

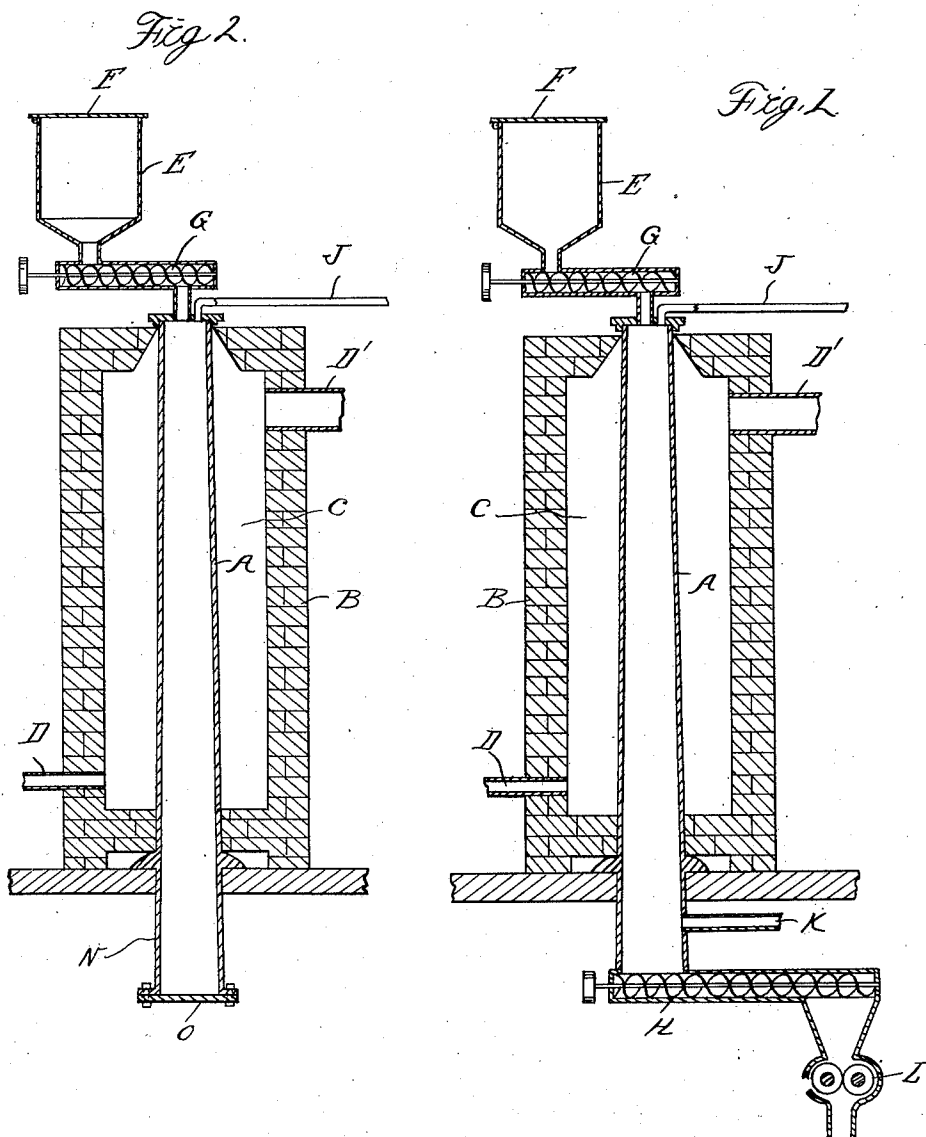
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COKE AND PROCESS OF PRODUCING THE SAME

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COKE AND PROCESS OF PRODUCING THE SAME

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My invention relates to the treatment of carbonaceous materials and more particularly to the carbonization of coal.

The primary object of the invention is to produce a new type of fuel which I have designated by the name of "instantaneous coke", this fuel having properties rendering it very desirable for use as a substitute for powdered coal in certain types of boiler plants.

Another object of the invention is to provide a method for the continuous production of the new fuel.

A further object is to provide a method for continuously producing a fuel gas of substantially constant heating value.

A still further object is to provide apparatus for producing a solid fuel and fuel gas which is economical to operate and can be run continuously to produce a uniform product.

These and other objects are attained by the process hereinafter described and illustrated in the accompanying drawings, wherein:

Figure 1 is a sectional elevation of an apparatus embodying my invention;

Figure 2 is a similar view of a slightly modified arrangement.

My improved method for producing powdered fuel is to feed rather finely crushed coal continuously and allow it to fall freely through an empty vertical retort maintained at a red heat thereby subjecting the coal to carbonization during the short interval required for its fall. As will be shown later, the time of carbonization may be only a fraction of a second and the time is so short in comparison with that at present required that I have adopted the term, "instantaneous carbonization" to differentiate this process clearly from the usual practice.

The carbonization of the coal particles results in a liberation of the volatile matter in the form of a fuel gas which may be withdrawn from the retort and treated in the usual manner for the recovery of tar, ammonia and other useful by-products. The solid particles after being carbonized are withdrawn from the bottom of the retort in the form of granular coke and may be preserved in this condition or subjected to further treatment as hereinafter described.

The physical structure of the instantaneous coke formed according to my improved process is very different from anything described hitherto. Each of the fine particles of coal, being almost instantaneously converted into coke, becomes puffed into a porous irregular globule with very thin walls which pulverizes readily. This material is therefore particularly adapted for conversion into a powdered fuel by merely passing the particles through crushing rolls, which easily reduced the coke to a fine powder. Since the fuel contains less volatile matter than the coal, from which it is formed, the complete combustion of the fuel in a boiler plant can be accomplished with the use of a smaller fire box than is necessary with ordinary powdered coal. When powdered bituminous coal is blown with air into the fire box of a boiler, the volatile matter of the coal is evolved and burns, and after the volatile matter is expelled, the resultant coke burns. A large fire box is required to carry out this sequence of operations, so as to insure complete combustion before the gases are chilled by contact with the boiler tubes. The fuel produced by my process is therefore superior to powdered bituminous coal because of the lower volatile content.

As an example of an apparatus for carrying out my process, Figure 1 illustrates a vertical retort A of metal, fire brick or other suitable material arranged in an outer casing B, forming an annular combustion chamber C, surrounding the tube and heated by gas or other fuel supplied through the pipe D. The gas burns around the retort and the products of combustion escape through the outlet tube D'. The retort A, may thus be heated to the desired temperature which is preferably above a low red heat. The crushed coal is stored in a hopper E closed with a gas tight cover F and is fed continuously by means of the worm conveyer G into the top of the retort A. The crushed coal drops through the heated retort and is carbonized as it falls, the resultant coke being collected at the bottom of the retort on a conveyer H, after it has cooled below the temperature of destructive distillation. Two conduits J and K communicate with the retort A above and below the heated zone, the

conduit J serving to introduce a gas such as hydrogen into the retort and the conduit K being the outlet for the hydrogen and the fuel gas evolved from the carbonization process. In order to pulverize the coke removed by the conveyer H, suitable pulverizing rolls L are provided. The powdered coke after passing from the rolls may then be collected in any suitable receptacle.

The factors which determine the amount of volatile matter liberated from the coke and the condition of the resulting carbonized product are first, the size of the coal introduced into the heated retort, second, the temperature of the retort and third, the length of the heated portion of the retort through which the particles fall. It will be evident that these three factors may be varied at will, in order to produce the desired product, thus providing means for accurately controlling the process.

I will now describe a series of tests which have been carried out showing how the various factors may be regulated in order to produce the desired results. The first experimental furnace which I tried, had as its retort a nichrome tube of two inches internal diameter mounted vertically and heated electrically for a length of about twenty-seven inches. Crushed coal was fed into this tube through a worm conveyer and the coke was collected as loose porous granules in a sealed receptacle at the bottom. The volatile products were sometimes drawn off from the top and sometimes from the bottom of this retort.

The following results with Elkhorn coal carrying 36.0 per cent of volatile matter are from tests with this 27 inch tube at temperatures of 950-1000° C.

Test No.	Size of coal mesh	Volatile matter in instantaneous coke	Volume gas, cu. ft. per lb. coal	Heating value of gas B. t. u. per cu. ft.	B. t. u. in gas per lb. of coal
12	35-48	6.4	7.28	487	3550
16	20-35	10.4	5.1	591	3100
19	14-20	28.4	2.2	465	1022

In the above table, as well as other tables giving the results of actual tests, the size of the coal is expressed by referring to the size of the sieve through which the largest particles of coal will all pass and the size of the sieve on which the finest particles of coal will all be retained. The size of the sieve is expressed in meshes to the linear inch.

In these tests hydrogen was passed through the tube during the runs in order to sweep the gases out of the tube more rapidly but the volume and heating value of this hydrogen have been deducted from the results given above. The hydrogen has improved the yield of gas but it is not believed to have had any

effect on the extent of the carbonization process. Practically no coke adhered to the walls in the tests reported above. It will be noted that even in this short fall of only two feet coal as coarse as 20-35 mesh was very materially carbonized.

Considerable difficulty was experienced in some of the other tests because of stoppages due to coke adhering to the tube. It was noted that these formed initially either at the top or the bottom of the heated zone and usually where the metal was below a red heat. It was thought that this was due to the cementing action of the coal which was sticky from incipient carbonization. Accordingly another retort, three inches in internal diameter and eighty-four inches long was built. It was found that this gave stoppages in the upper end of the retort until arrangements were made to feed the coal almost directly into the red hot portion of the tube. By the time the particles of coal finer than 20 mesh had dropped through this tube at a temperature of 700° C. they were so far carbonized that they no longer adhered to the walls of the tube. Particles coarser than 20 mesh which were incompletely carbonized were, apparently of too great mass to stick to the tube. Any minor deposits which did adhere to the tube were soft and loose and readily removed, and not hard and dense like deposits formed by decomposition of hydrocarbon vapors or gases.

The results with this large tube may be illustrated by a series of four consecutive runs on a sample of coal from Vermilion County, Illinois, whose original analysis was as follows:

	Per cent
Moisture	3.1
Volatile matter	47.4
Fixed carbon	44.9
Ash	4.6

This coal was crushed and sized in order to determine the effect of size on the operation and products. The retort in this series was three inches internal diameter and heated for seventy-two inches to about 800° C. The coal was fed through this apparatus at a rate of about three pounds per hour. The results are given below:

Exp. No.	Size of coal mesh	Volatile matter in instantaneous coke	Volume gas, cu. ft. per lb. coal	Heating value of gas B. t. u. per cu. ft.	B. t. u. in gas per lb. of coal
28	10-20	39.6	2.7		
29	20-28	29.7	5.4	501	2705
30	28-65	10.7	7.0	474	3318
31	65-dust	*11.7	8.3	424	3518

* Volatile matter in coke probably high because of loss of dust from fine powder while volatile matter was being determined.

The instantaneous coke formed in the experiments outlined above was subjected to microscopic examination and showed that

particles of coal coarser than fourteen mesh underwent very little change as they dropped through this tube. The edges were glossy and showed fusion, but the body of the particles seemed unaffected. Particles which passed a twenty-eight mesh sieve were uniformly puffed into glossy irregular globules. The fine particles were frequently fritted together to form irregular small aggregates of puffed globules. If a longer retort, or a higher temperature had been used, the coarser particles of coal might also have been coked.

The volatile matter in this instantaneous coke from any given coal may be controlled by the temperature and the length of the retort and by the size of the particles of coal dropped through the retort. The finer the particles of coal, the less will be the volatile matter of the coke.

Experiments on lignite showed that a granular coke of controlled volatile matter and a corresponding yield of gas could be obtained with this material in the same manner as from Illinois coal or Elkhorn coal.

It is thus evident that my process permits of the instantaneous carbonization of crushed coal under controlled conditions through variations in the length and temperature of the retort and the size of the coal fed, and that an instantaneous coke of constant volatile matter can be continuously obtained so long as the initial conditions are maintained constant. The quantity of product from one of these retorts will be much greater than one of the same size operated according to the usual present methods since in my process heat is transferred to the coal by convection and radiation, while in the present standard process the heat is transferred mainly by conduction.

This new process not only produces a soft, porous, instantaneous coke but also produces a gas of constant composition. In the present customary procedure the gas evolved during the early portion of the carbonization will have a heating value of perhaps 650 British thermal units per cubic foot, but in the latter stages of the run when the gas must filter through a thick layer of red hot coke the gas is so badly cracked that its heating value may drop to 450 British thermal units. In my process the quality of the gas is constant and may be controlled by the same factors which are used to control the quality of the coke. If a finely crushed coal is fed at a rapid rate into a retort at a low red heat it is evident that there will be very little secondary destructive distillation of the gas and that therefore a gas of high heating value will result.

The results quoted for test 29 showed a yield of 5.4 cubic feet of 501 B. t. u. gas from a pound of Illinois coal, while still leaving 29.7 per cent of volatile matter in the

instantaneous coke. This granular instantaneous coke when subjected to destructive distillation in a closed retort yielded a lump coke harder and denser than that obtained from the original coal by a similar process. This shows that some bituminous coals may be so heated in this instantaneous carbonization process as to make them better fitted to yield a marketable coke in the usual type of coke oven.

Figure 2 illustrates a modified construction of apparatus in which the lower portion N, of the retort A is closed and forms a receiver for collecting the coke after it has passed through the heated zone. Preferably a door O is provided through which the coke may be removed intermittently. With such an arrangement after the coke is collected below the heated zone it will be obtained from the apparatus shown in Figure 1. However, this form of apparatus lends itself readily to a further modification of the process for by allowing the coke to collect in the lower heated portion of the retort A, it may be subjected to a further and more complete carbonization while the particles are massed together. Thus the coal is first subjected to instantaneous carbonization as it falls through the free space and carbonization is completed as the instantaneous coke lies in a mass for a longer time in the lower part of the hot retort. Periodically the mass of completely carbonized coke is removed from the retort through the door O in any suitable manner. If a coal such as the Illinois coal on which experiments have already been cited were crushed and allowed to fall freely through the hot retort for a distance of perhaps only two feet, depending on the temperature of the retort and the fineness of the coal, such a degree of incomplete carbonization would be obtained that the instantaneous coke would fuse with the solid coke collected in the tube and form a solid coke superior to that obtainable from the same coal, by the present usual commercial operation of coke oven.

This process of partial carbonization by an instantaneous coking process, and more complete subsequent carbonization in a solid mass with longer time gives a richer fuel gas than is obtainable by the present methods of operation, since the gas liberated in the instantaneous carbonization does not have to pass through layers of red-hot coke on its way out of the retort.

While I have discussed in the preceding paragraphs the carbonization of bituminous coal, my invention is not necessarily limited to a process using this material for in certain broader aspects it may be utilized not only with other solid fuels, such as sawdust, peat, or other carbonaceous materials, but also in some cases with liquid fuels.

Although the retort which I have illus-

trated is of the vertical type through which the powdered coal falls by gravity, I do not necessarily restrict myself to this type, nor to the dimensions given. The main feature of my process is the subjection of the finely divided particles of coal to a temperature sufficient for destructive distillation, while maintaining the particles separate from each other during the initial carbonization process. Since the heat is transferred to the coal by radiation and convection, as well as by conduction, the limitations which describe the usual form of retort are largely removed. The fuel gas may be withdrawn from different portions of the retort and in Figure 1 the outlet is at the bottom whereas in Figure 2 the outlet is placed near the top of the retort.

I have already alluded to the beneficial effect of the introduction of hydrogen to the retort. This favorable action may have been due merely to its action as an inert gas in driving the hydrocarbon gas more quickly from the retort, but I believe it also acted beneficially by increasing the partial pressure of the hydrogen and preventing decomposition of the hydrocarbons. It is obvious that gases other than hydrogen might be used for producing the same or similar effects, while in some cases it may be desirable to eliminate the introduction of the gas and merely withdraw the various products produced by the distillation.

A further modification of the process is obtained by introducing steam into the retort. There is a particular efficiency in using steam in this process since the finely divided coke will react with the steam much more rapidly than would be the case where the coke was present in a large mass, as is the case in the usual coke oven operation.

From the above discussion it will be apparent that I have provided a new process for the carbonization of coal which is particularly adapted for the production of a powdered fuel of low volatile content. Furthermore my process is also novel in the production of a fuel gas of high heating value which remains substantially constant in its analysis and heating value throughout the entire coking process. I have also produced a new fuel which differs in its characteristics from anything which has hitherto been obtained from the destructive distillation of bituminous coal.

What I claim as my invention is:—

1. The process of producing coke which comprises showering particles of finely crushed solid carbonizable material through a retort whose walls are heated to a temperature substantially above 700° C. while maintaining said particles out of contact with an appreciable amount of air thereby subjecting the particles to destructive distillation so as to completely carbonize the finest particles and leave the larger particles partially carbonized, and removing the solid residue from said retort while it is in a finely divided state and still contains a substantial amount of volatile matter.

2. The process of producing coke which comprises showering particles of finely crushed solid carbonizable material through a retort whose walls are heated to a temperature substantially above 700° C. while maintaining said particles out of contact with an appreciable amount of air thereby subjecting the particles to destructive distillation so as to completely carbonize the finest particles and leave the larger particles partially carbonized, and removing the solid residue from said retort while it is in a finely divided state and still contains more than five per cent of volatile matter.

3. The process of producing coke which comprises showering particles of finely crushed solid carbonizable material through a retort whose walls are heated to a temperature substantially above 700° C. while maintaining said particles out of contact with an appreciable amount of air thereby subjecting the particles to destructive distillation so as to completely carbonize the finest particles and leave the larger particles partially carbonized, continuously introducing a gas containing free hydrogen into said retort during said distillation, continuously removing a gas from the retort containing volatile matter from the carbonaceous material and continuously removing the solid residue from said retort while it is in a finely divided state and still contains a substantial amount of volatile matter.

4. The process of producing coke which comprises showering particles of finely crushed solid carbonizable material through a retort whose walls are heated to a temperature substantially above 700° C. while maintaining said particles out of contact with an appreciable amount of air thereby subjecting the particles to destructive distillation so as to completely carbonize the finest particles and leave the larger particles partially carbonized, introducing steam into said retort to cause reaction with said carbonaceous material during the destructive distillation thereof, removing the volatile products from said retort and removing the solid residue from said retort while it is in a finely divided state and still contains a substantial amount of volatile matter.

5. The process of producing coke which comprises showering particles of finely crushed bituminous coal of graded fineness of particles through a retort whose walls are heated to a temperature substantially above 700° C. while maintaining said particles out of contact with an appreciable amount of air thereby causing said particles to undergo destructive distillation to different degrees, those particles with smaller mass being heated

ed more rapidly and to a higher temperature and becoming completely carbonized, and removing the solid residue from said retort while it is in a finely divided state and while the larger particles still have sufficient volatile matter to inflame readily when ignited and are therefore adapted to be used after crushing as a powdered fuel.

6. The process of producing coke which comprises showering particles of bituminous coal crushed to pass an eight mesh sieve through a retort whose walls are heated to a temperature substantially above 700° C. while maintaining said particles out of contact with an appreciable amount of air thereby subjecting the particles to destructive distillation so as to completely carbonize the finest particles and leave the larger particles partially carbonized and removing the solid residue from said retort while it is in a finely divided state and still contains more than five per cent of volatile matter.

7. The process of producing coke with a controlled content of volatile matter which comprises showering a mixture of crushed solid carbonizable fuel, the finest particles of which will pass a sieve with 65 meshes to the linear inch and the coarsest particles of which will substantially all pass a sieve with 12 meshes to the linear inch, down through a retort from which air is substantially excluded and whose walls are maintained at a temperature above 700° C. and whose length is sufficient to cause substantially complete carbonization of the finest particles of fuel but is insufficient to cause material carbonization and evolution of volatile matter from the center of the particles which barely pass the 12 mesh screen as they fall through the retort, causing the particles of fuel to fall freely through the retort and be carbonized in differing degrees, and withdrawing the solid residue from the lower part of the retort as a loose, puffed, finely divided, granular coke containing a substantial amount of volatile matter.

8. A new product of manufacture comprising finely divided particles of puffed, porous coke containing a substantial amount of volatile matter and made by showering particles of finely crushed solid carbonizable material through a retort whose walls are heated to a temperature substantially above 700° C. while maintaining said particles out of contact with an appreciable amount of air thereby subjecting the particles to a destructive distillation so as to completely carbonize the finest particles and leave the larger particles partially carbonized and removing the solid residue from said retort while it is in a finely divided state and still contains a substantial amount of volatile matter.

9. As a new product of manufacture, a coke composed of puffed, porous, friable, finely divided particles having thin walls and

adapted to be readily crushed to form a powdered fuel, said product containing more than five per cent volatile matter and being made by showering particles of finely crushed solid carbonizable material through a retort whose walls are heated to a temperature substantially above 700° C. while maintaining said particles out of contact with an appreciable amount of air thereby subjecting the particles to a destructive distillation so as to completely carbonize the finest particles and leave the larger particles partially carbonized and removing the solid residue from said retort while it is in a finely divided state and still contains a substantial amount of volatile matter.

10. As a new product of manufacture, a coke composed of puffed, porous, friable, finely divided particles having thin walls and adapted to be readily crushed to form a powdered fuel, said product containing more than five per cent volatile matter and being made by showering particles of bituminous coal crushed to pass an eight mesh sieve through a retort whose walls are heated to a temperature substantially above 700° C. while maintaining said particles out of contact with an appreciable amount of air thereby subjecting the particles to destructive distillation so as to completely carbonize the finest particles and leave the larger particles partially carbonized and removing the solid residue from said retort while it is in a finely divided state and still contains more than five per cent of volatile matter.

11. As a new product of manufacture, a coke composed of puffed, porous, friable, finely divided particles having thin walls and adapted to be readily crushed to form a powdered fuel, said product containing more than five per cent volatile matter and being made by showering a mixture of crushed solid carbonizable fuel, the finest particles of which will pass a sieve with 65 meshes to the linear inch and the coarsest particles of which will substantially all pass a sieve with 12 meshes to the linear inch, down through a retort from which air is substantially excluded and whose walls are maintained at a temperature above 700° C. and whose length is sufficient to cause substantially complete carbonization of the finest particles of fuel but is insufficient to cause material carbonization and evolution of volatile matter from the center of particles which barely pass the 12 mesh screen as they fall through the retort, causing the particles of fuel to fall freely through the retort and be carbonized in differing degrees, and withdrawing the solid residue from the lower part of the retort as a loose puffed finely divided granular coke containing a substantial amount of volatile matter.

In testimony whereof I affix my signature.

ALFRED H. WHITE.