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H. R. HORNER
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COKING OF A PREHEATED FLUIDIZED COAL

2,658,862

Filed June 9, 1950

2 Sheets-Sheet 1

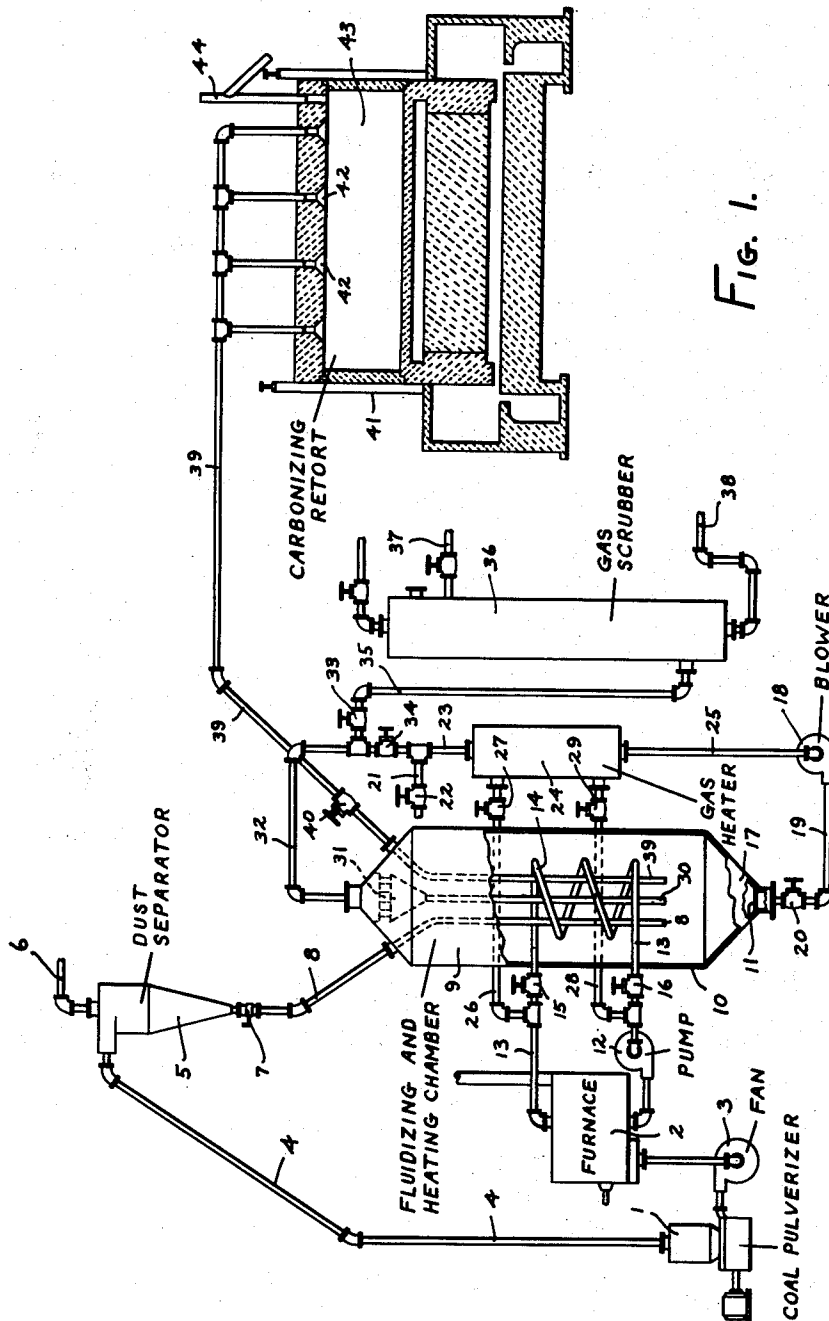


Fig. 1.

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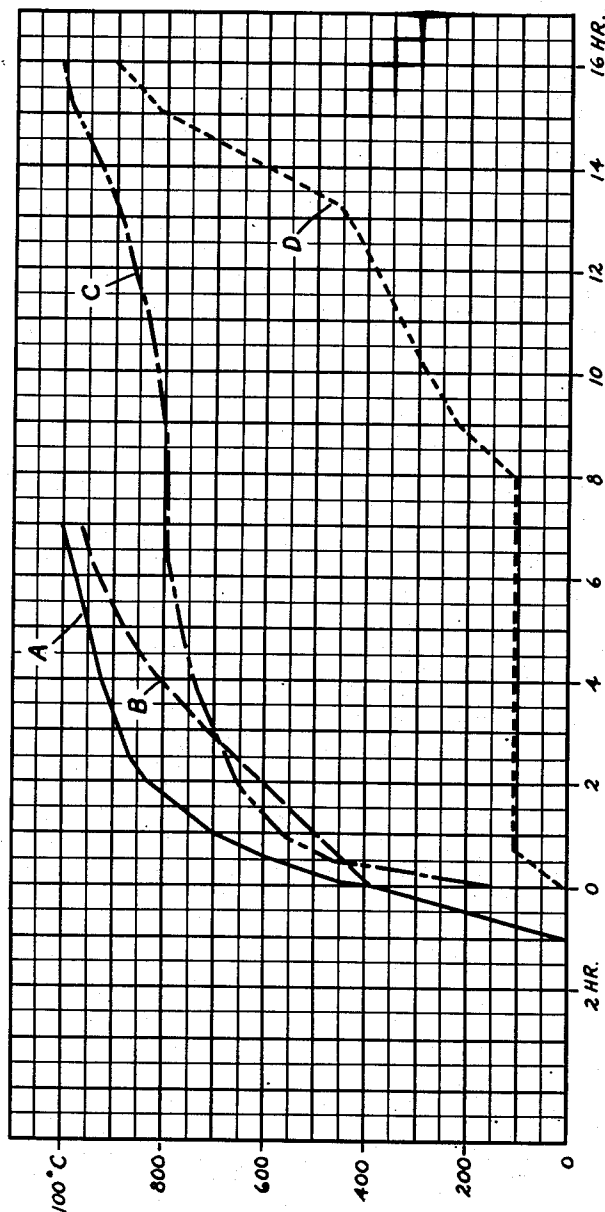
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FIG. 2.



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PROCESS FOR THE DEFLUIDIZATION AND
FIXED-BED COKING OF A PREHEATED
FLUIDIZED COALHarold R. Horner, Indianapolis, Ind., assignor to
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1 Claim. (Cl. 202—22)

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This invention relates to a process and also to an association of elements whereby coal may be fluidized preparatory to carbonizing in the process of making coke out of the coal. It is to be understood that the invention is not limited to the final carbonizing or coke making step, but deals primarily with the fluidizing of the coal itself, whatever may be done with it thereafter.

However in the particular description of the one particular form of the invention as set out hereinafter, the invention will be described in reference to the making of coke in order to continue through one complete process. It has long been known that considerable time is required in order to transmit heat through a body of coal in a stationary and more or less compacted bed whereby the bed of coal may be first raised to the temperature at which the coal coalesces and reaches a plastic state, and finally solidifies into the carbonized or coked condition.

In the ordinary coking ovens, it has been customary to apply heat externally of the oven over a sufficiently long period of time to elevate the temperature of the contained coal for the coking operation. The long time required means of course that only a limited number of batches of coal may be put through the coking oven in a given amount of time. If it were possible to increase the rate of heating of the coal within the oven, it would naturally follow that the oven would be more serviceable in respect to being able to handle more batches of coal within the same amount of time. In other words for the same investment, a greater use of the oven may be had so that unduly large installations of numbers of the ovens may be avoided by using the ovens more frequently in order to get out more coke as well as the gases and other fluid products coming therefrom during the operations. In other words the problem resolves itself into a question of the rate of heat exchange from the heating medium to the coal itself.

A detailed description of the apparatus and the method of operating the apparatus in order to produce a more rapid rate of heat exchange is made in reference to the accompanying drawings in which

Fig. 1 is a diagrammatic representation of the structure; and

Fig. 2 is a graph illustrating fluidized and non-fluidized coal bed runs.

Coal of the desired quality is fed into a coal pulverizer 1 by any suitable means wherein the conveying of the coal to the pulverizer is through a conventional conveyer or even fed to the pul-

verizer 1 by gravity. Here in the pulverizer 1, the coal is heated by gas being taken from a furnace 2 by a blower fan 3 to carry the heated air or gas into the pulverizer so as to warm the coal and at the same time tend to drive off some moisture.

In the pulverizer 1, the coal is ground to a fineness of approximately sixty-five per cent passing through two hundred mesh screen. The air supplied by the blower 3 carries the heated and pulverized coal from the pulverizer 1 up through any suitable conveying means herein shown as a pipe 4, to discharge the pulverized coal into a dust separator 5. Here in the separator 5, the air is separated from the coal to be vented in any suitable means such as through the pipe 6. The pulverized coal settles into the bottom of the separator 5, and is stored therein.

A valve 7 at the underside of the separator 5 controls discharge of the pulverized coal therefrom. Where a batch operation is followed, the valve 7 will be intermittently opened and closed, but where a continuous operation is to be employed, the valve 7 will be open, and the pulverized coal from the separator 5 may be flowed through a conductor 8, herein shown as being conveyed therethrough by gravity to a fluidizing chamber 9.

The fluidizing chamber 9 in its simplest form may consist simply of a cylindrical steel shell 10 having a grid or screen floor 11 extending across its lower end. The chamber 9 is to be heated by any suitable means, internally or externally, herein shown as being internally heated from the furnace 2 whereby a pump 12 circulates a heating medium through the pipe 13 through an internal coil 14, the coil 14 being located centrally within the shell 10. The flow of the heating medium is controlled by means of the valves 15 and 16 externally of the shell 10 and intercepting the pipe line 13, the valve 15 being on the pump discharge side and the valve 16 being on the pump intake side.

When the predetermined amount of pulverized coal is taken from the dust separator 5 and discharged through the duct 8 into the chamber 9, and onto the perforated floor 11, the valve 7 is closed off in the batch operation.

A fluidizing gas which might be steam, the make-gas from the carbonization retort, flue gas, or even gas secured from the pulverized coal within the fluidizing chamber, is fed into the shell 10 through the conical bottom 17 by any suitable means, herein shown as by a blower 18. The gas from whatever source it may be taken is flowed

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through the pipe 19 in which there is a valve 20 to regulate the flow into the shell 10 in order to give the velocity within the fluidizing chamber 9 just sufficient to fluidize the coal. Where the fluidizing gas is to be introduced from outside of the system, it is entered into the system through the pipe 21 under control of the valve 22. From the valve 22, the gas may be conducted through the pipe 23 through a heating chamber 24 and thence through the pipe 25 to the blower 18. The heater 24 may be supplied with heat from the furnace 2 by means of the pipe 26 controlled by the valve 27 and the return pipe 28 controlled by the valve 29.

The gas entering the bottom of the chamber 9 is distributed uniformly over the diameter of this chamber by being diffused through the screen floor 11. From the floor 11, the gas passes up through the bed of the pulverized coal. The velocity of this gas coming into the chamber 9 is regulated as previously indicated by the valve 29 so that the incoming gas in passing through the bed of coal will lift and separate the individual particles of that coal until the coal is separate one particle from the other to fluidize that coal and carry the particles in suspension, one particle substantially separated from all adjacent particles, to create a condition closely analogous to a liquid in respect to the coal itself. That is, the condition may be pictured as being that each individual coal particle is buoyed up by an encircling gas film so that the particles are really in a state of high agitation something like the picture of the individual atoms within a molecule. In order to maintain this fluidized state of the coal, the gas entering the chamber 9 is allowed to discharge under pressure into a cyclone separator 31 so as to separate the dust from the coal within the chamber 9, drop the separated dust through the pipe 30, and allow substantially clean gas to escape from the chamber through the pipe 32. At the same time, the interior of the chamber 9 is being heated by the coil 14 in the present instance to bring the temperature up to that point wherein the individual coal particles are heated to just below the stage where the coal will tend to soften. The temperature of 370 degrees C. is a good average, but each coal used will have a different softening range. In any event, it is necessary to stay just below this softening range of the coal because the coal particles will coalesce in the fluidizing chamber to form a semi-plastic mass which would be impossible to fluidize satisfactorily. Therefore, the fluidization must stop just before the coal reaches this temperature of producing softening so that the fluidized and heated coal may be transferred from the chamber 9. That is the transfer from the chamber 9 is made while the coal is still in its fluidized state.

During the fluidizing step within the chamber 9, while the coil thus fluidized is being heated, gases and vapors will be driven off from the coal to appear within the chamber 9. These gases along with the gas introduced through the valve 20 after being carried through the dust separator 31 in the upper end of the chamber 9 are carried all through the pipe 32 where the flow may be divided under control of the valve 33 and a second valve 34. The valve 33 controls a flow from the pipe 32 to a pipe 35 which leads to a gas scrubber 36 being of any conventional design. Scrubbed gas may escape from the pipe 37, and liquids may be conveyed from the scrubber through the pipe 38.

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However if it be desired, a part at least of the gas coming off through the pipe 32 may be circulated back through the chamber 9 by closing the valve 33 and opening the valve 34 which controls flow from the pipe 32 to the pipe 23. In this manner, advantage may be taken of the fact that the gas coming from the pipe 32 is then at a relatively high temperature so that it can be conveyed directly through the floor 11 and back into the chamber 9 without much additional heat if any having to be applied to that recirculating gas.

As indicated, the gas and vapors such as water vapor, in excess of the amount required for fluidization is bled off through the valve 33 and passed through the scrubber 36 for recovery of the desired elements thereof.

By reason of the fluid state of the pulverized coal within the chamber 9, heat transfer is rapidly effected from the coil 14 to the individual coal particles, by all three possible means such as by conduction, convection, and by radiation. By reason of the highly agitated mass, and by reason of the nature of the fluidized coal being somewhat in the nature of a liquid, the heated particles circulate through the entire mass to effect the transfer of heat very quickly.

The fluidized and heated coal is discharged from the chamber 9 after it has reached the temperature just below the coalescing temperature range, to be carried out through the duct or pipe 39 in which there is placed a control valve 40. This pipe 39 may lead to any desired type of a carbonizing or coking retort, herein conventionally shown in one form as a coking retort 41. The heated, fluidized coal, is discharged through the hatchways 42 into the carbonizing chamber 43.

The coal entering the chamber 43 in its fluidized state will tend to settle to its original volume, and the contained gas escapes and is taken off in the usual manner through a vent pipe 44 to be carried to a conventional gas handling system. The chamber 43 is heated as in any carbonizing retort, the initial heating tending to drive off the gas from the coal from its surface to aid in the settling of the coal.

When the coal has been reduced to its substantially original volume within the retort 41, carbonization of the coal continues by the application of heat to bring the coal up to higher temperatures the temperature being carried up to around five hundred and eighty degrees C., although this temperature of course will vary in accordance with the coal again, but in any event the carbonization is considered complete when the coal charge reaches a pre-determined temperature for the particular coal being treated.

Now while the coal in the retort 41 is in substantially the same volume as it would have been had it been put in the retort originally without being fluidized, there is a great saving of time in the time dwell of the carbon material within the retort as compared to fluidizing and non-fluidizing the coal.

The great advantage of operating a coke oven with a fluidized charge over operating the same kind of an oven with a stationary charge is set out in Fig. 2. The lines A and B show the fluidizing operation while the lines C and D show the standard stationary charge operation.

In the chart, Fig. 2, that part of the solid line to the left of the zero vertical line represents the fluidizing and pre-heating operation of the coal up to a point short of 400 degrees C. From that point, the fluidized coal is transferred into the

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coke oven. The continuing line A represents temperatures taken at the various time intervals within the coal, inside of the coke oven, close to the heating walls. The broken line B represents the temperature in substantially the center of the charge in the oven.

The line C represents or indicates temperatures taken at the time intervals indicated close to the heating walls within the oven of the stationary charge operation, while the line D indicates the temperatures taken within substantially the center of the stationary charge within the coke oven.

It is to be noted that the rate of climb of the fluidized coal upon being introduced into the coke oven and the rate of climb of temperature of the stationary charge in the standard operation run are at about the same rate. It is to be kept in mind that these temperature indications plotted on these portions of the lines represent the temperatures near the heating walls of the coke oven. However it is to be noted that the temperatures indicated by the lines C and D have an extremely wide spread as compared to the spread between the lines A and B. The line D very clearly indicates that a great amount of time required in the standard sixteen hour cycle for the stationary charge operation of a coke oven is taken up in bringing the stationary charge up to the four hundred degree C. temperature. In other words it takes substantially eight hours constant heating to bring the temperature of the coal in its central zone up to that point where it will start heating above the one hundred degree C. temperature. Then there is a gradual rise in the time from the initial eight hour period up to the thirteen hour period or a little therebeyond, which is substantially at the four hundred degree C. temperature when the central zone temperature will start to increase rapidly up to the end of the sixteen hour period. There is a tremendous amount of heat required to be transferred from the wall of the oven through the stationary charge to evaporate the water content, and when this heat has to be transferred through seven or eight inches of coal to the central zone of the charge, the delay indicated by the chart follows. Now this is not true in the fluidized heating through this zone.

That delay is overcome by the fluidizing of the coal and the pre-heating of the fluidized coal before it is put into the pre-heated coke oven. Thus it is to be seen that as the example indicates in Fig. 2, there is the tremendous saving of time in the operation of the standard by-product coke oven resulting in a saving of nearly nine hours.

The yield of products such as gas, tar, coke, and other well known products, are comparable with the products obtained when carbonizing the same coal non-fluidized under the same retort operating conditions. In the fluidizing operation as above indicated, some of those products will be recovered prior to the carbonizing step in the retort.

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Therefore it is to be seen that the system set up and the manner of its operation produce an extremely and highly beneficial result in that the use of the retort itself for the carbonizing step is reduced in time practically one-half of what it is in use in the conventional procedure. The cost of the apparatus and its operation for fluidizing the coal prior to flowing it into the retort is quite minimal as compared to the cost of building and operating additional retorts. While we have herein shown and described the invention in best form as now known to us, it is obvious that many structural changes may be employed in the system itself, and variations may be introduced in the method of operation all without departing from the spirit of the invention, and we therefore do not desire to be limited to that precise structure or method beyond the limitations which may be imposed by the following claim.

I claim:

In a process of producing a structurally dense, hard metallurgical coke from coal and securing a maximum yield of undecomposed by-products, those steps of heating the individual, discrete particles of finely ground coal in a fluidized state to a temperature immediately under its coalescing temperature range; conveying in suspension the heated fluidized coal beyond influence of continued fluidization directly into a heated confined retort; and heating the coal in said retort by indirect heating so as to defluidize said coal by driving off fluidizing gas and continuing heating said coal through a plastic state to a coked state.

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