United States Patent [19]

Kunii et al.

[11] **3,912,465**

[45] **Oct. 14, 1975**

[54] **CONTINUOUS CARBONIZATION AND GASIFICATION OF PARTICULATE COAL WITH DOUBLE RECIRCULATION OF FLUIDIZED PARTICULATE HEAT CARRIER**

[76] Inventors: **Daizo Kunii,** 1-25-16 Nakamachi, Meguro, Tokyo; **Taiseki Kunugi,** 7-17-22-903 Roppongi, Minato, Tokyo, both of Japan

[22] Filed: **July 30, 1974**

[21] Appl. No.: **493,647**

[30] **Foreign Application Priority Data**

Aug. 18, 1973 Japan 48-92080

[52] **U.S. Cl.** .... **48/101;** 48/202; 48/210; 23/288 S

[51] **Int. Cl.**[2] **C10J 3/54**

[58] **Field of Search** .... 48/210, 200, 201, 202, 48/203, DIG. 2, 197, 204, DIG. 1, 101, 123; 23/288 S

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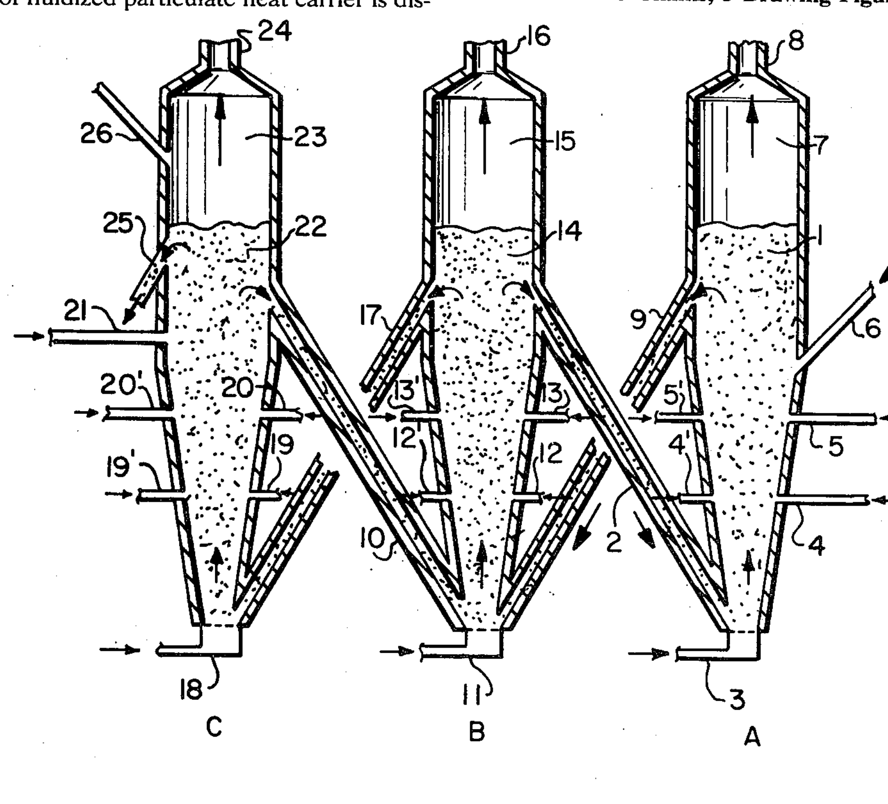
Primary Examiner—R. E. Serwin
Attorney, Agent, or Firm—Armstrong, Nikaido & Wegner

[57] **ABSTRACT**

An apparatus and continuous process for the carbonization and gasification of particulate coal with double recirculation of fluidized particulate heat carrier is disclosed wherein the carbonization and gasification are separately carried out. The process comprises the steps of fluidizing particulate heat carrier with steam to form a first fluidized bed, passing the particulate heat carrier through said first bed in a densely fluidized state from the bottom upwardly to the top of said first bed, and introducing particulate coal into the first bed thereby contacting said coal with said heat carrier to effect carbonization of the coal. The resultant gas and oil vapor are withdrawn from the first bed, and a mixture of the particulate heat carrier and particulate coke produced by the carbonization of the coal is passed from the top of the first bed to the bottom of a second fluidized bed, and the particulate mixture is combined at the bottom of the second fluidized bed with particulate heat carrier coming from a third fluidized bed at a higher temperature. The combined particulate materials are passed through the second fluidized bed in a densely fluidized state from the bottom upwardly to the top of the second bed to effect gasification of the particulate coke. The gasified product is withdrawn from the second bed and a portion of the particulate heat carrier is passed from the top of the second bed to the bottom of a third fluidized bed. The particulate heat carrier together with the accompanying ungasified particulate coke is passed through the third fluidized bed in a densely fluidized state from the bottom upwardly to the top of the third bed, and a hot combustion gas containing air or oxygen is introduced into the third bed thereby burning the ungasified particulate coke and heating said particulate heat carrier. The heated particulate heat carrier is passed from the top of the third bed to the bottom of the second bed for use in the gasification of coke, and another portion of the particulate heat carrier is passed from the top of said second bed to the bottom of said first bed for use in the carbonization of coal.

8 Claims, 5 Drawing Figures



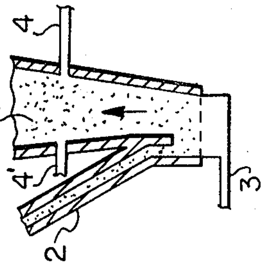


FIG. 3

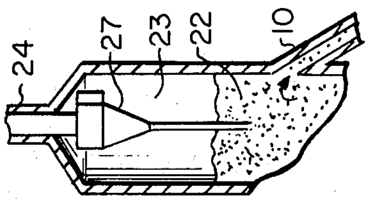


FIG. 2

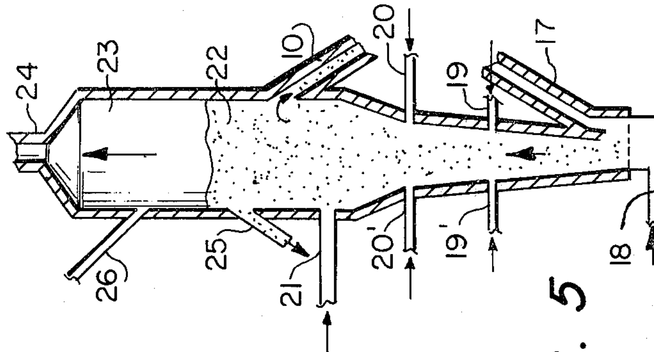


FIG. 5

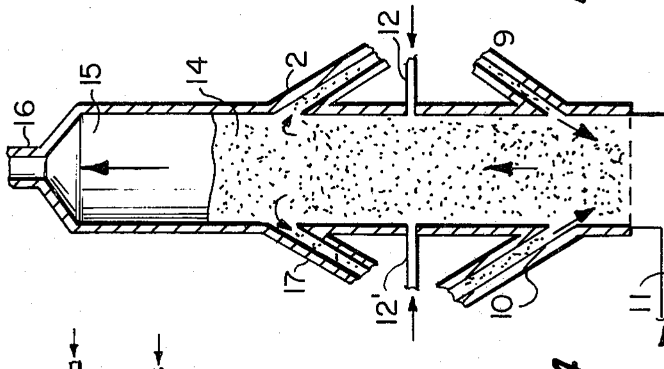


FIG. 4

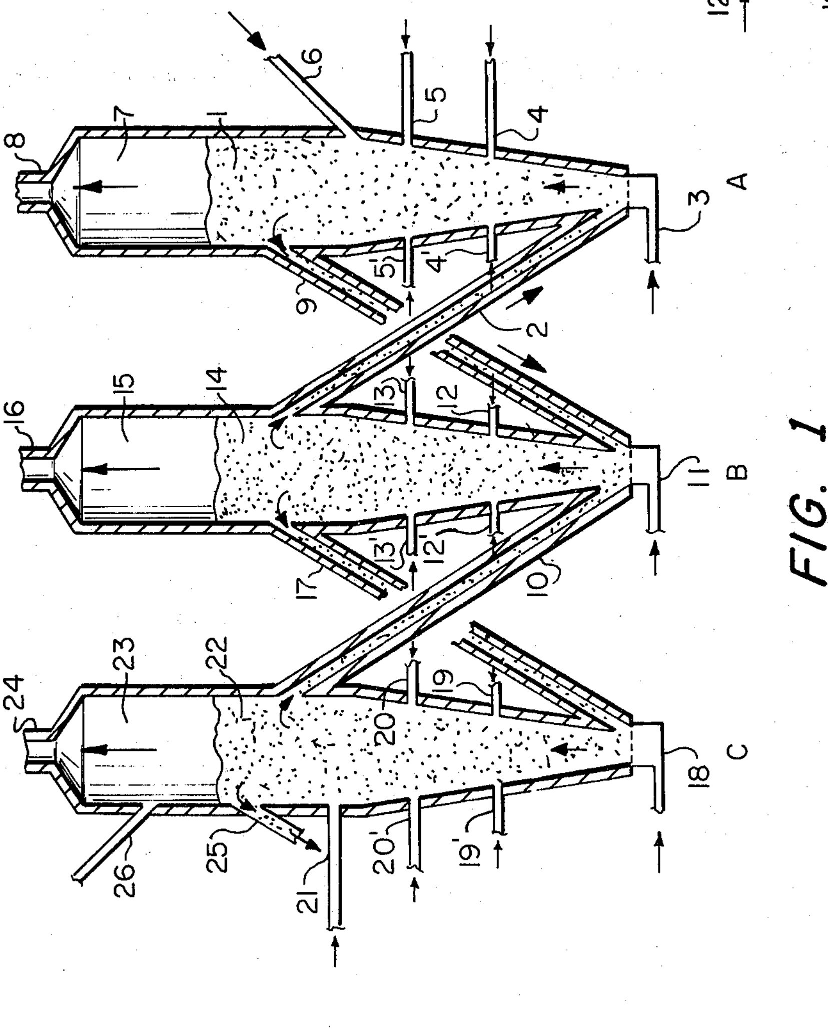


FIG. 1

CONTINUOUS CARBONIZATION AND GASIFICATION OF PARTICULATE COAL WITH DOUBLE RECIRCULATION OF FLUIDIZED PARTICULATE HEAT CARRIER

DETAILED EXPLANATION OF INVENTION

The invention relates to a continuous process for the carbonization and gasification of powdery or particulate coal (they are referred to "particulate coal" hereafter.) with double recirculation of fluidized powdery or particulate (they are referred to "particulate" hereafter.) heat carrier, and to an apparatus therefore. More particularly, it relates to such a process wherein solid particulate heat carrier having a relatively large particle size, for example, an average particle size of 0.1 to 5 mm, is recirculated through carbonization, gasification and combustion-heating columns; and wherein the carbonization column, particulate coal having an average particle size 0.1 to 5 mm is contacted with the particulate heat carrier which is kept in a densely fluidized state, thereby to effect carbonization of the coal at a temperature which may vary within a wide range of 500° to 800°C, and in the gasification column, particulate coke which has been formed in the carbonization step is gasified with steam in the presence of the particulate heat carrier kept in a densely fluidized state, whereby a gasified product predominantly comprised of hydrogen and carbon monoxide is produced.

We previously proposed and claimed a continuous process for the gasification of particulate coal with recirculated fluidized bed pf particulate heat carrier in Japanese Pat. Appln. No. 80,488/**1973,** which process comprises the steps of fluidizing solid particulate heat carrier, heated at a temperature of 850° to 1,100°C, with steam to form a first fluidized bed, passing said heated heat carrier through said first bed in a densely fluidized state from the bottom upwardly to the top of said first bed, introducing particulate coal into said first bed thereby contacting said coal with said heated heat carrier and said steam to effect gasification of the coal at a temperature ranging between 700° and 1,000°C, withdrawing the gasified product from said first bed, passing the heat carrier from the top of said first bed to the bottom of a second fluidized bed which is formed by fluidizing the heat carrier from said first bed with steam or with a mixture of steam and air, passing said heat carrier through said second fluidized bed in a densely fluidized state from the bottom upwardly to the top of said second bed, introducing air or a hot combustion gas into said second bed thereby to burn any remaining carbonaceous material in coal ash accompanied by said heat carrier and to heat said heat carrier to a temperature of 850° to 1,100°C and passing the heated heat carrier from the top of said second bed to the bottom of said first bed for use in the gasification of coal.

The gasified product obtained by the process we previously proposed comprises a mixture of various gases, including hydrogen, carbon monoxide, various hydrocarbons, and nitrogen- or sulfur-containing compounds. For some purposes it is desirable to separately obtain a fraction which is rich in hydrogen and carbon monoxide and another fraction which is rich in methane and other hydrocarbons.

Accordingly, a primary object of the invention is to provide a continuous process for the gasification of coal which enables to produce a gaseous mixture which is rich in hydrogen and carbon monoxide and another gaseous mixture which is rich in methane and other hydrocarbons, separately.

Another object of the invention is to provide a continuous process for the gasification of coal wherein heat carrier particles having a relatively large size may be used.

Still another object of the invention is to provide a continuous process for the gasification of coal wherein carbonization of coal at a temperature of 500° to 800°C and gasification of coke with steam at a temperature of 800° to 1,000°C may separately and efficiently be carried out.

A further object of the invention is to provide a novel apparatus for the gasification of particulate coal with fluidized bed of particulate heat carrier, which comprises a carbonization column for carbonizing particulate coal, a gasification column for gasifying particulate coke from the carbonization column with steam and a combustion-heating column for heating the spent heat carrier for re-use.

A still further object of the invention is to provide a novel system, adapted for use in the novel process and apparatus of the invention, for recirculating the particulate heat carrier through the carbonization, gasification and combustion-heating columns.

Other objects and advantages of the invention will be apparent from the following description.

In accordance with one aspect of the invention we provide a continuous process for the carbonization and gasification of particulate coal with double recirculation of fluidized particulate heat carrier wherein the carbonization and gasification are separately carried out, which process comprises the steps of fluidizing particulate heat carrier having an average size of 0.1 to 5 mm with steam to form a first fluidized bed, passing said particulate heat carrier through said first bed in a densely fluidized state from the bottom upwardly to the top of said first bed, introducing particulate coal having an average size of 0.1 to 5 mm into said first bed thereby contacting said coal with said heat carrier to effect carbonization of the coal while maintaining said first bed at a temperature of 500° to 800°C, as measured at the top of said first bed, withdrawing the resultant gas and oil vapor from said first bed, passing a mixture of the particulate heat carrier and particulate coke produced by the carbonization of the coal from the top of said first bed to the bottom of a second fluidized bed, said mixture being at a temperature of 500° to 800°C, combining at the bottom of said second fluidized bed said particulate mixture with particulate heat carrier coming from a third fluidized bed and being at a temperature of 850° to 1,100°C, said second fluidized bed being formed by fluidizing the combined particulate material with steam, passing said combined particulate material through said second fluidized bed in a densely fluidized state from the bottom upwardly to the top of said second bed while maintaining said second bed at a temperature of 800° to 1,000°C, as measured at the top of said second bed thereby to effect gasification of the particulate coke, withdrawing the gasified product from said second bed, passing a portion of the particulate heat carrier, which is at a temperature of 800° to 1,000°C and is accompanied by remaining ungasified particulate coke, from the top of said second bed to the bottom of said third fluidized bed, which is formed by fluidizing said particulate heat carrier with steam or with a mixture of steam and air, passing said particulate heat carrier together with said accompanying ungasified particulate coke through said third fluidized bed in a densely fluidized state from the bottom upwardly to the top of said third bed, introducing a hot combustion gas containing air or oxygen into said third bed thereby burning said ungasified particulate coke and heating said particulate heat carrier to a temperature of 850° to 1,100°C, withdrawing ash formed by the combustion of the coke from said third bed, passing said heated particulate heat carrier from the top of said third bed to the bottom of said second bed for use in the gasification of coke, and passing another portion of the particulate heat carrier, which is at a temperature of 800° to 1,000°C, from the top of said second bed to the bottom of said first bed for use in the carbonization of coal.

Usable heat carrier is particulate inorganic substance, such as cement clinker, coal ash, sand, refractories, porous alumina, iron ores and the like, having an average particle size of 0.1 to 5 mm. Among others, particulate ash produced by processing the starting particulate coal may conveniently be used.

By the term "coal" is meant solid fossil fuel, including, for example, peat, grass peat, lignite, brown coal, bituminous coal and the like.

In accordance with another aspect of the invention we provide an apparatus for the carbonization and gasification of particulate coal with double recirculation of fluidized particulate heat carrier, which apparatus comprising an upright, generally cylindrical carbonization column in which a first fluidized bed of particulate heat carrier kept at a temperature of 500° to 800°C, as measured at the top of said first bed, is formed for carbonizing particulate coal, said carbonization column having a height of at least three times as large as the maximum diameter, inlets provided at the bottom and lower portions of the side wall of said carbonization column for introducing steam into said carbonization column, at least one inlet provided at the side wall of said carbonization column above the positions where said inlets for steam are provided for introducing particulate coal into said carbonization column, an outlet provided at the top of said carbonization column for withdrawing a gas and oil vapor resulting from the carbonization of coal from said carbonization column, an upright, generally cylindrical gasification column in which a second fluidized bed of particulate heat carrier kept at a temperature of 800° to 1,000°C, as measured at the top of said second bed, is formed for gasifying particulate coke from the carbonization column, said gasification column having a height of at least three times as large as the maximum diameter, inlets provided at the bottom and lower portions of the side wall of said gasification column for introducing steam into said gasification column, an outlet provided at the top of said gasification column for withdrawing a gasified product resulting from the gasification of coke with stream from said gasification column, an upright combustion-heating column in which a third fluidized bed of particulate heat carrrier kept at a temperature of 850° to 1,100°C, as measured at the top of said third bed, is formed for burning any particulate coke and heating the particulate heat carrier to a temperature of 850° to 1,100°C, said combustion-heating column having upwardly increasing diameters and a height of at least three times as large as the maximum diameter, inlets provided at the bottom and lower portions of side walls of said combustion-heating column for introducing steam or a mixture of steam and air into said combustion-heating column, at least one inlet provided at the side wall of said combustion-heating column for introducing a hot combustion gas containing air or oxygen into said combustion-heating column, an outlet provided at the top of said combustion-heating column for withdrawing a combustion gas resulting from the burning of coke from said combustion-heating column, an outlet provided at the side wall of said combustion-heating column for withdrawing ash resultant from the burning of coke from said combustion-heating column, a duct for passing the particulate heat carrier from the approximate top of the first bed together with the particulate coke produced in the carbonization column to the bottom of the gasification column, a duct for passing a portion of the particulate heat carrier from the approximate top of the second bed to the bottom of the carbonization column, a duct for passing another portion of the particulate heat carrier from the approximate top of the second bed to the bottom of the combustion-heating column, and a duct for passing the particulate heat carrier from the approximate top of the third bed to the bottom of the gasification column.

Some preferred embodiments of the invention will be illustrated with reference to the accompanying drawings in which;

FIG. **1** is a schematic vertical cross-sectional view of an apparatus in accordance with the invention;

FIG. **2** is a schematic vertical cross-sectional view showing the upper part of another combustion and heating column which may be used in the practice of the invention;

FIG. **3** is a schematic vertical cross-sectional view showing the bottom part of another carbonization column which may be used in the practice of the invention;

FIG. **4** is a schematic vertical cross-sectional view showing another gasification column which may be used in the practice of the invention; and

FIG. **5** is a schematic vertical cross-sectional view showing still another combustion and heating column which may be used in the practice of the invention.

Referring to FIG. **1**, the illustrated apparatus comprises an upright generally cylindrical carbonization column A, an upright generally cylindrical gasification column B and an upright generally cylindrical combustion-heating column C, each having a height of at least three times as large as the maximum diameter of the column. In each column a densely fluidized bed of solid particulate heat carrier is formed. Each bed has a height of at least two times as large as the maximum diameter of the column. The combustion-heating column C has upwardly increasing diameters. The top of the fluidized bed formed in the carbonization column A and the top of the fluidized bed formed in the gasification column B are communicated through respective ducts **9** and **2** with the bottom of the gasification column B and the bottom of the carbonization column A, respectively. Further, the top of the fluidized bed formed in the gasification column B and the top of the fluidized bed formed in the combustion and heating column C are communicated through respective ducts **17** aand **10** with the bottom the combustion-heating column C and the bottom of the gasification column B, respectively.

Heat carrier, which has been passed from the top of the fluidized bed **14** in the gasification column B downwardly through a duct **2** predominantly by gravity to the bottom of the carbonization column A and is at a temperature of 800° to 1,000°C, is fluidized with steam, which is introduced through an inlet **3** into the carbonization column A at the bottom thereof, to form a fluidized bed **1**, and is passed upwardly through the carbonization column A while being kept in a densely fluidized state with steam, which is introduced through inlets **4,4'** . . . and **5,5'** . . . into the carbonization column A at lower portions thereof. Particulate coal to be processed, having an average size of 0.1 to 5 mm, is blown into the fluidized bed **1** through an inlet **6** provided in the side wall of the carbonization column A, contacted with the hot heat carrier and carbonized. The gas and oil vapor so produced together with the steam leaving the fluidized bed **1** are passed through a space **7** above the fluidized bed **1** in the carbonization column A, discharged from an outlet **8** of the column A and passed to subsequent processing steps. The number of the inlets **4,4'** . . . or **5,5'** . . . at each level, the number of such levels as well as the location and type of the inlets, and the type, number and location of the inlet **6** for feeding particulate coal are not limited to those as shown in FIG. **1** and may suitably be selected in accordance with a design known per se for the maintenance of the desired conditions in the carboniztion column A. The fluidized bed **1** is maintained at a temperature of 500° to 800°C, when measured at the top of the bed.

The particulate heat carrier and the particulate coke which has been produced by the carbonization of the particulate coal, both being at a temperature of 500° to 800°C, are then passed from the top of the fluidized bed **1** in the carbonization column A downwardly through a duct **9** predominantly by gravity to the bottom of the gasification column B, where they are admixed with the heat carrier which has been passed from the top of the fluidized bed **22** in the combustion-heating column C downwardly through a duct **10** predominantly by gravity to the bottom of the gasification column B and is at a temperature of 850° to 1,100°C and, the combined particulate material is fluidized with steam, which is introduced through an inlet **11** into the gasification column at the bottom thereof to form the fluidized bed **14**, and is passed upwardly through the gasification column B while being kept in a densely fluidized state with steam, which is introduced through inlets **12,12'** . . . and **13,13'** . . . into the gasification column B at lower portions thereof. In the fluidized bed **14**, the steam reacts with and gasifies the particulate coke. The gas so produced predominantly comprised of hydrogen and carbon monoxide together with unreacted steam leaving the fluidized bed **14** is passed through a space **15** above the fluidized bed **14** in the gasification column B, discharged from an outlet **16** of the column B and passed to subsequent processing steps. The number of inlets **12,12'** . . . or **13,13'** . . . at each level, the number of such levels as well as the location and type of the inlets are not limited to those as shown in FIG. **1** and may suitably be selected in accordance with a design known per se for the maintenance of the desired conditions in the gasification column B. The fluidized bed **14** is maintained at a temperature of 800° to 1,000°C, when mesured at the top of the bed.

A portion of the particulate heat carrier and ungasified particulate coke, both being at a temperature of 800° to 1,000°C, is then passed from the top of the fluidized bed **14** in the gasification column B downwardly through a duct **17** predominantly by gravity fo the bottom of the combustion-heating column C, fluidized with steam, which is introduced through an inlet **18** into the combustion-heating column C at the bottom thereof, to form the fluidized bed **22**, and is passed upwardly through the combustion-heating column C having upwardly increasing diameters while being kept in a densely fluidized state with steam or a mixture of steam and air, which is introduced through inlets **19,19'** . . . and **20,20'** . . . into the combustion-heating column C at lower portions thereof. A hot combustion gas containing air or oxygen is introduced into the densely fluidized bed **22** through an inlet **21** provided in the side wall of the combustion-heating column C thereby to substantially completely burn the ungasified particulate coke accompanied by the heat carrier from the gasification column B and to heat the particulate heat carrier to a temperature of 850° to 1,100°C. The resultant combustion gas leaves the fluidized bed **22** and is passed through a space **23** above the fluidized bed **22** in the column C and withdrawn through an outlet **24** from the system for subsequent treatments. The type, location and type of the inlets **19,19'** . . . , **20,20'** . . . and **21** are not limited to those as illustrated in FIG. **1.**

A part of particulate ash produced by the combustion the particulate coke is acompanied by the combustion gas and discharged from the system through the outlet **24.** If desired, the ash may be withdrawn from the combustion and heating column C through an outlet **25** provided in the side wall of the column C in the proximity of the top of the fluidized bed **22.** If a part of the particulate heat carrier is accompanied by the withdrawn ash, it may be separated from the ash outside the system and may be fed back to the system through an inlet **26.** While the illustrated apparatus has such an inlet **26** located at an upper portion of the combustion-heating column C, it should be appreciated that such an inlet **26** may be provided in any one of the columns.

As already described, the particulate heat carrier, which has been heated in the combustion-heating column C to a temperature of 850° to 1,100°C, travel from the top of the fluidized bed **22** in the column C downwardly through the duct **10** predominantly by gravity to the bottom of the gasification column B, where it is admixed with a mixture of the particulate heat carrier and particulate coke which mixture has come from the top of the fluidized bed **1** in the carbonization column A through the duct **9** and is at a temperature of 500° to 800°C. The combined particulate material is fluidized with steam supplied through the inlet **11** to form the fluidized bed **14** and passed upwardly trough the gasification column B while being kept in a densely fluidized state with steam introduced through the inlets **12,12'** . . . and **13,13'** . . . into the column B. During its passage through the gasification column B, the particulate coke in the fluidized bed **14** is gasified with the steam and, the fluidized bed **14** is maintained at a temperature of 800° to 1,000°C, as measured at the top of said bed. While a portion of the particulate heat carrier is passed from the top of the bed **14** through the duct **17** to the bottom of the combustion-heating column C, another portion of the particulate heat carrier is passed from the top of the bed **14** downwardly through the duct **2** predominantly by gravity to the bottom of the fluidized bed **1** in the carbonization column A, fluidized with steam, which is introduced through the inlet **3**, passed upwardly through the column A and used for the carbonization of the particulate coal fed through the inlet **6** into the column A.

The combustion gas withdrawn from the combustion-heating column C is accompanied by an amount of the particulate heat carrier. If desired, any accompanying heat carrier may be collected in a suitable collector, such as cyclone **27** (see FIG. **2**), provided just below the outlet **24** in the space **23** above the bed **22**, and may be fed back to the bed **22**. The same is applicable with respect to the columns A and B. Alternatively, such a collector **27** may be located just outside the outlet **24**, 16 or **8**.

It should be appreciated that the construction of the column A or B which may be used is not limited to that shown in FIG. **1**. For example, carbonization column A may has a construction as shown in FIG. **3**, with respect to the connection of the duct **2** to the bottom of the column A. Further gasification column B may have a substantially uniform cross-section, as shown in FIG. **4**. For efficient combustion and heating the column C should preferably has upwardly increasing cross-sectional areas. However, it is not necessary that the shape of column C is limited to that shown in FIG. **1**. Column C may be of the shape as shown in FIG. **5**. Further, Columns A, B and C may have different diameters.

In accordance with the invention the carbonization and gasification of particulate coal having an average particle size of 0.1 to 5 mm are separately carried out and, thus, a mixture of normally liquid hydrocarbons and normally gaseous hydrocarbons is obtained on one hand from the carbonization column A, and a gas rich in hydrogen and carbon monoxide is separately obtained from the gasification column B on the other hand. Since the former mixture may readily be separated into the normally liquid hydrocarbons and the normally gaseous hydrocarbons by a method known per se, the normally liquid hydrocarbons, the normally gaseous hydrocarbons as well as the gaseous mixture predominantly comprised of hydrogen and carbon monoxide may effectively be produced from coal without excessive decomposition of the valuble components of coal.

In the practice of the invention, recirculation of particulate heat carrier may be performed very stably and, controlling of the rate of recirculation and of tempertures of carbonization, gasification and combustion-heating columns are readily carried out.

When compared with the known process for the carbonization or gasification of coal wherein fluidized particulate heat carrier is used, the process of the invention is advantageous in that the particle size of the usable particulate heat carrier may vary within the specified wide range; that loss due to abrasion of the particulate heat carrier and parts of the apparatus may be minimized since in the practice of the invention there is no chance for particulate material to impinge against the wall of the apparatus at high velocities; and that the apparatus used can be low in height.

Thus, by the process in accordance with the invention, starting from any kinds of coal, including peat, grass peat, lignite, brown coal, bituminous coal and the like, useful liquid hydrocarbons and a fuel gas of high calories can be obtained from the carbonization column and, substantially pure hydrogen and carbon monoxide can be obtained from the gasification column, both with high efficiency.

The invention will be further described by the following working example in which the process was carried out using an apparatus of a type as shown in FIG. **1**.

EXAMPLE

Starting material:

Newdell coal, 1,000 Kg basis;

54% fixed carbon, 37% volatiles, 9% ash;

average particle size of 0.45 mm;

Temperature of the carbonization column at the top: 700°C

Temperature of the gasification column at the top: 900°C

Temperature of the combustion-heating column at the top:

1,000°C

Heat transfer medium:

Ash of Newdell coal having an average particle size of 0.32 mm;

Steam used:

16	atms.	400°C
71	Kg	in the carbonization column
861	Kg	in the gasification column
80	Kg	in the combustion-heating column
1,012	Kg	in total

Amounts of air introduced into the combustion-heating column: 3,320 Nm^3

Amounts of the recirculated heat carrier:

21,500	Kg	between the carbonization column and the gasification column
69,200	Kg	between the gasification column and the combustion-heating column

Produced carbonization gas:

142 Nm^2, 6,768 $Kcal/Nm^3$;

4% CO_2, 5% C_mH_n, 8% CO, 33% H_2, 50% CH_4;

Tar: 100 Kg

Gas liquor: 140 Kg

Mixed gas containing hydrogen and carbon monoxide:

1,290 Nm^2, 3,030 $Kcal/Nm^3$;

9.8% CO_2, 35.3% CO; 54.9% H_2

What is claimed is:

1. A continuous process for the carbonization and gasification of particulate coal with double recirculation of fluidized particulate heat carrier wherein the carbonization and gasification are separately carried out, which process comprises the steps of fluidizing particulate heat carrier having an average particle size of 0.1 to 5 mm with steam to form a first fluidized bed, passing said particulate heat carrier through said first bed in a densely fluidized state from the bottom upwardly to the top of said first bed, introducing particulate coal having an average particle size of 0.1 to 5 mm into said first bed thereby contacting said coal with said heat carrier to effect carbonization of the coal while maintaining said first bed at a temperature of 500° to 800°C, as measured at the top of said firstbed, withdrawing the resultant gas and oil vapor from said first bed, passing a mixture of the particulate heat carrier and particulate coke produced by the carbonization of the coal from the top of said first bed to the bottom of a second fluidized bed, said mixture being at a temperature of 500° to 800°C, combining at the bottom of said second fluidized bed said particulate mixture with particulate heat carrier coming from a third fluidized bed and being at a temperature of 850° to 1,100°C, said second fluidized bed being formed by fluidizing the combined particulate materials with steam, passing said combined particulate materials through said second fluidized bed in a desnely fluidized state from the bottom upwardly to the top of said second bed while maintaining said second bed at a temperature of 800° to 1,000°C, as measured at the top of said second bed thereby to effect gasification of the particulate coke, withdrawing the gasified product from said second bed, passing a portion of the particulate heat carrier, which is at a temperature of 800° to 1,000°C and is accompanied by remaining ungasified particulate coke, from the top of said second bed to the bottom of said third fluidized bed, which is formed by fluidizing said particulate heat carrier with steam or with a mixture of steam and air, passing said particulate heat carrier together with said accompanying ungasified particulate coke through said third fluidized bed in a densely fluidized state from the bottom upwardly to the top of said third bed, introducing a hot combustion gas containing air or osygen into said third bed thereby burning said ungasified particulate coke and heating said particulate heat carrier to a temperature of 850° to 1,100°C, withdrawing ash formed by the combustion of the coke from said third bed, passing said heated particulate heat carrier from the top of said third bed to the bottom of said second bed for use in the gasification of coke, and passing another portion of the particulate heat carrier, which is at a temperature of 800° to 1,000°C, from the top of said second bed to the bottom of said first bed for use in the carbonization of coal.

2. A continuous process for the carbonization and gasification of particulate coal with double recirculation of fluidized particulate heat carrier in accordance with claim **1**, wherein each of said first, second and third fluidized bed has an upright, generally cylindrical configuration.

3. A continuous process for the carbonization and gasification of particulate coal with double recirculation of fluidized particulate heat carrier in accordance with claim **2**, wherein said upright, generally cylindricaal configuration of each bed has a height of at least two times as large as the maximum diameter.

4. A continuous process for the carbonization and gasification of particulate coal with double recirculation of fluidized particulate heat carrier in accordance with claim **3**, wherein at least the third fluidized bed has upwardly increasing diameters.

5. A continuous process for the carbonization and gasification of particulate coal with double recirculation of fluidized particulate heat carrier in accordance with claim **1**, wherein the recirculation of the heat carrier is carried out in such a manner that the heat carrier is passed through a confined path from the top of one bed to the bottom of another bed predominantly by gravity.

6. A continuous process for the carbonization and gasification of particulate coal with double recirculation of fluidized particulate heat carrier in accordance with claim **1**, wherein said particulate heat carrier is particulate ash produced by processing the starting particulate coal.

7. An apparatus for the carbonization and gasification of particulate coal with double recirculation of fluidized particulate heat carrier, which apparatus comprising an upright, generally cylindrical carbonization column in which a first fluidized bed of particulate heat carrier kept at a temperature of 500° to 800°C, as measured at the top of said first bed, is formed for carbonizing particulate coal, said carbonization column having a height of at least three times as large as the maximum diameter, inlets provided at the bottom and lower portions of the side wall of said carbonization column for introducing steam into said carbonization column, at least one inlet provided at the side wall of said carbonization column above the positions where said inlets for steam are provided for introducing particulate coal into said carbonization column, an inlet provided at the top of said carbonization column for withdrawing a gas and oil vapor resulting from the carbonization of coal from said carbonization column, an upright, generally cylindrical gasification column in which a second fluidized bed of particulate heat carrier kept at a temperature of 800° to 1,000°C, as measured at the top of said second bed, is formed for gasifying particulate coke from the carbonization column, said gasification column having a height of at least three times as large as the maximum diameter, inlets provided at the bottom and lower portions of the side wall of said gasification column for introducing steam into said gasification column, an outlet provided at the top of said gasification column for withdrawing a gasified product resulting from the gasification of coke with steam from said gasification column, an upright combustion-heating column in which a third fluidized bed of particulate heat carrier kept at a temperature of 850° to 1,100°C, as measured at the top of said third bed, is formed for burning any particulate coke and heating the particulate heat carrier to a temperature of 850° to 1,100°C, said combustion-heating column having upwardly increasing diameters and a height of at least three times as large as the maximum diameter, inlets provided at the bottom and lower portions of side walls of said combustion-heating column for introducing steam or mixture of steam and air into said combustion-heating column, at least one inlet provided at the side wall of said combustion-heating column for introducing a hot combustion gas containing air or oxygen into said combustion-heating column, an outlet provided at the top of said combustion-heating column for withdrawing a combustion gas resulting from the burning of coke from said combustion-heating column, an outlet provided at the side wall of said combustion-heating column for withdrawing ash resultant from the burning of coke from said combustion-heating column, a duct for passing the particulate heat carrier from the approximate top of the first bed together with the particulate coke produced in the carbonization column to the bottom of the gasification column, a duct for passing a portion of the particulate heat carrier from the approximate top of the second bed to the bottom of the carbonization column, a duct for passing another portion of the particulate heat carrier from the aproximate top of the second bed to the bottom of the combustion-heating column, and a duct for passing the particulate heat carrier from the approximate top of the third bed to the bottom of the gasification column.

8. An apparatus for the carbonization and gasification of particulate coal with double recirculation of fluidized particulate heat carrier in accordance with claim **7**, wherein each column is provided with means for separating solid particulate material from the gas leaving said column.

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