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2,952,360

SPIRAL CONCENTRATOR APPARATUS

Filed Oct. 25, 1955

2 Sheets-Sheet 1

FIG. 1

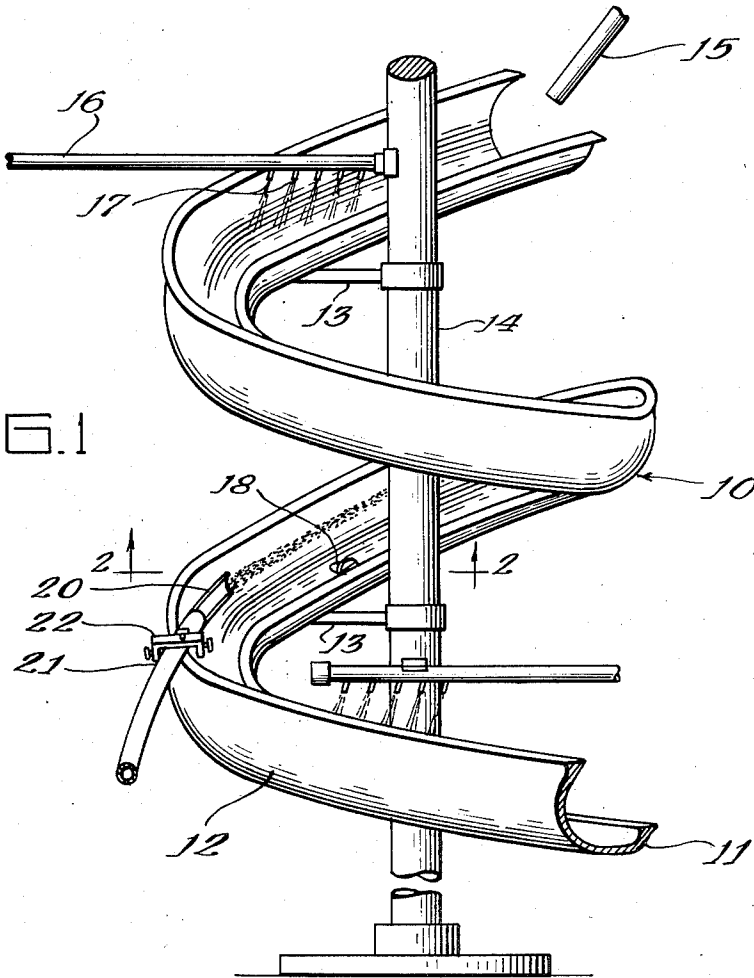
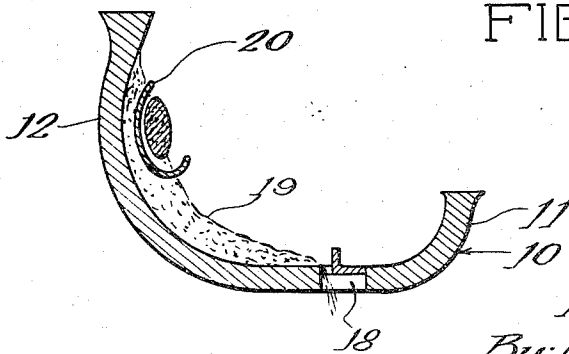


FIG. 2



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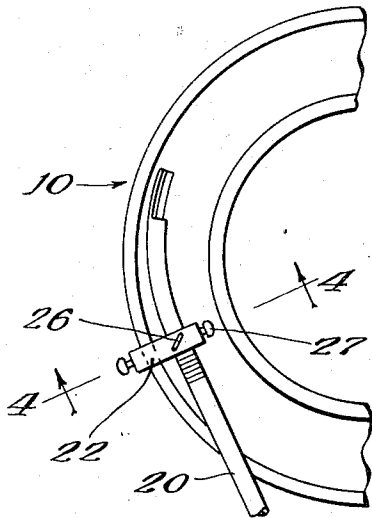


FIG. 3

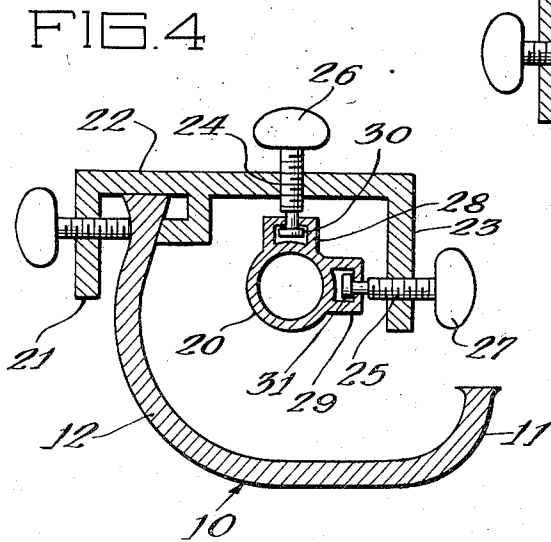


FIG. 4

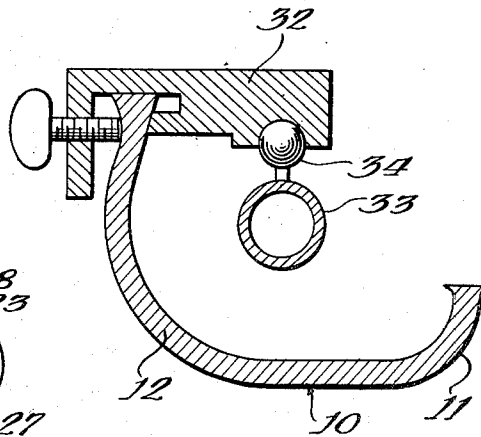


FIG. 5

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SPIRAL CONCENTRATOR APPARATUS

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This invention relates to apparatus for concentrating ores or the like. More particularly, it relates to the concentration of ores when flowing in a spiralling stream subject to the influences of gravity, centrifugal force and variations in the apparent specific gravity of the materials.

Spiral or helical chute concentrators have been in commercial use for the separation of gold, chromite, garnets, etc. found in beach sands. In such apparatus, the materials are carried in a liquid vehicle. When a slurry of material flows in a spiral path confined by a channel, the solids of the slurry are sorted out as to sizes and specific gravity with the heaviest material moving to the inside of the flow course and the lighter materials being distributed but in general moving to the outside of the wall of the flow course. When the gravitational force is greater than the centrifugal force, the heaviest materials move to the bottom of the trough and to the inside of the spiral.

Such apparatus has only in very special cases, based upon physical shape and character, been successful in the separation of materials having little difference in specific gravity.

It is a primary object of this invention to provide means for separating and separately collecting particles of like as well as unlike specific gravity.

It is another object to provide a method of concentrating ore wherein chemical reagents are utilized to provide a selective control of the stratifying action in a spiral concentrator in order to permit recovery of any desired fraction of the pulp.

It is still another object to provide means for selectively removing any desired fraction from the spiral flow course.

It is a further object to provide means for agitating and aerating a stream flowing in a spiral course whereby the orientation of flow paths of ore components which have been reagentized can be altered.

These and other objects of the invention will be apparent to those skilled in the art from the following description.

In carrying out the process of the instant invention, the materials to be separated are carried in a spiral channel and upon being oriented into relatively well defined flow paths in response to centrifugal force, gravity, bottom or frictional drag, intrastream forces, apparent or real specific gravity of materials, are removed by an adjustable scoop to a collection point outside the flow course.

In the flow of slurry in the spiral course, the relative positions sought by the ore components depend upon the relative effects upon the various materials in a particular system. It is possible to vary the separating action by changing the radius and gradient of the spiral, and by altering the roughness of the bottom of the channel. Where the materials are washed down with a large amount of water, the more buoyant materials are carried

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by the water and are little affected by bottom roughness while heavier materials may be considerably retarded by bottom characteristics causing them to be differently oriented than if the bottom were smooth. In the present process, the material which exhibits the higher specific gravity characteristic may or may not be the higher specific gravity component of the ore. The heavier material may, by proper selection of reagents, be caused to appear in a mineralized froth and thereby assume the characteristics of the light component under conditions hereinafter described.

In a mineralized froth type separation, an ore slurry is reagentized with material selective for one or more particular components of the ore. Reagentized slurry with or without dilution is agitated and/or aerated either before or after the feed slurry is introduced into the spiral trough. Preferably, the aeration is accomplished on the spiral by injection of air thru a series of tubes or by jets of water under pressure being impinged upon the flowing slurry stream.

The cross sectional configuration of a chute or conduit while subject to considerable variation should for best operation be curved from its inner edge toward the outer edge quite gradually, while at the outer edge the chute should be curved quite acutely so that the flowing stream will be quite deep adjacent to the outer wall and feather out to practically no depth at the inner edge.

This invention does not preclude removal of the apparently heavier material at separated points throughout the length of the chute and at the lowest cross sectional point thereof, thru a plurality of draw-off holes. These draw-off holes are generally circular in shape and the lowest cross sectional point of the chute is arranged to be approximately at the center of these holes. Each draw-off hole is provided internally with a circumferential shoulder forming a seat for rotatively supporting a gate which is a flat disc, the upper face of which is flush with the bottom of the inner face or bottom of the chute. This gate or valve comprises a portion of a circle and when rotated upon its seat will permit any desired portion of the inner edge of the stream and the material carried thereby to enter the take-off hole. Any suitable means for rotating the disc valve may be provided.

The size or volume of the stream of slurry in respect to the cross sectional area of the chute is such that the chute is not completely filled with the stream. The size of the stream is regulated so that at its inner and lower edge where the stream is running over or on that portion of the chute adjacent to its lower and inner side, it is comparatively shallow with the result that a thin or shallow zone of solids and liquid is moving at the inner lower side of the chute. It is at this side of the chute and in this shallow part of the stream that the particles within the stream having the greatest specific gravity concentrate to be periodically withdrawn as will be hereinafter described.

All parts of this stream carrying solids and liquid do not acquire the same speed of movement in the passage of the stream down along and through the helical or spiral chute. Promptly after introduction of the slurry or material-carrying-liquid into the helical flow path, the particles making up the solid material will stratify according to specific gravity with the result that those particles having the greater specific gravity will move to the bottom of the stream of liquid, and these particles in response to the force of gravity and frictional force of contact with the bottom of the chute will move to the inner and lower side of the chute with the result that the stream, after traveling a short distance, is composed of several zones each of which contains those particles having substantially the same specific gravity.

Those particles having a lesser specific gravity will be in the faster moving portions of the stream of liquid and will travel therewith and away from the particles having the higher specific gravities. As the stream of liquid with the solid material therein progresses downwardly through the spiral chute, the lighter materials will move to the outside of the spiral with the faster flowing liquid and arrange themselves within the stream in zones according to the specific gravities of the components of the solid material.

The material being concentrated and the specific manner of practicing the process can and will control the degree of purity, i.e., the cleanness of the concentrates collected. Where there is a wide demarcation in the specific gravity between the particles of different materials making up the mass, a clean concentrate is easily obtainable. Where there are particles of different materials having closely similar specific gravities, obtaining a clean separation is more difficult. If the nature of the concentrates being recovered is such as to dictate or require clean concentrates, changes may be made in the apparatus or in the process or both to accomplish this result. In the instant invention, it is preferred that the purity of the concentrate be obtained when working with materials of closely similar specific gravities by changing the apparent specific gravity. Generally this is accomplished by conditioning the solid material with flotation reagents having an affinity for one or more of the components of the material being separated. Choice of flotation reagents will depend upon the nature and relative abundance of the materials being separated. For example, when separating phosphate ore, it is possible to selectively reagentize either the phosphate component or the silica component. To remove the phosphate as the low-gravity component, flotation reagents such as fatty acids, tall oil and the like in combination with fuel oil and caustic may be added in a manner comparable with that utilized for flotation operations. After conditioning with such reagents, in the preferred embodiments of the invention, the conditioned and diluted slurry is introduced into the spiral. Adjacent to the inlet, a series of water jets extending transversely across the width of the spiral impinges upon the flowing stream, agitating and aerating the stream and causing the phosphate to appear in a mineralized froth having a specific gravity apparently markedly different from what the phosphate had naturally. On the other hand, if it is desired to float the silica, amine reagents such as Armac T or Alamac 26 are added to the phosphate slurry and the conditioned stream aerated as before explained in connection with phosphate flotation. The silica under these conditions appears as the mineralized froth and is carried as the light component separating from phosphate as the apparently heavier component. Useful reagents for flotation of ores are:

Cationic (quartz collectors):

Straight chain aliphatic amines of about 8 to 18 carbon chain lengths

Free bases or salts thereof (Cl, NO₃, COOH)

Anionic (phosphate collectors):

Oleic acid

Linoleic acid

Metal soaps of oleic and linoleic acids such as Na

Tall oil soap

This invention resides in the steps of the method and certain embodiments of the apparatus illustrated on the accompanying drawings in which:

Figure 1 is a side elevational view of the spiral separator.

Figure 2 is a cross sectional view along the line 2—2 of Figure 1.

Figure 3 is a fragmentary top view of the spiral.

Figure 4 is a sectional view along the line 4—4 of Figure 3.

Figure 5 is a sectional view of the ball joint adaptation of the scoop holder.

In the drawings, the numeral 10 designates a helical channel of suitable material of construction having a slightly convex central portion and tapering off to a reasonably flat surface adjacent its inner edge. Channel 10 is provided with a suitable wall 11 at its inner edge and a wall 12 at its outer edge. Channel 10 is supported by suitable bracket members 13 from a central vertical standard 14. Feed is introduced into the channel 10 by a conduit or pipe 15. Also supported by standard 14 are water spray pipes 16 positioned above the channel 10 and transversely across the channel 10, the spray jets 17 being directed downwardly into the trough of channel 10.

Material introduced into channel 10 by pipe 15, particularly when reagentized, is churned to a froth by aerating spray jet 17. Froth riding to the outside of the spiral as the water and solids flow down the channel 10 is removed by a cutter or scoop 20 in the form of a conduit for delivery of the froth beyond the confines of the channel 10. Material moving at the inner bottom edge of the flowing slurry is removed thru ports 18. Slurry 19 not removed by either the scoop 20 or thru ports 18 is discharged from the end of the spiral. Cutter 20 is supported on wall 12 of channel 10 by suitable clamping means 21, such as a C-clamp. Clamping means 21 is provided with an extension 22 terminating in a transverse arm 23. Extension 22 and arm 23 are adapted with threaded apertures 24 and 25 respectively. Threaded apertures 24 and 25 are adapted to receive in cooperating relationship threaded screw members 26 and 27. In this arrangement, cutter 20 is provided with slotted channel members 28 and 29. Extensions of screw members 26 and 27 are provided of a diameter to be received in sliding fit into the slots of channel members 28 and 29, and terminating in an enlarged head 30 and 31 respectively of a size to be received within the respective channel members 28 and 29.

By this arrangement, the scoop 20 may be adjusted vertically and laterally to cut out desired portions of material flowing in the channel 10.

In Figure 5, there is illustrated an alternative support mechanism for the scoop. In this figure, the spiral 10 supports a C-clamp 32. C-clamp 32 is provided with a ball socket 34 adapted to receive arm 35. Arm 35 supports scoop 33 in adjustable relationship to the interior of the spiral.

The utility of the invention is illustrated by the following example which is given by way of illustration and without any intention that the invention be limited thereto.

Example I

Florida pebble phosphate feed of substantially —1 mm. +35 mesh size and having a bone phosphate of lime content of about 48% and an insoluble content (principally silica) of about 36% was reagentized at about 70% by weight solids in aqueous medium with about 0.8 pound per ton of tall oil and 4 pounds per ton of a mixture of fuel oil and kerosene, and about .6 pound per ton of sodium hydroxide. The reagentized material was then diluted with water to about 30% by weight of solids and fed to spiral concentrator. The reagentized feed was introduced into the spiral at a rate of about 1.25 tons of solids per hour. Water was injected in an aerating operation as shown in the drawing at a pressure of approximately 25 pounds per square inch gauge. A layer of froth riding in close proximity to the outer edge of the spiral was removed by the scoop and recovered separate from the product issuing from the end of the spiral. This floated product analyzed about 67% bone phosphate of lime with an insoluble content of about 11% by weight. The tailing recovered from the end of the spiral analyzed approximately 30% bone phosphate of lime with an insoluble

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content of about 60% by weight to give an overall recovery of phosphate of approximately 67%.

Having thus described my invention, what is desired to be secured by Letters Patent is:

1. An apparatus comprising a helical channel having an inner and outer wall, feed means for introducing a slurry of reagentized ore at the top of the channel, aerating means positioned adjacent to the top of said channel including fluid nozzle means to impinge jets of fluid downwardly onto the slurry flowing in said channel said nozzle means being spaced transversely across the width of said channel, and adjustable scoop means positioned intermediate between the top and bottom of said channel at a point below said nozzle means and adjacent the radially outer portion of said channel for separating and removing froth from the channel for delivery to a concentrate receiver, said scoop means being spaced above the slurry conveying surface of said channel to skim off said froth as created by said jets preceding said scoop means.

2. An apparatus comprising a helical channel having an inner and outer wall, feed means for introducing a slurry of reagentized ore at the top of the channel, aerating means positioned adjacent to the top of said channel including fluid nozzle means disposed to jet fluid downwardly and transversely across the width of said channel

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into the slurry flowing in said channel, and scoop means positioned intermediate between the top and bottom of said channel at a point below said nozzle means and adjacent the radially outer portion of said channel for separating and removing froth from the channel for delivery to a concentrate receiver, said scoop means being spaced above the slurry conveying surface of said channel to skim off said froth as created by the downwardly jetting fluid preceding said scoop means.

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