only

in connection with the international application identified below

Title of the invention Method for Producing Clean Energy From Coal

Applicant's or agent's file reference 53-15755

International application number (if already available) PCT/US02/21099

filed with the following Office United States Patent and Trademark Office as receiving Office
and to make or receive payments on behalf of the undersigned

Signature of the applicant(s) (where there are several applicants, each of them must sign and in each signature indicate the name of the person signing and the capacity in which the person signs (if not capacity is not obvious from reading the request or the power))

Albert Calderon
Albert Calderon President

Date

X 12/9/2003

SUBSECRETARÍA Y COMERCIO
Radicación : 84802762 84802762 Folios: 135
Fecha (ARD): 2004-01-16 16:17:25
Trámite : 011 PCI-PATENT 379 FASE NACI 411 PRESENTAR
Dependencia: 0200 DIVISION DE NUEVAS CREACIONES

REQUISITOS NECESARIOS PARA PRESENTACION Y AGILIZACION DEL TRAMITE

	USUARIO	RADICADOR
PATENTE DE INVENCION ☒ MODELO DE UTILIDAD	()	()
- Indicación de que se solicita la concesión de una patente.	()	()
- Datos de identificación del solicitante o de la persona que se presenta la solicitud.	()	()
- Descripción de la invención.	()	()
- Dibujos de ser estos pertinentes.	()	()
- Comprobante de Pago de las tasas establecidas.	()	()

COMPLETA ()	INCOMPLETA ()
--------------	----------------

DISEÑO INDUSTRIAL ()	
- Indicación de que se solicita el registro de Diseño Industrial	()
- Datos de identificación del solicitante o de la persona que presenta la solicitud.	()
- Representación gráfica y fotográfica del Diseño Industrial o muestra del Material que incorpora el diseño.	()
- Comprobante de pago de las tasas establecidas	()

COMPLETA ()	INCOMPLETA ()
--------------	----------------

ESQUEMA DE TRAZADO ()	
- Indicación de que solicita el registro de un Esquema de trazado.	()
- Datos de identificación del solicitante o de la persona que presenta La solicitud.	()
- Representación gráfica del esquema de trazado	()
- Comprobante de pago de las tasas establecidas.	()

COMPLETA ()	INCOMPLETA ()
--------------	----------------

Firma Responsable:

Fecha:

Folios 136 et 139
Extracto publicaciones



2020
Bogotá, D C ,

Doctora
Dilia María Rodríguez D'Aleman
Apoderada
Calderon Syngas Company

8-534
Oficio N°
04750

ASUNTO	Radicación N°	04-2782
	Solicitud internacional	PCT/US2002/21099
	Fecha inicio fase nacional	09/02/2004
	Trámite	011
	Evento	379
	Actuación	430
	Folios	001

Como resultado del examen de forma, realizado con fundamento en el artículo 38 de la Decisión 486 de la Comisión de la Comunidad Andina, artículo 27 del Tratado de Cooperación en Materia de Patentes (PCT), regla 51 bis del Reglamento y Circular Única de la Superintendencia de Industria y Comercio, se le comunica que

- La solicitud no contiene la copia del documento en que consta la cesión del derecho a la patente del inventor al solicitante o a su causante (Art 26-k Decisión 486)
- La solicitud no contiene el poder debidamente otorgado, con el lleno de los requisitos exigidos por los artículos 63 y subsiguientes del Código de Procedimiento Civil. Adicionalmente, deberá presentar el documento que acredita la existencia y representación legal de la sociedad solicitante, cuando ésta fuere persona jurídica

En cumplimiento de lo dispuesto por el artículo 39 de la Decisión 486, se le requiere para que dentro del término de dos meses siguientes a la fecha de notificación del presente oficio, complete los requisitos anteriormente enunciados. En caso de no dar cumplimiento al presente requerimiento, la solicitud se considerará abandonada y perderá su prelación.

Notifíquese el presente oficio conforme a lo dispuesto en el numeral 5.2, literal e), del capítulo quinto del título primero de la Circular Única N° 10 de 2001.


ALIX CARMENZA CESPEDES DE VERGEL
Jefe de la División de Nuevas Creaciones.

El anterior requerimiento fue notificado por fijación en lista de fecha

07 MAYO 2004