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Kemmetmueller

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[54] **METHOD FOR DRYING COAL**

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Related U.S. Application Data

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[52] **U.S. Cl.** **34/10**, 432/15, 202/227

[51] **Int. Cl.** **F26b 3/08**

[58] **Field of Search** ..... 34/10, 26, 31, 32, 37, 34/40, 72, 57 A, 219; 202/150, 228, 227; 432/15, 58

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[57] **ABSTRACT**

A method for drying coal. The coal, in the form of coal particles, is fed into a drying chamber where the coal is suspended in a fluidized bed while being dried in an atmosphere of steam which is at a temperature too low to release oxygen but high enough to extract sulphur from the coal particles. The temperature of the atmosphere in the fluidized bed where the drying of the coal takes place is regulated with heating coils which directly contact the coal particles while the latter are suspended in the fluidized bed, so that further drying is achieved by direct contact between the coal particles and the heating coils. The coal with its reduced sulphur and moisture content is taken in a preheated condition from the dryer and delivered to a coke oven to reduce the extent to which coal must be heated therein. Gas extracted from the dryer is treated to have water condensed therefrom and to extract sulphur therefrom. In addition, pellets of calcium oxide and/or magnesium oxide are delivered to the fluidized bed together with the coal particles for further extracting sulphur from the atmosphere in the fluidized bed, these pellets also being subsequently treated, as by roasting, to extract sulphur therefrom.

4 Claims, 5 Drawing Figures

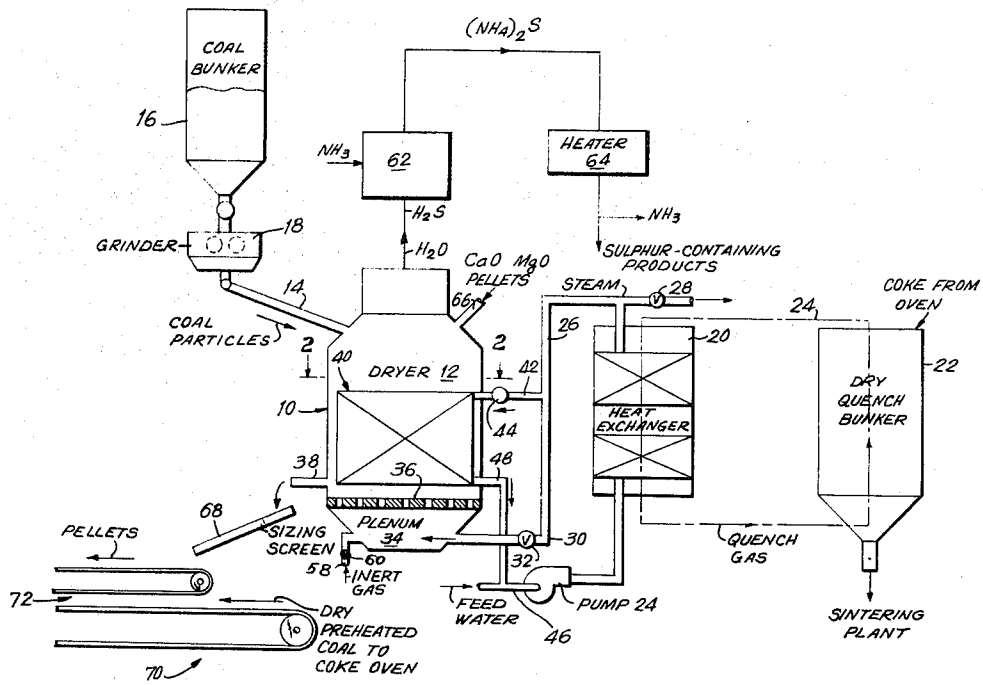


FIG. 1

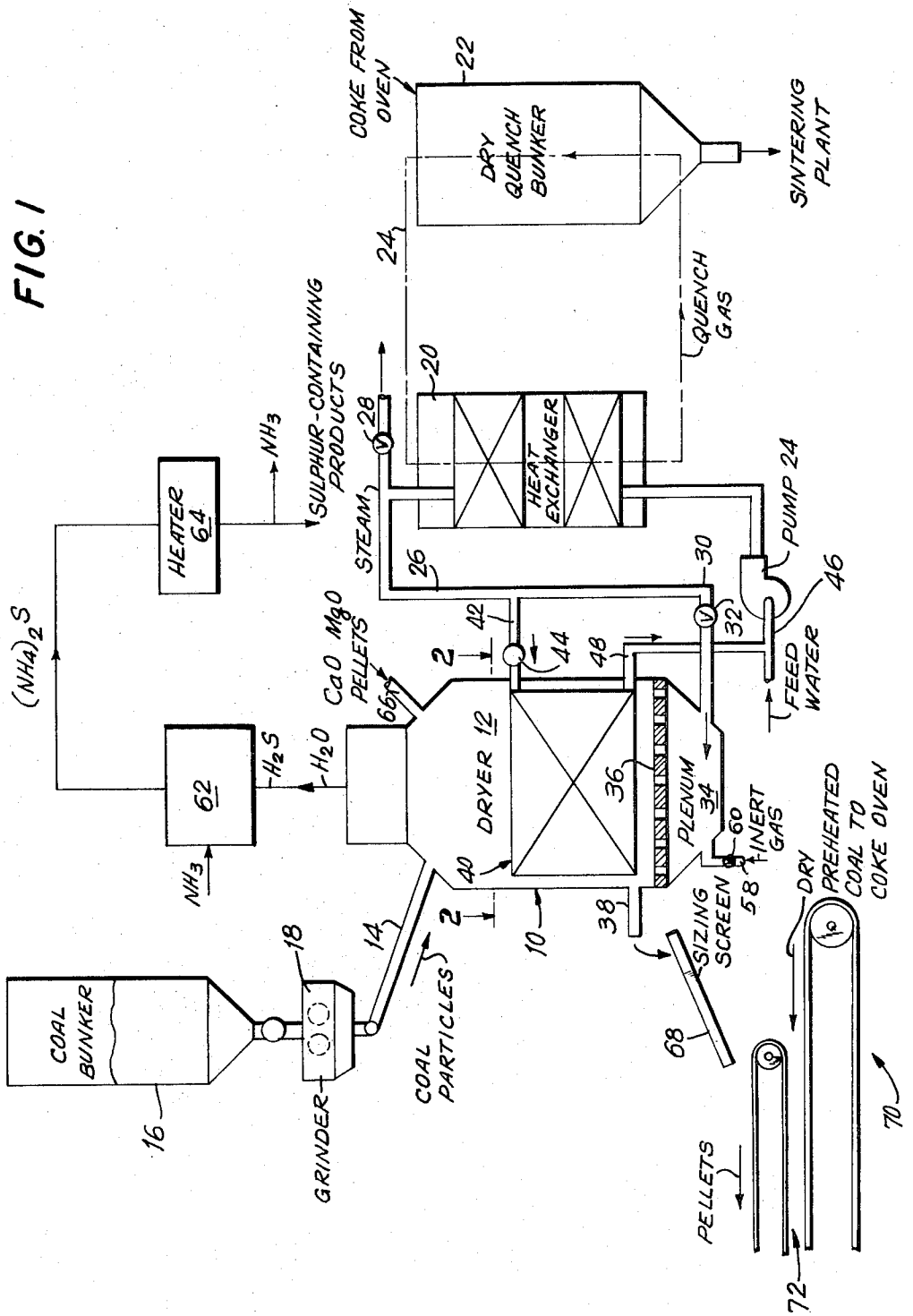

COKE FROM OVEN
22
DRY QUENCH BUNKER
SINTERING PLANT
24
QUENCH GAS
20
HEAT EXCHANGER
28
STEAM
26
30
PUMP 24
46
FEED WATER
32
42
44
48
2
CaO MgO PELLETS
66
DRYER 12
36
PLENUM 34
60
INERT GAS
58
40
38
10
SIZING SCREEN
68
DRY PREHEATED COAL TO COKE OVEN
70
72
PELLETS
COAL PARTICLES
14
18
GRINDER
16
COAL BUNKER
NH3
62
H2S
H2O
HEATER 64
SULPHUR-CONTAINING PRODUCTS
NH3
(NH4)2S

FIG. 2

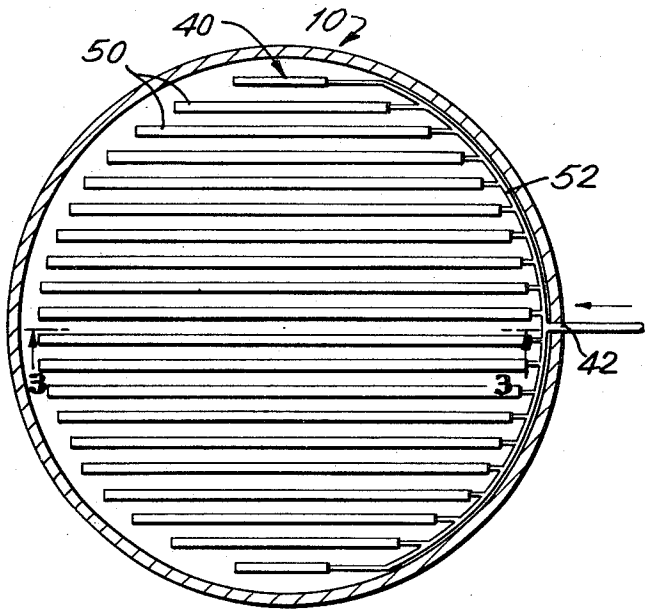
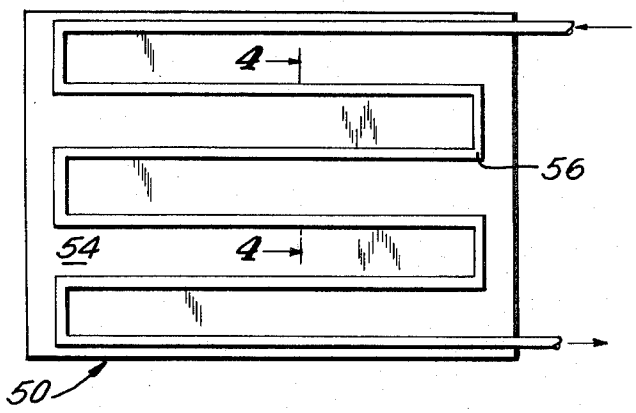


FIG. 3



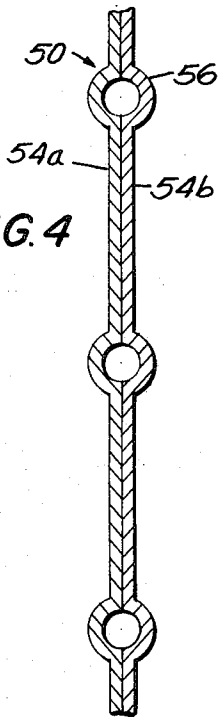
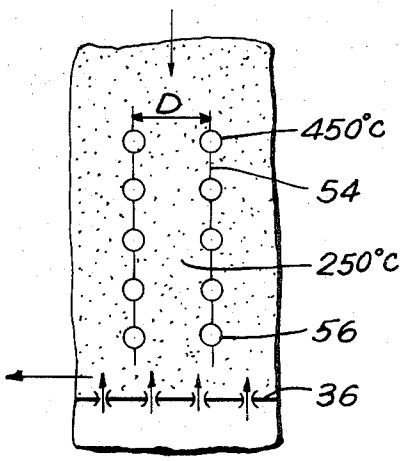


FIG. 4

FIG. 5



METHOD FOR DRYING COAL

CROSS REFERENCE TO RELATED APPLICATION

This application is a division of application Ser. No. 283,155, filed Aug. 23, 1972 and entitled "Method and Apparatus for Drying Coal."

BACKGROUND OF THE INVENTION

The present invention relates to methods for drying coal.

The present invention relates in particular to such methods as used in connection with coke plants where coal is converted into coke which is then available for use in blast furnace, for example.

In conventional coke plants it is customary to deliver coal directly from bunkers to coke ovens in which the coal is treated so as to be converted into coke. These conventional operations are accompanied by great disadvantages. For example, a considerable amount of heat energy is lost with conventional coke plant operations. In addition, these operations are accompanied by unavoidable discharge of pollutants to the outer atmosphere, creating problems with ecology as a result of contamination of the atmosphere, streams of water, and terrain in the vicinity of the coke plants. One of the more serious sources of this undesirable contamination is the sulphur which is released from the coal during the formation of the coke. Thus, considerable energy is required to drive moisture from the coal and in addition sulphur is released in an undesirable manner to the outer atmosphere with conventional coke plant operations.

It has already been proposed to dry coal prior to delivery thereof to the coke oven batteries, but these coal drying operations are extremely dangerous. All known installations for drying coal suffer to some degree from explosions which occur because of the presence of oxygen in the coal-drying atmosphere.

SUMMARY OF THE INVENTION

It is accordingly a primary object of the present invention to provide a method which will avoid the above problems.

In particular, it is an object of the present invention to provide a method capable of drying coal in such a way that the risk of explosions is eliminated.

Also it is an object of the present invention to provide a method for drying coal in such a way that sulphur is extracted from the coal to reduce the extent to which the sulphur pollutants are discharged.

Furthermore, it is an object of the present invention to provide a coal-drying method which makes use of energy available at a coke plant and which otherwise would be wasted, so that considerable economies will be achieved with the method and apparatus of the invention.

Furthermore, it is an object of the invention to treat the coal prior to delivery thereof to the coke oven battery in such a way that the operating time required for the coke oven battery can be considerably reduced.

Thus, it is an object of the invention to treat coal at a coke plant in such a way that utilization is made of energy which otherwise would be wasted, while at the same time further economies are achieved by reducing the time required for operation of the coke ovens to convert the coal into coke, and furthermore while reducing the extent to which pollutants are discharged.

In accordance with the invention coal particles are delivered to the interior of a drying chamber which is closed off from the outer atmosphere and the coal particles are dried in the drying chamber by utilizing for drying purposes steam which is at a temperature high enough to extract sulphur from the coal during drying thereof while at the same time the temperature of the steam is maintained low enough to prevent separation of oxygen from the steam. The drying steam is used to form a fluidized bed from the coal particles, and in the fluidized bed there are heating coils which control the temperature of the fluidized bed while at the same time further drying the coal by direct contact with the coal suspended in the fluidized bed. Hydrogen sulfide is formed in the drying chamber as a result of extraction of sulphur from the coal, and this hydrogen sulfide is treated in a number of ways so as to extract the sulphur as a by-product of the method of the invention. The coal which is discharged from the dryer in a preheated condition free of moisture and sulphur is delivered directly to the coke oven battery, to achieve in this way a reduction of the operating time of a coke oven battery which is on the order of 50 percent. Water which is condensed from gas which is discharged from the coal dryer is used to quench gas issuing from the coke oven battery, and heat extracted from the coke during dry-quenching thereof is used for heating in a heat exchanger steam which is used for drying the coal, so that in this way considerable economies are achieved.

BRIEF DESCRIPTION OF DRAWINGS

The invention is illustrated by way of example in the accompanying drawings which form part of this application and in which:

FIG. 1 is a schematic representation of a method according to the invention;

FIG. 2 is a schematic sectional plan view taken along line 2—2 of FIG. 1 in the direction of the arrows and illustrating the interior of a coal dryer of the invention;

FIG. 3 is an elevation taken along line 3—3 of FIG. 2 in the direction of the arrows and illustrating one of the partition walls which includes heating coils as a part thereof;

FIG. 4 is a fragmentary sectional elevation taken along line 4—4 of FIG. 3 in the direction of the arrows to illustrate further details of the structure of FIG. 3; and

FIG. 5 is a fragmentary schematic illustration of the manner in which the coal is treated in the coal drying of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. 1, there is illustrated therein a coal-drying installation according to the present invention. The coal-drying installation includes a housing means 10 which is closed off from the outer atmosphere and which defines in its interior a drying chamber 12, as indicated schematically in FIG. 1. A coal-feeding means 14 is provided for feeding particles of coal into the housing means 10 so that drying of the coal will take place in the drying chamber 12.

As is schematically indicated in FIG. 1, the coal is initially stored in bunkers 16. From the bunkers 16 the coal flows through grinding units 18 so as to be reduced

in this way to particles of a predetermined size. For example the coal particles may have a size on the order of ⅛ inch. It is to be understood that a group of bunkers are provided for the coal, these bunkers respectively communicating with grinders the output of which may all be combined with a single pipe which is operatively connected with the housing means **10**, in the manner indicated for the pipe **14**, so that in this way such a feedpipe will form a coal-feeding means for feeding the particles of coal into the drying chamber **12**. The particles of coal issue from the feeding means **14** into a central region of the chamber **12** and are distributed throughout the entire cross section of the chamber progressing downwardly therethrough in a manner described in greater detail below.

As has been indicated above, it is extremely important to avoid the presence of free oxygen within the drying chamber **12** since the presence of oxygen will unavoidably result in dangerous explosions. Thus, in accordance with one of the features of the present invention the drying of the coal takes place by exposing the coal particles in the drying chamber **12** to an atmosphere of steam which is maintained at a temperature low enough to prevent release of oxygen from the steam but high enough to drive sulphur out of the particles of coal during the dying thereof. Thus moisture and sulphur will be driven off from the particles of coal due to the drying action which takes place in the chamber **12**. Thus, the atmosphere of steam in the chamber is maintained at a temperature on the order of 250°C, since at this temperature organically bound H_2S will be driven off from the particles of coal. As long as the temperature of the steam in the drying chamber **12** is maintained at a temperature lower than 500°C, there will be no release of free oxygen from the steam, and the danger of explosions will be avoided.

According to one of the features of the present invention the steam used for drying purpose in the housing means **10** is derived from a heat-exchanger means **20** shown schematically in FIG. 1 between the housing means **10** and a bunker **22** in which coke from a coke oven is cooled by dry-quenching. As is illustrated in FIG. **1** by the dot-dash circuit **24**, gas which is used for quenching the coke in the bunker **22** circulates, after being heated by the coke which is cooled in the bunker **22**, through the heat exchanger means **20**. Thus, through suitable conduits and with the use of suitable fans or the like there will be a continuous circulation of the dry-quenching gas upwardly through the coke which is cooled in the bunker **22** and downwardly through the heat exchanger, so that heat extracted from the gas in the bunker **22** is given up to the fluid which is heated in the heat exchanger means **20** during cooling of the gas before it is returned to the bunker **22**. Feedwater is fed to the heat exchanger means **20** in any suitable way, as by a pump **24**, and in this way there will be derived from the heat exchanger means **20** steam which flows through the supply means **26**. This supply means **26** takes the form of suitable steam conduits which have a control valve **28** for controlling the flow of steam to any desired location where use will be made thereof. However, part of the steam-supply means includes a portion **30** of the conduit **26** which communicates with a plenum formed at a lower interior portion of the housing means **10**, the flow of the steam into the plenum being controlled by a valve **32**. The plenum **34** is defined beneath an apertured wall **36** which is carried by and extends across the interior of the housing means **10**. This way **36** may be constructed in any known way to form a fluidized bed of the coal particles with the steam issuing up through the wall **36**, so that in this way the coal particles are maintained in a fluidized bed in the chamber **12** and the wall **36** together with the plenum **34** forms a fluidizing means for forming a fluidized bed of coal particles. Thus, the wall **36** may take the form of a wall carrying suitable nozzles, or it may take the form of a suitably apertured plate, or it may be composed of a mesh of rods, all of which is well known in the art.

Thus, by way of the fluidizing means **34, 36** the steam supplied by the steam-supply means **30** will maintain the particles of coal suspended in a fluidized bed in the drying chamber **12**, The dry coal issues from the housing means **10** through a discharge means **38** which may take the form of a suitable discharge duct the diameter of which is such that in combination with the rate of supply of coal particles by the supply means **14** and the treatment of the coal in the fluidized bed there will be an issue of dry coal at a preselected rate from the discharge means **38**.

According to a further feature of the invention, the steam in the drying chamber **12** has its temperature regulated by way of a heating means **40** which takes the form of coils through which steam flows, these coils forming parts of partition walls in the manner described in greater detail below. The steam for the heating means **40** is also derived from the supply means **26**. Thus the conduit **26** has a branch **42** provided with a control valve **44** and communicating with the heating means **40** so as to deliver to the latter the same steam which is delivered to the plenum **34**. Actually a greater amount of steam is delivered to the heating means **40** while only a relatively small amount of steam is delivered to the plenum **34**. However, the same single source of steam, namely the conduit **26** which derives its steam from the heat exchange means **20** is used for supplying steam both to the heating means **40** and to the fluidizing means **34, 36**. After flowing through the heating means **40**, the steam discharges back to the inlet pipe **46** which delivers the feedwater to the pump **24**, a return flow pipe **48** being provided for this purpose. Thus the returning fluid from the heating means **40** is combined with the feedwater to be fed back to the heat exchanger and reheated before being returned to the heating means **40**, and the feedwater will make up for losses such as that which occurs in connection with the supply of steam to the plenum **34**.

Referring to FIG. **2**, it will be seen that the heating means **40** takes the form of a relatively large number of parallel plates **50** which are spaced from each other and mounted in any suitable way in the interior of the housing means **10**, as shown schematically in FIG. **2**. The supply pipe **42** communicates with a suitable header **52** which in turn communicates with the several plates **50** each of which has a construction as described below and illustrated in FIGS. **3** and **4**.

Thus, referring to FIG. **3**, it will be seen that each plate **50** is in the form of a wall **54** having coils **56** as a part thereof. As may be seen from FIG. **4**, each wall **54** is composed of a pair of plate portions **54*a*** and **54*b*** which are fixed in any suitable way to each other. These plate portions **54*a*** and **54*b*** are formed with grooves which register with each other when the plate portions are joined together, so that in this way each

wall 54 will have as a part thereof the coils 56 which may have a configuration as shown schematically in FIG. 3.

The manner in which the coal particles are treated with the above construction is shown schematically in FIG. 5. In the case where the coal particles have a size on the order of ⅛ inch, the walls 54 may be spaced from each other by a distance D which is on the order of 4 inches, with the coils 56 have a diameter on the order of 2 inches. Thus, the parallel walls 54 of the heating means 40 form partitions which define between themselves upright spaces having a width on the order of 4 inches, and it is in these relatively narrow spaces that the coal particles are confined in the fluidized bed above the apertured wall 36. This wall 36 is shown in FIG. 5, schematically, as including the nozzles which direct the steam from the plenum 34 upwardly into the drying chamber to maintain the fluidized bed of coal.

A number of advantages are achieved with this construction which is shown in FIG. 5. In the first place, it has been found in practice that by way of controls such as those derived from the valves 32 and 44 it is possible to very closely regulate the temperature of the steam in the drying chamber. The steam within the coils 56 is maintained at a temperature range of 250°–450°C, while the coal itself is maintained at a temperature range of 100°–250°C, with the steam in the fluidized bed being at a temperature on the order of 250°, as indicated schematically in FIG. 5, so that in this way the organically bound hydrogen sulfide will be driven off from the coal particles.

A further advantage achieved with the construction shown in FIG. 5 resides in the fact that the particles of coal repeatedly come directly into contact with the walls 54 and particularly with the heating coils 56 thereof, so that not only is the coal heated by way of the steam in the fluidized bed, but in addition it is heated by way of direct contact with the heating means, so that the drying of the coal is enhanced by contact-drying of the coal as a result of engagement of the coal particles directly with the heating means 40. Thus, an exceedingly efficient coal-drying operation free of any possibility of explosion is achieved with the method and apparatus of the invention. The coal which issues from the discharge means 38 is free of ammonia, water, and sulphur, and is in a preheated condition which is ideal for direct supply to a coke oven.

According to a further feature of the invention, instead of utilizing steam to form the fluidized bed, an inert gas may be supplied to the plenum 34 by way of a conduit 58 which is capable of being open and closed by way of a valve 60. For example, nitrogen or cleaned stack gas may be used as the inert gas. Irrespective of which particular inert gas is used to form the fluidized bed, the inert gas may be preheated so that it will have a suitable temperature. For example, the conduit 58 may communicate with coils in the heat exchanger 20 to which the inert gas is supplied so that the inert gas is heated by extracting heat from the dry-quenching gas which is heated as described above when flowing through the circuit 24.

During the operation of the drying installation through suitable fans and conduits steam vapor and hydrogen sulfide are continuously drawn out of the upper portion of the housing means 10 to be delivered to a reaction unit 62. Ammonia is supplied to this unit to react with the products flowing out of the housing means 10, and as a result with condensation there is achieved ammonia liquor which may be used for any desired purpose as well as $(NH_4)_2S$ which is delivered to a heating unit 64 to retrieve from the latter ammonia as well as various sulphur-containing products.

According to a further feature of the invention, the sulphur content of the atmosphere in the drying chamber 12 is reduced by operatively connecting with the housing means 10 a supply means 66 for supply to the drying chamber 12 pellets which will extract sulphur from the atmosphere in the chamber 12. These pellets may be calcium oxide and/or magnesium oxide pellets having a diameter on the order of ½ inch in the case where the coal particles have a diameter on the order of ⅛ inch. These pellets when progressing through the fluidized bed to the discharge means 38 combine with sulphur to form $Ca\ So_4$ and/or $Mg\ So_4$. The latter pellets are discharged together with the coal particles onto a sizing screen 68 by the discharge means 38. The mesh of the sizing screen is such that the smaller coal particles fall downwardly through the screen onto a conveyor 70 which conveys the dry preheated coal to the coke oven. The pellets which do not fall through the screen travel along the latter and drop onto a conveyor 72 which delivers the pellets to roasting ovens where the pellets return to their initial composition with extraction of sulphur dioxide therefrom.

With an installation as described above it is possible, particularly with the size ranges of the coal particles and heating means to achieve and output of the order of 100 tons of dry preheated coal per hour. This dry preheated coal is delivered directly to a coke oven battery, and with the use of this coal in the coke oven battery it has been found possible to reduce the operating time of the coke oven battery by 50 percent. Because sulphur is driven from the coal during the drying thereof the possibility of polluting the atmosphere with products from the coke oven batteries is greatly diminished. Moreover, the amount of water needed to quench coke oven gas issuing from the ovens is greatly reduced.

Thus, with the method of the invention the possibility of polluting atmosphere, streams, and adjoining terrain is very greatly reduced. In addition, the possibility of explosions occurring at the drying installations is also eliminated. Furthermore, the operations are carried out in such a way that use is made of energy which otherwise would be wasted, so that considerable economies are achieved. Furthermore, the coal delivered to the coke ovens is in a condition which greatly reduces the time required for operation of the coke ovens, as pointed out above.

What is claimed is:

1. In a coal-drying method, feeding coal particles which are to be dried to a drying chamber, drying the coal in said chamber with heating coils supplied with steam, heating the latter steam in the heating coils with a heat exchanger while deriving heat for the heat exchanger from coke-cooling gas used during dry-quenching of coke from a coke oven, extracting hydrogen sulfide from the drying chamber and reacting the hydrogen sulfide with ammonia for extracting sulphur from the hydrogen sulfide.

2. In a coal-drying method, feeding coal particles which are to be dried to a drying chamber, drying the coal in said chamber with heating coils supplied with

steam, heating the latter steam in the heating coils with a heat exchanger while deriving heat for the heat exchanger from coke-cooling gas used during dry-quenching of coke from a coke oven, feeding to the drying chamber simultaneously with the coal particles pellets which have a composition which will extract sulphur from the atmosphere in the drying chamber, the pellets being selected from the group consisting of calcium oxide and magnesium oxide.

3. In a coal-drying method, feeding coal particles which are to be dried to a drying chamber, drying the coal in said chamber with heating coils supplied with steam, heating the latter steam in the heating coils with a heat exchanger while deriving heat for the heat exchanger from coke-cooling gas used during dry-quenching of coke from a coke oven, the coal particles having a size on the order of ⅛ inch, maintaining the drying steam in the form of a fluidized bed in a temperature range of 100°–250°C, controlling the temperature in the drying chamber with heating coils having therein steam at a temperature range of approximately 250°–450°C, utilizing for the coils pipes of approximately 2 feet diameter and forming parts of partitions which define between themselves spaces in the fluidized bed having a width on the order of 4 inches, feeding to the fluidized bed pellets selected from the group consisting of calcium oxide and magnesium oxide and having a diameter on the order of ½ inch, discharging the pellets and the dry coal from the drying chamber, and then roasting the pellets.

4. In a coal-drying method, feeding coal particles which are to be dried to a drying chamber, drying the coal in said chamber with heating coils supplied with steam, heating the latter steam in the heating coils with a heat exchanger while deriving heat for the heat exchanger from coke-cooling gas used during dry-quenching of coke from a coke oven, extracting fluid from the drying chamber, condensing water therefrom, and utilizing said water for quenching gas issuing from a coke oven.

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