June 11, 1963 G. L. WILMOT 3,093,577

SEPARATING SYSTEM

Filed Sept. 30, 1960 2 Sheets-Sheet 1

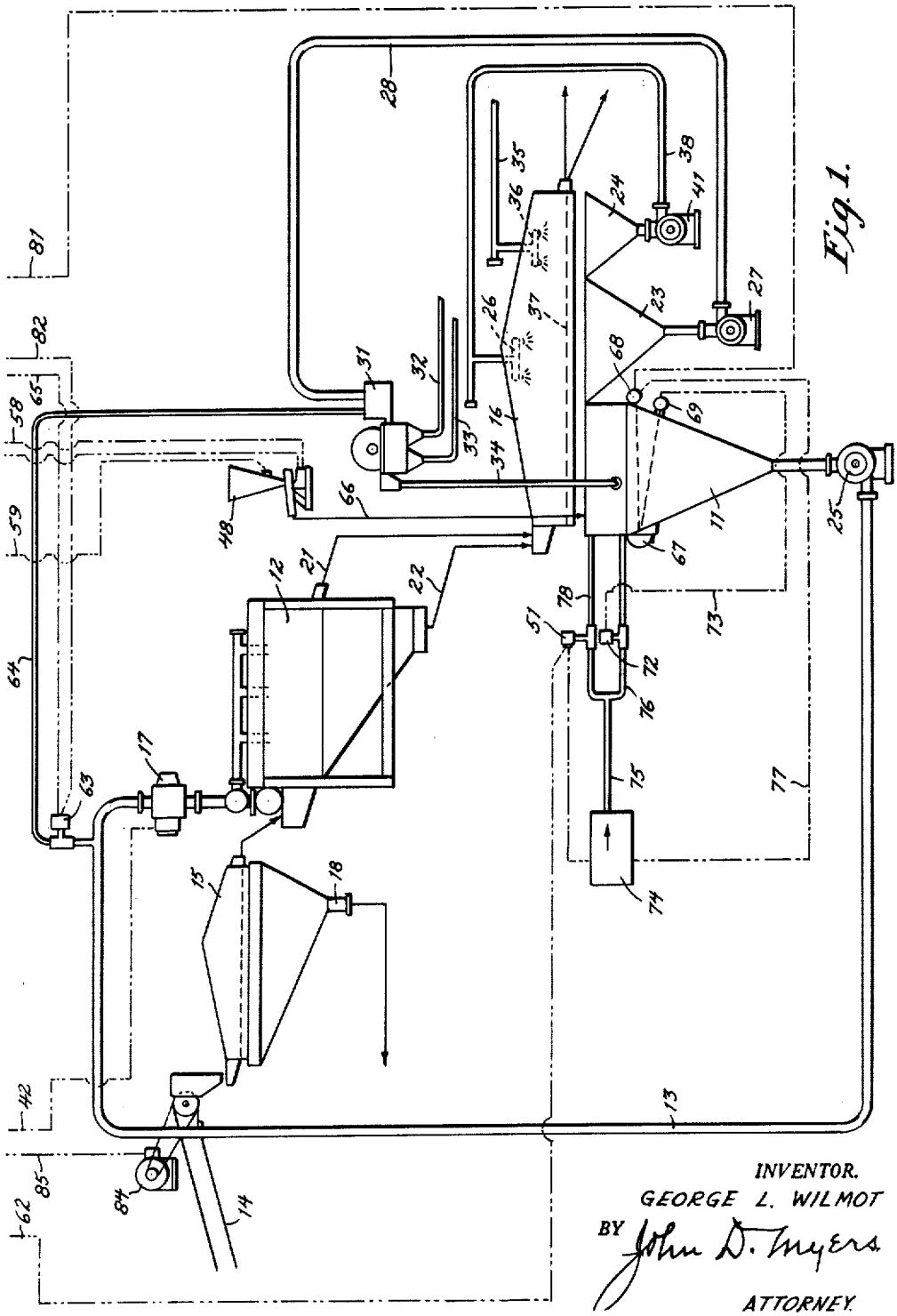

Fig. 1.

INVENTOR.
GEORGE L. WILMOT
BY John D. Myers
ATTORNEY

June 11, 1963 G. L. WILMOT 3,093,577

SEPARATING SYSTEM

Filed Sept. 30, 1960 2 Sheets-Sheet 2

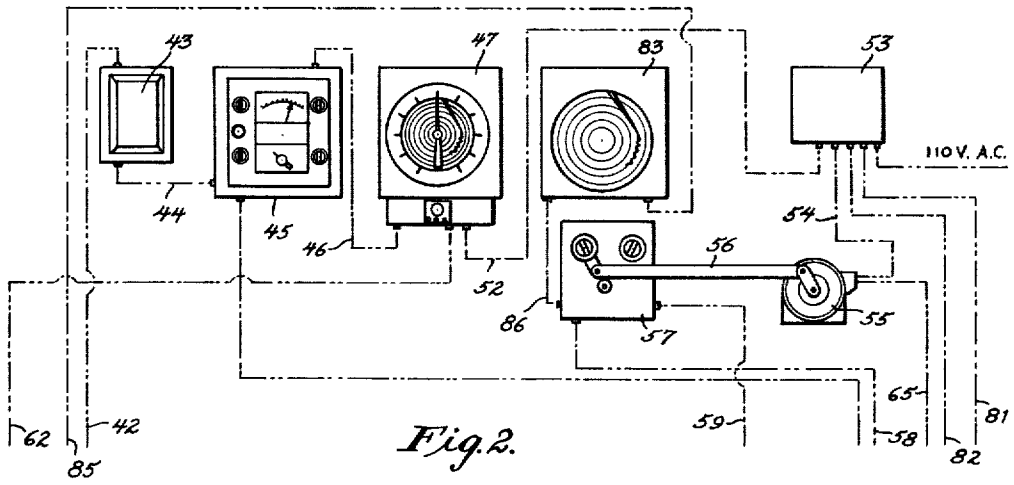

Fig. 2.

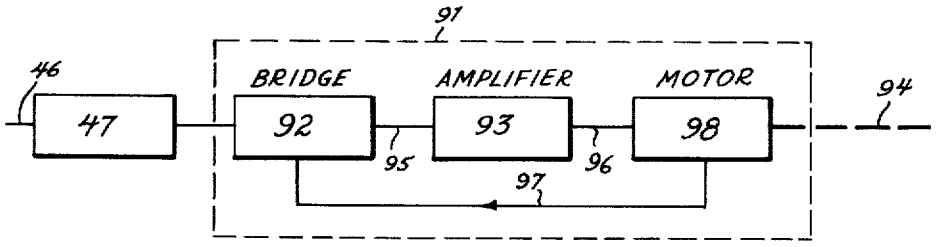

Fig. 3.

INVENTOR.
GEORGE L. WILMOT
BY John D. Meyers
ATTORNEY.

United States Patent Office 3,093,577 Patented June 11, 1963

3,093,577

SEPARATING SYSTEM

George L. Wilmot, Pocono Lake, Pa., assignor to Wilmot Engineering Company, White Haven, Pa., a corporation of Pennsylvania

Filed Sept. 30, 1960, Ser. No. 59,736
21 Claims. (Cl. 209—172.5)

This invention relates to improvements in a system for separating coal or the like from its raw material, and more particularly concerns a flotation separating process and system, and the automatic controlling of the density of the separating medium used therein.

Coal is graded as standard or substandard according to the amount of inherent ash and waste materials (clay, rock, sand, slate and other impurities) it contains. To remove the impurities from raw coal and obtain clean coal of high quality, many breaker plants have adopted a heavy medium separating system which is also widely used in ore separation. This "float-and-sink" method of removal of impurities uses a slurry of finely divided solids (for example, magnetite or ferrosilicon) in water. The specific gravity of the slurry medium is high enough to separate the coal from the heavier waste materials, causing the coal to float off free of the heavier slate, rock and other sink products.

However, there is a serious problem in the use of the "float-and-sink" method of separating in that the density of the separating medium is critical. Any variation in its density either causes extensive loss of coal, or causes the processed coal to have a high ash content, thereby making it substandard.

As an example, if the optimum specific gravity of the separating medium for the coal being processed is 1.70, and the specific gravity drops, the system loses good coal which sinks in the separating medium with the heavy refuse and passes out to waste.

On the other hand, if the specific gravity of the separating medium is too high, more near gravity refuse is floated with the coal than desired so that the resulting coal product has an ash content which is too high. Accordingly, the coal product is not of good quality and either has to be returned to the breaker for recleaning, or has to be sold as substandard coal at a reduced price.

Keeping the density of the separating medium constant is a problem since the raw coal must be washed before being fed to the separating system, and it retains a good deal of the wash water. This water on the raw coal continuously dilutes the separating medium and lowers its density.

In addition to this dilution by the water from the raw coal, the medium is constantly being diluted through the loss of some of its finely divided solids which pass out of the system with the processed coal or with the refuse. Provision is made to recover as much of the finely divided solids as possible, but a small amount does continually escape from the separating system.

It has heretofore been proposed to attempt to control the density of the separating medium by having a skilled operator test the density manually with a Denver cup. In this method, the operator scoops the slurry medium into a cup of a known size and then measures the specific gravity of the medium contained therein. If the specific gravity is too low, the operator adds magnetite, and if the specific gravity is too high, the operator adds water to the medium.

However, this Denver cup method has a number of disadvantages in that the specific gravity measurements are not too accurate, the measurements are not made continuously, and no provision is made for adding the right amount of magnetite or water, since the operator just

adds the amount of material or water that he guesses will bring the density back to its optimum value.

Accordingly, it is an object of this invention to provide a separator system which gives a high quality coal, with a minimum of coal going with the refuse to waste.

It is another object to recover a high percentage of the magnetite (or other finely divided solid) used in the separating medium, with very little of the magnetite passing out of the system with the coal or with the refuse.

It is another object to provide a separator system wherein the density of the separating medium is automatically and continuously controlled with a high degree of accuracy.

It is another object to provide a separator system wherein the level of the mixing sump (of the separating medium) is maintained within a predetermined range.

It is another object to provide a separating system with means for compensating for the water brought into the system with the raw coal to be processed, and with means for shutting off said compensating means when the raw coal is not being fed to the system.

Other objects and advantages of this invention including its simplicity and economy, as well as the ease with which it may be adapted to existing equipment, will further become apparent herein and in the drawings, in which:

FIG. 1 is a schematic view of a separating sysem constructed in accordance with this invention, with electrical conductors leading to a control panel shown in FIG. 2;

FIG. 2 is a schematic view of the control panel forming a part of this invention; and

FIG. 3 is a schematic view illustrating the electric proportional controller forming an element of the separating system.

Although specific terms are used in the following description for clarity, these terms are intended to refer only to the structure shown in the drawings and are not intended to define or limit the scope of the invention.

Turning now to the specific embodiment of the invention selected for illustration in the drawings, there is shown a system for separating coal from raw coal containing coal and refuse, comprising a mixing sump **11** into which is fed water and finely divided magnetite to form a coal-separating slurry medium, a coal-separating vessel **12** which receives the separating medium through a conduit **13** extending from sump **11**, means including raw coal feed-conveyor **14** and prewet vibrator **15** for feeding raw coal into vessel **12**, coal-separating means including coal-separating vessel **12** and the separating medium contained therein for separating the coal from the waste by causing the coal to float in the medium, means including partitioned vibrator dewatering screen **16** for separating the coal from the separating medium and returning the medium to sump **11**, and density sensing and control means including density measuring head **17** and the control panel of FIG. 2 for continuously measuring the density of the separating medium and automatically controlling the density by adding and subtracting water and magnetite to and from the system, in response to said measuring.

In operation, raw coal is delivered from the mine to the yard for washing, separating, and sizing. The raw coal is passed over a reciprocating picking table (where large rocks and timber are thrown out), and is crushed to size. Then it is delivered to perforated presizing and prewet vibrator **15**, where coal smaller than one-quarter inch goes through conduit **18** directly to the fine coal cleaning system for sizing and shipment, and coal of larger size is delivered to coal-separating vessel **12** for separating from ash. Prewet vibrator **15** eliminates some of the water on the raw coal to thereby reduce the amount of dilution of the separating medium caused by such

water when the raw coal enters coal-separating vessel **12**.

The raw coal enters vessel **12** at the surface level of the separating medium contained therein, and travels along that surface to be discharged as overflow through float conduit **21**.

The rock and other refuse sinks to the bottom of vessel **12** where it is removed by an oscillating rake and passes out through sink conduit **22**.

Both the coal and the refuse pass separately to partitioned vibrator dewatering screen **16** where the separating medium is recovered by the use of vibration and a series of sprays. Screen **16** is partitioned lengthwise to allow the coal and the refuse to pass therealong separately and discharge into separate chutes. The cleaned coal is elevated to sizing shakers and then transferred to retail coal pockets, and the refuse is dumped into bins for disposal.

The separating medium is recovered in the three sumps located beneath screen **16**: Main medium sump **11**, washings sump **23**, and rinsing sump **24**. A fraction of the medium is recovered by draining it through the vibrating screen deck **37** into the sump **11**.

Another fraction of the medium is recovered in washings sump **23**. This medium fraction has been diluted by water from sprays **26**, so it is transferred by pump **27** through conduit **28** to a magnetic separator **31** where water and fine coal particles are removed and the magnetite is recovered. The fine coal is transferred to a fine coal sizing shaker (not shown) through conduit **32**, and the water is disposed of through conduit **33**. The recovered concentrated magnetite is returned to sump **11** through conduit **34**.

The medium in sump **11** is circulated by pump **25** to coal-separating vessel **12** through conduit **13**.

In vibrator screen **16**, clear water is brought in through conduit **35** and is sprayed through the sprayheads **36** onto the material on the portion of vibrator screen deck **37** which is over rinsing sump **24**. The water and other material forced thereby into sump **24** is transported through conduit **38** by pump **41** and through sprayheads **26** onto screen deck **37** and into sump **23**. This arrangement is of advantage in that it cuts the water required in half and yet gives a double rinsing action. In effect, it washes the material in dirty water first (from sump **24** through sprayheads **26**) and then washes it off in clean water (from clear water line **35** through sprayheads **36**).

The water in rinsing sump **24** is somewhat dirty, since it has passed through the products on the portion of the screen deck **37** positioned over sump **24**. However, the products on the screen deck **37** above sump **24** have already been partly cleaned and so the water in sump **24** is not too dirty. This somewhat dirty water is passed through counterflow pipe conduit **38** and sprayheads **26** to prerinse the products on screen deck **37** above sump **23**. By this arrangement, most of the separating medium remaining on the coal and the refuse on the screen deck **37** above sump **24** are washed off into sump **24** and sprayed over the material on screen **37** above washings sump **23**. From sump **23** the magnetite and water are transported by pump **27** through conduit **28** to magnetic separator **31** where the magnetite is recovered.

Recovery of the magnetite is so complete that the process uses only two bags (two hundred pounds) of magnetite in separating about four hundred fifty tons of raw coal a day.

Controlling the Density of the Medium

In the constant recirculation of the separating medium through the system, its specific gravity varies because of the water enetering the system with the raw coal, and also because of the small amount of magnetite which is lost by passing out of the system with the clean coal or with the refuse.

To compensate for the variation in the density of the separating medium, mounted on conduit **13** is a density measuring head **17** which includes a radioactive source and a radiation detector. The radio active source generates a ray that is received by the radiation detector and is converted into a signal proportional to the density of the separating medium. This signal is passed through electrical conductors **42** to a preamplifier **43**, through electrical conductors **44** to a visual density instrument **45**, and through electrical conductors **46** to a specific gravity recorder and controller **47**.

In response to the signals from density measuring head **17**, controller **47** operates a magnetic feeder **48** (which adds magnetite to the system as desired), and a motorized valve **51** (which adds water to the separating medium as desired).

Controller **47** is connected to magnetite feeder **48** through electrical conductors **52**, proportioning relay **53**, electrical conductor **54**, Modutrol motor **55**, link **56**, magnetite feeder control **57**, and electrical conductors **59**.

Controller **47** is connected to motorized valve **51** by electrical conductors **62**.

A motorized by-pass valve **63** is also operated by controller **47**, and it bleeds separating medium from conduit **13** through a conduit **64** to magnetic separator **31**. Controller **47** is connected to by-pass valve **63** through conductors **52**, proportioning relay **53**, conductors **54**, and conductors **65**.

In normal operation, by-pass valve **63** is one-third open, and feeder **48** is supplying magnetite to the system continuously at a rate which compensates for the small amount of magnetite which is being withdrawn from the system and lost with the cleaned coal and refuse.

If the density of the medium becomes too high, the high density is sensed by density measuring head **17** and it transmits a signal to controller **47**. Controller **47** shuts off magnetite feeder **48** to stop the adding of magnetite to the system, and opens water valve **51** to add water to the system to bring the density of the separating medium back to normal. Then, density measuring head **17** signals controller **47** to return magnetic feeder **48** to its normal position (of adding magnetite to the system), and to close water valve **51**.

If the density of the separating medium is too low, density measuring head **17** signals controller **47** which operates feeder **48** to open it wider and thus add more magnetite. Controller **47** also opens by-pass valve **63** wider (to its three-quarter open position) and bleeds more medium to the magnetic separator **31** where the water is removed and magnetite is recovered. After the density returns to normal, density measuring head **17** signals controller **47** to return feeder **48** and by-pass valve **63** to normal position.

Magnetite is transferred from magnetite feeder **48** into the system through conduit **66** which leads directly into main medium sump **11**, but it will be realized that the magnetite may be transferred into the system at other points if desired.

In order to maintain a sufficient amount of separating medium in the system, and also to prevent the medium from overflowing sump **11** while its density is being adjusted, sump **11** is provided with level sensing and control means which includes a gamma ray source unit **67**, high level detector **68**, and low level detector **69**.

Low level detector **69** is connected to a motorized valve **72** by electrical conductors **73**, and when the level in the sump **11** becomes too low, a signal from detector **69** operates valve **72** to admit water from a water source **74** through conduits **75**, **76** into sump **11**.

If the level of separating medium in sump **11** is too high, high level detector **68** sends a signal through electrical conductors **77** to close valve **51** (overriding any signal from controller **47** which may have opened valve **51** to lower the density of the medium) and stop any water from flowing through conduit **78** into sump **11**.

High level detector 68 also lowers the level of the medium in sump 11 by sending a signal through electrical conductors 81 and 82 to open by-pass valve 63 wider (to its one-half open position) to bleed more medium through conduit 64 to magnetic separator 31, and thereby remove some of the water from the system.

In normal operation with the level in sump 11 within the normal range, by-pass valve 63 is one-third open, and feeder 48 is feeding magnetite continuously to the system at a normal rate to maintain the density of the separating medium at a predetermined optimum. But if no raw coal is being fed into the system, no dilution of the medium occurs from water on raw coal, and therefore the densifying operations of bleeding a portion of the medium to the magnetic separator and there dewatering it before returning it to the system, and of adding magnetite from magnetite feeder 48 to the system, would make the medium too dense. To avoid this, there is provided a recording ammeter 83 which is connected to drive motor 84 by electrical conductors 85. Ammeter 83 measures the current drawn by motor 84 and when the current drops below a predetermined value (which indicates that there is no load on feed conveyor 14), it sends a signal through conductors 86 and 58 to shut off magnetite feeder 48 and prevent it from adding magnetite to the system. Ammeter 83 also sends a signal through conductors 86, magnetite feeder control 57, link 56, Modutrol motor 55, and conductors 65, to shut off by-pass valve 63.

When raw coal is again being fed to the system, recording ammeter 83 signals magnetite feeder 48 and bypass valve 63 to return them to normal position.

Density measuring head 17 directs rays from a shielded radioactive source through conduit 13 and the separating medium, and measures variations in density as small as .001 specific gravity. A suitable measuring head 17 is manufactured by Industrial Nucleonics Corporation, Columbus, Ohio, and is known as Accu Ray Model PDH2.

The signal from measuring head 17 is amplified by preamplifier 43 and transmitted through the visual density measuring instrument 45 to specific gravity recorder and controller 47.

The specific gravity recorder and controller 47 may be the Electronik Circular Chart Electric Controller Class 14 Special Line (S 142–1), and position-controller (S 801–1), manufactured by Minneapolis-Honeywell Regulator Co. Controller 47 is an electric position-proportional control with automatic reset.

Proportioning relay 53 may be a R93B proportioning relay made by Minneapolis-Honeywell Regulator Co. and designed to control proportioning motors of the industrial type.

Coal-separator vessel 12 may be a Wilmot "OCC" H.M. vessel as described in U.S. Patent No. 2,752,040 and manufactured by Wilmot Engineering Company, White Haven, Pennsylvania.

Referring to FIG. 3 for a further explanation of the motorized valve apparatus, the signal from density measuring head 17 is transmitted to controller 47 by electrical conductors 46. Controller 47 transmits a signal over conductors 62 to control unit 91 of motorized valve 51. Within control unit 91, the error signal from controller 47 is received by bridge 92 and is transmitted over conductors 95 to a servo amplifier 93 which sends a signal over conductors 96 to actuate motor 98 to turn shaft 94 which is connected to the valve element in the conduit 78 (FIG. 1).

Motor 98 (FIG. 3) is connected by electrical conductors 97 to bridge 92 to provide a negative feedback which gives a subtractive signal to bridge 92 when the valve 51 is turned to the desired position so that the valve element avoids overshooting or hunting. The other motorized valves 63, 72 are similarly constructed.

Excellent results have been obtained from the process and system of this invention. For example during one nine and one-half hour run of the system in actual operation, the specific gravity was continuously recorded and the average variation in specific gravity from the 1.70 optimum desired was only plus or minus 0.004 throughout the entire operating period. This, of course, assures complete recovery of useable coal and an absolutely uniform product no matter what the composition of the raw coal entering the breaker.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred embodiment. Various changes may be made in the shape, size and arrangement of parts. For example, equivalent elements may be substituted for those illustrated and described, parts may be reversed, and certain features of the invention may be utilized independently of the use of other features, all without departing from the spirit or scope of the invention as defined in the subjoined claims.

The claimed invention:

1. A process of separating coal from raw coal containing coal and waste, comprising feeding water and finely divided magnetite to a mixing zone to form a coal-separating slurry medium, feeding separating medium from said mixing zone into a coal-separating zone, feeding raw coal to said coal-separating zone and there separating the coal from the waste by causing the coal to float in the separating medium and the waste to sink therein, separating a fraction of the medium from the coal and waste by draining and returning it to said mixing zone, separating another fraction of the medium from the coal and waste by diluting it, recovering magnetite from said dilute fraction and returning the recovered magnetite to said mixing zone, continuously measuring the density of the medium being fed to said coal-separating zone, and controlling said density by adding and subtracting water and magnetite automatically in response to said measuring.

2. A process of separating coal from raw coal containing coal and waste, comprising feeding water and finely divided magnetite to a mixing zone to form a coal-separating slurry medium, feeding a portion of said medium from said mixing zone to a coal-separating zone, feeding raw coal to said coal-separating zone and there separating the coal from the waste by causing the coal to float in said medium and the waste to sink therein, separating magnetite from the coal and waste and returning it to said mixing zone, feeding another portion of said medium from said mixing zone to a magnetite recovery zone and there separating out the magnetite, feeding the recovered magnetite to said mixing zone to make said medium more dense, continuously measuring the density of said medium being fed to said coal-separating zone, and controlling said density by adding and subtracting water and magnetite automatically in response to said measuring.

3. A process of separating coal from raw coal containing coal and waste, comprising feeding water and finely divided magnetite to a mixing zone to form a coal-separating slurry medium, feeding a portion of said medium from said mixing zone to a coal-separating zone, feeding raw coal to said coal-separating zone and there separating the coal from the waste by causing the coal to float in said medium and the waste to sink therein, separating magnetite from the coal and waste and returning it to said mixing zone, feeding another portion of medium from said mixing zone to a magnetite recovery zone and there separating out magnetite, feeding the recovered magnetite from the magnetite recovery zone to said mixing zone to make the medium more dense, automatically shutting off said feeding of the medium to said magnetite recovery zone when no raw coal is being fed to said coal-separating zone, automatically shutting off the feeding of water and magnetite to the medium in said mixing zone when no raw coal is being fed to said coal-separating zone, continuously measuring the density of the medium being fed to said coal-separating zone, and

controlling said density by adding and subtracting water and magnetite automatically in response to said measuring.

4. A process of separating coal from raw coal containing coal and waste, comprising feeding water and finely divided magnetite to a mixing zone to form a coal-separating slurry medium, automatically maintaining the level of the medium in the mixing zone, feeding a portion of the medium from said mixing zone to a coal-separating zone, feeding raw coal to said coal-separating zone and there separating the coal from the waste by causing the coal to float in medium and the waste to sink therein, separating magnetite from the coal and waste and returning it to said mixing zone, feeding another portion of the medium from said mixing zone to a magnetite recovery zone and there separating out magnetite, feeding the recovered magnetite from said magnetite recovery zone to said mixing zone to make the medium more dense, automatically shutting off said feeding of a portion of the medium to said magnetite recovery zone when no raw coal is being fed to said coal-separating zone, automatically shutting off the feeding of water and magnetite to the medium in said mixing zone when no raw coal is being fed to said coal-separating zone, continuously measuring the density of the medium being fed to said coal-separating zone, and controlling said density by adding and subtracting water and magnetite automatically in response to said measuring.

5. A process of separating an ore from raw ore containing ore and waste, comprising feeding a liquid and a finely divided insoluble material to a mixing zone to form an ore-separating slurry medium, feeding medium from said mixing zone to an ore-separating zone, feeding raw ore to said ore-separating zone and there separating the ore from the waste, separating said finely divided material from the ore and waste and returning it to said mixing zone, continuously measuring the density of the medium being fed to said ore-separating zone, and controlling said density by adding and subtracting liquid and finely divided insoluble material automatically in response to said measuring.

6. A process of separating an ore from raw ore containing ore and waste, comprising feeding a liquid and a finely divided insoluble material to a mixing zone to form an ore-separating slurry medium, automatically maintaining the level of the medium in the mixing zone, feeding medium from said mixing zone to an ore-separating zone, feeding raw ore to said ore-separating zone and there separating the ore from the waste, separating finely divided material from the ore and waste and returning it to said mixing zone, continuously measuring the density of the medium being fed to said ore-separating zone, and controlling said density by adding and subtracting liquid and finely divided insoluble material automatically in response to said measuring.

7. A process of separating an ore from raw ore containing ore and waste, comprising feeding a liquid and a finely divided insoluble material to a mixing zone to form an ore-separating slurry medium, feeding a portion of the medium from said mixing zone to an ore-separating zone, feeding raw ore to said ore-separating zone and there separating the ore from the waste, separating said finely divided material from the ore and waste and returning it to said mixing zone, feeding another portion of the medium from said mixing zone to a recovery zone and there separating out finely divided material, feeding the recovered finely divided material from said recovery zone to said mixing zone, continuously measuring the density of the medium being fed to said ore-separating zone, and controlling said density by adding and subtracting liquid and finely divided insoluble material automatically in response to said measuring.

8. A process of separating an ore from raw ore containing ore and waste, comprising feeding a liquid and a finely divided insoluble material to a mixing zone to form an ore-separating slurry medium, feeding a portion of medium from said mixing zone to an ore-separating zone, feeding raw ore to said ore-separating zone and there separating the ore from the waste, separating finely divided material from the ore and waste and returning it to said mixing zone, feeding another portion of medium from said mixing zone to a recovery zone and there separating out finely divided material, feeding the recovered finely divided material from said recovery zone to said mixing zone, automatically shutting off said feeding of a portion of the medium to said recovery zone when no raw ore is being fed to said ore-separating zone, automatically shutting off the feeding of water and magnetite to the medium in said mixing zone when no raw ore is being fed to said ore-separating zone, continuously measuring the density of the medium being fed to said ore-separating zone, and controlling said density by adding and subtracting liquid and finely divided insoluble material automatically in response to said measuring.

9. A process of separating an ore from raw ore containing ore and waste, comprising feeding a liquid and a finely divided insoluble material to a mixing zone to form an ore-separating slurry medium, automatically maintaining the level of the medium in the mixing zone, feeding a portion of said medium from said mixing zone to an ore-separating zone, feeding raw ore to said ore-separating zone and there separating the ore from the waste, separating finely divided material from the ore and waste and returning it to said mixing zone, feeding another portion of said medium from said mixing zone to a recovery zone and there separating out finely divided material, feeding said recovered finely divided material to said mixing zone, automatically shutting off said feeding of a portion of said medium to said recovery zone when no raw ore is being fed to said ore-separating zone, automatically shutting off the feeding of water and magnetite to the medium in said mixing zone when no raw ore is being fed to said ore-separating zone, continuously measuring the density of said medium being fed to said ore-separating zone, and controlling said density by adding and subtracting said liquid and said finely divided material automatically in response to said measuring.

10. A system for separating coal from raw coal containing coal and waste, comprising a mixing sump into which is fed water and finely divided magnetite to form a coal-separating slurry medium, a coal-separating vessel which receives the medium through a conduit extending from said sump and in which the coal separates from the waste by floating in the medium, means for feeding raw coal into said coal-separating vessel, means connected into said system for separating a fraction of the medium from the coal and waste and returning it to said sump, means for separating another fraction of the medium from the coal and waste by diluting it, means for recovering magnetite from said dilute fraction and returning the recovered magnetite to said mixing sump, and density sensing and control means connected in said system for continuously measuring the density of the medium being fed to said coal-separating vessel and automatically controlling said density by adding and subtracting water and magnetite to and from said system in response to said measuring.

11. A process of separating coal from raw coal containing coal and waste, comprising feeding water and finely divided magnetite to a mixing zone to form a coal-separating slurry medium, feeding separating medium from said mixing zone into a coal-separating zone, feeding raw coal to said coal-separating zone and there separating the coal from the waste by causing the coal to float in the separating medium and the waste to sink therein, separating magnetite from the coal and waste, returning said separated magnetite to the mixing zone, continuously measuring the density of the medium being fed to said coal-separating zone, and controlling said

density by adding and subtracting water and magnetite automatically in response to said measuring.

12. A system for separating coal from raw coal containing coal and waste, comprising a mixing sump into which is fed water and finely divided magnetite to form a coal-separating slurry medium, a coal-separating vessel to which said medium is fed from said sump and in which the coal is separated from the waste by floating in the medium, means for feeding raw coal into said coal-separating vessel, means connected into said system for separating magnetite from the coal and waste, means for returning said separated magnetite to the mixing sump, and density sensing and control means connected in said system for continuously measuring the density of the medium being fed to said coal-separating vessel and automatically controlling said density by adding and subtracting water and magnetite to and from said system in response to said measuring.

13. The system defined in claim 12, wherein said density sensing and control means includes a density measuring instrument having a radioactive source and a radiation detector which generates a signal proportional to the density of the medium, a magnetite feeder connected to said system, a water source connected to said system by a motorized valve, and means connected to said density measuring instrument and responsive to said signal for operating said magnetite feeder and said motorized valve to add magnetite and water as necessary to maintain the desired density of the medium.

14. A system for separating coal from raw coal containing coal and waste, comprising a mixing sump into which is fed water and finely divided magnetite to form a coal-separating slurry medium, a coal-separating vessel which receives the medium through a conduit extending from said sump and in which the coal separates from the waste by floating in the medium, means for feeding raw coal into said coal-separating vessel, means connected into said system for separating magnetite from the coal and waste, means for returning said separated magnetite to said sump, magnetite-separating means for separating out magnetite, bleed means for feeding a portion of the medium from said sump to said magnetite-separating means, means for feeding the recovered magnetite from said magnetite-separating means to said mixing sump to make the medium therein more dense, and density sensing and control means connected in said system for continuously measuring the density of the medium being fed to said coal-separating vessel and automatically controlling said density by adding and subtracting water and magnetite to and from said system in response to said measuring.

15. A system for separating coal from raw coal containing coal and waste, comprising a mixing sump into which is fed water and finely divided magnetite to form a coal-separating slurry medium, a coal-separating vessel which receives the medium through a conduit extending from said sump and in which the coal separates from the waste by floating in the medium, means for feeding raw coal into said coal-separating vessel, means connected into said system for separating magnetite from the coal and waste, means for returning said separated magnetite to said sump, magnetite-separating means for separating out magnetite, bleed means for feeding a portion of the medium from said sump to said magnetite-separating means, means for feeding the recovered magnetite from said magnetite-separating means to said mixing sump to make the medium therein more dense, means connected to said raw coal feed means and operative in response thereto for automatically shutting off said bleed means when no raw coal is being fed to said coal-separating vessel, and density sensing and control means connected in said system for continuously measuring the density of the medium being fed to said coal-separating vessel and automatically controlling said density by adding and subtracting water and magnetite to and from said system in response to said measuring.

16. The system defined in claim 15, wherein said means for automatically shutting off said bleed means comprises an ammeter connected to said raw coal feed means, said ammeter generating a signal responsive to the current in said conveyor motor, and a motorized valve positioned in a by-pass pipe of said bleed means and electrically connected to said ammeter and adapted to shut off said by-pass pipe in response to said signal.

17. A system for separating ore from raw ore containing ore and waste, comprising a mixing sump into which is fed a liquid and a finely divided insoluble material to form an ore-separating slurry medium, an ore-separating vessel which receives the medium through a conduit extending from said sump and in which the ore separates from the waste by floating in the medium, means for feeding raw ore into said ore-separating vessel, means connected into said system for separating finely divided material from the ore and waste, means for returning said separated material to said sump, and density sensing and control means connected in said system for continuously measuring the density of the medium being fed to said ore-separating vessel and automatically controlling said density by adding and subtracting the liquid and finely divided insoluble material to and from said system in response to said measuring.

18. The system defined in claim 17, wherein said density sensing and control means includes a density measuring instrument having a radioactive source and an radiation detector which generates a signal proportional to the density of the medium, a feeder for said insoluble material connected to said system, a water source connected to said system by a motorized valve, and means responsive to said signal for operating said feeder and said motorized valve to add the finely divided insoluble material and the liquid as necessary to maintain the desired density of the medium.

19. A system for separating ore from raw ore containing ore and waste, comprising a mixing sump into which is fed a liquid and a finely divided insoluble material to form an ore-separating slurry medium, an ore-separating vessel which receives said medium through a conduit extending from said sump and in which the ore separates from the waste by floating in the medium, means for feeding raw ore into said ore-separating vessel, means connected into said system for separating finely divided material from the ore and waste, means for returning said separated material to said sump, means for separating out finely divided insoluble material, bleed means for feeding a portion of the medium from said sump to said insoluble material separating means, means for feeding the recovered insoluble material from said material separating means to said mixing sump to make the medium therein more dense, and density sensing and control means connected in said system for continuously measuring the density of the medium being fed to said ore-separating vessel and automatically controlling said density by adding and subtracting liquid and finely divided insoluble material to and from said system in response to said measuring.

20. A system for separating ore from raw ore containing ore and waste, comprising a mixing sump into which is fed a liquid and a finely divided insoluble material to form an ore-separating slurry medium, an ore-separating vessel which receives the medium through a conduit extending from said sump and in which the ore separates from the waste by floating in the medium, means for feeding raw ore into said ore-separating vessel, means connected into said system for separating finely divided material from the ore and waste, means for returning said separated material to said sump, means for separating out insoluble material, bleed means for feeding a portion of the medium from said sump to said insoluble material separating means, means for feeding the recov-

ered insoluble material from said material separating means to said mixing zone to make the medium therein more dense, means connected to said raw or feed means and operative in response thereto for automatically shutting off said bleed means when no raw ore is being fed to said ore-separating vessel, means connected to said raw ore feed means and operative in response thereto for automatically shutting off feeding of said insoluble material into the medium in said mixing sump, and density sensing and control means connected in said system for continuously measuring the density of the medium being fed to said ore-separating vessel and automatically controlling said density by adding and subtracting liquid and finely divided insoluble material to and from said system in response to said measuring.

21. The system defined in claim 20, wherein said means for automatically shutting off said bleed means

comprises an ammeter connected to said raw ore feed means, said ammeter generating a signal responsive to the current in said conveyor motor, and a motorized valve positioned in a by-pass pipe of said bleed means and electrically connected to said ammeter and adapted to shut off said by-pass pipe in response to said signal.

References Cited in the file of this patent

UNITED STATES PATENTS

2,816,657	Austin	Dec. 17, 1957
2,877,896	Jones	Mar. 17, 1959
2,949,190	Pagnotti	Aug. 16, 1960

FOREIGN PATENTS

796,550	Great Britain	June 11, 1958
799,579	Great Britain	Aug. 13, 1958
819,868	Great Britain	Sept. 9, 1959