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PROCESS FOR CONCENTRATING ORES

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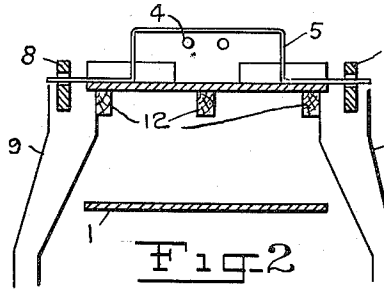


Fig-2

Fig-1

Fig-3

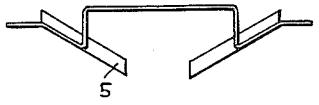


Fig-4

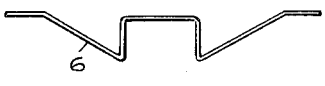


Fig-5



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PROCESS FOR CONCENTRATING ORES

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12 Claims. (Cl. 209—2)

Our present invention concerns a process for concentrating ores. This application constitutes a continuation in part of our copending apparatus application, filed in the Patent Office on October 31, 1934, Serial No. 750,787, and particularly relates to the process of ore concentration carried out upon the mechanical belt apparatus disclosed in said copending application. Both the process for ore concentration and the apparatus upon which the process is employed are particularly adapted for use in the concentration of non-sulphide, or phosphate ores.

Prior to the process disclosed by the present invention, the concentration of such ores has been effected by either of two processes, one of which is termed the froth flotation and the other the table process. In the froth flotation process, the ore pulp is chemically treated to make the non-sulphide, or phosphate constituent of the same floatable. This pulp is then diluted to a freely flowing consistency and subjected to froth flotation by means of mechanical agitation. In the process, the floatable constituent of the ore attaches itself to air bubbles formed during mechanical agitation of the water, and the same is, consequently, raised to the surface of the body of water employed. The froth supports the ore on the water surface and permits the same to be floated off.

In the tabling process for ore concentration, the ore is chemically treated to form loosely bonded agglomerates of the phosphate particles. The pulp is then diluted to a freely flowing consistency and the same is subjected to stratifying classification or separation as obtained upon a vibrating table. Stratification of the ore is accomplished in the presence of water, which is employed in obtaining the separation of the phosphate ore from the gangue according to their relative settling values. After separation has been effected, concentration of the valuable ingredients is caused by the passage of the water bearing the agglomerates across an obstruction.

In accordance with the teaching of the present invention, the process for concentrating ores, as practiced upon the belt apparatus hereinbefore referred to consists in continuously feeding a relatively thick, or dense, pulp of chemically treated ore to the surface of the belt. The dense mass, or pulp, of the ore contains approximately 25% moisture so that the same is relatively dry. The non-sulphide, or phosphate particles of the pulp are chemically treated to form a floatable constituent of the ore. Further, the treated ore pulp is moved in an elongated, intermittently directed, pile in a single direction of travel. Water is directed upon the pile from an overhead position and the floatable constituents of the ore are floated, or washed, off the pile in an unobstructed lateral direction of travel with relation to that of the moving mass. Separation of the phosphate ore is effected at the surface of the water. The non-floatable elements of the ore, or gangue are intermittently directed to maintain the same in the path of movement of the elongated pile of ore. The ore pile on the belt is also intermittently moved out of and into the freely flowing water, so that fresh parts of the ore pile are continually being moved into the path of the water for flotation. The floatable constituent of the ore floats, or is washed off the sides of the belt and is caught in a suitable launder. The non-floatable constituent of the ore remains on the belt and is finally carried over the end of the same.

Certain advantages of the invention over previous practice in the art are due, principally, to the fact that the ore is maintained at, or near, the water surface at all times. Aeration, and agitation of the ore as employed in the froth flotation process has been eliminated. A froth is not maintained on the surface of the water. Since the elevation of the floatable constituents to the water surface does not depend on air bubbles, it is possible to float larger particles of the ore.

The subaeration froth flotation process of separation depends on rising mineral laden air bubbles to separate the phosphate concentrate from the gangue. This method is definitely limited as to the coarseness of the particles which could be separated by it because of the inherent limitations in the size and buoyancy of the bubbles which could be employed effectively. As the particles of phosphate approach the limit of coarseness their attachment to the bubbles becomes unstable and their weight counterbalances the buoyancy of the bubbles.

The tabling or wet stratifying classification process of separation, as employed upon a vibrating apparatus, depends on the separation of relatively large bonded agglomerates of phosphate particles by the stratifying effect of the vibration or the stratifying effect of flowing the watered pulp across the riffles on the table. The gangue is required to settle between the riffles on the table and to be moved along them by the vibration of the table in a transverse direction to that of the flowing pulp. This requirement definitely limits the fineness of the particles which could be handled effectively in quantities suf-

ficient to warrant a commercial operation because the finer sized particles of gangue would be carried along with the pulp and concentrate across the riffles and impair the grade of the concentrate obtained.

In economical commercial operation the subaeration process is limited as to the approximate coarseness of the particle size which could be handled effectively to particles which would pass a 35-mesh standard Tyler sieve, while the tabling process is limited as to the approximate fineness of the particle size, which could be handled effectively to particles which would not pass a 48-mesh standard Tyler sieve. These two processes are complements of each other and both of them are required to recover the complete range of particle size existing in the ordinary phosphate washer debris unless a costly and wasteful grinding operation is resorted to.

The separating step of the process of the present invention substantially accomplishes the result obtained previously by the use of both of the older processes without the necessity for grinding the pulp and with the use of less reagents per ton of feed than are required by either of the older processes.

Our invention accomplishes this desired result by the application of the simple physical phenomena hereinafter to be more particularly described.

The apparatus, preferably utilized in carrying out the present process, is illustrated in the accompanying drawing, in which, Fig. 1 is an isometric view of the essential parts of the machine, assembled in their relative positions to each other. For purposes of clarity, the supporting structure of the apparatus has not been included.

Fig. 2 is a sectional view of the machine taken on line A—A, and

Figs. 3, 4 and 5 are isometric views of the individual types of baffles employed in connection with the apparatus.

Referring to the drawing, a continuous belt is indicated at 1, which is preferably a type similar to the ordinary rubber conveyor belt. The width and the length of the belt may be suited to the tonnage and conditions desired from the machine. In general, larger tonnages can be handled with wider and longer belts. Tonnages up to 30 tons per hour of feed have been handled successfully on a belt which was 30'' wide and 50' long between pulleys. The belt 1 operates on pulleys indicated in the drawing at 2. The bearings for the belt pulleys 2, the supporting structure for the bearings, and the drive mechanism for the belt are not shown, and may be similar to those used in any conveyor belt installation. The belt may be driven at any linear speed up to about 100' per minute, depending upon the tonnage and the conditions desired. The direction of motion of the belt is indicated in the drawing by the arrow. The belt is maintained in a flat, level position by a number of longitudinal support members shown at 12, in Fig. 2 of the drawing.

The belt is fed with a fairly thick, or dense pulp of chemically treated ore fines through a feed chute 3, located at one end of the apparatus. The belt and the material on it are watered from above by means of jets extending along the undersurfaces of the longitudinally located overhead pipes indicated in the drawing at 4.

Baffle members are indicated in the drawing at 5, 6 and 7, the same dragging on the side surface of the belt 1, being positioned, with respect to the belt, by means of longitudinally extending stationary pieces 8, which are provided with holes to receive the ends of the baffles. The individual types of baffles herein employed are indicated in detail in Figs. 3, 4 and 5 and the arrangement of the same in Fig. 1 is preferable when the machine is operating with a belt length of 50'.

The baffle 5, shown in Fig. 3 is constructed by attaching a piece of sheet metal to a small bent metal rod. The sheet metal may be any metal of moderate thickness and adequate rigidity. On a belt 30'' wide, 20–28 gauge galvanized iron baffles, which were 2½ x 18'' have been used, although these specifications are not strictly required. The metal rod is preferably about ¼'' in diameter and may be of any desirable material. Rust and corrosion resistant metals are preferable for these baffles. Baffles 6 and 7, shown in Figs. 4 and 5, are bent rods, and the preceding description applies with equal effectiveness to their construction. The angle which the baffles 5, 6 and 7 make, with the direction of motion of the belt 1, may vary considerably, angles of from 20° to 45° having been found to be most efficient in practical use. The functions of these baffles are to turn over the pile of ore as it is moved past them by the belt and to prevent the non-floatable constituent of the ore being washed off the side edges of the belt. In the former respect, their action is a plowing action which raises the ore above the water surface and then drops it into the water again. The later effect is purely a baffle action. The baffles 5, in Fig. 3, are more effective for keeping the non-floatable material on the belt, while the baffle types 6 and 7 have a better turning action on the material. The arrangement of the baffles on the belt depends upon the conditions and the results desired. We have found that a desirable arrangement for a roughing operation is to equip the first half of the belt with type 5 baffles and the last half with types 6 and 7 baffles. We have found that a cleaning operation on medium grade concentrates works well with type 5 baffles on the whole length of the belt.

The spacing of the baffles along the belt depends on the width of the belt, the speed of the belt, the tonnage handled, and the grade of product taken off. We have found that a spacing of about 6'' produces good results under quite a wide variation of conditions.

The floatable constituent of the treated ore moves off the sides of the belt and is caught in a concentrate launder, shown at 9 in the drawing. The non-floatable constituent, or gangue, is carried along on the belt and over the end pulley where it is washed off with a tailing wash 10 into a tailing trough 11.

The ore concentrating process as carried out in connection with the belt apparatus consists in first treating, or mixing the ore with chemical reagents to form a floatable constituent of the valuable elements of the same. The reagents used in the present process, per ton of dry ore are approximately as follows: 1.5 pounds of fuel oil; 1.2 pounds of fatty acid oil; 0.3 pounds of caustic soda; and 0.05 pounds of pine oil. The ore, as it is mixed with the reagents contains approximately 25% of moisture so that the same forms a pulp or mass, which is relatively dense, or of sufficient consistency to form in a pile on the belt. By means of chute 3, the treated ore is fed to the moving belt 1. This step of the

process consists in moving the ore in an elongated pile in a single direction of travel (indicated by the arrow in Fig. 1). The pile of ore along the belt surface is approximately longitudinally centered thereon and extends in a continually moving relatively narrow elongated heap. Water from the overhead pipes 4 is directed upon the pile during its continual movement and the floatable constituents of the ore are floated, or washed off the pile in an angularly traverse direction of travel to that of the moving pile. The floatable constituents are washed over the unobstructed sides of the belt and are collected in the concentrate launders indicated at 9 in the drawing. The spaced baffles 5, 6 and 7 intermittently direct the non-floatable elements of the ore, or gangue, to maintain the same in the path of movement of the ore pile on the surface of the belt. With baffle type 6 and 7, the ore pile is intermittently moved out of and into the path of the water so that fresh parts of the ore pile are continuously being moved to come under the influence of the flotation step in the process caused by the presence of the water.

In accordance with the teaching of our invention, the separation of the oiled phosphate particles from the gangue is brought about at the surface of the water. The deslimed and treated pulp composed of both phosphate and gangue particles is brought onto the water surface either by plowing the thick pulp up through a shallow depth of water or by impinging jets of water directly into a pile of the dense pulp or by causing a violent turbulence in a shallow depth of water over a thick pulp. Both the phosphate and the gangue particles are brought equally onto the water surface, which is preferably not more than one or two inches in depth, by the positive methods described in such a way that very large particles, some as large as small sized pebbles, are raised to the water surface. The oiled phosphate particles ride on the water surface either as a skin or film float or as an adhering mat of phosphate particles supported by air bubbles. The gangue particles of the pulp are wetted by the water and sink as the flow of water carries the concentrates off to be collected. After being brought onto the water surface particles so coarse that they will just pass a 14-mesh standard Tyler sieve will float with considerable stability. On the other hand, the flow of water away from the pulp is controlled so as not to carry fine particles of gangue with the concentrates.

The air bubbles which help to support the float concentrate may be introduced into the water surface in any convenient manner. These bubbles may be generated crudely as by water jets impinging on the water surface, as indicated in the structural provisions of the apparatus in the drawing, because it is not necessary for them to be of any particular size or stability as would be the case were they utilized to raise the concentrate particles.

An important advantage of the process, as herein disclosed, is the ready visibility of the efficiency of the separating step as it is carried out on the apparatus. The operator is able to observe the pile of material on the conveyor throughout this step and can quickly adjust the operation of the apparatus to produce the best results.

Having thus described the ore concentrating process carried out upon our belt apparatus, what we claim is:

1. The process of concentrating phosphate ore which consists in desliming the ore, mixing the deslimed ore with a minimum of chemical reagents to coat the phosphate constituent of the same and form a relatively dense commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, feeding the relatively dense commingled ore mass to the surface of a unidirectionally moving belt to provide a longitudinally centered elongated pile of ore thereon, impinging a plurality of jets of water in a downwardly direction upon the piled ore mass, along substantially the entire length of the pile, to raise portions of the mass by the force of reaction of the water jets to the surface of the flowing thin body of water provided on the pile by the jets, separating the phosphate ore and gangue at the water surface, redirecting the non-floatable constituent of the ore mass after separation, to maintain the same in the path of movement of the pile, and collecting the separated floatable constituent of the ore.

2. The process of concentrating phosphate ore which consists in desliming the ore, mixing the deslimed ore with a minimum of chemical reagents to coat the phosphate constituent of the same and form a relatively dense commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, feeding the relatively dense commingled mass to the surface of a unidirectionally moving belt to provide a longitudinally centered elongated pile of commingled ore thereon, impinging a plurality of jets of water in a downwardly direction upon the piled ore mass to provide a thin body of water flowing laterally with respect to the path of movement of the pile, raising and lowering the commingled ore mass in the path of its movement through the surface of the thin body of water, separating at the water surface the floatable and non-floatable constituents of the ore mass, redirecting the non-floatable constituent, after separation, to maintain the same in the path of movement of the piled ore mass, and collecting the separated floatable constituent of the ore.

3. The process of concentrating phosphate ore which consists in desliming the ore, mixing the deslimed ore with a minimum of chemical reagents to coat the phosphate constituent of the same and form a relatively dense commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, feeding the relatively dense commingled mass to the surface of a unidirectionally moving belt to provide a longitudinally centered elongated pile of ore thereon, providing a laterally flowing thin body of water on the piled ore mass by impinging a plurality of jets of water in a downwardly direction, thereon, bringing portions of the piled ore mass to the surface of the thin body of water by raising and lowering the same in the path of its movement through the water surface and by the reaction of the impinging water jets upon the pile, separating at the water surface the floatable and non-floatable constituents of the ore, redirecting the non-floatable constituent, after separation, to maintain the same in the path of movement of the piled ore mass, and collecting the separated floatable constituent of the ore.

4. The process of concentrating phosphate ore which consists in mixing the ore with a chemical reagent to coat the phosphate constituent of the same and form a commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, supporting and mov-

ing an elongated pile of the dense commingled ore mass in a continuous single direction of travel, impinging jets of water in a downwardly direction upon the unidirectionally moving piled ore mass to raise the commingled ore in the path of the jets by the force of reaction to the surface of a laterally flowing thin body of water formed by the jets on the piled ore mass, floating the floatable constituent of the ore off the piled mass on the surface of the thin body of water provided by the jets, redirecting the non-floatable constituent to maintain the same in the path of movement of the piled mass, and collecting the floatable constituent of the ore.

5. The process of concentrating phosphate ore which consists in mixing the ore with a chemical reagent to coat the phosphate constituent of the same and form a commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, supporting and maintaining an elongated pile of the commingled ore mass while moving the same continuously in a single direction of travel, impinging downwardly directed jets of water upon the unidirectionally moving commingled mass to float the floatable constituent of the ore off the pile in an unobstructed lateral direction of travel with relation to that of the moving mass, redirecting the non-floatable constituent to maintain the same in the path of movement of the ore pile, and collecting the floatable constituent of the ore.

6. The process of concentrating phosphate ore which consists in mixing the ore with a chemical reagent to coat the phosphate constituent of the same and form a commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, supporting and maintaining an elongated pile of the commingled ore mass while moving the same continuously in a single direction of travel, raising and lowering the piled ore mass in the path of its movement through the surface of a thin body of water provided on the pile by a plurality of downwardly directed water jets to float the floatable constituent of the ore off the pile in an unobstructed lateral direction of travel with relation to that of the moving mass, redirecting the non-floatable constituent of the ore mass to maintain the same in the path of movement of the ore pile, and collecting the floatable constituent of the ore.

7. The process of concentrating phosphate ore which consists in mixing the ore with a minimum of chemical reagents to coat the phosphate constituent of the same and form a relatively dense commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, supporting and maintaining contiguous portions of the relatively dense commingled ore mass while moving the same in a single direction of travel, providing a thin body of water upon the moving commingled ore mass, by means of a plurality of downwardly directed jets of water, adapted to flow in a transverse direction of travel with relation to the path of movement of the mass, bringing portions of the ore mass to the surface of the thin body of water provided by raising and lowering the mass in the path of its movement through the water surface and by the reaction of the water jets directed upon the same, separating the floatable and non-floatable constituents at the water surface to produce a floating concentrate of the phosphate constituent of the ore, and collecting the float.

8. The process of concentrating phosphate ore which consists in mixing the ore with a chemical reagent to coat the phosphate constituent of the same and form a relatively dense commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, supporting and maintaining contiguous portions of the relatively dense commingled ore mass while moving the same in a single direction of travel, impinging a plurality of jets of water upon the contiguous ore mass to raise, by the force of reaction, the ore in the path of the jets to the surface of a thin body of water, provided by the jets, flowing laterally with respect to the path of movement of the commingled mass, separating the floatable and non-floatable constituents of the ore at the water surface to produce a floating concentrate of the phosphate constituent, and collecting the float.

9. The process of concentrating phosphate ore which consists in mixing the ore with a chemical reagent to coat the phosphate constituent of the same and form a relatively dense commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, supporting and maintaining contiguous portions of the relatively dense commingled ore mass while moving the same in a single direction of travel, providing a thin body of water upon the moving commingled ore mass flowing in a transverse direction of travel with relation to the path of movement of the mass, raising and lowering portions of the commingled ore mass, in the path of its movement, through the surface of the provided thin body of water, separating the floatable and non-floatable constituents of the ore mass at the water surface to produce a float of the phosphate constituent, and collecting the float.

10. The process of concentrating phosphate ore which consists in mixing the ore with a chemical reagent to coat the phosphate constituent of the same and form a relatively dense commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, raising and lowering portions of the commingled ore mass through the surface of a relatively thin body of flowing water to produce by separation of the ore constituents at the water surface a floating concentrate of the phosphate constituent, and collecting the float.

11. The process of concentrating phosphate ore which consists in mixing the ore with a chemical reagent to coat the phosphate constituent of the same and form a relatively dense commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, impinging jets of water upon a heaped body of the commingled ore mass to raise the mass in the path of the jets by the force of reaction to the surface of a relatively thin body of water, provided by the jets, flowing off the heaped ore body to produce, by separation of the floatable and non-floatable constituents of the ore at the water surface, a floating concentrate of the phosphate constituent, and collecting the float.

12. The process of concentrating phosphate ore which consists in desliming the ore, mixing the deslimed ore with a minimum of chemical reagents to coat the phosphate constituent of the same and form a dense commingled mass in which this constituent is floatable and in which the gangue constituent is non-floatable, the mass

containing not more than twenty-five percent by weight of water, feeding the dense commingled ore mass to the surface of a unidirectionally moving belt to provide a longitudinally centered elongated pile of ore thereon, intermittently interrupting the mass at the side portions of the pile in the movement of the ore upon the belt, impinging a plurality of jets of water in a downwardly direction upon the intermittently interrupted ore mass to provide a thin body of water flowng laterally with respect to the path of movement of the pile, raising and lowering the commingled ore mass at the points of its intermittent interruption in the path of its movement through the surface of the thin body of water, separating the phosphate ore and gangue at the water surface, re-directing the gangue constituent of the ore mass, after separation, to maintain the same in the path of movement of the pile, and collecting the separated floatable constituent.

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