

Dec. 16, 1958

C. C. THROOP ET AL

2,864,537

BULK DENSITY CONTROL OF COKING COAL

Filed Aug. 14, 1956

2 Sheets-Sheet 1

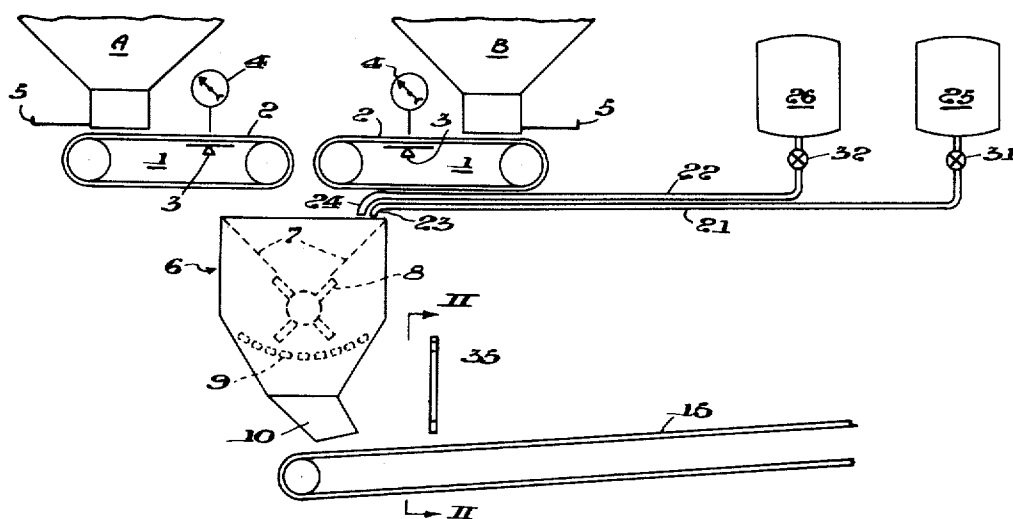


Fig. 1.

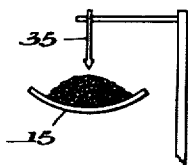


Fig. 2.

INVENTORS,
CHARLES C. THROOP
and ORLEN V. WINCE.
BY
Ralph B. Brink
their
ATTORNEY.

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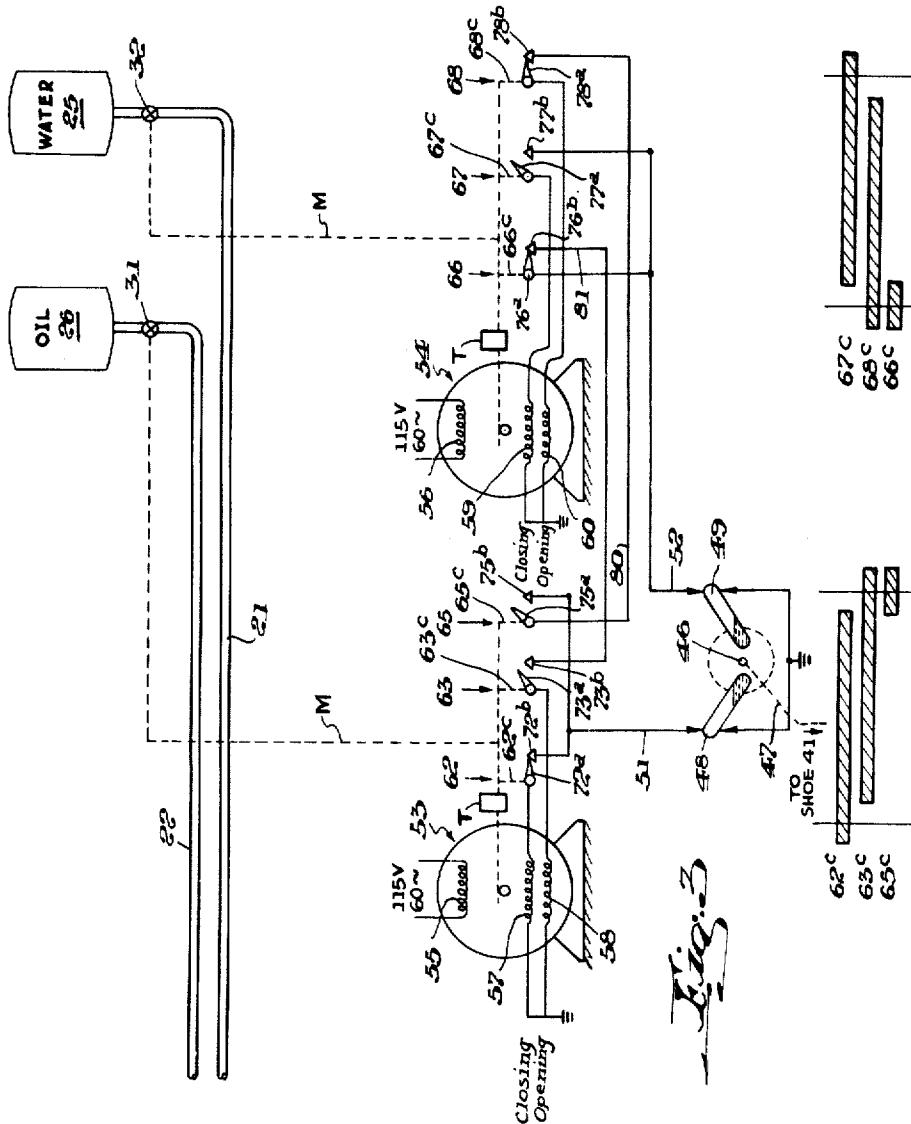


Fig. 3

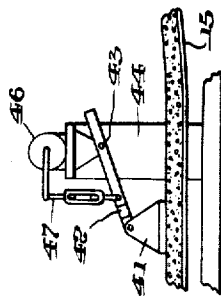


Fig. 4

INVENTORS.
CHARLES C. THROOP
and ORLEN V. WINCE
BY
Ralph B. Brick
their ATTORNEY.

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BULK DENSITY CONTROL OF COKING COAL

Charles C. Throop and Orien V. Wince, Monessen, Pa.,
assignors to Koppers Company, Inc., a corporation of
Delaware

Application August 14, 1956, Serial No. 603,943

8 Claims. (Cl. 222—57)

This invention relates to apparatus for controlling variations in the bulk density of coking coal due to variations in its surface moisture and comprises a continuation-in-part of application, Serial No. 360,174, filed in the U. S. Patent Office on June 8, 1953, now Patent No. 2,765,266.

It is now generally recognized that one of the most important factors affecting the uniformity of coke oven operations and the quality of the coke produced is the bulk density of the coal that is charged into the oven. Changes in that bulk density not only cause irregular heating, which is reflected in the impaired quality of the coke; but also cause variations in oven capacity, which affect the coke yield. The principal cause of bulk density changes in coking coal is the variation in its surface moisture. As the surface moisture increases up to a limit of around 8% or 9%, the coal increases in volume and its bulk density decreases. Conversely, as this wet coal dries out, it shrinks in volume and its bulk density increases. Between dry coal and wet coal, the bulk density may vary as much as 15% or more; and in coke oven operations it is seldom uniform or predictable, since coking coals are generally a blend of different coals, some of which may have been freshly mined and have a low moisture content, and others of which may have more or less surface moisture, depending on the processing to which they have been subjected and on the weather conditions under which they have been transported and stored. While it is generally recognized that some moisture is desirable in the coke oven charge, the difficulty has been to control it, and keep it uniform.

It has heretofore been discovered that small amounts of oil added to wet coal cause a significant increase in its bulk density, as described in Patent No. 2,378,420 for "Regulating the Bulk Density of Coke Charges," issued on June 19, 1941. Since that discovery, various methods and devices have been used with indifferent success to control the bulk density by adding varying amounts of oil and/or water to coking coals, ranging from dry coal to wet coal, in order to obtain and maintain the minimum moisture content and the specific bulk density that is best suited for a particular coking operation. Accordingly, the general object of the present invention is to provide an apparatus for controlling the bulk density of coking coals by the addition of oil and/or water that will be an improvement over those now used.

In accordance with this invention, pulverized coking coal is delivered at a substantially uniform rate by weight onto a conveyor that is moving at a constant speed, whereby variations in the bulk density of the coal will be indicated by variations in the height of the coal on the moving conveyor, and means is provided for adding to the coal before it is delivered to the conveyor in accordance with variations from a predetermined level in the height of coal thereon predetermined proportions of at least one of the group consisting of water and oil in order to maintain the coal on the conveyor at a predetermined

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height corresponding to the desired minimum moisture content and to the desired bulk density.

The preferred embodiment of this invention is illustrated in the accompanying drawings in which—

Figure 1 is a schematic view of the apparatus as disclosed in the parent application, Serial No. 360,174;

Figure 2 is a cross section of a portion of the apparatus shown in Figure 1, the plane of view being indicated by the line II—II on Figure 1;

Figure 3 is a schematic view of a portion of the apparatus embodying the present invention, disclosing automatic control means for controlling the valves connected to the oil and water supply source;

Figure 4 is a view of the height gauge used in combination with the automatic control means to sense variations of the height of coal on the conveyor belt.

In a coke oven plant, the raw coal as it comes directly from the mine, or from storage bins, or from the stockyard is generally delivered to a plurality of blending bins, each bin containing a different type of coal, or mixture of coals, that are to be blended in desired proportions. Two such bins, A and B, are shown in Figure 1. At the outlet of each bin, there is provided a weight-controlling feeder 1 of conventional design for withdrawing a specified weight of coal per unit of time from the bin. Each feeder includes a conveyor 2, a weighing means 3 which supports a portion of the conveyor, a weight indicator 4, and an adjustable gate 5, at the outlet of the feeder. The gate is controlled by the weighing means and varies the amount of coal that is withdrawn from the bin, so that a specified weight of coal per unit of time will be discharged by the conveyor 3 to a hammer mill 6. Each feeder will, of course, discharge coal from its associated bin at a predetermined rate that will determine the composition of the final blend.

The hammer mill 6 is also of conventional design and includes a hopper 7, rotating hammers 8, grate bars 9, and a discharge chute 10. Coal is fed into the hammer mill from the feeders at a rate not exceeding the output capacity of the mill, so that the pulverized coal will be discharged from the mill at substantially the same rate as the raw coal is introduced therein, i. e., the pulverized coal will leave the mill at a substantially uniform rate by weight. Below the chute 10 is mounted a delivery conveyor 15, preferably having an arcuate cross section (as shown in Figure 2) which conveys the pulverized coal from the hammer mill to a larry car (not shown) for charging into the coke ovens. This conveyor moves at a uniform speed.

Since the pulverized coal is discharged from the hammer mill onto the conveyor 15 at a substantially uniform rate by weight, it will also be discharged at a uniform rate by volume so long as its bulk density remains unchanged, and since the conveyor is moving at a constant speed, the deposit of a uniform volume of coal thereon per unit of time will be reflected by a uniform depth of coal on the conveyor. If the depth of coal on the conveyor increases, it means that the same weight of coal now occupies a larger volume than it did before, i. e., its bulk density has decreased. Similarly, if the depth of coal on the conveyor decreases, it means that the same weight of coal now occupies a smaller volume, i. e., its bulk density has increased. Accordingly, changes in the depth of coal on the conveyor may be used to measure changes in the bulk density of the coal that is introduced into a hammer mill from the blending bins.

To control the bulk density of the coal within desired limits, and to maintain at the same time a minimum moisture content, means are provided for adding oil and/or water to the coal stream. Those additions are

preferably made before the coal is pulverized, so that the oil and/or water will be intimately mixed with the coal while it is being reduced in the hammer mill. For this purpose, a water pipe 21 and an oil pipe 22 are mounted with their outlets 23 and 24, respectively, above the inlet of the hammer mill, and the other ends of those pipes are respectively connected to a water storage tank 25 and an oil storage tank 26. Valve means 31 and 32 are provided for regulating the flow of liquid through those pipes. A depth gauge 35, which is pivotally mounted to swing in a vertical plane above the conveyor 15, is set at a predetermined height that is slightly above the average level of the top of the coal bed in the conveyor when the coal thereon has the desired minimum moisture content and the desired bulk density. Variations in the average level of the coal on the conveyor, corresponding to changes in its bulk density, can then be visually observed and controlled within desired limits by adding the necessary amounts of oil and/or water. For example, whenever the average depth of pulverized coal on the conveyor is lower than the predetermined height indicated by the gauge, the coal has a higher bulk density (lower moisture content) than is desired and that condition can be remedied by opening valve 31 in the water line and adding the necessary amount of water to the coal in the hammer mill. Similarly, if the depth of coal on the conveyor rises above a predetermined level, indicating too low a bulk density, the addition of oil to the coal by opening valve 32 will restore the desired bulk density. Occasionally, it may be desirable to add a minimum amount of oil to the coal and control its bulk density by adding or withholding water.

Bulk density control of coking coal in accordance with the present invention has been successfully practiced by applicant with a blend of four different coals having a varying moisture content. The types of coals used and the quantities of each were as follows:

	Tons/hr.	Percent
Penna. low Volatile.....	25	(8)
W. Va. low Volatile.....	50	(17)
Weathered High Volatile.....	90	(30)
Freshly Mined High Volatile.....	135	(45)
	300	(100)

The above types of coal were delivered at the rates indicated to a hammer mill, where they were blended together and reduced in size to particles ranging from about 1½ inches to dust (1½ × 0), of which about 75% would pass through a ½ inch screen. Over a given period, the surface moisture content of the above coal after it was blended and pulverized was found to vary considerably, being on an average somewhat less than the 4½% considered best for the particular coking operation. To compensate for the decrease in its bulk density due to moisture in excess of 4½% and also due to its reduction in the hammer mill (lump coal having a greater bulk density than the same coal after it is pulverized), it was found practicable to add oil to the coal in the hammer mill at the rate of about 25 gallons per hour. Variations in the bulk density of the coal due to variations in its surface moisture content, where the moisture did not exceed 4½%, were then controlled by adding varying amounts of water at a rate up to 750 gallons per hour. In other words, with this particular blend of coals, the bulk density was largely controlled by adding varying amounts of water, plus the addition of uniform amounts of oil, changes in the latter being made only when the surface moisture content exceeded certain limits. In determining the amount of oil and/or water to be added to the coal, the delivery conveyor onto which the coal was discharged from the hammer mill was run at a uniform speed sufficient to maintain the top of the coal thereon at an average height of about six inches above the edge of the conveyor when the coal was of the proper bulk

density and moisture content. That height was maintained within limits of about ±¼ inch by observing the clearance between the height gauge and the top of the coal stream. When the height increased more than ¼ inch above the desired level, the operator reduced the amount of water added to the coal. When cutting off the water entirely did not sufficiently reduce the height of coal, the operator increased the amount of added oil to bring the height of the coal back to the desired level. Conversely, when the height of the top of the coal stream dropped more than ¼ inch below the desired level, the operator increased the amount of water added to the coal until its height was raised the necessary amount. If the bulk density had not been controlled in this way, it might have varied as much as 16%, and the height of the coal stream might have varied over a range of one inch. However, by adding oil and/or water to the coal as indicated by changes in the height of the coal shown on the conveyor, the bulk density of the coal charged into the coke ovens was maintained substantially constant and the coal was assured the minimum moisture content that was most beneficial for the formation of coke oven gas.

It is an advantage of this invention that it provides an economical method of controlling the bulk density of coking coal within narrow limits, and one that can be easily used in existing plants without expensive alterations to existing equipment.

Referring to Figures 3 and 4, apparatus for automatically adding oil or water to the coal in accordance with variations from a predetermined level in the height of the coal on the conveyor is disclosed in place of the depth gauge mechanism 35 used for manual control as shown in Figures 1 and 2 of the drawings.

As can be seen in Figure 4, the height gauge itself includes a control shoe 41 pivotally suspended from the end of rod 42. Rod 42, in turn, is mounted to pivot about fulcrum 43 fixed to support platform 44. A shaft 46 is rotatably mounted on the support platform and is linked to rod 42 by means of a suitable linkage 47 which can be a bell crank. With this arrangement, the pivotal movement of rod 42 causes rotatable movement of shaft 46. The rod 42 is caused to pivot clockwise or counterclockwise in accordance with variations in the height of coal on conveyor belt 15. In this connection, it will be noted that these variations are sensed by control shoe 41 positioned in a spaced manner above belt 15.

Mounted on rotatable shaft 46, as is disclosed schematically in Figure 3, are a pair of conventional mercury liquid level switches 48, 49. These switches are tilted into open or closed position in accordance with the angular position of the shaft 46, thus, opening or closing the circuit in which each is included.

In this connection, it will be noted that the contacts of these switches 48, 49, are connected by lines 51 and 52, respectively to a motor control system which automatically controls valves 31 and 32 for the oil and water supply, respectively.

The motor control system includes electric motors 53 and 54 which are used to drive valves 31 and 32, respectively, into closed and open positions. These motors can be of a conventional shaded pole type, each motor 53 and 54 having an excitation winding 55 and 56, respectively, energized by a suitable source of alternating current. Each of the motors 53 and 54 further has a pair of shading windings 57, 58 and 59, 60, respectively. Through suitable gear trains T and mechanical connections M, schematically shown by dotted lines in Figure 3, the motors are connected to their respective valves 31 and 32.

In this connection, each motor 53 and 54 is connected with its valve so that the motor operates in a direction to drive its valve to an opening position when the circuit is completed for winding 58 and 60 and to a closing position when the circuit is completed for winding 57 and 59. The completion and interruption of the circuits is controlled by armatures 72a, 73a, and 75a, contacts 72b, 73b, and 75b, and the cam units 62, 63, and 65 driven

by motor 53; and the armatures 76a, 77a, and 78a, contacts 76b, 77b, and 78b and the cam units 66, 67 and 68 driven by motor 54. The completion of the circuit is further dependent upon the selected engagement of either of the aforementioned switches 48 or 49. As aforementioned, this engagement is dependent upon the position of control shoe 41 which is disclosed in Figure 3 schematically as linked to the switches by bell crank linkage 47. Thus, when switch 48 is tilted counter-clockwise, a circuit is completed by way of line 51 and the engagement of armature and contact 72a, 72b, for winding 57 of motor 53 so as to operate motor 53 to close valve 31 and thus shut off the oil and thereafter, if the level continues low by way of the engagement of armature and contact 75a, 75b, lead line 80 and armature and contact 78a, 78b for winding 60 of motor 54 so as to operate motor 54 to open valve 32, thus adding water. On the other hand, if the level is high then contact switch 49 is tilted clockwise, a circuit is completed by way of line 52 and the engagement of armature and contact 77a, 77b for winding 59 of motor 54 so as to operate motor 54 to close valve 32 and thus shut off the water and thereafter, if the level continues high by way of the engagement of armature and contact 76a, 76b, line 81 and the engagement of armature and contact 73a, 73b for winding 58 of motor 53 so as to operate motor 53 to open valve 31, thus adding oil to cause the level to decrease.

It is to be noted that the engagement and disengagement of the armatures and contacts of units 62, 63, and 65 are controlled by respective cams 62c, 63c, and 65c driven by motor 53; and, the engagement and disengagement of the armatures and contacts 66, 67, and 68 are controlled by cams 66c, 67c, and 68c driven by motor 54. The cams can be of a conventional well known type, the cams serving to actuate their respective armatures to give the cam pattern illustrated in Figure 3.

In a typical operation of the present invention, assuming that the coal on conveyor belt 15 is at the desired height and, therefore, at the desired bulk density, both of the valves 31 and 32 will be closed. As aforementioned, in an advantageous embodiment of this invention, this height can be set on the bed so as to be at 6 inches. At this point, the switches 48 and 49 are so positioned that neither is tilted. Now assuming that the height of the bed decreases, this decrease serves to indicate an increase of the bulk density. Accordingly, it is then desirable to add water. Now, since the actual level has dropped, shoe 41 actuates linkage 47 to tilt switch 48 counter-clockwise. Since the oil valve is closed at that moment, the cams on the oil valve motor are so contoured that in such a position, armature and contact 72a, 72b on the oil valve circuit are open; simultaneously, armatures and contacts 73a, 73b, 75a and 75b are closed. With armature and contact 75a, 75b closed, the circuit is continued through closed armature and contact 78a, 78b on the water motor to shading winding 60 thus operating motor 54 to cause the water valve to open, moving toward full open position. However, if enough water has been added to decrease the bulk density and raise the height of the coal to the desired level, switch 48 will be returned to level position leaving the water valve in a partially open position with both motors 53 and 54 stopped. It is to be noted that if the height of coal had not returned to the desired point, the water valve would continue to open until it reached full open position so that maximum water is added to decrease the bulk density.

Assuming that maximum water was not required and the required level had been reached, then the water valve would remain partially open. Now, assuming that the level continues to rise beyond the desired set point, this results in switch 49 being tilted, thereby completing the circuit between the contacts of the switch. When this occurs, the cams are so contoured that armature and contact 77a, 77b are closed completing the circuit to

winding 59 to drive motor 54 to close valve 32. If the level continues to rise, since armature and contact 76a, 76b and armature and contact 73a, 73b are closed, a circuit through coil 58 is completed to thus drive motor 53 to open oil valve 31 and oil is added to increase the bulk density. As the level falls with an increase of bulk density, the coal reaches a predetermined level and switch 49 moves counter-clockwise to open position. If the level continues to fall, switch 48 closes and a circuit through armature and contact 72a, 72b is completed through closing winding 57 to drive motor 53 to close valve 31 and cut-off the oil supply.

It is to be understood from the above disclosure that oil or water is added to the system automatically in accordance with the height of the coal on the bed. It is further to be understood that electric signal lights can be included in the switch system of Figure 3 in order to indicate when one of the two valves is at its traveling limit. In this connection, it will be obvious that due to the interlocking circuit disclosed in Figure 3, the oil and water valve are so arranged that they cannot operate simultaneously. Further, it is to be understood that the coal from the mixer bins to the hammer mill (Figure 1) can be controlled by valve or weight, since there is little effect of moisture content on the bulk density prior to the feeding of the coal to the hammer mill. Finally, it is to be understood that each of the coals to be mixed can be pulverized before mixing and then mixed in any suitable mixer.

The invention claimed is:

1. Apparatus for obtaining coking coal of uniform bulk density, comprising a conveyor moving at a uniform speed, means for discharging coal onto the conveyor at a uniform rate by weight, means for determining the volume of said discharged coal and means for adding to the coal before it is discharged onto the conveyor and in accordance with variations from a predetermined level in the height of coal thereon at least one of the compounds of the class consisting of oil and water, oil being added to decrease the height of coal on the conveyor to said predetermined level corresponding to the desired bulk density and water being added to increase the height of coal on the conveyor to the same predetermined level and thereby to maintain said discharged coal at a predetermined volume.

2. Apparatus according to claim 1 in which said volume determining means comprises a height gauge for indicating variations from a predetermined level in the height of coal on the conveyor.

3. Apparatus according to claim 2 in which said height gauge comprises a member pivotally mounted at a predetermined height above said conveyor.

4. Apparatus for obtaining coking coal of uniform bulk density, comprising a pulverizer for reducing the coal to the desired fineness, means for feeding coal to the pulverizer at a uniform rate by weight, a conveyor moving at a uniform speed for receiving coal from the pulverizer at the same rate as coal is fed to the pulverizer, gauge means located above said conveyor for determining the height of the discharge coal and means for adding to the coal before it is discharged onto the conveyor and in accordance with variations in the height of coal thereon at least one of the compounds of the class consisting of oil and water, oil being added to decrease the height of coal on the conveyor to a predetermined level corresponding to the desired bulk density and water being added to increase the height of coal on the conveyor to the same level by decreasing its bulk density, whereby the bulk density of the coal on the conveyor can be maintained uniform.

5. Apparatus for obtaining coking coal of uniform bulk density, comprising a conveyor moving at a uniform speed, means for discharging coal onto the conveyor at a uniform rate by weight, and means for adding to the coal before it is discharged onto the conveyor and in ac-

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cordance with variations from a predetermined level in the height of the coal thereon at least one of the compounds of the class consisting of oil and water, said means including a sensing mechanism for sensing the variations from said predetermined level in the height of the coal, an oil supply and a water supply, said oil supply and water supply having valve means therefor, power means for said valve means, said power means operatively associated with said sensing means to selectively actuate said valve means such that oil is added to decrease the height of the coal on the conveyor to said predetermined level corresponding to the desired bulk density and water is added to increase the height of the coal on the conveyor to the predetermined level.

6. The apparatus of claim 5 in which said power means includes valve control means whereby the valve means for one of the compounds is closed before the valve means for the other compound is open.

7. Apparatus for obtaining coking coal of uniform bulk density, comprising a conveyor moving at a uniform speed, means for discharging coal onto the conveyor at a uniform rate by weight, and means for adding to the coal before it is discharged onto the conveyor and in

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accordance with variations from a predetermined level in the height of the coal thereon at least one of the compounds of the class consisting of oil and water, said means including a sensing means for sensing the variations from said predetermined level in the height of the coal, an oil supply and a water supply, valve means for said oil supply and water supply, power means for said valve means, and a control circuit connecting said power means with said sensing mechanism to cause said power means to operate said valve means whereby oil is added to decrease the height of the coal on the conveyor to said predetermined level corresponding to the desired bulk density and water is added to increase the height of the coal on the conveyor to the predetermined level.

8. The apparatus of claim 7, said control circuit including cam means operated by said power means, said cam means causing the valve means for one of said supplies to be closed before the valve means for the other is opened.

References Cited in the file of this patent

UNITED STATES PATENTS

2,510,158 Van Ackeren ----- June 6, 1950

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,864,537

December 16, 1958

Charles C. Throop et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 24, for "valve" read -- volume--.

Signed and sealed this 21st day of April 1959.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents