Feb. 8, 1966 | C. R. NAILLER | 3,233,731

METHOD OF SEPARATING COAL

Filed Dec. 27, 1960 | 3 Sheets-Sheet 1

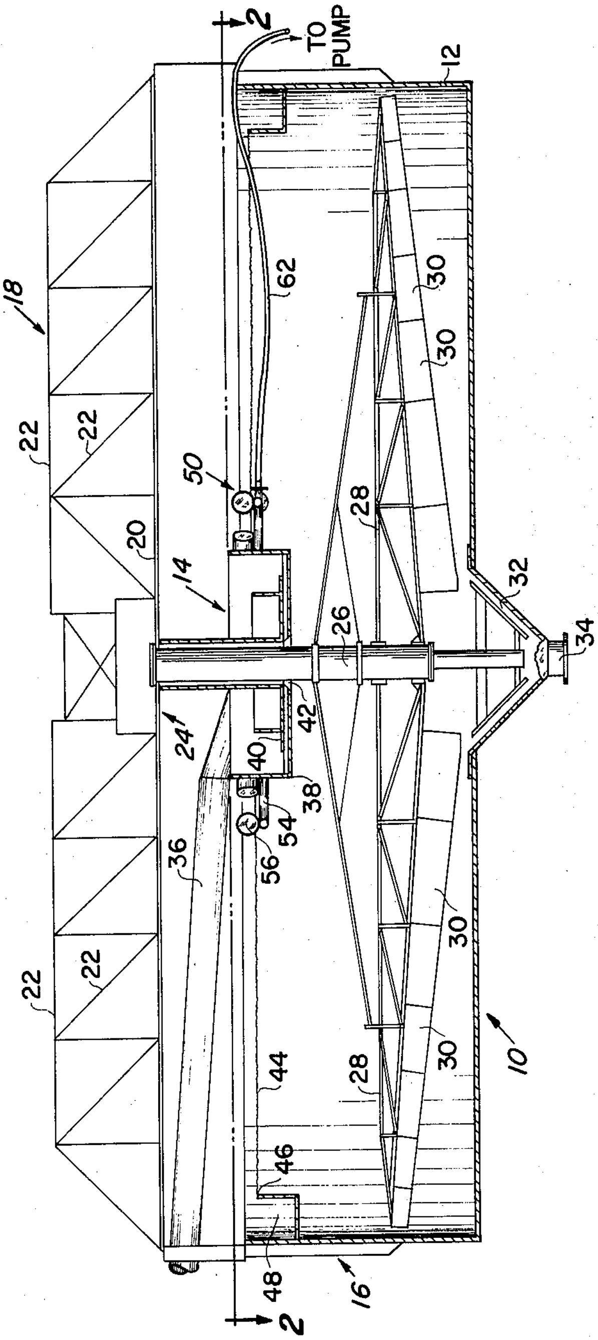

FIG. 1

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METHOD OF SEPARATING COAL

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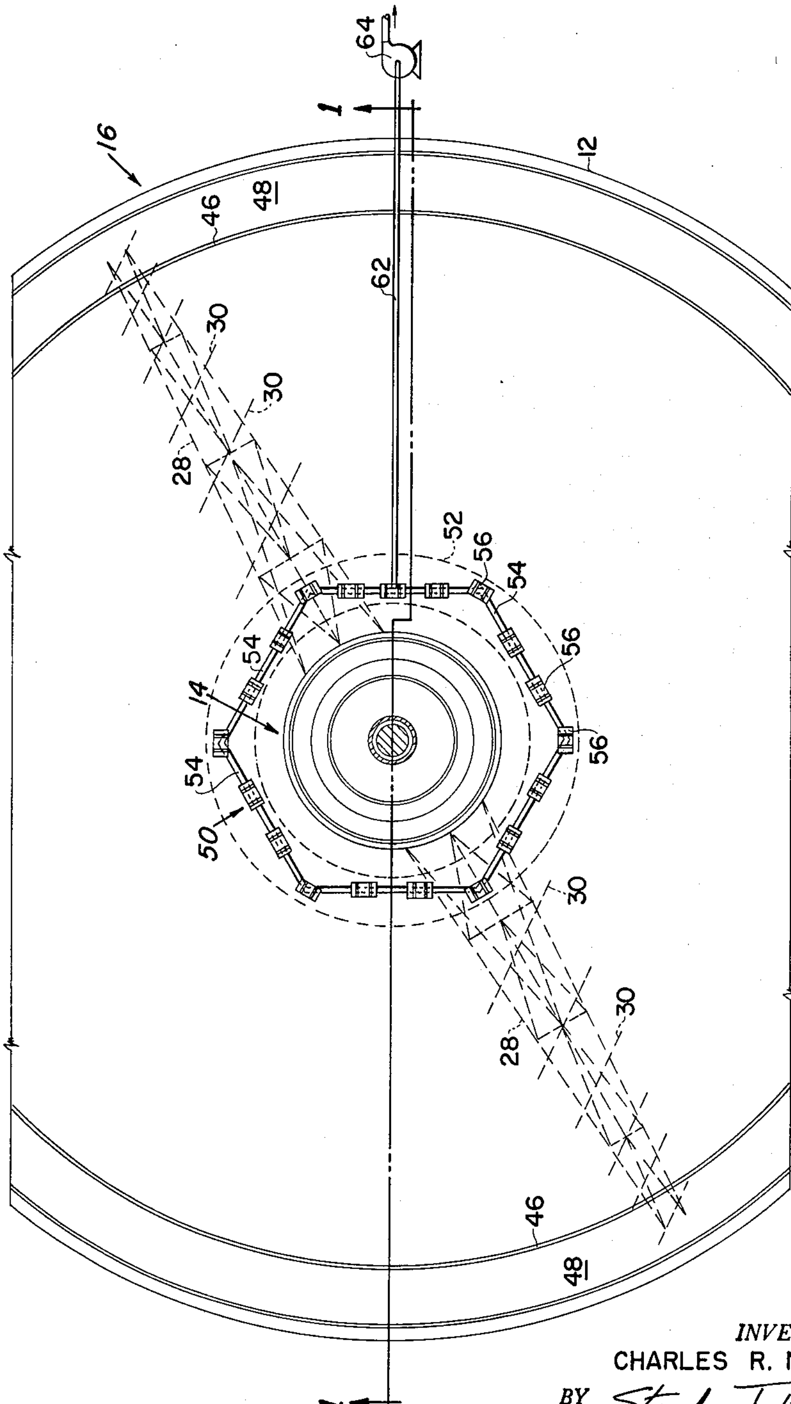

FIG. 2

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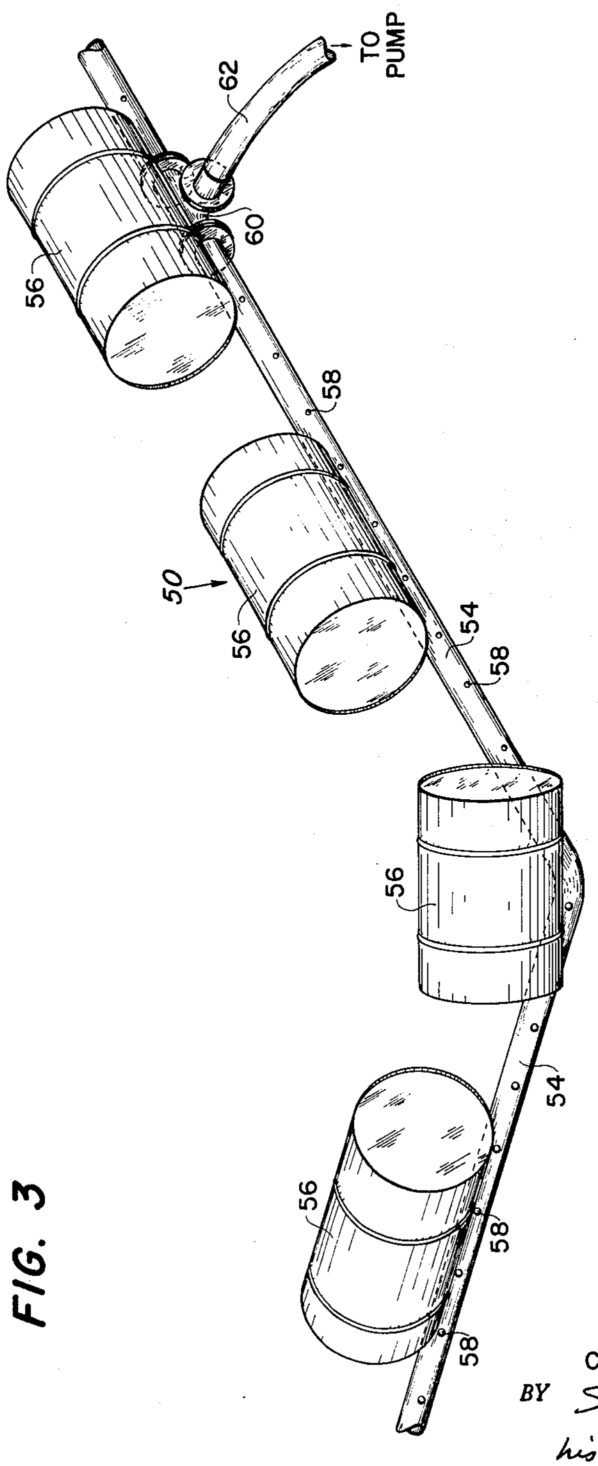

FIG. 3

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METHOD OF SEPARATING COAL

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This invention relates to coal preparation, and more particularly to a method of thickening and reducing the ash content of a coal-liquid slurry.

Raw coal as it is mined contains inorganic impurities such as rock, slate, clay and other inorganic matter. The inorganic impurities are incombustible and have a higher specific gravity than coal and are conventionally separated from the coal by gravity separation processes. Modern coal preparation plants clean the coal by removing the high gravity ash impurities therefrom in order to produce high grade coal product, the very fine coal sizes are separated from the more coarse coal sizes early in the preparation process. The fine coal is cleaned separately and is, in certain instances, destined for different markets than the coarse coal particles.

One type of impurity that is found in raw coal and is considered an ash constituent is pyrite sulphur or pyrites. The pyrite (FeS_2) is found both as layers or bands within the coal strata and also grains of pyrites are found dispersed throughout the coal strata. A substantial amount of pyrites that appear as grains in the coal strata are exposed or detached from the coal particles when the coal particles are comminuted to a relatively small size. Pyrites has a specific gravity of about 5.5, whereas clean relatively ash free coal has a specific gravity of between 1.25 and 1.35. The gravity of the admixture is indicative of the ash content. Where the particulate material has a low gravity, it contains little, if any, impurities or ash. Conversely, where the gravity of the material is relatively high, the admixture contains a substantial amount of impurities commonly called ash.

In the course of cleaning fine coal within modern preparation plants, the coal is handled in slurry form, that is, it is mixed with water for ease of movement and to facilitate certain of the cleaning processes. The fine coal, in slurry form, is cleaned on reciprocating coal cleaning tables and then dewatered on vibrating screens. The underflow from the vibrating screens is sent to a cyclone separator where a major portion of the water is separated from the fine coal particles as cyclone separator overflow. The overflow from the cyclone separator is a dilute slurry containing about 10% solids by weight. These solids are of an extremely fine size and have a relatively high ash content. In order to utilize the coal contained in the dilute slurry product from the cyclone separator, large accumulating vessels known as thickeners are employed to separate the solids from the water carrier. These thickeners maintain the slurry in a quiescent state so that the solids settle out to the bottom of the vessel.

Large slurry thickeners are well known in the coal cleaning art. Primarily, the coal slurry is introduced to the large cylindrical tank of the thickener in a quiescent state at the center of the tank. The coal settles out of the slurry to the bottom of the tank and a substantially clear water overflow is removed from the periphery of the tank. The coal particles which settle to the bottom of the tank are removed through a coal discharge port at the center of the thickener tank. The overall water content of the thickened product removed from the coal discharge port is substantially reduced over the water content of the dilute slurry introduced to the thickener. A dilute slurrry having 10% or less by weight of solids when entering the

thickener tank is dewatered to the extent that the slurry removed from the coal discharge port has 50% or more by weight of solids.

The present invention is directed to a novel method for simultaneously reducing the overall ash content of the solids in the slurry leaving the thickener while the slurry is being thickened. The solids in the dilute slurry product introduced into the thickener are of an extremely fine size and have a relatively high ash content. For example, the ash content of the solids introduced to the thickener may be as high as 15% by weight of the solids. This high ash content can be attributed in part to the inefficient cleaning of fine sized solids by conventional coal cleaning apparatus and the colloidal properties of certain types of ash. Ash is the solid, noncombustible waste material which is mined with the coal and may consist of particles of rock, slate, clay, or other foreign material which is intermixed with the raw coal as it comes from the mine.

Coal which leaves a modern preparation plant is graded according to the amount of ash content in the cleaned coal. The cleaner coal, that is, the coal having a reduced ash content, has a greater sale value than the coal having a greater ash content. Thus, if the ash content of coal can be reduced by one or two percent, it then becomes a more salable product.

The present invention, by reducing the overall ash content of the thickener product, increases its value to an extent that under certain instances the thickener product may be recombined with other cleaned coal to thereby increase the overall yield of cleaned coal issuing from the preparation plants.

To practice the present invention, a coal slurry within the thickener is separated by a strategically located slurry withdrawal means which separates a relatively low concentration slurry having a relatively high ash content from the thickener. Because the ash content of the slurry removed by the withdrawal means is substantially greater, percentagewise, than the average ash content of the slurry introduced to the thickener, the slurry leaving the thickener through the coal discharge port has a subsantially reduced ash content. It was discovered that the coal slurry within the thickener had varying solids concentration and varying ash content throughout the radial extent of the thickener. This varying coal concentration and ash content was charted and the slurry withdrawal means was positioned within a zone of the thickener where a slurry having a high ash concentration could be removed.

In the practice of the present invention, so much slurry can be removed through the slurry withdrawal means that substantially no clear water overflows the thickener tank at its periphery. Thus, the slurry level within the thickener tank is maintained only by the amount of slurry withdrawn through the withdrawal means of this invention. In other instances, it may be desirable to withdraw slurry through the withdrawal means of this invention in reduced amounts. When so operated, clear water will overflow the thickener tank at the periphery thereof to maintain the slurry level within the tank.

With the foregoing considerations in mind, it is a primary object of the present invention to provide an improved method for simultaneously thickening and reducing the ash content of a coal slurry.

Another object of this invention is to provide an improved method of simultaneously thickening and reducing the ash content of a coal slurry within a conventional slurry thickener.

These and other objects of this invention will become apparent as this description proceeds in conjunction with the accompanying drawings.

In the drawings:

FIGURE 1 is a sectional elevation of a slurry thickener embodying the present invention taken along line 1—1 of FIGURE 2.

FIGURE 2 is a partial plan view of the thickener of FIGURE 1 taken along line 2—2 of FIGURE 1.

FIGURE 3 is an enlarged perspective view of a portion of the slurry withdrawal means shown in FIGURES 1 and 2.

In the following description of the present invention, the conventional slurry thickener will be described in some detail and the pattern of solids concentration and ash content throughout the conventionally operating slurry thickener will be considered. The structure of the present invention which modifies the thickener operation will then be described in detail.

Referring to FIGURES 1 and 2, a slurry thickener **10** has a cylindrical tank **12**. The tank **12** may be constructed above ground level or it may be positioned in a recessed portion of the topography so that substantially the whole thickener tank **12** is below ground level. The tank **12** has a central portion indicated generally at **14** and a peripheral portion indicated generally at **16**.

As seen in FIGURE 1, a tank superstructure **18** extends diametrically across the tank **12** above the level of tank **12**. Superstructure **18** includes a walk way **20** which is maintained in suspension by truss supports **22**. The superstructure **18** also supports a rake drive mechanism indicated generally at **24**. The rake drive mechanism is located over the central portion **14** of tank **12** and drives a vertically depending drive shaft **26**.

entering through slurry inlet conduit **36** passes between the bottom of chamber **38** and the inlet baffle **40** and enters the tank **12** through the annular tank inlet port **42**. By providing the baffle **40** and insuring that the inlet **42** is below the surface **44** of the slurry, the slurry enters the tank **12** with a minimum of turbulence so that the slurry within tank **12** is maintained in a quiescent state. The surface **44** of the slurry within the tank is maintained at its level by an overflow weir **46** which is formed about the periphery of the tank **12**. Overflow weir **46** together with the wall of the tank **12** forms an annular launder **48** through which the overflow from tank **12** flows and from which the overflow utimately is removed.

As described thus far, the slurry thickener is conventional in all respects. In operation, the conventional slurry thickener receives a fine coal water slurry through conduit **36** and the slurry enters the tank **12** through inlet port **42**. Upon entering the tank **12**, the slurry radiates outwardly and the solid particles within the slurry begin to drop toward the bottom of tank **12**. The rakes **30** direct the solid particles toward the coal discharge sump **32** at the bottom center portion of tank **12**. The water of the slurry overflows into the annular trough **48** extending around the periphery of tank **12** and is withdrawn. The water overflowing into trough **48** is substantially free of any particles.

During operation of a conventional slurry thickener, an analysis of the solids content and ash distribution throughout the thickener was made. The results of this analysis are tabulated in the following Table I.

TABLE I

Analysis of solids and ash distribution four inches below the surface of a conventional thickener operating at 3100 g.p.m. inlet and 2000 g.p.m. overflow.

Distance from center	Inlet		14 feet		28 feet		42 feet		56 feet		70 feet	
Solids concentration by weight	8.8%		0.45%		0.17%		0.10%		0.07%		0.07%	
Size fractions	Size percent by weight of total solids	Percent ash by weight of fraction	Size percent by weight of total solids	Percent ash by weight of fraction	Size percent by weight of total solids	Percent ash by weight of fraction	Size percent by weight of total solids	Percent ash by weight of fraction	Size percent by weight of total solids	Percent ash by weight of fraction	Size percent by weight of total solids	Percent ash by weight of fraction
+28 mesh	------	------	------	------	------	------	------	------	------	------	------	------
28 x 48 mesh	1.3	7.9	1.4	4.9	------	------	------	------	------	------	------	------
48 x 60 mesh	10.5	3.6	0.9	3.6	0.7	5.2	1.3	5.0	------	------	------	------
60 x 100 mesh	19.2	4.6	3.9	3.7	2.2	4.1	1.3	5.0	0.6	4.6	0.5	4.9
100 x 200 mesh	14.9	5.5	6.3	4.1	4.7	4.1	4.4	5.0	4.1	4.6	3.3	4.9
200 x 0 mesh	54.1	22.4	87.5	48.6	92.4	50.8	93.0	47.0	95.3	45.5	96.2	55.3
Total	100.0	14.3	100.0	43.0	100.0	47.3	100.0	44.1	100.0	43.6	100.0	53.4

Secured to drive shaft **26** and extending radially therefrom are rake arms **28**. The rake arms **28** have a plurality of rakes **30** secured thereto. As viewed in FIGURE 2, the rake arms **28** turn in a clockwise direction so that rakes **30** drag the thickened product on the bottom of the tank **12** toward the central portion **14** of the tank.

At the bottom central portion of the tank **12**, a coal discharge sump **32** is formed. The coal discharge sump **32** empties into a coal discharge conduit **34** through which the thickened coal slurry is withdrawn from the tank **12**. This thickened coal slurry which is removed through conduit **34** is often termed the "underflow" from the thickener.

As seen in FIGURE 1, a slurry inlet conduit **36** extends radially inwardly from a source of fine coal slurry (not shown) into an annular inlet chamber **38** formed at the central portion **14** of the tank **12**. Other inlet conduit means for the slurry may be provided such as a trough or sluiceway along the walk way **20**. Inlet chamber **38** has an inlet baffle **40** which is suspended from the superstructure **18** and which extends radially in close proximity to the bottom wall of inlet chamber **38**. The coal slurry

As indicated in Table I, an analysis of the solids concentration and ash distribution was made four inches below the surface of the conventional thickener operating at a slurry inlet rate of 3100 gallons per minute and having 2000 gallons per minute overflow into the annular trough **48**. Thus, 1100 gallons per minute were removed from the underflow or through the coal discharge port **34**. In collecting the data presented in Table I, samples of the coal slurry within the thickener were taken from the inlet port, and at distances of 14, 28, 42, 56 and 70 feet from the center of the tank **12** four inches below the surface of the slurry. The radius of tank **12** was 70 feet, so that a sample taken at 70 feet was substantially clear water overflow from the conventionally operating slurry thickener.

As further shown in Table I, the inlet slurry had a solids concentration of 8.8% by weight and a total ash content of 14.3% of the solids concentration. The ash content by size fraction of the inlet slurry is broken down in the first two columns of Table I. Thus, it may be seen that of the total solids in the inlet slurry, 1.3% pass through a 28 mesh Tyler Standard screen and remain on a 48 mesh Tyler Standard screen. Of this 28 x 48 mesh fraction, 7.9% was ash. Further, reading from columns 1 and 2, it will be seen that 54.1% of the total solids in the inlet slurry pass through a 200 mesh screen. Of this 200 x 0 fraction, 22.4% was ash.

As samples were taken progressively further out from the center of the tank, the overall solids content by weight of the slurry within the thickener became substantially reduced. Thus, at 14 feet, 0.45% of the slurry by weight was solids. At 56 feet, only 0.07% of the slurry was solids. By a review of Table I it can further be determined that at 14 feet where the solids concentration was .045% by weight, 43% of those solids were ash. At 56 feet where the solids concentration was .07% by weight, 43.6% of those solids were ash.

By charting the solids and ash distribution as is done in Table I, zones may be selected where a substantial quantity of ash may be removed from the slurry. For example, the inlet slurry contains ash of only 14.3%. If slurry is removed from a zone at 14 feet, the ash content of the slurry removed is 43%. Thus, the overall percentage of ash content in the slurry remaining in tank **12** will be substantially reduced.

In addition to selecting a zone which contains a high percentage of ash, the overall solids concentration of the slurry should be considered. If the overall solids concentration of the slurry is relatively high, a greater absolute quantity of ash will be removed from the tank than if a removal zone is selected where the overall concentration of the slurry is less. Thus, for example, at 14 feet, 0.45% solids concentration, only 43% by weight of the solids are ash. At 28 feet, on the other hand, 47.3% of the solids are ash. But at 28 feet, the solids concentration of the slurry is only .17% by weight. Thus, although the percentage of solids that are ash is much higher at 28 feet, the total absolute quantity of ash which can be removed from the vessel is higher at 14 feet becaue the total solids removed at 14 feet in every gallon of slurry removed will be more than double the total solids removed at 28 feet in every gallon of slurry removed.

The data set forth in Table I is intended to represent only one set of conditions at a particular preparation plant. There may be installations where the dilute slurry product fed to the thickener is substantially higher in ash, especially clay type ash. Under these circumstances the solids concentration at the 14 foot point could be as high as 3%.

After considering the analysis of the solids and ash distribution within a conventional thickener, it will be seen that an annular zone may be selected where a quantity of slurry may be withdrawn from the thickener and disposed of in order to decrease the ash content of the thickened slurry leaving outlet port **34**. An apparatus for withdrawing slurry from a thickener tank is indicated generally at **50** on FIGURES 1, 2 and 3. A slurry withdrawal zone **52** is selected from an analysis of the solids and ash distribution within the thickener so that an optimum amount of ash will be removed without undue sacrifice of the overall quantity of thickened slurry leaving the tank **12**. A withdrawal zone **52** is indicated by dotted lines in FIGURE 2.

Within withdrawal zone **52**, a series of pipe sections **54** are connected to each other to form a closed polygon. The pipe sections **54** are secured to a number of float drums **56** which float the apparatus **50** on the surface of the slurry so that the pipe sections **54** remain at a fixed distance below the surface of the slurry **44**. For economy and simplicity of fabrication, the apparatus **50** is formed from a series of straight pipe sections. It will be appreciated that a continuous circular pipe section would be provided at greater expense and without the ease of fabrication.

As best seen in FIGURE 3, the pipe sections **54** have a series of holes **58** formed therein. Although the apertures **58** are indicated as positioned on the external periphery of the polygonal pipe sections, it should be understood it is within the scope of the invention to position the apertures on the inner periphery and thereby provide means to secure a depending polygonal curtain to the pipe sections **54** and provide a compartmentalized thickener.

One of the pipe sections **54** has a T fitting **60** secured thereto so that the interior of the pipe sections **54** may communicate with a flexible conduit **62** extending radially from the polygonal structure formed from pipe sections **54**.

Communicating with the end of a flexible conduit **62** is a pump **64** shown in FIGURE 2. Pump **64** is designed to withdraw slurry through flexible conduit **62**, pipe sections **54**, and out of the tank **12**.

In order to promote uniform flow from the tank **12** into the pipe sections **54**, the holes **58** formed in pipe sections **54** vary in size at progressively greater distances from the T connection **60** which joins the flexible conduit **62** to pipe sections **54**. The holes **58** formed in the pipe section **54** in which T connection **60** is located, are of relatively small size. The holes **58** in the pipe sections **54** next adjacent to the pipe section containing T fitting **60** are slightly larger. The holes **58** in the pipe sections **54** at greater distances from T fitting **60** are even larger. Thus, the pressure drop through the polygonal structure formed from pipe sections **54** does not materially affect the flow of slurry from tank **12** into the polygonal structure since there is a greater area open to the interior of the structure at the farthermost points where the force drawing the slurry into the structure is least.

A slurry thickener equipped with the structure of the present invention may be operated to maintain an amount of overflow around the periphery of tank **12** into annular trough **48**, or the slurry withdrawal apparatus **50** of the present invention may be operated to withdraw all excess slurry from the tank **12** so that there is no overflow about the periphery of tank **12**. For optimum de-ashing, the apparatus of the present invention should be operated so that there is no overflow over the launder **46** into trough **48**. However, in some instances it is desirable to reduce the overall de-ashing in order to obtain a higher quantity of usable material from the outlet port **34**.

A slurry leaving the tank **12** through flexible conduit **62** is a mixture of fine coal particles and water. This slurry has a very high ash content (well over 40%) so that the solid material is not recoverable as a useful product. Accordingly, the slurry leaving tank **12** through flexible conduit **62** may be disposed of in any manner conventionally utilized for disposing of waste slurry products.

With this invention, the overall percentage of ash in the solids recovered from a coal-water slurry may be reduced as much as 2%. This 2% reduction in ash content often means the difference between an unmarketable coal product and a useful coal product which is highly marketable. A reduction in ash can be obtained with a very simple modification to the structure of a conventional thickening unit.

According to the provisions of the patent statutes, I have explained the principle, preferred construction and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. A method of separating high gravity solids from a mixture containing different gravity solids, said solids having a spectrum of sizes and a substantial portion of fine high gravity solids, said method comprising introducing said solids in the form of a slurry of solids and water into the central portion of a tank, said tank having a central portion and a peripheral portion, maintaining said slurry under substantially quiescent conditions in said tank so that certain of said solids in said slurry settle to the bottom of said tank, determining the percent by weight concentration of solids in said slurry at predetermined radial locations from the center of said tank, determining the relative proportion of high gravity particulate material at each preselected location, withdrawing a dilute slurry having a decreased solids concentration relative to said slurry introduced into said tank from a zone adjacent the upper level of said slurry in said tank and at a selected one of said predetermined radial locations from the center of said tank, said solids in said dilute slurry having an increased concentration of fine-sized high gravity solids relative to said solids introduced into said tank, and withdrawing a concentrated slurry from the bottom of said tank, said concentrated slurry having an increased solids concentration relative to said slurry introduced into said tank, said solids in said concentrated slurry having decreased concentration of high gravity solids and an increased concentration of larger sized solids relative to said solids introduced into said tank.

2. A method of separating fine particulate material having a high gravity from a mixture containing different gravity particulate material, said particulate material having a spectrum of sizes including said high gravity fine particulate material, said method comprising introducing said particulate material in the form of a slurry of particulate material and water into the central portion of a tank, maintaining said slurry under substantially quiescent conditions in said tank so that certain of said particulate material in said slurry settles to the bottom of said tank and certain of said high gravity fine particulate

material remains suspended in a zone adjacent the upper surface of said slurry in said tank and at a predetermined radial location from the center of said tank, determining the percent by weight concentration of solids in said slurry at predetermined radial locations from the center of said tank, determining the relative proportion of high gravity particulate material at each preselected location, withdrawing a dilute slurry from said zone at a selected one of said predetermined radial locations from the center of said tank, said dilute slurry having a decreased solids concentration relative to said slurry introduced into said tank, said dilute slurry having an increased concentration of high gravity fine particulate material relative to said slurry introduced into said tank, and withdrawing a concentrated slurry from the bottom of said tank, said concentrated slurry having an increased concentration of particulate material relative to said slurry introduced into said tank, said particulate material in said concentrated slurry having a decreased concentration of fine high gravity particulate material relative to said particulate material introduced into said tank.

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