LOW SULPHUR FUEL SYSTEM UTLIZING COAL CHAR, AND COPRODUC S THEREOF

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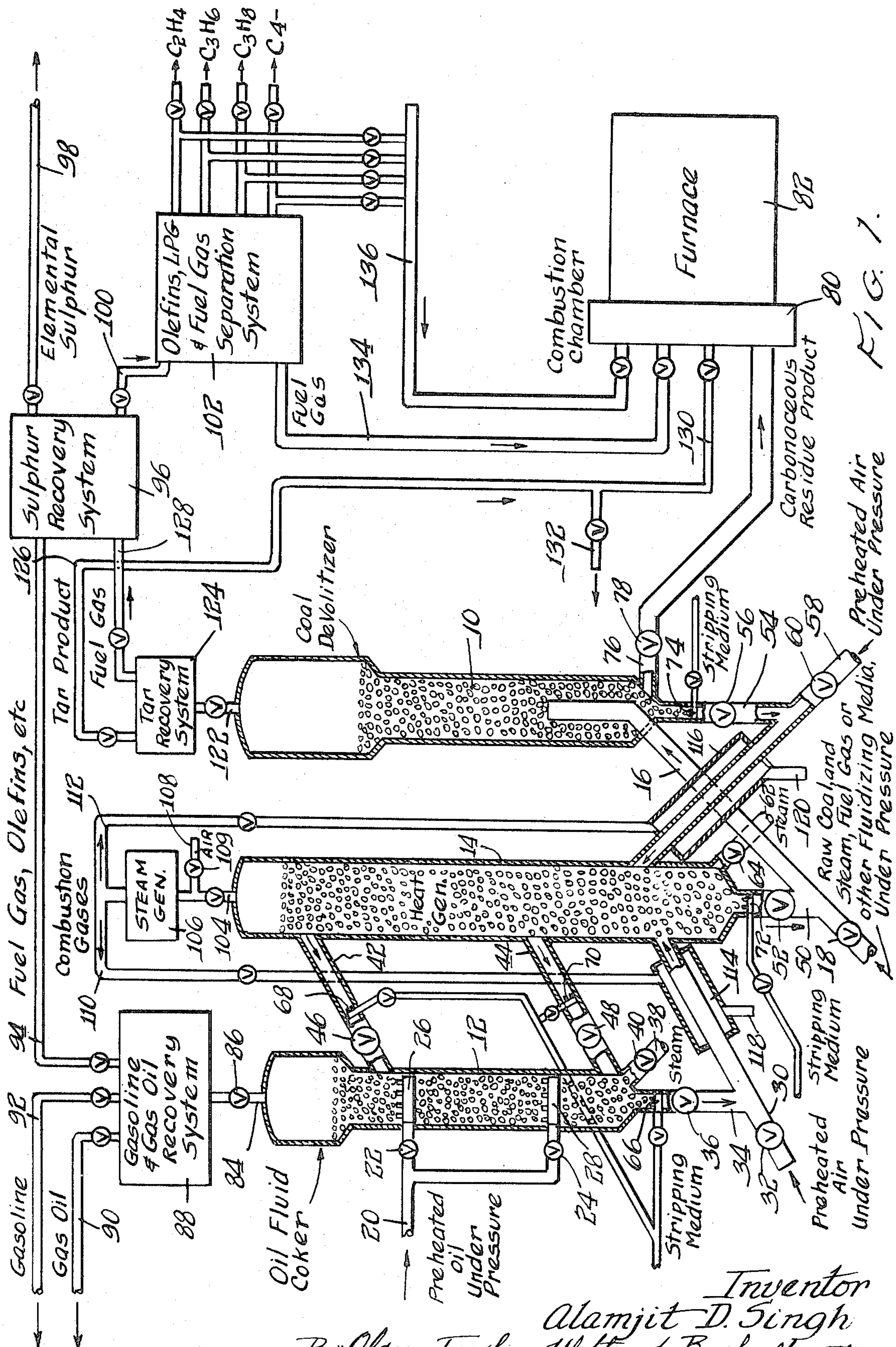

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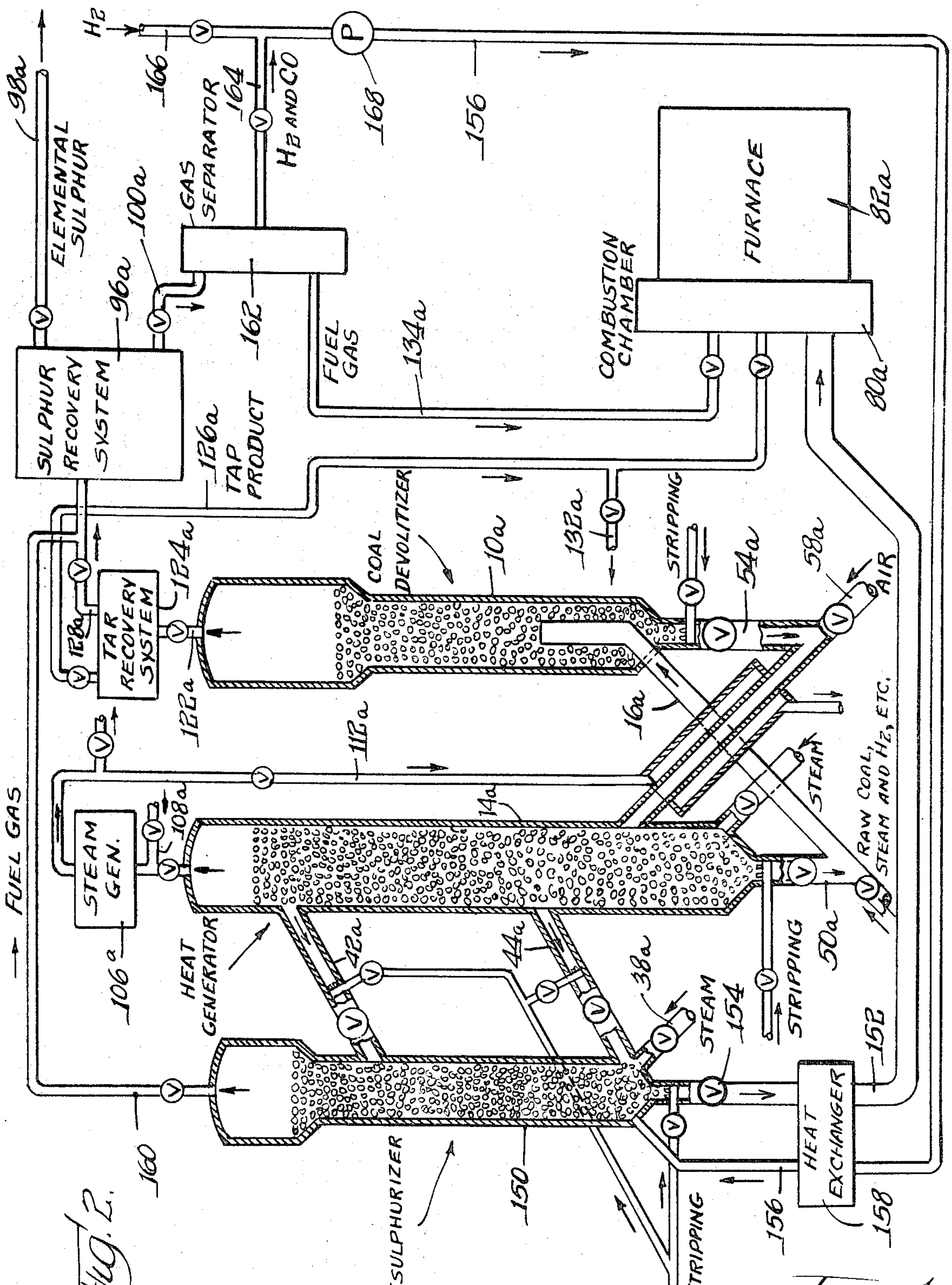

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LOW SULPHUR FUEL SYSTEM UTILIZING COAL CHAR, AND COPRODUCTS THEREOF

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Continuation-in-part of application Ser. No. 801,460, Feb. 24, 1969, which is a continuation-in-part of application Ser. No. 415,603, Dec. 3, 1964. This application Aug. 24, 1970, Ser. No. 66,337
Int. Cl. C10l *5/00;* C10g *1/00*
U.S. Cl. 44—1 R 15 Claims

ABSTRACT OF THE DISCLOSURE

In accordance with the disclosure of the present invention in one embodiment, coal in granular form is heated and introduced under pressure into a coal devolatilizer forming a reaction chamber for the coal and from which reaction by-products are separately withdrawn. Preheated oil is introduced under pressure into an oil fluid coker forming a reaction chamber for the oil, and from which oil reaction products are separately withdrawn. Granular residue from the coal devolatilizer and oil fluid coker are introduced under pressure into a heat generator in which further reaction takes place, there being means for effecting an interchange of material between the coal devolatilizer and the heat generator, and between the oil fluid coker and the generator. The by-products from the oil fluid coker and from the coal devolatilizer are separately processed, and the desulphurized fuel components thereof are used with the carbonaceous product, which is a combined coal char and oil fluid coke, produced by the system; whereby to provide a low sulphur fuel system, and also elemental sulphur and other useful by-products which may be separately utilized. The use of the oil fluid coker is optional; and in one form of the invention the oil fluid coker vessel is used as a further processing vessel for desulphurizing the coal, into which hydrogen is introduced to further the desulphurization process.

This invention relates to the treatment and production of fuels, and coproducts or by-products therewith, and concerns more specifically a low sulphur fuel system utilizing coal and oil, or coal alone, wherein the fuel produced has greatly reduced sulphur content, compared with the sulphur content of the original coal and oil utilized in the system.

The application is a continuation-in-part of my prior application Ser. No. 801,460, filed Feb. 24, 1969, now abandoned, which is in turn a continuation-in-part of my prior application titled "Process for Producing Combined Coal Char and Oil Coke, and Co-Products Therewith," Ser. No. 415,603, filed Dec. 3, 1964, and now issued as Pat. No. 3,437,562, dated Apr. 8, 1969.

In said prior copending application Ser. No. 415,603, now Pat. No. 3,437,562, there is disclosed a process, and accompanying apparatus, wherein coal in granular form, and hydrocarbon oil, are introduced into a system comprising a coal devolatilizer, an oil fluid coker, and a heat generator; whereby to provide a carbonaceous fuel which is a combination of coal char and oil coke, and coproducts or by-products therewith which may be separately processed. As is pointed out in said copending application, coal char has a lower sulphur content, as compared with the coal from which it is made, whereas oil fluid coke may have a somewhat higher sulphur content as compared with the oil from which it is produced. However, the carbonaceous fuel which is a combination of coal char and oil coke will have a sulphur content which lies between but is lower than the combination of the two individual components from which it is produced. Thus if a coal having a relatively higher sulphur content is utilized with oil having a relatively lower sulphur content, a combined coal char and oil coke may be produced which has a considerably lower sulphur content than the original coal. The process of said prior copending application thus inherently provides means, and methods, for producing a carbonaceous fuel which is a combination of coal char and oil coke, and which has a lower sulphur content compared with the sulphur content of the original oil and coal of the system. Lower sulphur in relation to heat value further results from the elimination of moisture and moisture producing components, as will be more particularly hereinafter described.

However, the amount of the sulphur reduction as above is dependent upon the amount of oil used, which is generally the more expensive component, in relation to the coal; and it may be that the sulphur content of the coal, or of the oil, or economic considerations, dictate the desirability of further sulphur reduction to minimize sulphur dioxide (SO_2) emission in the burning of the fuel; whereby to reduce air pollution, and comply with municipal regulations concerning the emission of sulphur dioxide into the atmosphere.

In accordance with the present invention, in one embodiment thereof, the basic process of the prior copending application is used, but further means and methods are provided for the reduction of sulphur in the resulting fuel; whereby to permit the utilization of coal having a relatively high sulphur content which otherwise cannot be used without excessive atmospheric pollution. Specifically in accordance with the present invention, pressurization is used within the coal devolatilizer and the oil fluid coker, wherein it has been found that such pressurization increases the interaction between hydrogen and sulphur, effecting increased extraction of the sulphur from the coal and from the oil. Further, in accordance with the present invention, the fuel components of the coproducts or by-products of the system are desulphurized, and then combined with or utilized with the carbonaceous fuel, which is the combined coal char and oil coke, in a manner to produce a combined fuel which has a greatly reduced sulphur content as compared with the oil and coal which form the charging components for the system. In this manner means and methods are provided for utilizing oil and coal, and particularly the latter, which are excessive or high in sulphur content, and thus may not be used without excessive sulphur dioxide emission and air pollution. Still further, the coproduct or by-product recovery, in accordance with the system of the present invention, which includes the recovery of elemental sulphur, provides for by-product utilization and economic advantages which are materially enhanced, as compared for example with the attempted recovery and utilization of SO_2 as a single by-product from the vastly greater volumes of waste furnace stack gases.

The combination of the coproducts or by-products of the system, with the char, whereby to provide a low sulphur combined fuel, and the pressurization features of the present invention, are useful in a system utilizing coal alone, and such a system is shown in one embodiment. In such embodiment hydrogen is introduced into contact with the char to further the desulphurization process.

It is accordingly an object of the present invention to provide a treatment and production method for fuels, to produce a carbonaceous fuel which is a combination of coal char and oil coke, or coal alone, and wherein pressure is utilized during the processing in a manner to reduce the sulphur content of the resulting fuel, and hydrogen is applied to the carbonaceous fuel to further the desulphurization process.

A further object of the invention is to provide a process for the production of fuel, which includes the production of a carbonaceous fuel which is a combination of coal char and oil coke, or coal char alone, and wherein the fuel components of the produced coproducts or byproducts are desulphurized and then used with the carbonaceous fuel, in a manner to provide a maximum of heat energy in relation to the sulphur content of the fuel.

A still further object of the invention is to provide in a fuel producing system, as above set forth, for the separation and utilization of by-products or coproducts produced from the coal and from the oil; which may be recovered and utilized for maximum economic worth.

Various other objects, advantages and features of the invention will be apparent from the following specification when taken in connection with the accompanying drawings, wherein certain preferred embodiments of the invention are set forth for purposes of illustration.

FIG. 1 illustrates an embodiment utilizing coal and oil; and

FIG. 2 sets forth an embodiment utilizing coal alone.

Referring more particularly to the drawings, in the embodiment of FIG. 1, the fuel processing apparatus comprises, generally, a coal devolatilizer **10**, an oil fluid coker **12** and a heat generator **14**. Coal, together with steam, fuel gas or other fluidizing media is introduced into the coal devolatilizer, under pressure, through a supply conduit **16**. By way of illustration, the coal may preferably be bituminous coal, of a particle size for example eight mesh and smaller down to relatively fine particles, and it may be either coking or non-coking in character. The introduction of the coal and the fluidizing media is under the control of a valve, as indicated at **18**. Within the coal devolatilizer the coal is processed and coal char is formed.

As stated, the coal and fluidizing media are introduced into the supply conduit **16** under pressure, and during the processing, in accordance with the present invention, the coal devolatilizer and the heat generator and the oil fluid coker, are all maintained under the same relatively high pressure, which as will be presently pointed out, increases the extraction of sulphur from the material being processed, particularly in the reactions which occur within the coal devolatilizer and the oil fluid coker. There does not appear to be criticality in any particular pressure, viz, as the pressure is increased the extraction of sulphur is increased; and accordingly the pressure within the coal devolatilizer **10**, the oil fluid coker **12**, and the heat generator **14** may be as much as 1500 pounds per square inch, or more. However, in a preferred embodiment the pressure may be on the order of 150 to 200 pounds per square inch, which, it has been found, effects a material increase in sulphur extraction, as compared with non-pressurized operation; while at the same time avoiding very high pressures which increase the cost of fabrication of the pressure vessels. As will be understood, in a full scale commercial installation, these may be one hundred feet or more in height.

Preheated oil under pressure is delivered from a supply line **20**, under control of a pair of valves **22** and **24**, to a pair of spray heads or atomizers **26** and **28**, disposed within the oil fluid coker **12**. The oil supplied may be any suitable hydrocarbon mineral oil. Examples are oil from crude oil wells or tar sands or oil shale, or asphalt, either in natural form or from which one or more fractions have been removed such as reduced crude or "Bunker C" oil. The oil may also be obtained from the processing of coal or other carbonaceous materials such as lignite, or peat and the like. The oil will be selected in accordance with the economics of the particular location of the apparatus. Within the fluid coker the oil is cracked, and a generally granular fluid coke or char is produced.

Preheated air under pressure is supplied from a line **30**, under control of a valve **32** leading to the heat generator **14**, and this line interconnects with a line **34** under control of a valve **36** leading from the bottom of the oil

fluid coker, by means of which the oil fluid coke or reaction product within the oil fluid coker is withdrawn and intermixed with the preheated air in the line **30** and delivered into the bottom of the heat generator **14**.

A steam line for steam under pressure, as indicated at **38**, controlled by a valve **40**, is provided leading into the bottom of the oil fluid coker, to aid in fluidizing the char bed within the fluid coker, and maintaining agitation therein.

Char from the heat generator is returned to the oil fluid coker through a pair of conduits **42** and **44**, under control of valves **46** and **48**; the conduits **42** and **44**, and the conduits **30** and **34** thus providing for interchange of char between the oil fluid coker and the heat generator in a continuous circulation.

In a similar manner continuous circulation or interchange of char between the coal devolatilizer and the heat generator is provided. To this end, a conduit **50**, under control of a valve **52**, is provided at the lower end of the heat generator, interconnecting with the coal supply line **16**, in a manner so that char is supplied from the heat generator into the coal devolatilizer, along with the incoming raw coal. Similarly, the lower end of the coal devolatilizer is provided with a conduit **54**, under control of a valve **56**, which conduit interconnects with a supply line **58**, under control of a valve **60** for preheated air under pressure, leading to the lower portion of the heat generator **14**. By this means char and reaction products are continuously interchanged between the heat generator and the coal devolatilizer, through conduits **50** and **16**, and conduits **54** and **58**, providing continuous circulation.

A steam line, as indicated at **62**, for steam under pressure, leads to the lower end of the heat generator, to control the temperature therein, and to maintain proper agitation of the fluidized char bed. Steam line **62** may be controlled by a valve **64**, as will be understood.

The preheated air introduced into the heat generator through the conduits **30** and **58**, effects a partial burning of the char product therein, thus supplying heat for the operation of the system. In an illustrative embodiment the temperature within the heat generator may be maintained in the range of 1200–1250° F., with the temperature within the oil fluid coker and the coal devolatilizer being maintained in the range of 900–950° F.

In order to preclude the improper flow of gases downwardly through the conduit **34**, at the bottom of the oil fluid coker, there is provided a valve controlled stripping device, as indicated at **66**, into which steam is supplied under pressure so as to sweep the gases upwardly, through the vessel **12**, and to preclude downward flow through the conduit **34**. Such steam under pressure also aids in fluidizing the char bed within the oil fluid coker. In a similar manner conduits **42** and **44** are provided with pressure steam stripping devices, as indicated at **68** and **70**; conduit **50** at the lower end of the heat generator is supplied with a stripping device **72**; and conduit **54** at the lower end of the coal devolatilizer is provided with a pressure steam stripping device **74**.

As is pointed out in the copending application to which reference has hereinbefore been made, in a system constituted as hereinbefore described, the continuous interchanger of granular carbonaceous material between the coal devolatilizer and the heat generator and the oil fluid coker, with the processing of the material within the coal devolatilizer and the oil fluid coker with heat supplied by the heat generator, and the further processing of the material within the heat generator, produces a granular carbonaceous fuel, the individual particles of which comprise a combination of coal char and oil fluid coke. The carbonaceous granular fuel thus produced, may be withdrawn from any of the three vessels, but in the embodiment herein shown, it is withdrawn from the bottom of the coal devolatilizer by means of a conduit **76**, under control of the valve **78**. Conduit **76** leads to the combustion chamber **80**, of a furnace **82**, as shown.

In accordance with the present invention, as heretofore set forth, a suitable high pressure is maintained within the coal devolatilizer **10**, the heat generator **14**, and the oil fluid coker **12**, which may be on the order of 150–200 p.s.i. on up to 1500 p.s.i., or more, if the strength capacity of the vessels so permits. Hydrogen is formed during the processing operation, and it has been found that the elevated pressure materially increases the interaction between the hydrogen and the sulphur in the coal, and in the oil, particularly in the coal devolatilizer and the oil fluid coker, whereby the carbonaceous fuel product produced has a materially lower sulphur content. The reacted hydrogen and sulphur are withdrawn and transmitted to the byproduct or coproduct recovery system, which will now be described.

Byproducts or coproducts are exhausted or withdrawn from the top of the oil fluid coker through an exhaust line **84**, under control of a valve **86**, leading to a gasoline and gas oil recovery system, which may be of any conventional character, designated diagrammatically at **88**. From the recovery system the gas oil is directed through a valve controlled exhaust line **90**, the gasoline is directed to a valve controlled exhaust line **92**, and the fuel gas, olefins, and the like are directed by means of a valve controlled exhaust line **94** to a sulphur recovery system diagrammatically designated at **96**. The fuel gas from the oil fluid coker may contain carbon monoxide, hydrogen, methane, ethane, propane, and hydrogen sulfide; and the olefins may comprise ethylene, propylene, butylene, etc., as will be understood. The sulphur recovery system may be any conventional type such, for example, as the diethanolamine-Clause process or other suitable high temperature acceptor system. From the sulphur recovery system elemental sulphur is withdrawn or discharged through a valve controlled discharge line **98**, whereas the olefins, LPG (liquid petroleum gases) and fuel gas, are directed through a valve controlled discharge line **100** into an olefin, LPG and fuel gas separation system, of any conventional type, diagrammatically indicated by the reference numeral **102**.

Referring to the heat generator **14**, the gases discharged or withdrawn from the upper end thereof will be primarily gases of combustion, and as shown, these are discharged from the heat generator through a valve controlled discharge line **104** to a steam generator, diagrammatically designated as **106**, wherein the primary heat of the combustion gases is extracted and used for the generation of steam used elsewhere in the system as heretofore described. Air to insure complete combustion of the gases is introduced into line **104** from an air supply line **108** controlled by a valve **109**.

From the steam generator the combustion gases are discharged through a pair of valve controlled conduits, as indicated at **110** and **112**, leading respectively to heat exchangers **114** and **116**, for further heating the incoming air in lines **30** and **58**; after which the combustion gases are led respectively to exhaust lines **118** and **120**, and thereafter to suitable scrubbing devices (not shown) and exhausted into the atmosphere. In instances wherein sufficient heat is extracted in the steam generator so that the gases cannot be advantageously used in the heat exchanger, the gases may be vented from lines **110** and **112** through exhaust lines **111** and **113**.

Referring to the coal devolatilizer **10**, the coproducts or byproducts discharged therefrom, at the upper end, through a valve controlled exhaust conduit **122**, pass into a tar recovery system, of any conventional type, designated by the reference numeral **124**. The tar product from the tar recovery system leads to a valve controlled discharge line **126**, as shown, whereas the fuel gas is directed through a valve controlled discharge line **128** to the sulphur recovery system **96**.

In accordance with the present invention, the tar product, which is low in sulphur, may be led into the furnace combustion chamber through a combustion supply line,

as indicated at **130**, or if market conditions so warrant, the tar product may be discharged through a valve controlled discharge line **132** to be used for other industrial purposes, such for example in the treatment of open hearth steel, etc.

Referring further to the olefin, LPG, and fuel gas separation system **102**, it will be seen that the fuel gas component is delivered from this separation system to the combustion chamber of the furnace through a valve controlled discharge line or conduit **134**, whereas the other discharge products such as ethylene (C_2H_4) and propylene (C_3H_6) and propane (C_3H_8) and butanes (C_4—) may be individually discharged through valve controlled discharged lines, as shown, or directed by valve controlled bypass lines into a valve controlled conduit **136** leading to the combustion chamber **80** of the furnace **82**. As in the case of the tar product, market conditions will dictate whether these components are to be burned, or to be separately discharged for other industrial uses.

It is important to note that the fuel gas, and the other discharge products of the olefin, LPG, and fuel gas separation system, are essentially sulphur-free, by reason of the sulphur extraction in the sulphur recovery system **96**.

It will be seen that in accordance with the present invention, means and methods are provided for producing furnace fuel of greatly reduced sulphur content, as compared with the sulphur content of the coal and oil supplied, and from which the fuel is produced. By way of example, a low cost coal having a sulphur content so high that it cannot be used as a furnace fuel, in accordance with municipal requirements, and without undue pollution of the atmosphere by sulphur dioxide, may be combined with oil, having a lower sulphur content, whereby to produce by such combination a combined coal char and oil fluid coke of reduced sulphur content, compared with the sulphur content of the original charging ingredients. In accordance with the invention, the high pressure in the coal devolatilizer **10**, and in the oil fluid coker **12**, and in the heat generator **14**, further reduces the sulphur content of the granular carbonaceous fuel produced, by the increased interaction between hydrogen and sulphur, particularly in the oil fluid coker and the coal devolatilizer. This sulphur appears in the fuel gas, and in the olefins and the like transmitted to the sulphur recovering system wherein elemental sulphur is extracted and recovered for industrial use. The essentially sulphur-free fuel gas, and optionally the other hydrocarbons recovered in the separation system, may then be transmitted to the combustion chamber of the furnace, along with the essentially sulphur-free tar product from the coal devolatilizer whereby, and by reason of the system thus provided, a maximum of heat energy is provided by the coal and oil, with a minimum of sulphur, or as it may be expressed, a minimum number of pounds of sulphur emission to the atmosphere, per million B.t.u.'s.

As previously mentioned, due to the elimination of moisture from the combined carboneous fuel, and due to the elimination of hydrogen, the formation of moisture in combustion is minimized, thus providing minimized heat loss due to moisture and increased heat value in relation to the sulphur present; further reducing the sulphur content per million B.t.u.'s of available heat.

The value of the recovered co-product or by-products essentially offsets the cost of the separation system.

As will be understood, the use of the oil fluid coker in the system is optional. To this end it will be noted that the oil fluid coker can be cut off completely from the system by manipulation of the valves in the various pipe lines, thus to utilize the coal devolatilizer and the heat generator, in the manner therefore described, and for the purposes heretofore set forth. When the oil fluid coker is thus not utilized, the advantages flowing from the use of oil in the system are not obtained; but a sulphur reduction is nevertheless secured, in the manner heretofore set forth, as compared with the sulphur content of the coal supplied to the system.

In FIG. 2 an embodiment of the invention is set forth, utilizing coal alone, and wherein the oil fluid coker vessel is replaced by a vessel for further processing the coal, so as to effect a further removal of the sulphur therefrom.

Referring to FIG. 2, the coal devolatilizer **10***a* and the heat generator **14***a* are provided, functioning in the manner heretofore described. In place of the oil fluid coker, and interconnected with the heat generator in the manner previously described, there is provided a vessel indicated by the reference numeral **150**, and designated as a "desulphurizer."

Referring to FIG. 2, the raw coal is introduced into the coal devolatilizer by means of a pipe line, indicated as **16***a*, as in the embodiment previously described. From the coal devolatilizer the coal or char is transmitted to the heat generator **14***a* by means of conduits **54***a* and **58***a*, as in the embodiment previously described. From the heat generator the coal or char is transmitted to the desulphurizer **150** through conduits **42***a* and **44***a*, also as previously set forth.

The processed coal, in the form of char, is withdrawn from the desulphurizer by means of a conduit **152**, under control of a valve **154**, for transmission to the combustion chamber of the furnace.

The entire system preferably is pressurized, as in the previously described embodiment. The temperature within the coal devolatilizer may be maintained within the range of 800° F. to 1000° F. Within the heat generator the temperature may be maintained within the range 1000° F. to 1200° F., by reason of the partial burning of the coal or char which takes place therein; and within the desulphurizer the temperature may be maintained within the range of 1300° F. to 1700° F.

The higher temperature range within the desulphurizer is obtained, in the embodiment set forth, by a reaction of hydrogen with the coal char, within the desulphurizer chamber. To this end, hydrogen is introduced into the desulphurizer by means of a conduit or pipe line **156**, leading into the lower section of the chamber, to aid in maintaining a fluidized bed, along with the stripping medium and the steam introduced through the pipe line **38***a*. The hydrogen pipe line **156** passes through a heat exchanger **158** through which the char exhaust conduit **152** also passes, and wherein the hydrogen gases will be heated from the exhaust char.

The exhaust gases from the desulphurizer, which will comprise essentially fuel gas containing H_2S, CO, CH_4 and H_2, are transmitted by means of a conduit or pipe line **160** to the pipe line **128***a* which leads from the tar recovery system **124***a* of the coal devolatilizer; for transmission to the sulphur recovery system, as previously described, and as indicated by the reference numeral **96***a*. From the sulphur recovery system the elemental sulphur is recovered through conduit **98***a*, whereas the gases are transmitted through the conduit **100***a* to a gas separator, as indicated at **162**. Within a gas separator, which may be of conventional type, the H_2, containing CO, is transmitted by means of a pipe line **164** to the hydrogen supply line **156**; excess fuel gas being transmitted by the conduit, as indicated by the reference numeral **134***a*, to the combustion chamber of the furnace. Makeup hydrogen is introduced into conduit **156** from a supply line **166**, and a pump or blower as indicated at **168** is provided in pipe line **156** to insure a free circulation of the gases therethrough.

It will be seen that the combined fuel transmitted to the furnace has a greatly reduced sulphur content, as compared with the sulphur content of the original coal. Within the coal devolatilizer, at elevated pressure, the H_2 which is formed extracts sulphur from the char, with the exhaust from the coal devolatilizer being transmitted to the tar recovery system **124***a*, as previously described. The tar product which is transmitted to the furnace through the conduit **126***a* will be essentially sulphur-free. Within the desulphurizer, at elevated pressure, at elevated temperature, the hydrogen introduced through conduit **156**, along with such additional hydrogen as is extracted from the char within the desulphurizer, combines with the sulphur to form H_2S, and effect a further removal of sulphur from the char. The char, with greatly reduced content is then transmitted to the furnace through conduit **152**, whereas the H_2S and other components of the fuel gas are transmitted from the desulphurizer to the sulphur recovery system **96***a*, whereby the fuel gas transmitted to the furnace for combustion, through conduit **134***a* is essentially sulphur-free. As in the previously described embodiment, the combined fuel transmitted to the furnace will have greatly reduced sulphur content as compared with the sulphur content of the original coal.

While in the drawings the various reaction chambers are indicated as separate vessels, it will be understood that the chambers may be formed, if desired, as individual chambers within a single vessel.

It is obvious that various changes may be made in the particular embodiments set forth for purposes of illustration, without departing from the spirit of the invention. The invention is accordingly not to be limited to the particular embodiments shown and described, but only as indicated in the following claims.

The invention is hereby claimed as follows:

1. The method of producing granular carbonaceous product which comprises separately subjecting coal and oil in predetermined proportions to the action of heat and pressure on the order of 150 p.s.i. or more to devolatilize the coal and crack the oil, and thereafter further processing a mix of the coal and oil to provide a carbonaceous product of relatively low sulphur content the individual particles of which comprise combined coal char and oil fluid coke.

2. The method of producing a granular carbonaceous product which comprises introducing coal into a first chamber, subjecting the coal therein to the action of heat and pressure on the order of 150 p.s.i. or more to devolatilize the coal and produce a coal char, introducing oil into a second chamber, subjecting the oil therein to the action of heat and pressure on the order of 150 p.s.i. or more to crack the oil and produce a fluid coke, and subjecting a mix of the char and the fluid coke to the action of heat to provide a carbonaceous product the individual particles of which comprise combined coal char and oil fluid coke.

3. The method of producing a granular carbonaceous product as defined in claim **2** wherein the coal char, oil fluid coke, and carbonaceous product are continuously recirculated between said chambers.

4. The method of producing fuel from coal and oil which comprises separately subjecting coal and oil in predetermined proportions to the action of heat to devolatilize the coal and crack the oil, reacting the hydrogen thereby produced with the sulphur in the coal and oil to provide a sulphur-containing fuel gas, further processing a mix of the coal and oil to provide a carbonaceous product the individual particles of which comprise combined coal char and oil fluid coke, removing the sulphur from the fuel gas, and combining the carbonaceous product and the fuel gas to provide a relatively low sulphur furnace fuel.

5. The method of producing fuel as defined in claim **4** wherein the coal and oil are subjected to the action of heat under pressure of at least several atmospheres.

6. Apparatus for producing a granular carbonaceous product which comprises a first chamber, means for pressurizing said chamber to a pressure on the order of 150 p.s.i. or more, and means for supplying coal thereto, means for supplying heat thereto to devolatilize the coal and produce a coal char, a second chamber, means for pressurizing the second chamber to a pressure on the order of 150 p.s.i. or more, means for introducing oil into said second chamber, means for supplying heat to the second chamber to crack the oil therein to produce a fluid coke, means for mixing the coal char and oil fluid coke, and means for supplying heat to the mix of coal char and oil fluid coke to thereby provide a relatively low sulphur carbonaceous product the individual particles of which comprise combined coal char and oil fluid coke.

7. Apparatus for producing a granular carbonaceous product as defined in claim **6** wherein conduit means is provided connected to each of said chambers for withdrawing by-products therefrom.

8. Apparatus for producing a granular carbonaceous product which comprises a first chamber, means for pressurizing said chamber to a pressure on the order of 150 p.s.i. or more, and means for supplying coal thereto, means for supplying heat thereto to devolatilize the coal and produce a coal char, a second chamber, means for pressurizing the second chamber to a pressure on the order of 150 p.s.i. or more, means for inrtducing oil into said second chamber, means for supplying heat to the second chamber to crack the oil therein to produce a fluid coke, a third chamber, means for maintaining pressure on the order of 150 p.s.i. or more therein, and means for introducing the coal char and oil fluid coke therein, and means for supplying heat to the mix within the third chamber to thereby provide a relatively low sulphur carbonaceous product the individual particles of which comprise combined coal char and oil fluid coke.

9. Apparatus for producing fuel which comprises a first chamber, means for supplying coal thereto, means for supplying heat thereto to devolatilize the coal and produce a coal char, means for reacting hydrogen with said coal char to form a sulphur-containing fuel gas, a second chamber, means for introducing oil into said second chamber, means for supplying heat to the second chamber to crack the oil therein and produce a fluid coke, means for reacting hydrogen with the fluid coke in said second chamber to provide a sulphur-containing fuel gas, means for further processing the coal char and oil fluid coke to form a carbonaceous product the individual particles of which comprise coal char and oil fluid coke, means for removing sulphur from the fuel gas, and means for combining and delivering the sulphur-free fuel gas and carbonaceous product to a common combustion system.

10. Apparatus for producing fuel as defined in claim **9** wherein means is provided for pressurizing said chambers to a pressure of at least several atmospheres.

11. The method of producing fuel from coal which comprises subjecting the coal to heat to devolatilize the coal, reacting the hydrogen thereby produced with the sulphur in the coal to provide a sulphur-containing fuel gas, further processing the coal to form a coal char, extracting sulphur from the char during said further processing, extracting the sulphur from the fuel gas, and combining the fuel gas and char to provide a relatively low sulphur furnace fuel.

12. The method of producing fuel from coal as defined in claim **11** wherein the further processing of the coal comprises a partial burning thereof.

13. The method of producing fuel from coal as defined in claim **12** wherein the further processing of the coal comprises subjecting the coal to the action of hydrogen at elevated temperature to effect the desulphurization thereof.

14. The method of producing fuel from coal which comprises introducing the coal into a first chamber, subjecting the coal to the action of heat in said chamber to effect a partial desulphurization thereof, introducing the coal into a second chamber, effecting a partial burning of the coal in said second chamber, introducing the coal into a third chamber, and subjecting the coal to the action of hydrogen at elevated temperature in said third chamber to effect a further desulphurization of the coal.

15. The method of producing fuel from coal as defined in claim **14** wherein the hydrogen is processed to remove sulphur therefrom, and then recirculated to said third chamber for further reaction with the coal.

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