PATENT SPECIFICATION

(11) 1 225 211

DRAWINGS ATTACHED

1 225 211

(21) Application No. 19471/69 (22) Filed 16 April 1969
(31) Convention Application No. 778 446 (32) Filed 25 Nov. 1968 in
(33) United States of America (US)
(45) Complete Specification published 17 March 1971
(51) International Classification B 03 b 3/30
(52) Index at acceptance
B2H 2

(54) LAMINAR FLOW SLUICE CONCENTRATOR

(71) We, CARPCO RESEARCH & ENGINEERING, INC, a corporation organised and existing under the laws of the State of Florida, United States of America, of P.O. Box 3272, Jacksonville, Florida 32206, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process and an apparatus in the form of a concentrator for separating a desired particulate material from a mixture of particulate materials in which other materials are present having specific gravities similar to that of the desired material and in which the desired material is present in very small quantities.

A well-known phenomenon occurs when a liquid in which particulate materials of different specific gravities are suspended, i.e., a slurry of such materials, is permitted to flow in a relatively tranquil state through a conduit. The particulate materials stratify into a plurality of strata according to their relative specific gravities; the material of greatest specific gravity being on the bottom and the material of the least specific gravity being on the top, with the materials of intermediate specific gravities being arranged therebetween.

This phenomenon has been used advantageously for separating minerals of different specific gravities. Generally, a tapered sluice concentrator is provided, through which a substantially laminar flow of a slurry of the minerals to be separated is directed. In the presence of the laminar flow, the mineral particles arrange themselves, under the influence of gravity, into strata according to their specific gravities. Further, and as taught in United States patent 1,711,081, an increase in the depth and velocity of the slurry tends to accelerate the rate of stratification.

However, conventional tapered sluice concentrators of this type have not proved suitable for separating finely divided mineral particles of similar specific gravities because the velocity of the slurry cannot be increased sufficiently to stratify the minerals efficiently without disrupting the laminar flow. Thus, in such concentrators, as the flow rate is increased the slurry tends to ripple along the concentrator sidewalls, introducing turbulence into the flow. Such turbulence tends to intermingle the suspended mineral particles and thus impede stratification.

The present invention provides a solution to the aforementioned difficulty associated with conventional tapered sluice concentrators in a process and an apparatus particularly adapted for separating finely divided minerals of similar specific gravities.

Accordingly it is an object of the invention to provide a laminar flow sluice concentrator that is adapted to efficiently separate finely divided minerals of different specific gravities.

Therefore according to the present invention we provide a concentrator for separating particulate materials of different specific gravities including a conduit having an upper feed end and a lower discharge end, at least one sluice section defined by said conduit and adapted to receive a slurry of the materials to be separated from said feed end, said sluice section including a first portion defining means for initiating and maintaining a laminar flow of the slurry therethrough and converging said flow, thereby increasing the depth and velocity of the slurry and stratifying the materials into a plurality of strata according to the different specific gravities thereof, a second portion contiguous with said first portion, said second potrion defining means for maintaining the laminar flow of the slurry and diverging said flow, thereby decreasing the depth and velocity of the slurry and evenly spreading said strata, and a discharge means disposed adjacent said second portion for removing a fraction of the stratified materials from the concentrator.

A further feature of the present invention includes a process for separating particulate materials of different specific gravities comprising; initiating a laminar flow of a slurry of the materials to be separated; converging

said flow while maintaining the flow in a laminar condition, thereby increasing the depth and velocity of the slurry and stratifying the materials into a plurality of strata according to the different specific gravities thereof; thereafter diverging said flow while maintaining the flow in a laminar condition, thereby decreasing the depth and velocity of the slurry and evenly spreading said strata; and thereafter removing a fraction of the stratified materials from the slurry.

In order that the invention may be more clearly understood and readily carried into effect reference is now drawn to the accompanying drawings, in which:—

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view of the concentrator of the invention;

Fig. 2 is an elevational view, partially in section, of the concentrator shown in Fig. 1;

Fig. 3 is a vertical sectional view of the concentrator shown in Fig. 1;

Fig. 4 is a sectional view taken along line 4—4 of Fig. 3; and

Fig. 5 is an enlarged vertical sectional view of a portion of the concentrator shown in Fig. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the concentrator of the invention is shown in Figs. 1 and 2, as designated by reference numeral 10. Concentrator 10 includes a conduit 16 defining a first sluice section 12, a second sluice section 14 and a third sluice section 15; the feed end of second section 14 being contiguous with the discharge end of first section 12 and the feed end of third section 15 being contiguous with the discharge end of second section 14. Conduit 16 comprises a pair of opposed, converging, continuous sidewalls 18 and a continuous bottom wall 20, and is supported by a plurality of legs 22. Legs 22 support the conduit in an inclined attitude so that a slurry of particulate materials introduced into the upper or feed end 21 thereof will flow down the conduit and be discharged therefrom at the lower or discharge end 23 thereof. Concentrator 10 also includes a feed means 24 for introducing the slurry into first sluice section 12. The feed means is described in detail below.

A flow guide 26 is connected to the inside surface of each sidewall 18 along the section of conduit 16 defining first sluice section 12. The flow guides preferably are connected to the sidewalls by adjustable means which permit the position of the guides to be regulated longitudinally of conduit 16. Such means conveniently comprise slots 17 formed in sidewalls 18 within which are accommodated threaded studs 19 affixed to flow guides 26. The studs are locked in position by nuts 25.

The inside surface of each of flow guides 26 is defined by an inwardly curved segment 28 and an outwardly curved segment 30. Each inwardly curved segment is contiguous with the associated outwardly curved segment and forms therewith a continuous unbroken convex curve.

Bottom wall 20 and inwardly curved segments 28 form a first portion 32 of first sluice section 12. First portion 32 defines means for initiating a laminar flow of the slurry introduced therein and converging such flow. Convergence of the flow causes the depth and velocity of the slurry to increase. In the presence of the laminar flow, these conditions induce the particulate materials in the slurry to stratify, under the influence of gravity, into a plurality of strata according to their relative specific gravities.

Bottom wall 20 and outwardly curved segments 30 form a second portion 34 of first sluice section 12. Second portion 34 defines means for maintaining the laminar flow of the slurry and diverging such flow. Divergence of the flow causes the depth and velocity of the slurry to decrease. In the presence of the laminar flow, these conditions induce the strata of particulate materials to spread laterally of the flow across the surface of bottom wall 20.

First sluice section 12 also includes a discharge means 36 disposed adjacent second portion 34 for removing a fraction of the stratified particulate materials from the concentrator. The discharge means comprises a plate 38 which is removably insertable into a recess 40 (Fig. 5) in bottom wall 20, and which preferably is located near the junctures 35 of outwardly curved segments 30 and the inside surface of sidewalls 18. Plate 38 may be made of plastics material, such as polyvinyl chloride, or any other suitable material, and has a transverse slot 42 therein which overlies a transverse slot 44 in bottom wall 20. A fraction of the stratified particulate materials passes through slots 42 and 44 as the slurry flows thereover, and may be separately collected below conduit 16. Since plate 38 is removable, other similar plates having slots of different shapes and dimensions can be substituted for plate 38 as required for reasons discussed in detail below.

Second sluice section 14 commences at discharge means 36. A flow guide 39 is connected to the inside surface of each sidewall 18 along the portion of conduit 16 defining sluice section 14. If desired, flow guides 39 may be connected to sidewalls 18 by adjustable means which permit the position of the flow guides to be regulated longitudinally of conduit 16, as described above in connection with flow guides 26.

Flow guides 39 are structurally similar

to flow guides 26 and form with bottom wall 20 a first portion 41 and a second portion 43. First portion 41, similarly to first portion 32, defines means for maintaining the laminar flow of the slurry introduced into the feed end of section 14 from the discharge end of section 12 and reconverging such flow. Reconvergence of the flow causes the depth and velocity of the slurry to again increase, thereby inducing the particulate materials in the slurry to restratify after the first fraction has been removed therefrom. Second portion 43, similarly to second portion 34, defines means for maintaining the laminar flow of the slurry and rediverging such flow. Redivergence of the flow causes the depth and velocity of the slurry to again decrease, thereby inducing the particulate materials in the slurry to again spread laterally across the surface of bottom wall 20.

Second sluice section 14 also includes a discharge means 46, which is structurally similar to discharge means 36, for removing a second fraction of the stratified particulate materials from the concentrator. Discharge means 46 preferably is located near the lower junctures 45 of flow guides 39 and inside surfaces of sidewalls 18.

Third sluice section 15 commences at discharge means 46, and includes a pair of flow guides 47, which are structurally similar to flow guides 26 and 39, and a discharge means 48 which is structurally similar to discharge means 36 and 46. A third fraction of the stratified particulate materials is removed from the concentrator by discharge means 48.

Conduit 16 extends downwardly a short distance beyond third sluice section 15, which terminates at discharge means 48, to discharge end 23. The fraction of the particulate materials not removed by discharge means 36, 46 and 48 flows out of conduit 16 at discharge end 23.

To promote the laminar flow of the slurry down conduit 16, the inside surfaces of sidewalls 18, bottom wall 20, and flow guides 26, 39 and 47 are made as smooth as is economically feasible, such as by coating such surfaces with a durable plastics material, thereby reducing boundary layer turbulence along the surfaces of the conduit contacted by the slurry.

Feed means 24 includes a receptacle 50 which is positioned above feed end 21 and which comprises a plurality of sidewalls 52, 54, 56 and 58, and a bottom wall 60. Receptacle 50 has an open top through which a continuous supply of the slurry of particulate materials to be separated is introduced therein. The receptacle has at least one port, and preferably a plurality of ports 62, opening therefrom above bottom wall 60. As shown in Fig. 4, ports 62 preferably comprise a plurality of horizontally spaced circular openings in sidewall 56; the latter being disposed transversely of conduit 16.

As shown in Fig. 3, when a head of the slurry is established in receptacle 50 the slurry flows out of ports 62 into feed end 21. This arrangement has at least two beneficial effects. First, an even flow of the slurry is introduced into the conduit irrespective of the feed rate of the slurry into receptacle 50. Second, any foreign matter, such as twigs, rocks, or the like, contained in the slurry either falls to the bottom of the receptacle 50 or floats on the surface of the head established therein. In either event the foreign matter does not clog or pass through ports 62 and therefore does not affect the flow of the slurry into and down conduit 16.

Feed means 24 also includes a baffle 63 disposed transversely of conduit 16 and interposed between receptacle 50 and first portion 32 of first sluice section 12. Baffle 63 has a rectangular cutout therein which is positioned adjacent bottom wall 20 and defines therewith a relatively narrow transverse opening 65, through which the slurry flows from feed end 21 into first portion 32. Any turbulence generated by the passage of the slurry from receptacle 50 into feed end 21 is suppressed by the passage of the slurry through opening 65. Baffle 63 is thus insures that a relatively tranquil flow of the slurry will pass into first portion 32.

Concentrator 10 is specifically adapted to separate finely divided minerals of different specific gravities. And in particular, the concentrator has proven extremely efficient for separating a desired heavy mineral from mixtures in which other minerals are present having specific gravities similar to that of the desired mineral and in which the desired mineral is present in very small quantities. An example of such a desired heavy mineral is monazite, an ore of cerium and thorium. Monazite has a specific gravity of 5.0, and frequently is found in mixtures containing ilmenite specific gravity 4.7 zircon, specific gravity 4.68; garnet, specific gravity 4.3; rutile, specific gravity 4.25; staurolite, specific gravity 3.75; kyanite, specific gravity 3.66 and other minerals of lesser specific gravities. It is not economically feasible to separate the monazite from the other minerals comprising this mixture utilizing conventional tapered sluice concentrators. This deficiency derives from the fact that the specific gravities of the minerals comprising the mixture are of similar values. Thus, if the velocity of a slurry containing such a mixture is increased sufficiently to obtain the desired stratification it is virtually impossible to maintain a laminar flow of the slurry in conventional tapered sluice concentrators. Concentrator 10 overcomes this deficiency.

In operation, a continuous supply of a slurry of a mixture of the minerals to be separated is introduced into receptacle 50 and a head of the slurry established therein (Fig. 3). From receptacle 50 the slurry flows through ports 62 into feed end 21 and through baffle opening 65 into first portion 32 of first sluice section 12.

As the slurry commences flowing through first portion 32, a laminar flow condition is achieved almost immediately. The flow is then converged smoothly as the flow passes through the zone defined by portion 34 so that the depth and velocity of the slurry is gradually increased. As this occurs, the mineral particles are efficiently stratified according to their different specific gravities with the desired heavy mineral, such as monazite, comprising the lower-most strata.

The slurry then passes into the second portion 34 of first sluice section 12 where the laminar flow condition of the slurry is maintained and the flow diverged smoothly. As a result of this divergence, the depth and velocity of the slurry is decreased so that the strata of mineral particles are slowed down and spread evenly across the width of bottom wall 20. These conditions facilitate the removal of a concentrates fraction by discharge means 36.

The initial convergence of the flow promotes the recovery of a high grade concentrates fraction and the subsequent divergence of the flow promotes a high recovery rate of such fraction.

After passing discharge means 36, the slurry flows successively through second and third sluice sections 14 and 15. As the slurry flows through each of sluice sections 14 and 15, the laminar flow condition is maintained and the flow is converged and diverged in the manner described above with respect to first sluice section 12. As the slurry passes discharge means 46 and 48 a first and a second middlings fraction are removed from the concentrator. A tailings fraction then passes out of conduit 16 at discharge end 23. If desired, the first or second, or both, middlings fractions may be recirculated through the concentrator. It has been found that when concentrator 10 is utilized for separating monazite from a mixture of minerals similar to that described above, a single pass through the concentrator is sufficient to reduce the amount of monazite remaining in the tailings fraction to a minimal percentage. Thus, a final tailings is obtained in a single pass.

EXAMPLE

Two samples of monazite ore were separated utilizing a concentrator similar to concentrator 10. For the first sample, the guides were removed from the concentrator and for the second sample the flow guides were installed as described above. Both samples contained less than 4.0 per cent monazite. The separation results are shown in Table 1 below.

TABLE 1

	Per Cent of Total Monazite				
	Head Feed	Concentrates	First Middling	Second Middling	Tailing
First Sample (flow guides removed)	100	72.1	13.0	3.42	3.75
Second Sample (flow guides installed	100	77.3	15.0	3.36	2.12

The results shown in Table 1 indicate that the flow guides improved the grade of the concentrates fraction by 7.2 per cent, an economically significant increase.

As mentioned above plate 38 may be removed from recess 40 and replaced by a similar plate having a slot therein of a different shape and dimensions than slot 42. Similarly, the plates of discharge means 46 and 48 may be replaced by other plates having slots of different shapes and dimensions therein. Obviously, the wider the slot in a particular plate, the greater will be the amount of mineral particles removed from the concentrator by the discharge means in which such plate is employed. This permits the grade and recovery rate of the separated fractions to be accurately controlled.

Concentrator 10 comprises an efficient and relatively inexpensive means for separating particulate materials of different specific gravities, and in particular for separating a desired heavy mineral from a mixture of finely divided mineral particles in which other minerals having specific gravities similar to that of the desired mineral are present.

WHAT WE CLAIM IS:—

1. A concentrator for separating particulate materials of different specific gravities including a conduit having an upper feed

In operation, a continuous supply of a slurry of a mixture of the minerals to be separated is introduced into receptacle 50 and a head of the slurry established therein (Fig. 3). From receptacle 50 the slurry flows through ports 62 into feed end 21 and through baffle opening 65 into first portion 32 of first sluice section 12.

As the slurry commences flowing through first portion 32, a laminar flow condition is achieved almost immediately. The flow is then converged smoothly as the flow passes through the zone defined by portion 34 so that the depth and velocity of the slurry is gradually increased. As this occurs, the mineral particles are efficiently stratified according to their different specific gravities with the desired heavy mineral, such as monazite, comprising the lower-most strata.

The slurry then passes into the second portion 34 of first sluice section 12 where the laminar flow condition of the slurry is maintained and the flow diverged smoothly. As a result of this divergence, the depth and velocity of the slurry is decreased so that the strata of mineral particles are slowed down and spread evenly across the width of bottom wall 20. These conditions facilitate the removal of a concentrates fraction by discharge means 36.

The initial convergence of the flow promotes the recovery of a high grade concentrates fraction and the subsequent divergence of the flow promotes a high recovery rate of such fraction.

After passing discharge means 36, the slurry flows successively through second and third sluice sections 14 and 15. As the slurry flows through each of sluice sections 14 and 15, the laminar flow condition is maintained and the flow is converged and diverged in the manner described above with respect to first sluice section 12. As the slurry passes discharge means 46 and 48 a first and a second middlings fraction are removed from the concentrator. A tailings fraction then passes out of conduit 16 at discharge end 23. If desired, the first or second, or both, middlings fractions may be recirculated through the concentrator. It has been found that when concentrator 10 is utilized for separating monazite from a mixture of minerals similar to that described above, a single pass through the concentrator is sufficient to reduce the amount of monazite remaining in the tailings fraction to a minimal percentage. Thus, a final tailings is obtained in a single pass.

EXAMPLE

Two samples of monazite ore were separated utilizing a concentrator similar to concentrator 10. For the first sample, the guides were removed from the concentrator and for the second sample the flow guides were installed as described above. Both samples contained less than 4.0 per cent monazite. The separation results are shown in Table 1 below.

TABLE 1

	Per Cent of Total Monazite				
	Head Feed	Concentrates	First Middling	Second Middling	Tailing
First Sample (flow guides removed)	100	72.1	13.0	3.42	3.75
Second Sample (flow guides installed	100	77.3	15.0	3.36	2.12

The results shown in Table 1 indicate that the flow guides improved the grade of the concentrates fraction by 7.2 per cent, an economically significant increase.

As mentioned above plate 38 may be removed from recess 40 and replaced by a similar plate having a slot therein of a different shape and dimensions than slot 42. Similarly, the plates of discharge means 46 and 48 may be replaced by other plates having slots of different shapes and dimensions therein. Obviously, the wider the slot in a particular plate, the greater will be the amount of mineral particles removed from the concentrator by the discharge means in which such plate is employed. This permits the grade and recovery rate of the separated fractions to be accurately controlled.

Concentrator 10 comprises an efficient and relatively inexpensive means for separating particulate materials of different specific gravities, and in particular for separating a desired heavy mineral from a mixture of finely divided mineral particles in which other minerals having specific gravities similar to that of the desired mineral are present.

WHAT WE CLAIM IS:—

1. A concentrator for separating particulate materials of different specific gravities including a conduit having an upper feed

end and a lower discharge end, at least one sluice section defined by said conduit and adapted to receive a slurry of the materials to be separated from said feed end, said sluice section including a first portion defining means for initiating and maintaining a laminar flow of the slurry therethrough and converging said flow, thereby increasing the depth and velocity of the slurry and stratifying the materials into a plurality of strata according to the different specific gravities thereof, a second portion contiguous with said first portion, said second portion defining means for maintaining the laminar flow of the slurry and diverging said flow, thereby decreasing the depth and velocity of the slurry and evenly spreading said strata, and a discharge means disposed adjacent said second portion for removing a fraction of the stratified materials from the concentrator.

2. A concentrator for separating particulate materials of different specific gravities as recited in claim 1, further comprising a feed means associated with said conduit for feeding an even flow of said slurry into said feed end, said feed means including turbulence suppressing means for promoting a tranquil flow of the slurry from said feed end.

3. A concentrator for separating particulate materials of different specific gravities as recited in claim 1 or 2 wherein said first and second portions are formed by said conduit and a pair of opposed continuous flow guides.

4. A concentrator for separating particulate materials of different specific gravities, as recited in claim 3, wherein said flow guides are curved inwardly along said first portion and are curved outwardly along said second portion.

5. A concentrator for separating particulate materials of different specific gravities as recited in claim 3 or 4, wherein said flow guides are adjustable longitudinally of said conduit.

6. A concentrator for separating particulate materials of different specific gravities as recited in claim 1, 2, 3 or 4 wherein said discharge means comprises a transverse slot in said conduit.

7. A concentrator for separating particulate materials of different specific gravities as recited in claim 1, further comprising: a second sluice section defined by said conduit and contiguous with said first mentioned section, said second sluice section being adapted to receive the slurry after it has passed through said first section and including a first portion defining means for maintaining the laminar flow of the slurry and reconverging said flow, thereby again increasing the depth and velocity of the slurry and restratifying the materials into a plurality of strata according to the different specific gravities thereof after said first-mentioned fraction is removed therefrom, a second portion defining means for maintaining the laminar flow of the slurry and rediverging said flow, thereby decreasing the depth and velocity of the slurry and again evenly spreading said strata, and a second discharge means disposed adjacent said second portion of said second section for removing a second fraction of the stratified materials from the concentrator.

8. A concentrator for separating particulate materials of different specific gravities as recited in claim 7, further comprising: a third sluice section defined by said conduit and contiguous with said second section, said third sluice section being adapted to receive the slurry after it has passed through said second section and including a first portion defining means for maintaining the laminar flow of the slurry and reconverging said flow, thereby again increasing the depth and velocity of the slurry and restratifying the materials into a plurality of strata according to the different specific gravities thereof after said second fraction is removed therefrom, a second portion defining means for maintaining the laminar flow of the slurry and rediverging said flow, thereby again decreasing the depth and velocity of the slurry and again evenly spreading said strata, and a third discharge means disposed adjacent said second portion of said third section for removing a third fraction of the stratified materials from the concentrator.

9. A concentrator for separating particulate materials of different specific gravities as recited in claim 8, wherein said first and second portion of each of said first, second and third sluice sections are formed by said conduit and a pair of opposed continuous flow guides.

10. A concentrator for separating particulate materials of different specific gravities as recited in claim 9, wherein said flow guides are curved inwardly along said first portion of each said first, second and third sections and are curved outwardly along said second portion of each of said sections.

11. A concentrator for separating particulate materials of different specific gravities as recited in claim 1, wherein said feed means includes a receptacle for receiving a continuous supply of the slurry, said receptacle having at least one port opening therefrom above the bottom thereof, said port being positioned above said feed end so that a head of the slurry will be established within the receptacle and the slurry will be discharged therefrom through said port in an even flow into the feed end.

12. A concentrator for separating particulate materials of different specific gravi-

* C L M S *

ties as recited in claim 11, wherein said receptacle includes a plurality of walls, at least one of which is disposed transversely of said conduit; and wherein said port comprises an opening in said one wall.

13. A concentrator for separating particulate materials of different specific gravities as recited in claim 12, wherein said receptacle has a plurality of ports opening therefrom comprising a plurality of substantially horizontally spaced openings in said one wall.

14. A concentrator for separating particulate materials of different specific gravities as recited in claim 11, 12 or 13, wherein said feed means further includes a baffle disposed transversely of said conduit and interposed between said receptacle and said first portion, said baffle having a cutout therein and defining with said conduit an opening through which the slurry flows from said feed end to said first portion so that any turbulence in the flow of the slurry will be suppressed by the passage of the slurry through said opening and the slurry will pass in a tranquil flow into the first portion.

15. A process for separating particulate materials of different specific gravities comprising: initiating a laminar flow of a slurry of the materials to be separated; converging said flow while maintaining the flow in a laminar condition, thereby increasing the depth and velocity of the slurry and stratifying the materials into a plurality of strata according to the different specific gravities thereof; thereafter diverging said flow while maintaining the flow in a laminar condition, thereby decreasing the depth and velocity of the slurry and evenly spreading said strata; and thereafter removing a fraction of the stratified materials from the slurry.

16. A process for separating particulate materials of different specific gravities comprising: initiating a laminar flow of a slurry of the materials to be separated; alternately converging and diverging said flow while maintaining the flow in a laminar condition; thereby alternately increasing the depth and velocity of the slurry and stratifying the materials into a plurality of strata according to the different specific gravities thereof and decreasing the depth and velocity of the slurry and evenly spreading said strata; and removing a fraction of the stratified materials from the slurry after each divergence of the flow.

17. A concentrator for separating particulate materials substantially as hereinbefore described with reference to the accompanying drawings.

18. A process for separating particulate materials substantially as hereinbefore described.

WITHERS & SPOONER,
Chartered Patent Agents,
148—150, Holborn,
London, E.C.1,
Agents for the Applicants.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1971.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.

