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Bodycomb, Jr. et al.

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[54] **APPARATUS FOR CONTINUOUSLY DETERMINING THE MOISTURE CONTENT OF A MOVING ORE BED**

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[52] **U.S. Cl.** ..... **324/65 R**, 191/59.1

[51] **Int. Cl.** **G01r 27/02**

[58] **Field of Search** ..... 324/65 R, 65 P; 191/29, 191/59.1, 49; 73/421 R

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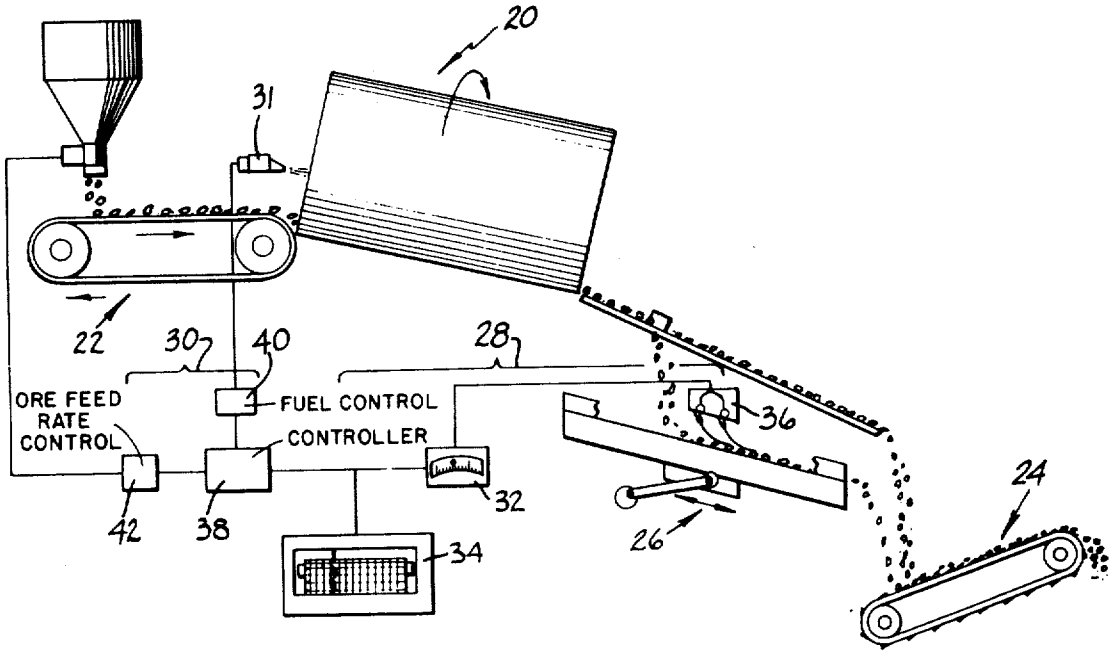
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[57] **ABSTRACT**

The disclosure relates to a method for controlling the moisture content of ore exiting from a drier and an apparatus for effecting the measurement of the moisture content. A portion of the ore exiting from the drier is diverted onto a conveyor to form a moving ore bed sample. The moisture content of this sample is measured by an apparatus which comprises a conductivity meter provided with a pair of electrodes having convex surfaces in contact with the moving surface of the ore sample. The electrodes are maintained a fixed relative distance apart to insure a constant amount of ore therebetween and thus an arcuate relative measurement of the moisture content for different positions of the ore bed as the ore passes by the electrodes. The measurements are converted to signals which actuate control apparatus to effect any necessary adjustments in the drying process to maintain the moisture content of the ore within specified limits.

2 Claims, 3 Drawing Figures



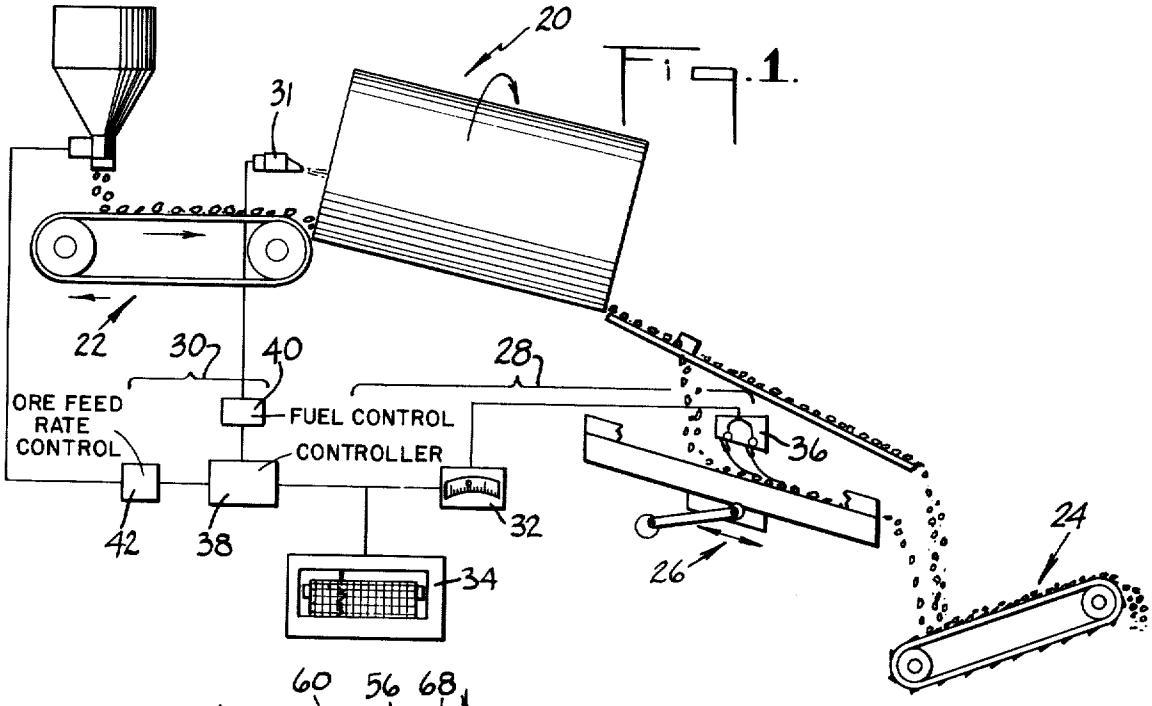


Fig. 1.

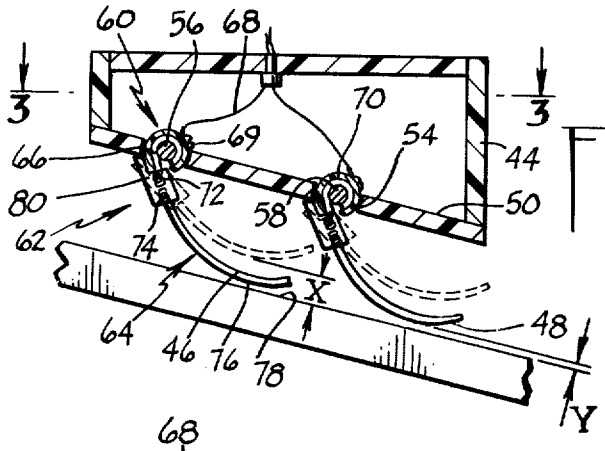


Fig. 2.

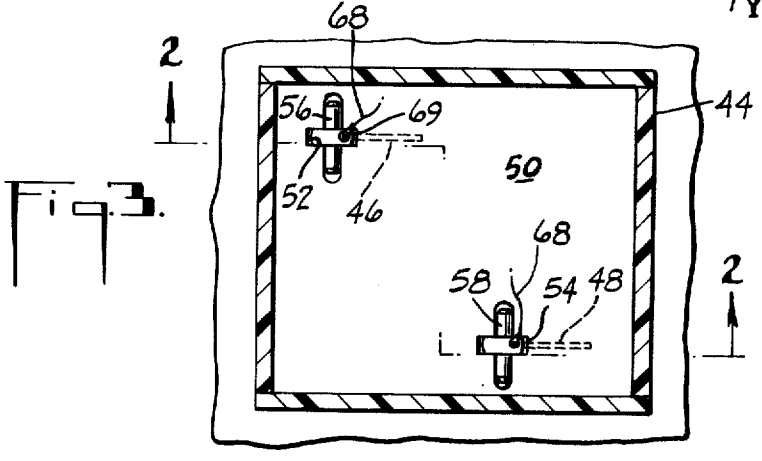


Fig. 3.

APPARATUS FOR CONTINUOUSLY DETERMINING THE MOISTURE CONTENT OF A MOVING ORE BED

BACKGROUND OF THE INVENTION

This invention relates to a method of controlling the moisture content of ore exiting from a drier and the apparatus for effecting an accurate measurement of the moisture content.

After asbestos ore is removed from a mine, it is initially crushed and then dried in large driers. Depending on the part of the mine from which the ore is taken and other factors, the ore entering the driers contains variable amounts of moisture. In the past, to assure that the wettest ore was dried to an optimum degree of 2 to 2½ percent water by weight, the ore containing lesser amounts of moisture was overdried. This resulted in wasted fuel, inefficient use of equipment, and possible damage to the overdried asbestos fiber due to calcination. Since changes in the moisture content of the ore entering the driers occur fairly rapidly, there is a need to continuously determine the moisture content of the asbestos ore leaving the driers and effect the necessary changes in the driers to maintain the moisture content of the exiting ore within specified limits.

It is the object of the present invention to provide a rapid continuous determination of the moisture content of asbestos ore by an electrical conductivity measurement. This measurement is utilized to determine the ore feed rate through the driers or the rate of the burner fuel consumption within the drier. Thus, all of the ore can be dried to the optimum degree without using the equipment inefficiently, wasting fuel, or damaging any portions of the ore.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides an apparatus for measuring the moisture content of a moving ore bed. The apparatus comprises a conductivity meter which is provided with first and second electrodes having curved contact portions with convex surfaces of the contact portions riding on the surface of the moving ore bed. The curved contact portions of the electrodes are maintained in fixed relative positions to maintain a constant amount of ore therebetween.

The invention also provides a method of controlling the moisture content of ore exiting from a drier wherein a portion of the ore exiting from the drier is diverted onto a conveyor to form a moving ore bed sample. The moisture content of the sample is measured with the moisture measuring apparatus of the present invention, and the drying process in the driers is adjusted in accordance with the measurement to maintain the moisture content of the ore within specified limits.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects of the invention will become more apparent and other objects of the invention will become apparent from the following detailed description of a preferred embodiment of the invention and the accompanying drawings wherein:

FIG. 1 is a schematic representation of a process employing the method and apparatus of the present invention;

FIG. 2 is an elevational view in section of the electrode assembly of the present invention along lines 2—2 of FIG. 3 showing the electrodes in their lowermost positions (solid line) and normal operating position (phantom line); and

FIG. 3 is a plan view partially in section of the electrode assembly of the present invention along lines 3—3 of FIG. 2.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, FIG. 1 illustrates a drier 20 provided with an input conveyor 22 and an output conveyor 24. An ore sample conveyor 26 is alsoo illustrated together with a moisture measuring apparatus 28 and a control system 30 for regulating the drying process.

The input conveyor 22 carries crushed, wet ore from the mine and deposits the ore within the drier 20. The ore is dried within the drier by hot air which is heated by means of burners 31 and passed through the drier 20. The major portion of the ore exiting from the drier 20 is discharged onto output conveyor 24 which conveys the ore to a dry rock storage area. However, a sample portion of the exiting ore is diverted to the vibrating conveyor 26 where the moisture content of the sample is measured to determine the moisture content of the exiting ore at that moment. From the vibrating conveyor 26 the sample portion of ore passes to the output conveyor 24 which then takes the ore directly to the dry rock storage area.

The moisture measuring apparatus 28 utilizes the correlation between ore moisture content and ore electrical conductivity. The conductivity of the ore increases as the moisture content of the ore increases, and conversely the conductivity of the ore decreases as the moisture content of the ore decreases. Thus the moisture measuring apparatus 28 comprises a conventional conductivity meter 32 provided with a chart recorder 34 to maintain a record of the conductivity readings and an electrode assembly 36.

The electrode assembly 36 is connected to the input terminals of the conductivity meter 32. The chart recorder 34 and a conventional controller 38 of control system 30 are connected to the output terminals of the conductivity meter 32. Thus an input signal which is indicative of the conductivity of the material between the electrodes is fed from the electrode assembly 36 to the conductivity meter 32 where it is measured. Due to the correlation between the conductivity and moisture content of the material, the output signal from the conductivity meter 32, produced by this measurement, is indicative of the moisture content of the ore sample. This output signal is fed to the chart recorder 34 and the controller 38 of the control system.

The chart recorder 34 provides a visual record of the moisture content of the ore exiting from the drier 20 thereby enabling the operator to easily ascertain whether the system has been or is operating normally. The output signal fed to the controller 38 causes the controller to initiate any required changes in the drying process. The controller 38 can actuate the fuel control 40 (e.g., a valve control) to adjust the fuel consumption of the burners 31 and thereby alter the temperature of the air within the drier. The controller 38 can also actuate the ore feed rate control 42 (e.g., bin gate control) to adjust the rate of flow of ore into and through the drier 20. Thus the drying process can be controlled through the fuel control 40, the ore feed rate control 42, or a combination of the two to maintain the moisture content of the

ore exiting from the drier within specified limits.

The electrode assembly **36** comprises a housing **44** plus a pair of electrodes **46** and **48.** The housing is dust proof and at least the lower supporting plate **50** which carries the electrodes **46** and **48** is made from a non-conducting material. The support plate **50** is provided with a pair of apertures **52** and **54.** Shafts **56** and **58** bridge the apertures **52** and **54,** are affixed to the support plate **50,** and support the electrodes **46** and **48.** The apertures **52, 54** are laterally and longitudinally spaced with respect to each other (see FIG. 3) to offset the electrodes **46, 48** and prevent ore lumps from being wedged between the electrodes. The clearence between the sidewalls of apertures **52** and **54** and the electrodes **46** and **48** is minimized to prevent dust from entering the housing through the apertures.

Since electrodes **46** and **48** are identical in construction, only electrode **46** will be discussed in detail to prevent unnecessary repetition. Electrode **46** comprises an upper section **60,** a coupling collar **62,** and a replaceable lower section **64.** The upper and lower sections **60** and **64** have been made of three-eighths of an inch diameter metal rod with the complementary metal collar **62** joining the upper and lower sections. However, electrodes of different sizes and lengths can be used.

The upper section **60** of the electrode has a loop **66** at its upper end which is pivotally retained on shaft **56.** One of the two lead wires **68** connecting the electrodes **46** and **48** to the input terminals of the conductivity meter **32** is secured to the loop **66.** The electrical connection is formed by securing the lead wire **68** to the loop with a screw **69** or another conventional connection. The connection is located on the loop **66** where it will not contact the housing and interfere with pivotal movement of the electrode during operation.

the upper section **60,** including loop **66,** can be provided with a teflon coating **70** to help prevent mineral fibers from adhering to the section and working their way into the housing **44.** In this way, a material buildup within the housing, which could form a conductive path between the electrodes, is prevented. The other end of the upper section **60** extends down beyond the support plate **50** and has a coupling collar **62** mounted thereon. The coupling collar **62** has a bore extending axially therethrough somewhat greater in diameter than sections **60** and **64** and is provided to rigidly connect the upper and lower sections **60** and **64** of the electrode. The collar **62** is affixed to the upper section **60** of the electrode by a pin **72** which passes diametrically through the collar **62** and a terminal portion of upper section **60** which is encased within the collar. An upper terminal portion of lower section **64** is also encased within collar **62.** A pin **74** passes diametrically through the collar **62** and the terminal portion of section **64** to affix the lower section in the coupling.

The lower section of the electrode has a contact portion **76** which engages and rides on the upper surface of the ore bed. The contact portion **76** is curved with the lower end of the electrode trailing the upper end of the electrode in the direction of flow of the moving ore bed sample and the convex surface of the contact portion **76** riding on the upper surface of the ore bed. While in the preferred embodiment the convex surface of the curved contact portion **76** is a continuous curve in which the radius of curvature can change, it is to be understood that the convex surface can include flat portions as long as the overall configuration of the surface is convex. With this convex surface of the electrode **46** in contact with the ore bed, the electrode **46** can ride on top of the moving bed of ore with a minimum amount of abrasion and little or no buildup of asbestos material about the electrodes. Since a buildup of asbestos material on the electrodes could alter the conduction between the electrodes **46** and **48** and cause inaccurate measurements, it is important to minimize or eliminate such buildups of material.

Since the electrode **46** is pivotally mounted on shaft **56,** the electrode is free to move up and down, As shown in FIG. **2,** the pivotal mounting allows the electrode to ride on the ore sample bed regardless of the depth X of the bed. The pivotal mounting also allows the electrode to ride over lumps that are located on the upper surface of the ore bed. However, the pivotal movement of the electrode must be limited to prevent contact between the electrode **46** and the pan **78** of the vibrating conveyor **26** when no material is on the conveyor. To prevent the electrode **46** from contacting the conveyor pan the collar **62** is provided with a boss **80.** Boss **80** abuts the underside of support plate **50** before contact is made between the contact portion **76** of the electrode and the conveyor pan **78** and assures that a minimum clearance Y is maintained between electrode **46** and pan **78.**

If the electrodes were not held out of contact with the pan, the pan **78** of the conveyor **26** would form a conductive path between the electrodes when no ore was present and cause moisture measuring apparatus **28** to indicate a moist ore. Since the electrode is held out of contact with the pan **78,** the conductivity measured is very low or negligible with no ore present (corresponding to very dry ore). Thus, the fuel rate is automatically minimized to conserve energy while the conveyor continues in operation to automatically feed ore to the drier **20** as soon as it is available.

In operation the contact portions **76** of the electrodes ride on the surface of the ore bed as shown in phantom line in FIG. **2.** The contact portions **76** of the electrodes are maintained a set distance apart e.g., 6 inches with the electrodes easily riding over the rough surface of the ore bed due to their pivotal mounting and the convex surface of the contact portion. The weight of the electrodes **46** and **48** normally maintains them in contact with the surface of the ore bed. However, additional weight can be added to the electrodes **46** and **48** if they are not making adequate contact with the surface of the ore bed. Thus, a constant amount of ore is maintained between the electrodes **46, 48** and the electrodes are maintained in contact with the bed to assure that the conductivity readings of meter **32** give an accurate measurement of the moisture content as the ore sample bed passes by the electrodes.

The output signal from the conductivity meter **32** actuates the controller **38** which effects the necessary adjustments in the fuel consumption of the burners or the ore feed rate. Thus the conditions in the drier **20** are regulated to maintain the moisture content of the ore exiting from the drier with specified limits.

We claim:

1. An apparatus for measuring the moisture content of a moving mineral ore bed comprising a first conveyor means for moving the ore bed, a conductivity meter, first and second electrodes connected to said conductivity meter, said electrodes having surfaces for

contacting the surface of a moving ore bed, said contact portions being a fixed relative distance apart, the improvement comprising diverter means to divert a small portion of the moving ore bed from said first conveyor means to form a moving ore bed on an ore sample conveyor, each of said electrodes having a convex surface portion of equal curvature, the electrodes being pivotally mounted at one end to enable the convex surfaces of said electrodes to ride on the surface of the moving ore bed on said ore sample conveyor, each electrode having an upper section which is pivotally mounted and a lower section with said convex surface portion thereon, said lower section being separably secured to said upper section to facilitate the replacement of said lower section when required, and each of said electrodes being provided with a stop means to prevent said electrodes from pivoting into contact with said ore sample conveyor when there is no ore on the ore sample conveyor.

2. An apparatus for measuring the moisture content of a moving ore bed as defined in claim 1 wherein said electrodes are offset with respect to each other.

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