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HYDRAULIC CLASSIFICATION METHOD

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Fig. 3

Fig. 4

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This invention relates to hydraulic classification and more particularly relates to treatments of this character in which settled sands or coarse solids are moved in the treatment zone from a lower pool to an elevated point of discharge relative to the surface of the pool by a mechanical action, while slimes or fine solids are maintained in suspension in the pool by said mechanical action and caused to overflow therefrom in a continuous action.

Treatments of the above described character have been employed in the past principally for size classification of solids in a pulp. In ore dressing treatments, such operations usually were employed in a grinding circuit with the classification effecting a sorting action returning oversize particles to a mill for regrinding or further reduction in the size, while the overflow product containing fines of various composition were removed from the circuit by overflow and passed to additional treatment stages.

Such separations required only that the constituents of either product of the separation have corresponding settling properties. Consequently, products of different size but equivalent mass weight were settled together, often with deleterious effects on other stages of the treatment in which the operation was performed.

Thus in a milling operation in which the ore was ground in closed circuit with a classifier and the overflow product was subjected to a froth flotation treatment for the recovery of a constituent metal of the pulp, the classification stage would be operated to overflow particles of <5 mesh or finer, while the solids coarser than <100 mesh would be returned to the mill for further reduction. Theoretically, the metal to be recovered would pass with the overflow product to the flotation stage. However, a considerable amount of the metal in the finer sizes frequently returned to the mill due to high specific gravity conditions, inducing settling at the classification stage. Other mineral of corresponding size would be returned to the mill because of its entrainment with settling sands.

All such metals so returned would be of optimum size for recovery by flotation, and regrinding of this product would induce excessive silting to the detriment of the flotation separation as well as causing the mill to do unnecessary work of an expensive character.

More recently, hydraulic classifiers of the aforementioned type have been used for many purposes other than the conventional milling operation. For example, sand washing operations require a close grading of sizes, and constituents of uniform mass weight but in different sizes require separation in the treatment. Obviously, an operation in which the grading is dependent solely on the settling rate of particles in the liquid of the treatment will be ineffective for this purpose, as a variety of sizes of uniform mass weight will comprise the final product of the treatment.

In other treatments the material taken for classification frequently will comprise a mixture of water-soluble and insoluble particles in the same size ranges and of corresponding weight. Elimination of the soluble constituents may be a derelict of the treatment, but in the usual operation of this character the period of submergence of the soluble content will be ineffective to attain the desired dissolution, particularly when such soluble content is embedded in a layer of mixed solids of substantial depth.

It is an object of the present invention to provide a simple, efficient and economical process for dissolving soluble constituents in a treatment in which solids in a variety of sizes in liquid suspension are size classified into graded products.

Another object of the invention is to provide a simple and efficient method of removing entrained fines in coarse settled solids in a hydraulic classification treatment.

A further object of the invention is to provide a simple and efficient method of separating particles of different sizes but uniform mass weight in a hydraulic classification treatment.

Other objects reside in novel steps and treatments in conjunction with hydraulic classification treatments, all of which will be fully described in the course of the following description.

The present invention is intended for utilization in conventional type classifiers and is performed in conjunction with the usual operations of such apparatus as a supplement thereto rather than involving a fundamental change in the character of such operations. Having been so designed, it is susceptible of embodiment in a variety of apparatus. Certain features of the invention have been shown and described in my co-pending application Serial No. 471,988, filed January 11, 1943, for Classifier apparatus, and features described but not claimed herein have been made the subject matter of claims in the aforesaid application.

In its broadest concept, the present invention involves the formation of a bed of settled solids within a pool, the progressive movement by mechanical action of the settled bed of material to a point of discharge elevated with respect to the
surface of the pool, the maintenance of solids in fine sizes in suspension in the pool by said mechanical action, and washing the settled solids at a plurality of stages in said progressive movement, while the portion of such bed subjected to the washing influences is loosened and made more permeable. Preferably, although not necessarily, such loosening is performed in conjunction with a thinning of the bed to afford a more thorough penetration thereof by the wash fluid.

Such washing action may be performed while the bed of settled solids is submerged in the pool or after it has been elevated above the surface of the pool. Under the last mentioned conditions, there is a tendency for some of the settled solids to become suspended in the stream of wash fluid flowing to the pool by gravity after completion of the washing action. While such action is desirable for the purpose of removing entrained fines or slimes constituents from the settled solids, it is detrimental if solids in the size ranges intended for removal with the settled solids become so suspended. For this reason, provision is made in the treatment to induce a rapid settling of larger solids in the wash fluid flow.

Furthermore, a plurality of such washing stages in the course of the progressive movement of the solids, the bed of material is permeated by the wash fluid to a sufficient degree to remove substantially all entrained fines therewith. Similarly, when dissolution of soluble matter is sought, the repeated washings afford sufficient solids-liquid contact to attain the desired results.

However, in other treatments where the primary purpose of the washing action is size classification a single washing action may be adequate in some treatments.

Having thus described the features of the present treatment in a general way, reference will now be made to the accompanying drawings illustrating typical installations for the practice of the present invention. In the drawings in the several views of which like parts have been designated similarly.

Figure 1 is a vertical section through a classifier of the spiral conveyor or "Akins" type embodying the features of the present invention; Figure 2 is a vertical central section through a drag type classifier embodying features of the present invention; Figure 3 is a fragmentary perspective view of the washing zone of a classifier of the "Akins" type embodying features of the present invention; and

Figure 4 is a fragmentary cross sectional view through the washing zone of an "Akins" type classifier, embodying features of the present invention.

The classifier illustrated in Figure 1 is an "Akins type," generally similar to the construction shown and described in my aforementioned co-pending application, Serial No. 471,989. It comprises a tank 5 having a lower overflow weir 6 across which the slimes or fines product passes, and an upper discharge outlet 7 for settled sands. Pulp is fed to the tank at its lower end through a feed box (not shown). The tank is inclined by suitable supports (not shown) to position the outlet 7 at a substantial distance above the level of a pool 8 determined by the height of the overflow weir 6.

Solids settling in the pool are arrested by the inclined bottom 9 of the tank and form a bed of material 10 which is progressively moved by a spiral conveyor 12 along the inclined bottom out of the pool to the discharge outlet 7. A suitable conveyor or chute 13 conducts the discharging solids to a stock pile or another treatment stage such as a ball mill, for example.

Sufficient agitation is imparted to the pool by the conveyor 12 to maintain in suspension solids of less than a predetermined maximum specific gravity, designated "fines," while heavier or oversized particles settle in the liquid. The mixture of fines and liquid reaching the weir 6 passes across the same and discharges from the treatment. A suitable conductive member, such as a launder 14, conducts this product to storage, waste or another treatment stage, such as a flotation circuit, for example.

At intervals along the bottom 9 of tank 5, wash boxes 15 are arranged in the path of the upwardly moving solids bed. These boxes extend from a point near the center line of the bottom 9 to a terminus well above the bottom of the tank on the side thereof toward which the solids are directed by the action of the spiral conveyor. Thus, the lengthwise axis of any box 15 is transverse to the direction of movement of the solids bed 10.

Referring now to Figure 4, each box is provided with a series of discharge outlets 16 preferably covered by a cap element 17 and having a series of side-opening slots 18 under the cap through which liquid may discharge into the tank 5. A wash liquid is delivered from a header 19 into each box 15 by conduits 20, and the flow through these conduits may be regulated by manual adjustment of a valve 21.

While not essential in some treatments, it has been found advantageous to attach a flexible baffle member 22 along the lower side of each box 15, and to extend the baffle beyond the box for a substantial distance as shown in Figure 3. A rubber strip is particularly recommended for this purpose because of its excellent wear-resistant properties in addition to possessing the desired degree of flexibility.

In the treatments in which the present invention is utilized, the primary function of the spiral conveyor 12 is to move the settled solids along the inclined bottom 9 to the discharge outlet 7. However, advantage is taken of the spiral design to incorporate other functions into the conveyor assembly.

The conveyor comprises a series of plate members 23 and 23a supported from a shaft member 24 extending lengthwise from tank 5. The shaft is journaled in a submerged bearing 25 at the lower end of tank 5 and a swivel bearing 26 at the upper end of the tank. The shaft is rotated by any suitable prime mover (not shown) through the intermediary of a gear assembly 27. Preferably the bearing 25 is carried on a lifting mechanism indicated by the fragmentary member 28.

In this form of classifier the blades 23 are arranged in two groups, designated A and C, with substantial spacing between adjoining convolution runs, while the blades 23a of the intermediate group B are more closely spaced. The blades 23 are supported directly from shaft 24 by arms 29 while the blades 23a are supported by a series of bars 30 attached to a spider 31 mounted on shaft 24 at each end of the group.

It is desirable to agitate the solids bed in conjunction with the washing action to this end a series of lifter blades 32 is provided, preferably formed of angle irons extending from one convolution of the spiral to another adjacent the outer peripheries of said blades. Rotation of the
a,873,662 spiral serves to move the blades 22 into the bed 18 keeping the same spread out and loosened as it is moved upwardly by the spiral blades.

In addition to their function in loosening the solids bed, the blades 22 also act as structural members to stabilize the spiral section B. In the preferred construction illustrated in Figure 1, a double spiral is employed with one stretch disposed at 180° to the other as will be best understood by reference to the ends of the spiral members and adjacent bearing 25.

In the intermediate spiral portion B, a quadruple spiral is provided with the stretches disposed at 90° intervals about the shaft. Alternate ones are extensions of the aforementioned spirals of the sections A and C while the other two are inserted between the convolutions of these extensions. As a consequence of this arrangement, the distance between adjoining convolutions in the section B is only about one-half the distance between adjoining convolutions in the sections A or C.

Inasmuch as there are more surfaces pushing the settled solids in a given length of section B than there are in the same length of sections A or C, the width of the blades is reduced in section B without reduction in elevating or conveying capacity. This arrangement serves to thin the solids bed permitting more ready penetration of the wash liquid into the solids bed as it passes across the wash boxes because of its lesser depth.

Likewise, so altering the bed serves to loosen or tumble the solids of the bed when it is first brought into contact with blades 23a as these blades are not wide enough to engage the entire depth of the bed as formed by the wider blades 23 of section C. Additionally, the bed is further agitated and loosened by the action of the lifter blades 22 moving through and out of the same.

In the operation in which the apparatus of Figure 1 is utilized, entering feed fills the lower end of tank 8 to the level determined by the position of weir 6. After which there is a continuous overflow of fines during continuity of the operation. The spiral conveyor is rotated continuously during the treatment and the agitation imparted thereby serves to maintain slimes and fines in suspension in pool 9 while coarser sands settle to the bottom 9. The bed 8 is formed at the level of weir 6a. A conveyor 12a moves the settled solids bed 10 through the pool along the inclined bottom 8a of the tank. As the blades assume the depending position at the lower end of the conveyor they contact the bed of material 10 and impart to the portion so contacted a progressive movement upwardly along the inclined bottom 8a.

When a given portion of the solids bed being thus moved is brought into the washing zone, it is caused to pass over baffles 22a and due to the shape and position of such baffles, the solids are substantially loosened and to some extent thinned. The wash boxes 18a in this form of the device are substantial duplicates of the boxes 18 with the exception that they are superposed on the inclined bottom 8a with the nozzles 16 of a given box disposed at a uniform distance above the bottom 8a.

The forceful discharge of wash liquid into the loosened and thinned body of solids thoroughly penetrates thesame and induces a dissolution of soluble constituents, or when the solids comprise only insoluble matter, the washing action is utilized to separate particles of uniform mass weight but different size.

Again in this form of the device, it is desirable...
to have a succession of wash boxes along the course of the discharging solids and some of 
these may be below the level of the overflow weir 62 while others are above the same as clearly 
indicated in Figure 2.

It will be apparent from the foregoing description that when the present invention is utilized in conjunction with other ore dressing treatments an efficient separation of graded products can be obtained. Thus, if the feed to flotation is to be a \(-100\) mesh product, for example, the pulp on its first pass through the classifier will be sub-
stantially free of any extreme fines or slimes. The agitation imparted to the pool by the spiral 
conveyor 12 and particularly by the blades 32 carried by the spiral, serves to agitate and loosen 
the bed of material 10 sufficiently to free entrained fines therefrom and to maintain all such 
fines at the surface of the liquid where they are promptly eliminated by overflow.

The solids too coarse to remain in suspension under the aforesaid agitative action are moved progressively along the bottom until they pass into the wash box zone. There they are sub-
jected to the penetrating influences of the en-
tering wash liquid and fines still entrained in such solids are elevated from the bed and return 
to the pool 8. After the solids bed 10 has passed 
through a succession of such treatments, it is 
substantially free of the fines requiring no fur-
ther grinding, and consequently the coarse prod-
uct at final discharge is substantially free of 
particle sizes within the range requiring no 
further grinding.

Under present day operation requirements, 
many plants are forced to put a much greater 
tonnage through a plant of a given size than 
would be done under ordinary conditions. The 
present invention lends itself readily to such re-
quirements as the spiral may be rotated at a 
much faster rate than normally prescribed with-
out appreciable reduction in metallurgical effi-
ciency. This is due to the utilization of the sev-
eral features of the present invention.

Likewise, in sand washing operations or in 
other operations where the removal of soluble 
colloids from the solids bed is a desideratum, 
the present invention has attained a high degree 
of efficiency.

What I claim and desire to secure by Letters 
Patent is:

1. The method of classifying solids in liquids, 
which comprises maintaining a liquid-solids mix-
ture enclosed on three sides and the bottom to 
form a pool, continuously supplying a liquid-
solids mixture to the pool, continuously over-
flowing fines in liquid from the pool, progressively 
moving solids settling in the pool upwardly along 
an inclined course to a point of discharge at a 
higher elevation than the surface of the pool, 
thinning and loosening the mass of solids during 
said progressive movement between the lower end 
of the pool and the point of discharge by ob-
structing the elevating movement of the under-
portion of said mass, and subjecting said solids 
of the under layer while loosened and thinned to 
the influence of a wash liquid forcefully injected 
below the loosened mass and penetrating to the 
surface of the same.

2. The method of classifying solids in liquids, 
which comprises maintaining a liquid-solids mix-
ture enclosed on three sides and the bottom to 
form a pool, continuously supplying a liquid-
solids mixture to the pool, continuously over-
flowing fines in liquid from the pool, progressively 

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moving solids settling in the pool upwardly along 
an inclined course to a point of discharge at a 
higher elevation than the surface of the pool, 
thinning and loosening the mass of solids within 
the pool prior to their elevation out of the pool 
in said progressive movement between the lower 
end of the pool and the point of discharge by ob-
structing the elevating movement of the under-
portion of said mass, and subjecting said solids 
of the under layer while loosened and thinned to 
the influence of a wash liquid forcefully injected 
beneath the loosened mass and penetrating to the 
surface of the same.

3. The method of classifying solids in liquids, 
which comprises maintaining a liquid-solids mix-
ture enclosed on three sides and the bottom to 
form a pool, continuously supplying a liquid-
solids mixture to the pool, continuously over-
flowing fines in liquid from the pool, progressively 
moving solids settling in the pool upwardly along 
an inclined course to a point of discharge at a 
higher elevation than the surface of the pool, 

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solids mixture to the pool, continuously over- 5
flowing fines in liquid from the pool, progressively moving solids settling in the pool upwardly along an inclined course to a point of discharge at a higher elevation than the surface of the pool, loosening and thinning the mass of solids by obstructing the elevating movement of the under portion of said mass during said progressive movement and after progressing out of the pool, and subjecting said solids while loosened and thinned to the influence of a wash liquid force-fully injected beneath the loosened mass and penetrating to the surface of the same.

7. The method of classifying solids in liquids, which comprises maintaining a liquid-solids mix- 10
ture enclosed on three sides and the bottom to form a pool, continuously supplying a liquid- solids mixture to the pool, continuously over- flowing fines in liquid from the pool, progressively moving solids settling in the pool upwardly along an inclined course to a point of discharge at a higher elevation than the surface of the pool, thinning and loosening the mass of solids by upsetting the under portion of said mass during said progressive movement and after progressing out of the pool, subjecting said upset solids while loosened and thinned to the influence of a wash liquid forcefully injected beneath the loosened mass and penetrating to the surface of the same, and inducing settling of coarse particles in the wash liquid descending to the pool after penetrating said loosened mass.

8. The method of classifying solids in liquids, which comprises the treatment of a mixture of water soluble and insoluble particles in liquid, maintaining said intermixture enclosed on three sides and the bottom to form a pool, continuously supplying said intermixture to the pool, continuously overflowing fines in liquid from the pool, progressively moving solids settling in the pool upwardly along an inclined course to a point of discharge at a higher elevation than the surface of the pool, thinning and loosening the mass of solids by upsetting the under portion of said mass during said progressive movement between the lower end of the pool and the point of discharge, and subjecting said upset solids while loosened and thinned to a succession of washing actions at intervals along the course in which actions a wash liquid is forcefully injected beneath the loosened mass and penetrates to the surface of the same.

9. The method of classifying solids in liquids, which comprises the treatment of a mixture of water soluble and insoluble particles in liquid, maintaining said intermixture enclosed on three sides and the bottom to form a pool, continuously supplying said intermixture to the pool, continuously overflowing fines in liquid from the pool, progressively moving solids settling in the pool upwardly along an inclined course to a point of discharge at a higher elevation than the surface of the pool, loosening and thinning the mass of solids during said progressive movement between the lower end of the pool and the point of discharge by obstructing the elevating movement of the under portion of said mass, and subjecting said under portion of solids while loosened and thinned to a progression of washing actions along the course of sufficient duration to dissolve substantially the entire soluble content of the moving solids.

10. The method of classifying solids in liquids, which comprises the treatment of particles of different sizes but of uniform mass weight in a liquid, maintaining said liquid-solids intermix- 35
ture enclosed on three sides and the bottom to form a pool, progressively moving solids settling in the pool upwardly along an inclined course to a point of discharge at a higher elevation than the surface of the pool, continuously supplying the liquid-solids intermixture to the pool, overflowing fines in liquid from the pool, loosening and thinning the mass of solids during the progressive movement between the bottom of the pool and the point of discharge by upsetting the under portion of said mass, and subjecting upset constituent particles of said thinned and loosened mass to the impelling influence of an upwardly directed stream of water directed against the under surfaces of the particles at sufficient velocity to elevate the larger sized particles while leaving other particles of equivalent weight but lesser size deposited within said moving body.

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