United States Patent [19]
Humphreys

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[45] June 24, 1975

[54] **HELICAL CHUTE CONCENTRATOR AND METHOD OF CONCENTRATING**

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[52] **U.S. Cl.** **209/211;** 209/459
[51] **Int. Cl.** **B03b 3/04**
[58] **Field of Search** 209/211, 459

[56] **References Cited**

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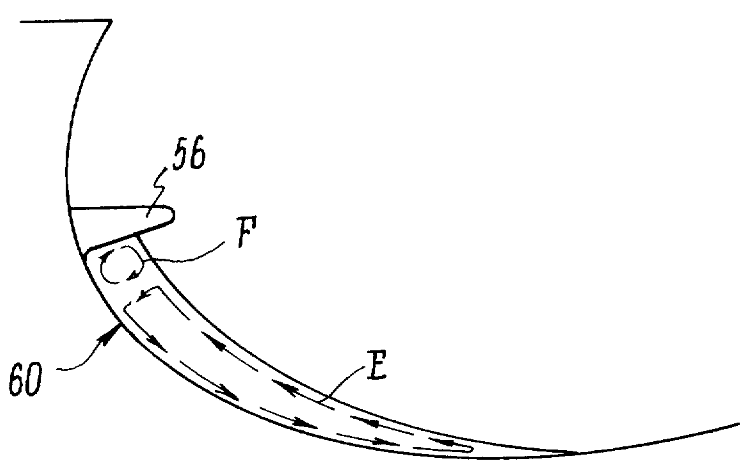
Primary Examiner—Tim R. Miles

[57] **ABSTRACT**

A concentrator for separation of particulates of different specific gravities which embodies a downwardly inclined helical chute receiving a stream of intermixed liquid and particulates at the upper end thereof. The helical chute has an inner low concave side wall and an abruptly terminated outer side wall defined by an upstanding abutment originating at the bottom wall of the chute.

4 Claims, 8 Drawing Figures



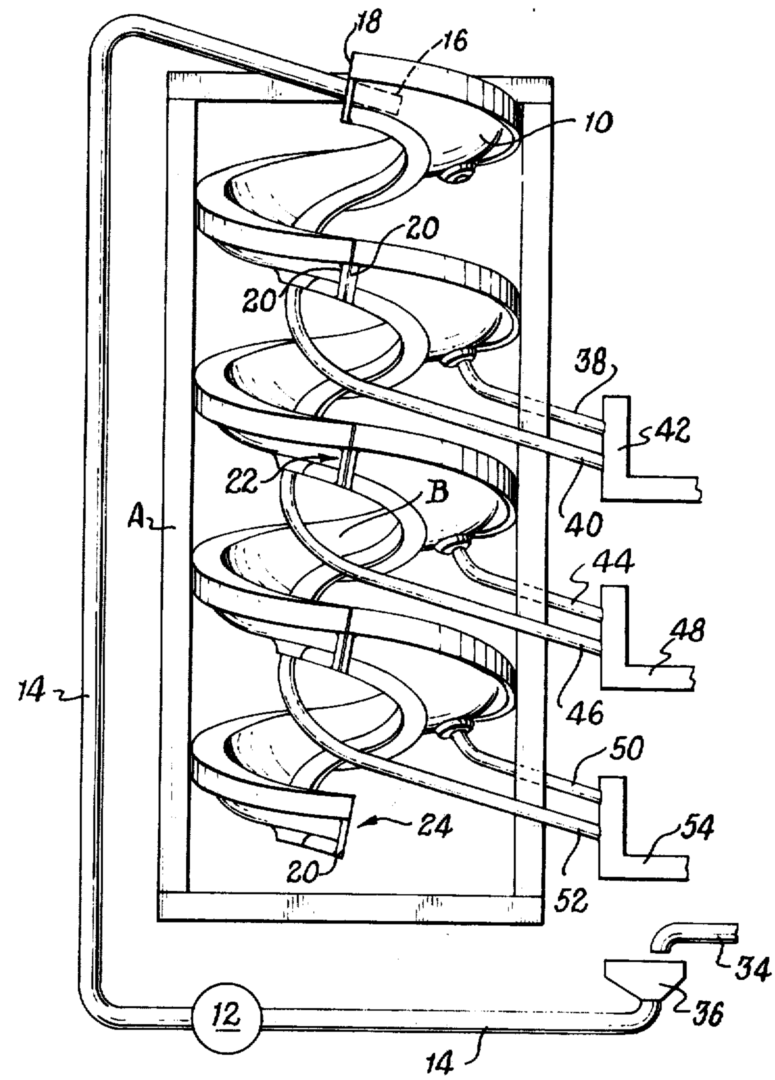


Fig. 1

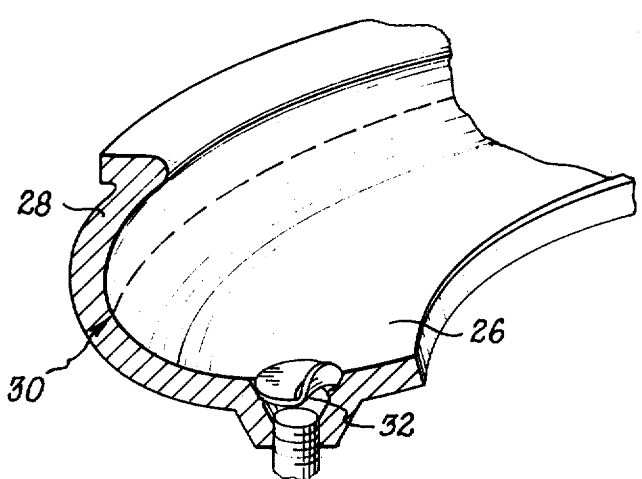


Fig. 2
[PRIOR ART]

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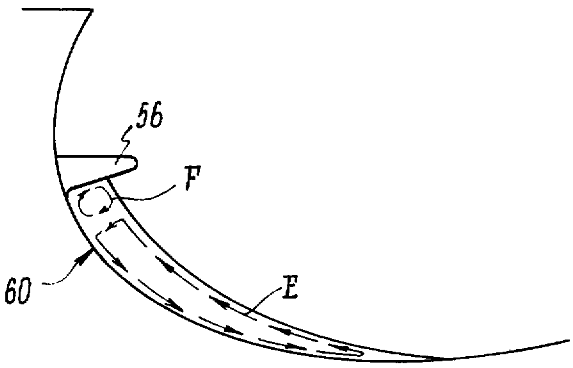


Fig. 6

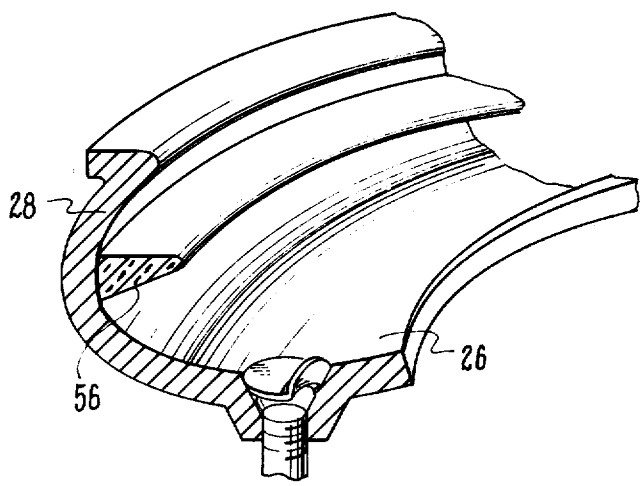
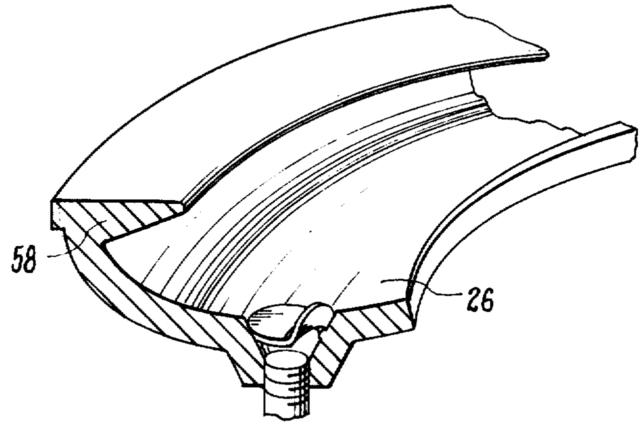


Fig. 4

Fig. 5



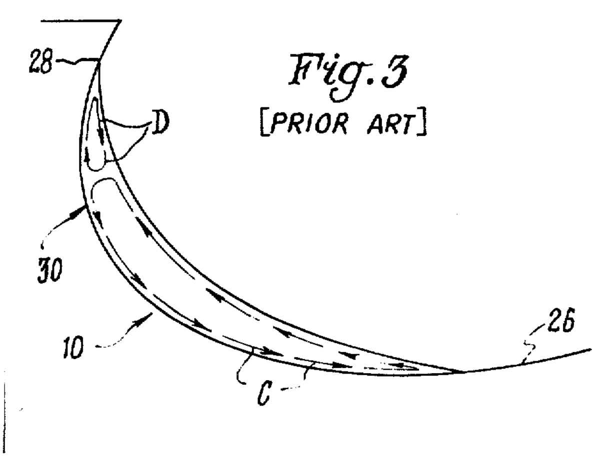


Fig. 3
[PRIOR ART]

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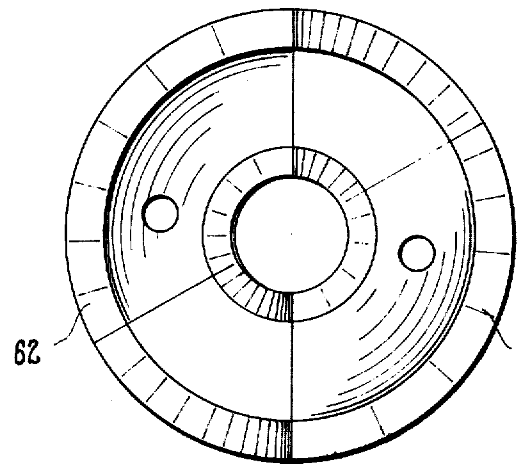

Fig. 8

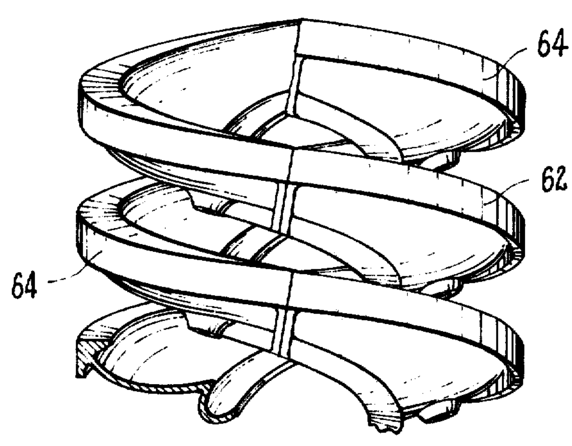

Fig. 7

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HELICAL CHUTE CONCENTRATOR AND METHOD OF CONCENTRATING

The present invention relates to a method and apparatus for concentrating ores or the like for the purpose of separating and separately collecting from a mass those particulates or elements which have approximately the same specific gravity.

The invention herein disclosed and claimed constitutes an improvement on my earlier inventions subject of U.S. Letters Pat. Nos. 2,431,559 and 2,431,560, each dated Nov. 25, 1947.

As in the case of my earlier patents, the novel and inventive concentrating method of my present invention in broad terms is one wherein the separation of the particles comprising the mass being worked is accomplished by intermixing the mass with water or some other liquid and thereafter directing the liquid containing the particles through or over a path which will permit the particles within the stream of fluid to effect a stratification by gravitational fall of the particles in accord with the specific gravity of the particles.

Likewise, and as in the case of my earlier patents, the inventive apparatus concept in broad terms comprises a spiral or helical conduit which may be either open at one side or completely closed at all of its sides and which causes the liquid carried particles to follow a curved path so that in accord with the laws of nature various portions of the stream of particle-carrying liquid will assume different speeds of travel and will at all times continue these specific speeds and assume the same pattern throughout the travel of the stream. From different sections or parts of the flowing stream the particles carried by that portion of the stream are removed by suitable mechanical means.

In addition to the concentration or separation of the particles in accordance with their specific gravities the method also results in a classification of the particles, that is, a sizing, in each zone of concentration, of the particles which have been concentrated into the several zones within the moving stream. More specific description of this feature of the method will appear hereinafter.

More specifically, the novel apparatus for practice of the new inventive method consists of substantially the identical basic apparatus as is subject of my earlier patents with one important modification. The modification referred to consists in a very significant change in the cross-sectional configuration of the helical chute of the concentrator, which change in configuration has been discovered to afford a novel and much improved operational function when it is desired to attain certain results from the apparatus.

In even more specific terms the structural configuration of the helical chute of my earlier invention has been changed to the extent that the outermost side edge of the chute has been reconstructed and relocated to effect an operational change in the apparatus.

It is an object of the improvements of the present invention to provide a helical chute concentrator in which a reduction in liquid or water requirement of as much as one-third is effected for concentrators of the same pitch over the water requirements of devices of the same purpose known and being part of the prior art, including my own prior inventions.

A further object of this invention is to provide an improved helical chute concentrator in which an improved and more effective classification of the finer and lighter particulates is obtained over the classification and separation achieved by prior art apparatus.

It is still another purpose of this invention to provide an improved helical chute concentrator the construction of which enables the fabrication and operation of an "entwined" or "double-chute" unit at advantageous pitch inclinations, at which pitch prior art apparatus was incapable of such double construction and, consequently, double capacity operation.

With reference to the accompanying drawings in which like numerals indicate similar parts throughout the several views:

FIG. **1** is a side elevation of apparatus typifying the present invention.

FIG. **2** is a fragmentary pictorial view of a helical chute typical of prior art concentrators.

FIG. **3** is a diagramatic view of liquid flow laterally of a chute of the prior art construction.

FIG. **4** is a view similar to FIG. **2** of a helical chute of the present invention.

FIG. **5** is a view of a modified form of the helical chute of FIG. **4**.

FIG. **6** is a diagramatic view of liquid flow laterally of a chute of the construction of FIG. **4**.

FIG. **7** is a fragmentary elevation of an "entwined" concentrator as opposed to the single chute of FIG. **1**.

FIG. **8** is a top plan view of the "entwined" structure of FIG. **7**.

The inventive method and apparatus is not limited to a concentration of any particular ores or in the working of a mass made up of any particular constituents, and fully contemplates the use of reagent additives to produce the usual agglomeration of ore particulates within the liquid slurry.

For the purpose only of a better understanding of the present invention, a description of the concentration of a particular sand containing minerals will be hereinafter given, which is effectively the same illustration used in connection with my earlier invention. The mineral-bearing sand selected for illustrative purposes is a beach sand found in the State of Oregon which contains particles of gold, chromite, garnets, and silica. The gold particles have the highest specific gravity; the chromite the next highest; the garnets the next highest; and the silica the lowest specific gravity. The chromite and garnet particles have specific gravities which are very close to one another and the most difficult part of the concentration will be between the chromite and garnet particles. As will appear hereinafter in the specific description of the operation of the invention, a 100 percent pure concentrate between chromite and garnet particles is not obtained but the take-off of chromite particles will consist of a concentrate which consists almost entirely of chromite and garnet particles and constitutes a concentrate which is sufficiently high in chromite particles as to make this concentrate a marketable product.

In operation there will be obtained a very high gold concentrate and both it and the chromite concentrate will be substantially entirely free of silica, and tailings discharge at the lower end of the chute will be practically free of gold and chromite.

Another illustration of an advantageous use of the improved concentrator herein described, and a specific adaptation wherein the water savings feature of the present invention is of particular importance and advantage, is in the concentration and separation of iron ores in the eastern Canada ranges.

Describing the herein illustrated apparatus in detail and using like reference numerals and characters to designate similar parts throughout the following description, A designates a frame or support for the spiral or helical concentrator channelway or conduit **10**.

The drawings illustrate the frame or support as carrying a single concentrator but it is to be understood that any number could be provided in accord with the capacity it is desired that the plant or installation have in the handling of the illustrative mineral-bearing sands.

The sand or heads, that is the mass of comminuted particles containing the particles of chromite and other material, is suitably mixed, in any desired economical manner, with water or some other suitable liquid and then this liquid with the sand therein is forced by a pump **12** or otherwise suitably fed through a pipe **14** the discharge end **16** of which is disposed within the upper or receiving end **18** of the spiral or helical conduit or channelway **10**.

For convenience and economy both in manufacture and assembly the spiral or helical conduit is made up of a plurality of open-sided sections each of which is designated as an entirety by B. Each section at its ends is provided with a flange **20** and by placing the flanges of the sections in abutment and bolting or otherwise suitably securing them together as at **22** a conduit of any desired length can be quickly assembled.

The number of chute sections employed will determine the length of the chute or conduit and the length of the conduit will be determined by the particular material being worked and resulting concentration obtained. It would, of course, obviously be unnecessary to elongate the chute beyond a point where any separation and collection of the particles sought to be recovered is being obtained. It is also to be recognized that a helical chute may be formed or cast as a single unit.

In the drawings four convolutions of the chute are illustrated and the discharge end **24** of the chute carries one of the flanges **20** by which the chute can be readily elongated should it be found desirable.

The cross-sectional configuration of the helical chute has been determined to be critical to attainment of prescribed end results. In prior concentrators the chute, as illustrated in FIG. **2**, consisted of a low inner side **26** and a high outer side **28** such that the greatest depth of the stream of liquid (slurry) in the chute occurs at an intermediate point **30** spaced inwardly from the high outer wall. Point **30** defines in the chute of my prior inventive concentrator what becomes identified as the "foam line" in operation of the apparatus. The foam line occurs at the point transversely of the chute where a division occurs in the lateral flow patterns of liquid while progressing downwardly (longitudinally) of the chute. The foam line occurs laterally of the chute at what is also the approximate deepest point of liquid stream in the chute. These internal flow patterns are illustrated by arrows C and D in FIG. **3** of the drawings. Arrows C indicate the pattern of internal flow from the low side of the chute outwardly to the foam line, and arrows D illustrate the pattern of internal flow from the foam line at point **30** outwardly to the highest side above the chute.

In operation of the helical chute concentrator typifying the prior art and as illustrated in FIGS. **1** through **3** of the drawings, the stream of water or other liquid bearing the mixed particulate material to be concentrated is introduced into the spiral or helical chute at the upper end **18** thereof through the feed pipe **14**.

At separated points along its inner and lower wall **26** the chute is provided with draw-off holes or openings **32** through which the concentrated particles having closely similar specific gravities are progressively discharged to a suitable point of collection, as will hereinafter more fully appear. These draw-off holes are illustrated as being circular in shape but they could be oblong or shaped otherwise without detrimentally affecting the practice of the method. Each draw-off hole is provided with a movable splitter disc **32***a* which enables control of the amount of material discharged at that point. The number of draw-off holes provided is optional, but one in each of the chute sections B has been adopted for convenience in manufacture. The number of draw-off holes and the spacing of them in respect to one another is optional and would be varied if need for variation were found by reason of the particular material being operated upon; or the desire of separating and collecting a plurality of concentrates of different materials; or the desirability of the collection, for reworking, of a plurality of middlings.

The material to be concentrated and separated can be mixed in any convenient manner with the water or other liquid. In FIG. **1** of the drawings this is illustrated as being accomplished by supplying water from any convenient source through a pipe **34** to a hopper **36**. The material to be worked is dumped into the hopper and the intermixed water and material is drawn from the hopper through the pipe **14** by the pump **12**.

The concentrates which are withdrawn from the take-off or outlet openings **32** can be collected in any suitable and convenient manner. In FIG. **1** of the drawings the collected concentrates are illustrated as being conveyed from the first utilized two take-offs by pipes **38** and **40** to a main conduit **42** which serves to convey the concentrates to a point (not shown) for collection.

Similarly the next utilized two take-offs are connected by conduits **44** and **46** to a main conveyor discharge conduit **48** and the remaining last utilized two take-offs are connected by pipes **50** and **52** to a conveyor conduit **54**.

The specific arrangement for conveying the concentrates to a point of collection could and probably would vary in accord with the particular material being sent through the concentrator. The arrangement illustrated is suitable for working the particular ore bearing sands hereinbefore referred to, as will be made clear from the following description of the operation of the method.

The size or volume of the stream of particles carrying liquid 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 its lower and inner side, it is comparatively shallow with the result that a thin or shallow zone or film of intermixed solid material and liquid is moving over the chute at its inner lower side. It is at this side of the chute and in this shallow part of the stream that the particles within the stream having the greater specific gravity concentrate to be periodically drawn off, as will hereinafter appear.

All parts of this stream or material carrying liquid do not require the same speed of movement in the passage of the stream down, along and through the helical or spiral chute. Neither do the comminuted particles carried by the stream of liquid all acquire the same speed of travel through and along the chute.

Promptly after the introduction of the solid material carrying liquid into the chute 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 also in response to the force of gravity 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 portions of the traveling stream of liquid which are on the bottom of the stream and in contact with the bottom of the chute and at the lower inner side will travel the slowest. The particles having the greater specific gravity will for the foregoing reasons sink to the bottom of the traveling stream of liquid and move to the lower and inner side of the chute.

It will be understood that the water or liquid, like the particles, responds in its movement to the force of gravity and that as a result the water on the bottom of the stream will have some tendency to move from the high to the low side of the stream and that this movement in response to gravity will set up in the stream a movement transverse the stream and transverse the forward and downward movement of the stream. This transverse movement of the water will assist in moving the particles of high specific gravity toward the inner lower side of the stream and to the inner lower side of the chute, all as explained above.

Those particles having the 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 water with the solid material therein progresses downwardly through the spiral chute the lighter materials or particles having the lesser specific gravity will move along with the faster flowing portion of the stream and the remaining material will arrange itself within the stream in zones according to the specific gravities of the several particles making up this material.

The particles of different specific gravities will arrange themselves in the zones as described by reason of a natural stratification which causes those particles having the highest specific gravities to be positioned in the slowest moving stream or zone of the stream. These heavier particles will concentrate in these zones because they will as the stream moves through the chute gradually work to the inner and lower side of the chute by moving under the faster moving portion of the stream which is carrying with it the lighter materials. Actually the comminuted particles assume a position in the chute and stream which is determined by their velocity down the chute and this pattern of operation and concentration is not disrupted or distrubed by the admission of liquid and material to the upper end of the spiral and the pattern is altered only progressively by the removal of concentrates from or through the inner lower side of the chute. The concentrates are removed and collected progressively in accord with their specific gravities.

The improvement of the prior art devices which constitute the present invention is best illustrated in FIGS. **4**, **5** and **6** of the drawings. In FIG. **4** of the drawings there is illustrated a helical chute configuration which is substantially identical to the configuration of the chute shown in FIG. **2** illustrative of the prior art with the important exception of the provision in the construction of FIG. **4** of an abutment strip **56** which is secured to the bottom wall of the chute to project upwardly therefrom at a point in the bottom wall which substantially coincides with point **30** shown in FIG. **2** of the drawings as being the approximate positioning of the foam line occurring in operation of a helical chute constructed in accordance with the prior art. The abutment strip **56** may extend continuously through each segment or section of the chute, or selectively it may extend through only a portion of the entire length of the concentrator chute. The abutment strip of FIG. **4** may be formed of any semi-rigid material such as hard rubber or the like, and may be permanently, or removably secured to the bottom of the chute to provide a confining partition for the liquid material flowing down the chute for purposes to be hereinafter explained.

In FIG. **5** of the drawings there is shown a helical chute construction which is modified from the construction typifying the prior art as is illustrated in FIG. **2** in that the upper outer wall of the chute is shaped as at **58** to provide a confined abutment substantially identical in configuration to the abutment strip **56** heretofore described in reference to FIG. **4**. In the modified chute construction of FIG. **5** the length or extent of the upper outer wall of the prior art chute construction of FIG. **2** is shortened so that the lateral dimension of the chute bottom from the base of the wall abutment **58** to the lower inner edge of the chute **26** in this form is substantially identical to the lateral dimension defined between the inner base edge of the abutment strip **56** of FIG. **4** to the lower inner edge **26** of the chute of that same construction.

It has been discovered that certain advantageous results occur by confining the downwardly flowing stream inwardly of the chute construction of the prior art in the manner by which the abutment strip **56** of FIG. **4** or the reconstructed outer wall **58** of FIG. **5** will confine the liquid stream in those particular configurations. The resulting change in the internal flow laterally of the chute is illustrated in FIG. **6** of the drawings wherein arrows E and arrows F represent the internal flow corresponding to arrows C and D, respectively, illustrated in FIG. **3** of the drawings. What is seen to result is a substantial reduction in the area of liquid outside of the foam line over the prior art structure, and it is seen that the foam line **60** of the chute construction of FIG. **6** is displaced only a short distance inwardly from the abutment strip **56** thereof when measured proportionately to the inward relocation of the outer extremity of the flowing stream in respect to its positioning in the prior art structure.

By reason of the ability obtained by the heretofore described modification of the helical chute to relocate the outer extremity of the flowing liquid stream without any marked change in the location of the foam line, and hence without any marked reduction in the principal working area of the stream, it may immediately be seen that a substantial savings in the quantity of water or other liquid necessary to be mixed with the particulate material is accomplished. This ability to reduce water requirements is of vital importance in many geographical areas where water availability is minimal and where the cost of it can be an important factor in the operation of concentrators of the type herein described. Additionally, any percentage of reduction of water requirements produces a corresponding reduction in the equipment and power required to pump liquid in the concentrator apparatus.

In many installations it is desirable, because of limited space availability, to construct spiral concentrators of the type herein described in a double or "entwined" arrangement. A fragmentary segment of such a concentrator assembly is illustrated in FIG. 7 of the drawings wherein one helical chute **62** is interposed between the convolutions of a second helical chute **64**.

It has also been determined through experience that the most favorable operational inclination of a helical chute in the majority of concentrating operations encountered is at a pitch of 13½ inches, but it has also been found essential, in order to attain sufficient working room between the helical chutes, to increase that pitch to 17½ inches for those helical chutes assembled in "entwined" or double construction as illustrated in FIGS. **7** and **8**. Thus, in double chute constructions heretofore optimum operating conditions have been sacrificed in order to attain a savings in space requirements for assembly of the concentrators. By utilization of the improved concentrator construction herein disclosed in FIG. **5** of the drawings, it is seen that the height and extent of the higher outer side of the chute has been reduced, and this reduction from the dimensions of the prior art has been discovered to permit the assembly of an "entwined" or double construction as illustrated in FIG. 7 at the optimum pitch of 13½ inches with retention or provision of adequate work room between the convolutions which was not available or attainable under the prior art.

It has been additionally discovered, as is best seen from the liquid flow diagramatically illustrated in FIG. **6** of the drawings, that a small fraction of the finest concentrates which are normally stratified in the outermost boundary of the liquid stream which, in the prior art construction, would be beyond or outwardly from the foam line are substantially retained by the present invention within the operating area of the flowing stream and are thereby normally recovered as opposed to being lost in a single pass of the liquid through the concentrator.

Having thus described and explained the novel construction and method constituting my present invention, what I desire to claim is:

1. An apparatus for concentrating and separately collecting from a mass of intermixed particles of different specific gravities those particles having like specific gravity comprising, a stationary downwardly inclined helical chute, means for feeding an intermixture of liquid and particles of said mass as a stream to the upper end of said chute, said chute having an inner low concave side wall terminating only a little beyond the lowermost point of the chute bottom and an outer side wall defined by an upstanding abutment projecting at approximately 90° from the chute bottom, and the bottom of the chute in spaced relationship lengthwise thereof and in substantially the said lowest portion thereof being provided with outlet openings for the discharge of a portion of said stream and the particles therein.

2. An apparatus for concentrating and separately collecting from a mass of intermixed particles of different specific gravities those particles having like specific gravity comprising, a stationary downwardly inclined helical chute, means for feeding an intermixture of liquid and particles of said mass as a stream to the upper end of said chute, said chute having a high and concave outer side wall and an inner low concave side wall terminating closely adjacent and beyond the lower-most point of the chute bottom, an abutment affixed to the chute bottom to project substantially perpendicularly from the chute bottom at a point inwardly from the outer side wall, said abutment extending through a portion of the length of said chute to confine the outermost edge of said stream therewithin, and the bottom of the chute in spaced relationship lengthwise thereof and in substantially the said lowest portion thereof being provided with outlet openings for the discharge of a portion of said stream and the particles therein.

3. An apparatus for concentrating and separately collecting from a mass of intermixed particles of different specific gravities those particles having like specific gravity comprising, a stationary downwardly inclined spiral chute, means for feeding an intermixture of liquids and particles of said mass as a stream to the upper end of said chute, said chute having an interior which is of a concave shape in cross-sectional configuration and has its lowest portion transverse any given point in the length of the chute adjacent to and spaced inwardly from the inner edge of the chute, an abutment affixed to the chute bottom to project substantially perpendicularly from the chute bottom at a point inwardly from the outer side wall at what would otherwise be the approximate deepest point in said stream, said abutment extending through a portion of the length of said chute to confine the outer edge of said stream therewithin, and the bottom of said chute in substantially the said lowest portion thereof being provided with a plurality of outlet opendings in spaced relation lengthwise of the chute for the discharge of a portion of the inner edge of said stream and the particles therein.

4. The method of concentrating and separately collecting from a mass of intermixed particles of different specific gravities those particles having like specific gravity comprising, mixing particles of said mass with a liquid and causing said liquid with said particles therein to flow as a stream in a downward helical course, confining said stream in a manner to give the stream a deep outer side edge extending at substantially right angles to the helical course and a low inner side which from a point within the stream is of decreasing depth outwardly toward the inner edge of the stream with a considerable portion of said inner stream side being shallow and terminating at its edge in a depth which is substantially of only film thickness and the deepest point in said stream being positioned closely adjacent and inwardly of the outermost side edge thereof, continuing said stream travel until the particles therein stratify in accordance with their specific gravities and assume by reason of their speed and direction of travel such position that particles of like specific gravities are in side by side zones extending longitudinally of the stream with those particles having the greatest specific gravities in a zone at the inner edge of the stream and with the remaining zones in a direction toward the high side of the stream being of progressively decreasing specific gravity, and thereafter separately removing and collecting from said stream the particles within each of said zones.

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