March 2, 1943. B. M. BIRD ET AL 2,312,865

METHOD OF TREATING MATERIAL

Filed Jan. 3, 1941 3 Sheets-Sheet 1

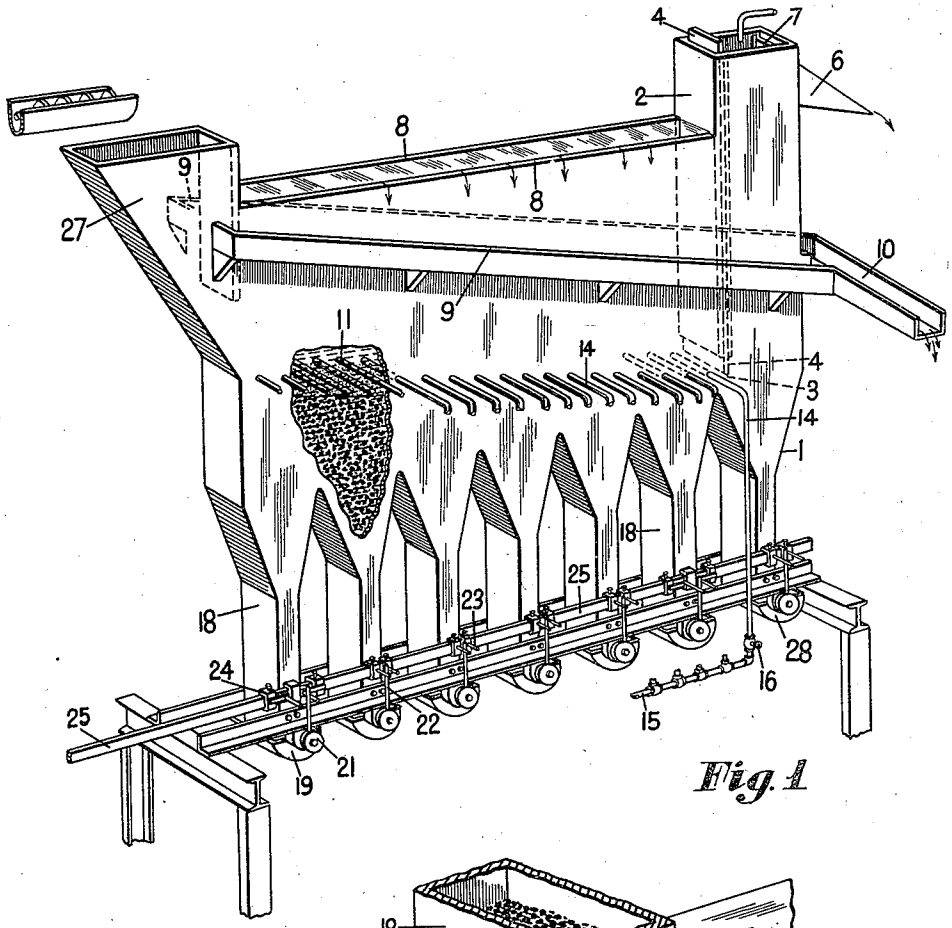


Fig. 1

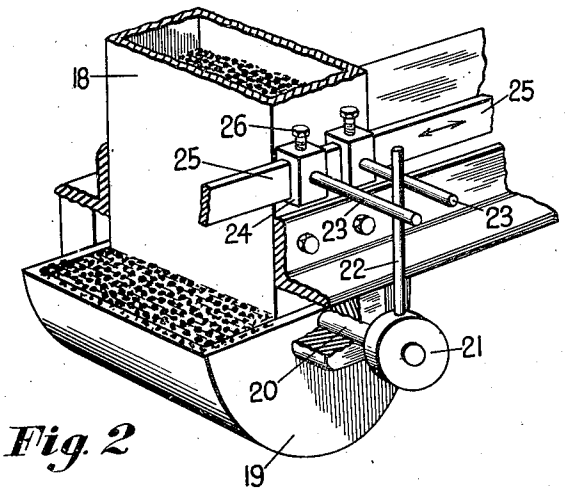


Fig. 2

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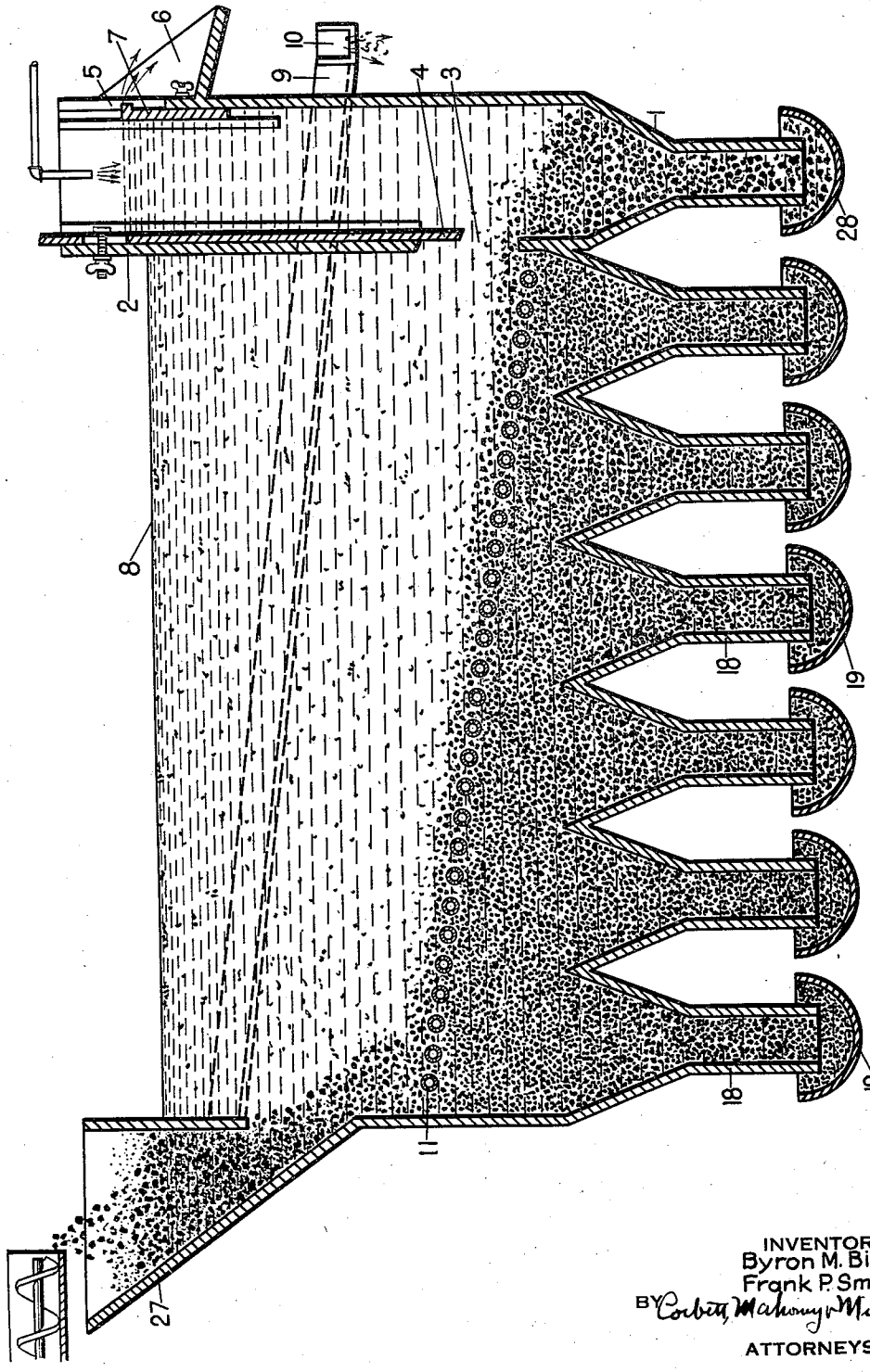


Fig. 3

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METHOD OF TREATING MATERIAL

Filed Jan. 3, 1941 3 Sheets-Sheet 3

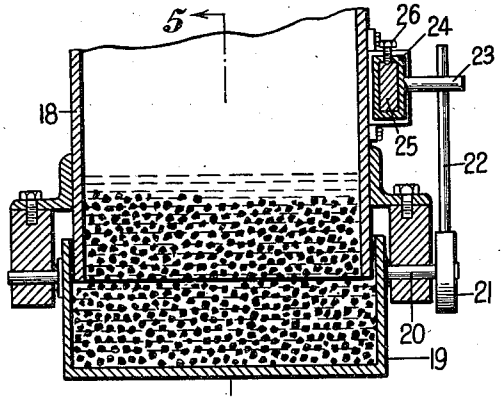


Fig. 4

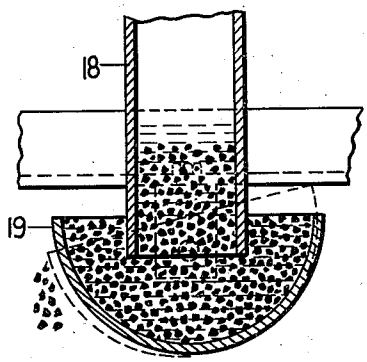


Fig. 5

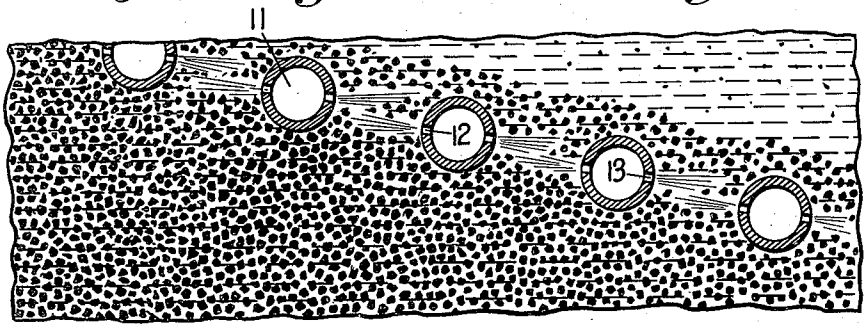


Fig. 6

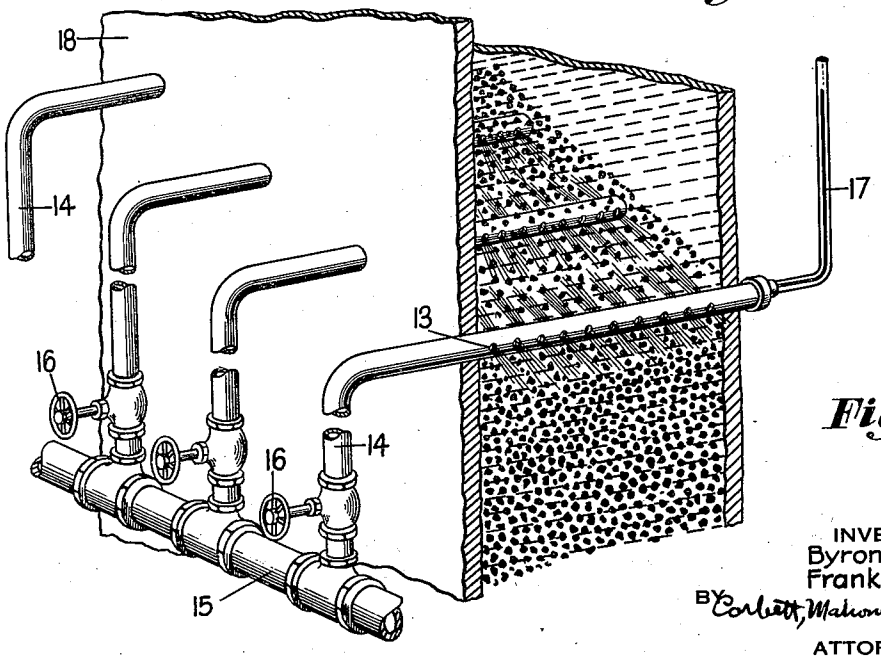


Fig. 7

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UNITED STATES PATENT OFFICE

2,312,865

METHOD OF TREATING MATERIALS

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Application January 3, 1941, Serial No. 373,016

10 Claims. (Cl. 209—155)

Our invention relates to a method of treating materials. It has to do, particularly, with the treatment of granular materials, such as ores and coals. It is particularly applicable to the separation of such materials into different sizes and specific gravities. It is especially suitable in the separation of materials in connection with closed-circuit grinding, although it is not necessarily limited thereto.

In ore dressing, grinding mills are usually run in closed-circuit with a desliming device designed to remove the materials that are sufficiently ground and to return the balance of the ore to the mill for further grinding. In general, large circulating loads are used so that a minimum of overgrinding may result in the mill itself. In addition to the desliming device, the practice is becoming common of introducing concentrating devices such as jigs or tables in the circuit to recover concentrates as soon as they are liberated from gangue particles.

One object of this invention is to provide a method which will not only be applicable to the desliming of ores but which will also be applicable to the concentration of such ores in the so-called "closed-circuit" grinding systems.

Another object of this invention is to provide a method which will be generally applicable to the concentration of ores and to the cleaning of coals to remove high ash and high sulfur impurities.

Other objects of this invention will appear as this description progresses.

With particular relation to the treatment of ores, our invention contemplates a method whereby the slime is removed from the ores and, at the same time, the remaining materials are so treated that they are separated according to specific gravity. In this way, the sufficiently ground materials are removed and the balance may be readily returned to the mill for further grinding. Thus, one important feature of our invention lies in the fact that our method makes possible the simultaneous desliming of the ores and concentration of such ores so that final concentrates or tailings may be produced therefrom.

Another important feature of our invention lies in the fact that we utilize gravity travel of the ground material as the principal means of imparting mobility to the particles thereof and that we use upward currents of liquid in only a minor role as an aid to mobility. The combined effect is that the fine materials of a desired size are removed with relatively low dilution of the overflow product, while the coarse materials of high specific gravity are stratified in the bottom layers of the mass of solids as this mass moves along.

More specifically, our method involves the use of a launder in such a way that the ground materials are more or less in constant motion along a downwardly inclined surface of previously deposited particles. At the same time, they are subjected to gently flowing vertical currents, which are not adequate to maintain all of the materials in a state of "teeter," as in the usual hindered-settling classifier, but which are adequate to suspend and remove fine particles of a selected size.

While the ground materials are flowing downward in a completely mobile condition under the combined effect of the upward currents of liquid and of gravity, the coarser materials, not carried over by the upward currents, are stratified to a substantial extent according to specific gravity with those of highest specific gravity on the bottom, those of intermediate specific gravity in intermediate layers, and those of lowest specific gravity in the top layers of the moving mass. Our invention takes advantage of this stratification to recover rougher or finished concentrates while the desliming operation is in progress by the provision of suitable draws for removing the concentrates as they are deposited from the moving mass.

The launder which we preferably use is provided with a series of perforated pipes disposed at elevations which are successively lower as approach is made to the lower end of the launder. Through these pipes low velocity currents of liquid are admitted to aid in bringing about desliming and stratification. In addition, this launder is provided with a plurality of draws which may be continuously operated to withdraw coarser materials deposited at various points throughout the length of the launder. The top edge of our launder is preferably approximately horizontal. The general path of the liquid is vertically upward from points approximately at the top of the bed of the material and passes over the edges of the launder, carrying with it the collected slimes. At the feed end is also provided a suitable receptacle for receiving the feed.

Under our method, the deposited bed in the launder is inclined at a relatively steep angle to the horizontal. Usually, it conforms approximately to the plane formed by the series of perforated pipes. The result is that when the solids move over this deposited bed, which is normally

rough, the top layers are greatly retarded. This brings about a rolling and sliding of the solids with respect to each other which is an important aspect of our invention. However, if the plane of the pipes is at too steep an angle, the solids move as a mass downwardly thereover without the desired rolling or sliding of the particles with relation to each other. Thus, the successful operation of our method and apparatus involves finding by experiment the approximately correct inclination of the plane of the series of perforated pipes in order to insure this rolling and sliding action.

The apparatus which we preferably use in the performance of our method is shown in the accompanying drawings wherein:

Figure 1 is a perspective view partly broken away of our launder and associated parts.

Figure 2 is a perspective view of one of the draws and the operating mechanism therefor.

Figure 3 is a vertical longitudinal section of our launder, showing the materials being treated therein.

Figure 4 is a vertical sectional view taken through one of our launders in a plane transversely of the launder.

Figure 5 is a detailed view taken in section on line 5—5 of Figure 4.

Figure 6 is a detailed view in section illustrating the preferred location of the ports in our perforated pipes.

Figure 7 is a detailed view in perspective of a portion of our launder and illustrating the perforated pipes disposed within the launder.

With particular reference to the drawings, it will be seen that the launder is provided with a draw 1 which is generally similar to other bottom draws in the lower portion, which will be subsequently described. This draw 1, however, is partially separated from the interior of the launder by a wall 2 having an opening 3 connected with the main body of the launder and under the control of an adjustable gate 4. This draw 1 is upwardly extended to a point above the upper edge of the main body of the launder. Extending into the upper end of the draw 1 is a pipe for delivering liquid into said draw in order to maintain any desired head of liquid in the draw for purposes which will be subsequently explained. The upper end of this draw 1 is also provided with an overflow weir 5 leading to a discharge trough 6 and having an adjustable gate 7.

The launder is further provided with upper longitudinal edges 8 over which the liquid may be permitted to flow into side troughs 9 which deliver to an end trough 10. In the closed-circuit classification of ores, this overflow operation is particularly important because the overflowing liquid is designed to carry with it the slime that has been separated from the material by the currents of liquid flowing from the inclined series of spray pipes within the launder which are now to be described.

These spray pipes are shown generally in Figure 3 of the drawings and are designated 11. They are shown more in detail in Figures 6 and 7 where it will be seen that each pipe has a series of ports 12 that deliver liquid substantially horizontally towards the receiving end of the launder and a series of ports 13 that deliver liquid substantially horizontally towards the delivery end of the launder. Liquid is supplied to these spray pipes by means of pipes 14 leading from a manifold 15 and each being under the control of a hand operated valve 16. With this form of apparatus, the liquid is preferably fed into the spray pipes under a head of 2 to 12 inches to insure uniformity of distribution from the individual perforations. Each spray pipe is connected with an upwardly extending manometer 17 so that the head of liquid may be inspected and regulated in accordance with the desired conditions of operation.

The lower part of the launder is provided with a series of draws 18 which are preferably under the control of oscillatable buckets 19. These buckets may be automatically actuated, if desired, to effect continuous oscillation thereof by means of spindles 20 carrying disks 21 with upstanding rods 22 designed to cooperate with spaced rods 23. These spaced rods 23 are carried by brackets 24 upon a longitudinal rod 25, which is reciprocable by any suitable means (not shown). The brackets 24 are adjustable by means of set screws 26. This adjustability makes it possible to regulate the slope of the bed of materials to compensate for the various types of material being fed into the apparatus. It may under certain circumstances be desirable to withdraw the concentrates at earlier or later points in the length of the apparatus while at the same time maintaining the slope of the bed substantially constant. The oscillatable buckets 19 and the adjustability of the degree of oscillation will vary the amount of material withdrawn through any given draw.

In the performance of our method in the treatment of ore, particularly with closed-circuit ore-grinding mill systems, the ore to be treated is discharged from the grinding mill into the hopper 27 and is delivered thereby into the launder proper. It is first permitted to build up to the level of the spray pipes 11 and is then withdrawn at 28 at such a rate as to maintain a bed with an upper surface that substantially conforms to the inclined plane of the series of spray pipes. Thereafter, the material to be classified slides and rolls down the inclined upper surface of the bed of materials while, at the same time, being subjected to the substantially horizontal sprays of liquid. The movement of the particles along the inclined upper surface of the bed brings these particles into a mobile condition so that all particles are free to move with respect to each other. During this motion, the more or less horizontally projected sprays of liquid thoroughly diffuse before taking a vertical direction. This diffusion makes it possible to obtain the maximum utility of every gallon of liquid used. As stated, with this form of apparatus, the liquid is likewise preferably fed into the pipes under a head of 2 to 12 inches to insure uniformity of distribution from the individual perforations, the head being indicated by the tubes 17.

The ground materials are more or less in constant motion along a downwardly inclined surface while, at the same time, they are being subjected to gently flowing vertical currents which are not adequate to maintain all of the materials in a state of teeter, as in hindered-settling, but which are adequate to suspend and remove the fine particles of the desired size. These fine particles are carried to the top of the launder and are delivered over the upper edges thereof with their carrying liquid and into the troughs 9, being finally delivered to the trough 10. These fine particles, which constitute the slimes, may then be delivered for subsequent treatment to a suitable concentration apparatus, such as a flotation machine.

The materials that settle initially between the spray pipes 11 are slowly withdrawn by the oscillation of the buckets 19, and are replaced by materials deposited from the flowing mass of solids. Concentrates usually deposit over the first two or three draws, particles of valuable mineral and gangue deposit over the next few draws and, finally, gangue particles may flow into the last draw pocket, which is designated 1 in the drawings. The concentrates may be bypassed directly to a concentrate bin; the middlings may be returned by any suitable means to the grinding mill; and any tailings may be sent to the tailings pile.

To insure that the slimes will travel upwardly to and over the upper edges of the launder, the column of liquid in the draw pocket 1 is preferably maintained with a head in excess of the head within the launder. The result is that there is produced a gentle flow of liquid from the draw pocket 1 and through the opening 3 into the launder proper to insure that slimes do not pass into the draw pocket 1. As indicated, this opening 3 is under the control of an adjustable baffle member or gate 4. Adjustment of this baffle member or gate permits the variation of the size of the opening 3. The overflow weir for the draw pocket 1 has already been designated 5 and is at a slightly higher elevation than the main weir formed by the longitudinal sides of the launder.

The top edge of the launder which we utilize is preferably approximately horizontal, while the general path of the liquid is vertical and a substantial part of it overflows the side edges or weirs of the launder. As indicated, there are suitable troughs along the side edges and, in treating ores in closed-circuit grinding systems, this liquid which overflows the side edges of the weirs of the launder carries with it the slime particles.

Thus, it will be seen, that in the treatment of ores, our method and apparatus can be used to effect concentration and desliming simultaneously. Furthermore, in the treatment of ores in a closed-circuit grinding system, our apparatus can be made to take the place of two separate units, namely, a desliming apparatus, and a concentrating apparatus. Moreover, our one apparatus may be used to effect desliming, and at the same time, to effect separation of the concentrates, the middlings and the tailings, all at the same time.

In the use of our method and apparatus for the treatment of coal or like materials where desliming is not a primary function, only a very small amount of liquid is introduced. In this application of our method, the bed of materials is preferably permitted to build up to about the level of the spray pipes. The shale and bone settle to the bottom layers. They may be withdrawn automatically and continuously from the draws by the buckets 19. The method may be utilized to separate the coal simultaneously into several layers of material, so that the waste material may be removed and that, simultaneously therewith, separation of one or more qualities of coal may be effected. At the same time, coal flows over into the draw pocket 1, from which it may be withdrawn by the bucket at 28.

It will be understood that, whether our method and apparatus is applied to ore or to coal the comparatively high angle to the horizontal of the top of the stationary layer of material results in the solids moving over a surface which is so disposed that the bottom layers of the moving materials are greatly retarded. This brings about a rolling and sliding of the solids with respect to each other. As indicated above, the fact that we utilize this thin layer of solids which roll and slide with relation to each other makes it possible to use an upward current of low velocity just sufficient to cause a smooth flow of the particles over the deposited bed of refuse materials.

Another feature of our invention consists in the fact that the liquid is introduced into the materials above the bottom thereof and preferably approximately adjacent the top of the bed instead of through the bottom of the bed. Thus, it is possible to obtain results desired either in ore concentration or in coal separation by the use of a greatly reduced quantity of liquid, which makes it unnecessary to take the usual steps required for the removal of the liquid. In other words, since the longitudinal flow of the materials is induced mainly by gravity a minimum of liquid may be used for the actual separation of the particles of relatively low density. In the treatment of ores, the slimes are thus removed and pass over the side weirs of the launder while, in the treatment of coal, the material of relatively low specific gravity is mainly conducted along the bed and over the end weir of the launder. At the same time, the materials of greater specific gravity are delivered through the bottom draws of the launder and the operation may be so regulated that the materials delivered through some of these bottom draws differ in character from the materials delivered to the other bottom draws.

In ore concentration and, more particularly, in closed-circuit grinding, our method lends itself exceptionally well to the removal from the circuit of a product suitable for flotation processes while, at the same time, removing concentrates of different specific gravity. In other words, the slimes may be directly removed at upper points with a minimum amount of liquid while the concentrates are removed without upward flow of liquids through the bottom draws in such a way that the main concentrates can be separated from the middlings which may subsequently be ground. At the same time, the tailings may be separated by passing to the last draw pocket, whence they may be delivered to a tailings pile or to a flotation apparatus if this is deemed desirable.

It is desirable that the moving bed of materials be relatively thin and the substantially horizontal sprays of liquid facilitate operations under these conditions.

It is clear from the above that the utilization of the gravity travel of the ground material as a principal means for imparting mobility to the particles thereof makes possible the use of upward currents of liquid in only a minor role to aid mobility.

It is also clear that our method involves the use of a launder in such a way that the ground materials are more or less in constant motion along a downwardly inclined surface of previously deposited particles. At the same time, they are subjected to gently flowing vertical currents which are not adequate to maintain all of the materials in a state of "teeter" such as is characteristic of the usual hindered-settling classifier. Nevertheless, as indicated, these gently flowing vertical currents are adequate to suspend and remove the fine particles of selected sizes.

It will also be apparent to anyone skilled in the art that in starting the launders described in this

application it will be desirable to fill the apparatus approximately to the level of the spray pipes before introducing any spray water. This can be done manually or by means of any suitable mechanical device. This practice will avoid any tendency for the solids to wash out through the buckets before stratification can take place.

Although our invention has been described for use with liquid, it may also be used with air.

Various other advantages of our method will appear from the claims appended hereto.

Having thus described our invention, what we claim is:

1. A method of separating granular materials which comprises delivering the granular materials to the upper end of a substantially continuous surface composed of granular particles which is inclined at such an angle that said granular materials flow by gravity downwardly along such surface and that the bottom layer of such granular materials is retarded with the result that the particles above such bottom layer move with relation to such bottom layer and with relation to each other, simultaneously applying, to such mobile material, upward currents of liquid which are of just enough velocity to suspend the slime particles initially intermingled with the granular particles without suspending the granular particles, withdrawing the suspended slime particles which are thus separated from the granular particles by overflow, allowing the remaining granular material to separate according to specific gravity as it flows down the inclined surface, withdrawing concentrates of different specific gravity vertically downwardly by gravity substantially throughout the length of the inclined surface at a rate to insure that the slope required for causing the particles of such granular materials to move continuously with relation to such surface and with relation to each other is maintained.

2. A method according to claim 1 wherein a current of liquid is applied to such mobile material adjacent the lower end of said inclined surface and in a direction opposite to the direction of movement of such material, with said current of liquid having a velocity adequate to retard the withdrawal of the slime particles with the granular particles.

3. A method of separating granular materials which comprises delivering the granular materials to the upper end of a substantially continuous surface composed of granular particles which is inclined at such an angle that said granular materials flow by gravity downwardly along such surface and that the bottom layer of such granular materials is retarded with the result that the particles above such bottom layer move with relation to such bottom layer and with relation to each other, simultaneously applying, to such mobile material, upward currents of liquid which are of a velocity insufficient to support the coarser of the particles of granular materials but sufficient to remove the finer particles from the interstices of the coarser particles of such materials, withdrawing the finer particles which are thus separated from the coarser particles, and withdrawing such coarser particles vertically downwardly by gravity substantially throughout the length of the inclined surface at a rate to insure that the slope required for causing the particles of such granular materials to move continuously with relation to such surface and with relation to each other is maintained.

4. A method according to claim 3 wherein a current of liquid is applied to such mobile material adjacent the lower end of said inclined surface and in a direction opposite to the direction of movement of such material, with said current of liquid having a velocity adequate to retard the withdrawal of the slime particles with the coarser particles.

5. A method of separating granular materials which comprises delivering the granular material to the upper end of a substantially continuous bed composed of such granular material and having a substantially continuous upper surface which is inclined at such an angle that said granular material flows by gravity downwardly along such surface and that the bottom layer of such granular material is retarded with the result that the particles above such bottom layer move with relation to such bottom layer and with relation to each other, simultaneously applying, to such mobile material, upward currents of liquid at points above the bottom of the bed which are of just enough velocity to suspend the slime particles initially intermingled with the granular particles without suspending the granular particles, withdrawing the suspended slime particles which are thus separated from the granular particles by overflow, allowing the remaining granular material to stratify according to specific gravity as it flows down the inclined surface, withdrawing concentrates of different specific gravity vertically downwardly by gravity from the bed substantially throughout the length of the bed to insure that the slope of the inclined surface required for causing the particles of such granular material to move continuously with relation to such surface and with relation to each other is maintained.

6. A method of separating granular materials which comprises delivering the granular material to the upper end of a substantially continuous bed composed of such granular material and having a substantially continuous upper surface which is inclined at such an angle that said granular material flows by gravity downwardly along such surface and that the bottom layer of such granular material is retarded with the result that the particles above such bottom layer move with relation to such bottom layer and with relation to each other, simultaneously applying, to such mobile material, upward currents of liquid at points above the bottom of the bed which are of a velocity insufficient to support the coarser of the particles of granular material but sufficient to remove the finer particles from the interstices of the coarser particles of such material, withdrawing the finer particles which are thus separated from the coarser particles, and withdrawing such coarser particles vertically downwardly by gravity from the bed substantially throughout the length of the bed to insure that the slope of the inclined surface required for causing the particles of such granular material to move continuously with relation to such surface and with relation to each other is maintained.

7. A method of separating granular materials which comprises delivering the granular material to the upper end of a substantially continuous bed composed of such granular material and having a substantially continuous upper surface which is inclined at such an angle that said granular material flows by gravity downwardly along such surface and that the bottom layer of such granular material is retarded with the result that the particles above such bottom

layer move with relation to such bottom layer and with relation to each other, simultaneously applying, to such mobile material, at a series of points along the path of flow and at substantially equal distances below the upper surface of the flowing material horizontally directed currents of water of just enough velocity so that they will diffuse and turn upwardly after delivery and carry upwardly the slime particles initially intermingled with the granular material so as to remove them by overflow and at the same time will support the particles of intermediate specific gravity without supporting the particles of high specific gravity, allowing the remaining granular material to separate according to specific gravity as it flows down the inclined surface, withdrawing concentrates of different specific gravity vertically downwardly by gravity from the bed substantially throughout the length of the bed at a rate sufficient to insure that the slope of the inclined surface for causing the particles of such granular material to move continuously with relation to such surface and with relation to each other is maintained.

8. A method according to claim 7 wherein a current of liquid is applied to such mobile material adjacent the lower end of said inclined surface and in a direction opposite to the direction of movement of such material, with said current of liquid having a velocity adequate to retard the withdrawal of the slime particles with the granular particles.

9. A method of separating granular materials which comprises delivering the granular material to the upper end of a substantially continuous bed composed of such granular material and having a substantially continuous upper surface which is inclined at such an angle that said granular material flows by gravity downwardly along such surface and that the bottom layer of such granular material is retarded with the result that the particles above such bottom layer move with relation to such bottom layer and with relation to each other, simultaneously applying, to such mobile material, at a series of points along the path of flow and at substantially equal distances below the upper surface of the flowing material horizontally directed currents of water of just enough velocity so that they will diffuse and turn upwardly after delivery so as to remove the finer particles from the interstices of the coarser particles of such material and at the same time will support the particles of intermediate size without supporting the coarser particles of such material, withdrawing the finer particles which are thus separated from the coarser particles, and withdrawing such coarser particles vertically downwardly by gravity from the bed substantially throughout the length of the bed at a rate sufficient to insure that the slope of the inclined surface required for causing the particles of such granular material to move continuously with relation to such surface and with relation to each other is maintained.

10. A method according to claim 9 wherein a current of liquid is applied to such mobile material adjacent the lower end of said inclined surface and in a direction opposite to the direction of movement of such material, with said current of liquid having a velocity adequate to retard the withdrawal of the slime particles with the coarser particles.

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