April 25, 1944. G. J. HOLT ET AL 2,347,264

PROCESS AND APPARATUS FOR SEPARATING FRAGMENTARY MATERIALS

Filed Oct. 21, 1940 3 Sheets-Sheet 1

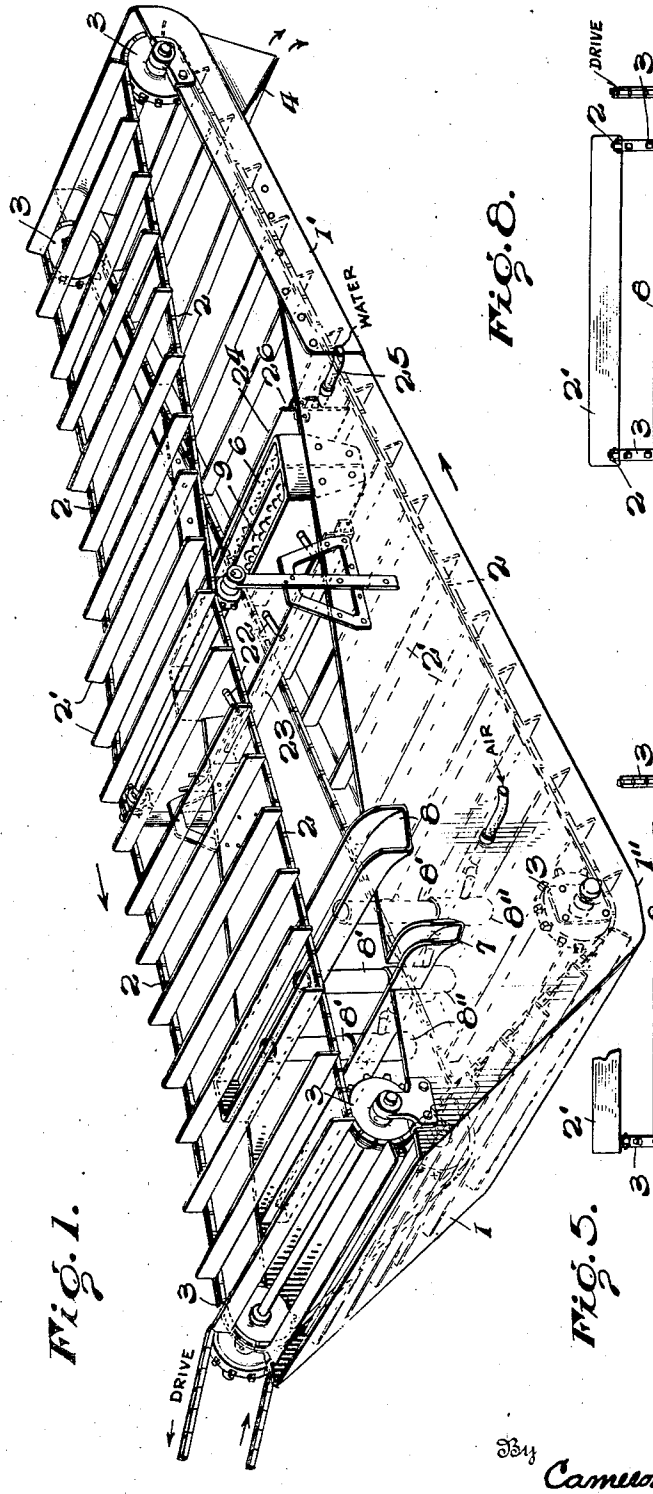

Fig. 1.

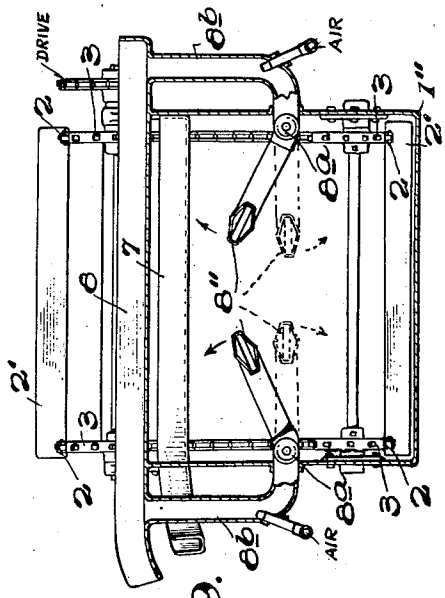

Fig. 8.

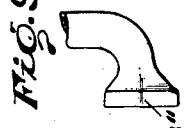

Fig. 9.

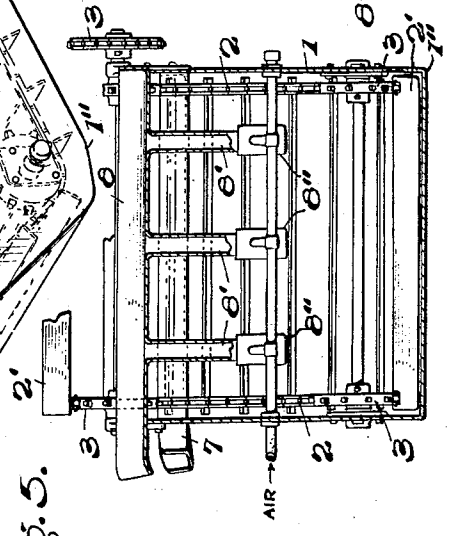

Fig. 5.

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PROCESS AND APPARATUS FOR SEPARATING FRAGMENTARY MATERIALS

Filed Oct. 21, 1940 3 Sheets-Sheet 2

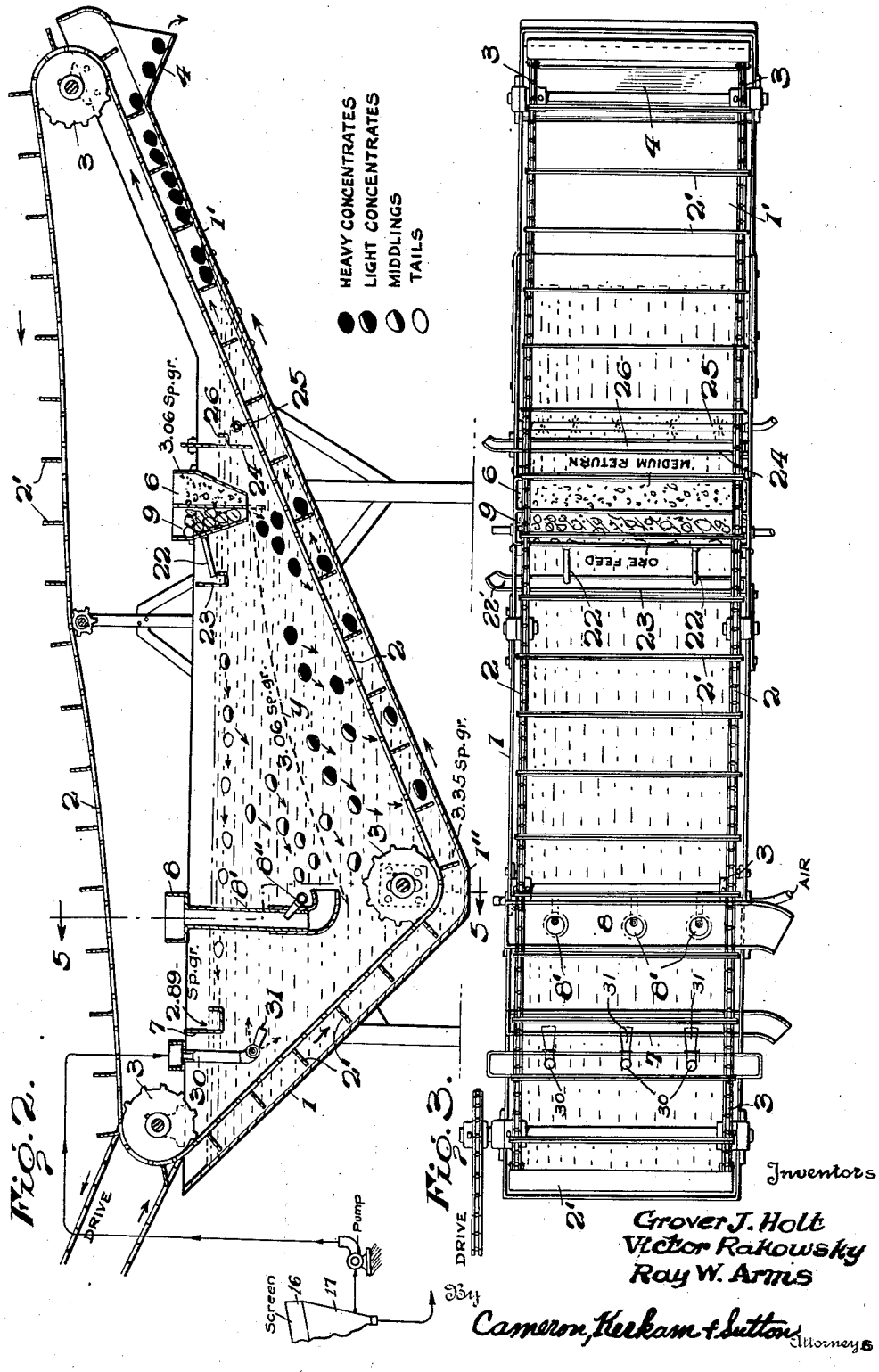

Fig. 2.

Fig. 3.

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PROCESS AND APPARATUS FOR SEPARATING FRAGMENTARY MATERIALS

Filed Oct. 21, 1940 3 Sheets-Sheet 3

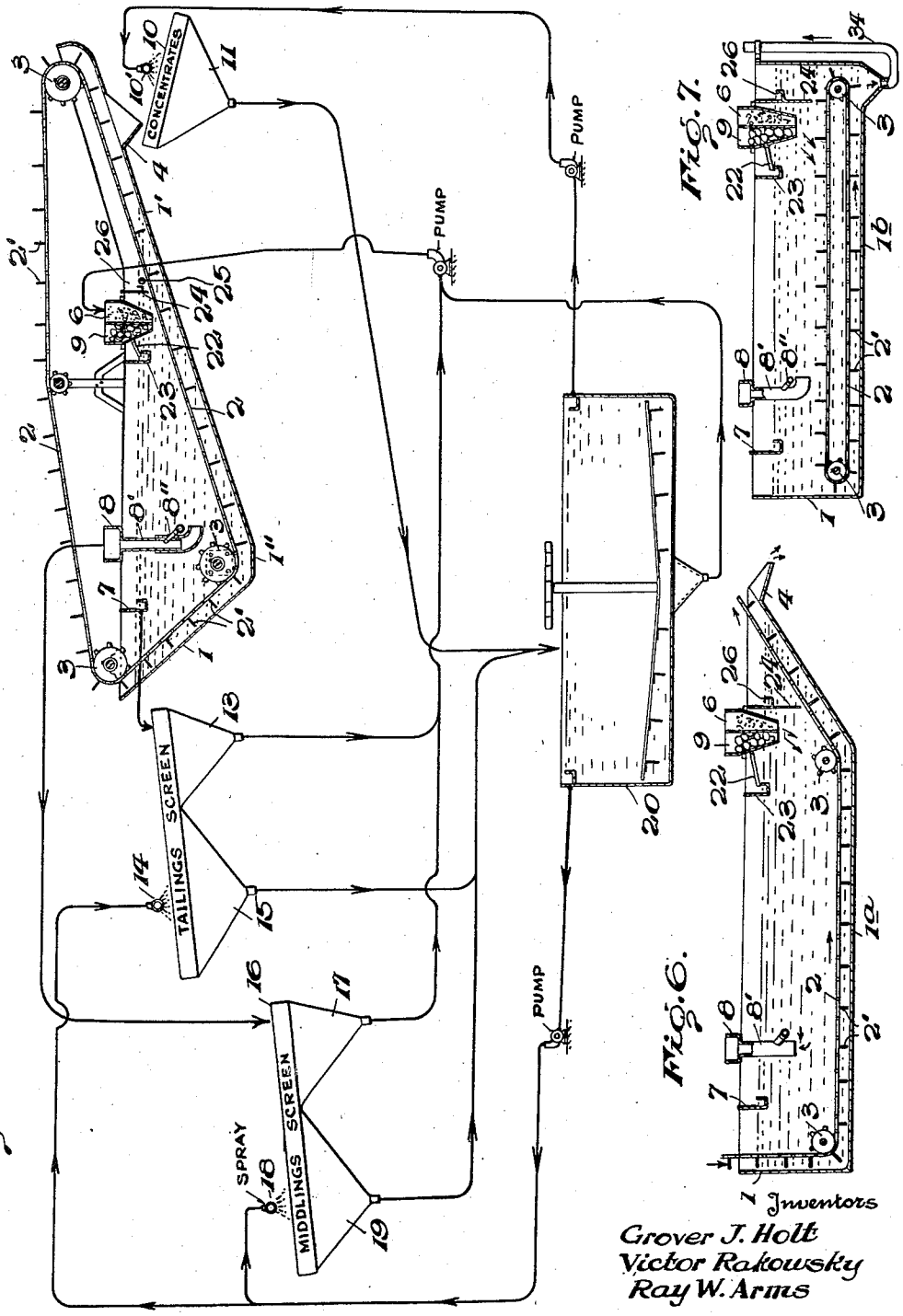

Fig. 4.

Fig. 7.

Fig. 6.

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UNITED STATES PATENT OFFICE

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PROCESS AND APPARATUS FOR SEPARATING FRAGMENTARY MATERIALS

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Application October 21, 1940, Serial No. 362,144

17 Claims. (Cl. 209—173)

This invention has for its object to provide a novel continuous and efficient process and apparatus for separating fragmentary materials of different specific gravities, such as coal, ores and the like.

With this object in view, according to the present invention a tank of some considerable extent in length and of approximately uniform width is provided, which tank preferably gradually increases in depth from the rear end where the materials to be separated are introduced toward the opposite rear end. While this gradual increase in depth of the tank is preferred, it is not essential, since in some cases a tank of approximately uniform depth from the rear end to the front end and of uniform width may be employed.

Into a tank of the character described a separating medium composed of water and comminuted solids and preferably of uniform specific gravity is continuously introduced adjacent the rear end of the tank and is caused to flow through the tank toward the front end at a slow rate. As the medium flows slowly through the tank the comminuted solids of the medium very slowly settle, the rate of settling depending on the strength of the current and the make-up of the medium. The result is that the medium becomes one of gradually increasing specific gravity from the top downward, the rate of increase being controlled by the rate of flow of the medium, whereby a constantly increasing differential between the specific gravities of the top and bottom of the tank is established. Moreover, as the medium flows through the tank from the point of introduction the specific gravity of the upper portion gradually decreases while that of the lower portion gradually becomes greater. The current through the tank is secured and controlled by a plurality of means. One is in the form of an overflow at a point toward the front end of the tank opposite from the point of introduction of the medium. Another is in the form of means for withdrawing medium from the tank at some point or even a plurality of points below the surface thereof and intermediate the point of introduction and said overflow. Both the overflow and the intermediate means for withdrawing medium from the tank are preferably adjustable longitudinally along the tank. That is, the overflow means are preferably arranged to be adjusted toward or from the point of introduction of the medium; and the means for removing the medium from the tank intermediate the point of introduction and the overflow may be adjusted toward or from the point of introduction. Moreover, this intermediate means of removal of the medium may be adjusted to different heights within the body of the medium to the end that the medium may be removed from the tank at different levels therein.

By the means described there is afforded a control of the increase in the specific gravity of the medium from the top downward, which control may be effected anywhere along the tank between the point of introduction of the medium and the point of overflow. There is thus secured a plural control; that of the rate of increase in the differential density of the medium (degree of increase in specific gravity from the top downward) and the position of withdrawal of the medium at any point in the tank between the point of introduction and the overflow, whereby the operator is enabled to select the particular differential density best adapted to effect a separation of the ores under treatment.

For the purpose of illustrating the invention, reference is had to the accompanying drawings, in which—

Fig. 1 is a diagrammatic view somewhat in perspective of one form of tank which may be employed;

Fig. 2 is a diagrammatic longitudinal sectional elevation of the tank shown in Fig. 1;

Fig. 3 is a diagrammatic plan view of said tank;

Fig. 4 is a diagrammatic view illustrating the apparatus employed for recovering the solids from the used medium;

Fig. 5 is a view on the section line 5—5 of Fig. 2;

Fig. 6 is a diagrammatic side elevation of a modified form of the tank;

Fig. 7 is a like diagrammatic side elevation of still another form of tank that may be employed;

Fig. 8 illustrates a construction alternative to that shown in Fig. 5; and

Fig. 9 is a detail of the entrance ports of the air lifts.

Referring to the drawings, in which like reference numerals indicate like parts throughout the several views, 1 is a tank of considerable longitudinal extent and preferably of approximately uniform width, which tank is of constantly increasing depth from the rear end 1' to the point 1''. While the tank may be of constantly increasing depth from the rear end to the other, as shown in Fig. 1, such increase in depth at the end 1'' is not absolutely essential. At or near the point 1'' the bottom of the tank may be flat, or of other desired shape. As shown in Figs. 1 and

2, a plurality of endless carriers 2—2, preferably in the form of chains, and carrying suitably spaced scraper flights 2' are passed over sprockets 3—3, driven from any suitable source of power, said sprockets being so arranged that the scraper flights 2' drag along or close to the bottom of the tank, moving in the direction indicated by the arrows. An extension of the bottom of the tank (on the right hand as illustrated in Figs. 1 and 2) projects a considerable distance upward out of the tank to a chute 4.

Extending across the tank from side to side near the shallow end thereof, is a chute 6 through which a ribbon of a separating medium of uniform specific gravity is continuously introduced into the tank, said ribbon extending across the tank from side to side. Extending across the tank and adjacent the end opposite from the medium feed chute 6 is an overflow trough or conduit 7, the bottom of which is somewhat below the surface of the medium in the tank when in operation. This overflow chute 7 may be and preferably is adjustable longitudinally of the tank. That is, it may be moved nearer to or more remote from the medium feed chute 6. Between the medium feed chute 6 and the overflow 7 means are provided for removing medium from the tank which means are preferably adjustable both longitudinally and vertically in the tank. As here shown, such means take the form of a chute 8 adjustable longitudinally of the tank 1 toward or from the overflow. The chute carries telescopic conduits 8' which, by reason of the telescopic construction, enable the entry ports 8'' to the conduits to be adjusted vertically, thus providing means whereby the inlet ports 8'' (Fig. 2) of the conduits 8' may be raised or lowered within the tank. While this construction is preferred, any suitable means for adjusting the entrance ports 8'' vertically and longitudinally of the tank may be employed. As illustrated in Fig. 8, the entrance port or ports 8'' may be in the form of an open end or ends of a tube or tubes having a universal mounting 8a in the side walls of the tank and connected with suitable means 8b for withdrawing medium from the tank through the ports 8'', such as a pump, air lift or the like.

Means for feeding the material to be separated are provided, preferably adjacent to and immediately in front of the medium feed chute 6, said means taking the form of a chute 9 or other feed means extending across the tank from side to side and arranged to feed a ribbon of the ores or other materials across the tank from side to side and immediately in front of the ribbon of medium delivered into the tank from the medium chute 6, to the end that the separating medium and the materials to be separated are fed in the form of adjacent ribbons extending across the tank.

Disregarding now for the moment the infeed of the materials to be separated, it will be noted that when the medium is fed into the tank and the same becomes filled to the level of the overflow 7, a current will be created along the tank, the rate of flow of the current depending upon the rate of flow of the medium at the inlet. When the medium enters the tank at the chute 6 it is of uniform specific gravity, and being composed of water and comminuted solids, the solids will tend to very gradually settle toward the bottom of the tank as the current or medium moves along towards the overflow 7 and the air lift 8'. The result of this very gradual settling of the comminuted solids is to convert the medium which was of uniform specific gravity when it was introduced into the tank into a medium of differential density, that is, one in which the specific gravity of the medium gradually increases from the top to the bottom. Moreover, as the medium flows through the tank the specific gravity of the upper portion of the medium gradually decreases, while the specific gravity of the lower portion of the medium gradually increases, and these specific gravities will continue such gradual decrease and increase as the medium flows along through the tank. This gradient or differential between the top and bottom specific gravity is controlled by the rate of flow of the medium from the intake chute 6 to the overflow 7 and the air lifts 8'. The rate of flow of the current and the position of the overflow and the air lifts all being under the control of the operator, the gradients are under his control.

There will be a line between the top and bottom of the medium, as it flows along through the tank, where the specific gravity will be that of the medium at the point where it is introduced. The exact position of this line will vary depending upon the rate of flow of the medium through the tank, but there will always be a line at any cross section of the tank and somewhere between the top and the bottom where the specific gravity of the medium will be that of the medium when introduced into the tank.

When the particles to be separated are fed across the tank in the form of a ribbon immediately adjacent or near the inflowing ribbon of medium of uniform specific gravity, particles of ore fall upon said medium and the particles whose specific gravity materially exceeds that of the incoming medium will quickly sink to the bottom, while any of the particles which are lighter than the specific gravity of the medium at the point of introduction will float possibly carrying with them entangled therewith some particles whose specific gravity even exceeds that of the incoming medium; other particles having a specific gravity equal to or greater than that of the desired concentrates may be carried along by the medium current for some distance but will sooner or later sink to the bottom. As the medium flows along the specific gravity at the top decreases and any particles whose specific gravity exceeds that of the overflow will settle in the medium until they reach a depth where their specific gravity is the same as that of the medium. This separates the ore particles into concentrates, middlings and tails.

This is diagrammatically illustrated in Fig. 2. When medium of a uniform specific gravity, for example, 3.06, and composed of water and comminuted solids, is introduced at the chute 6 and caused to flow through the tank to the overflow 7 and air lifts 8', the solids in the medium will very slowly settle, the rate of settling depending upon a number of factors, such as the character of the solids in the medium, the proportion of solids and water and the rate of flow of the medium through the tank. This gradual settling of the solids will produce in the tank a medium in which the specific gravity will gradually increase from the top downward. Furthermore, as the medium advances through the tank from the feed chute 6 the specific gravity of the top portion of the medium gradually and continuously decreases, while the specific gravity of the bottom portion of the medium grad-

ually and continuously increases. There will always be a line extending from the feed chute 6 towards the opposite end of the tank which will be of the same specific gravity as that of the medium at the point of introduction. If the specific gravity of the introduced medium is 3.06, for example, there will be a line extending along through the medium in the tank where the medium has a specific gravity of 3.06. The exact position of this line will, of course, vary, but for the purpose of illustration it is shown in Fig. 2 at *y*. All of the ore particles introduced at the chute 9 whose specific gravity exceeds 3.06 will settle below this line *y*, and all of those particles whose specific gravity is less than 3.06 will be floating or suspended in the medium above or but slightly below that line. Before they reach the air lift 8' all of the concentrates whose specific gravity equals or exceeds that of the bottom (say 3.35) will have settled into the path of the flights 2'; all of the ore particles whose specific gravity is equal to or less than that of the surface portion of the medium in the tank when it reaches the air lift will float and will be discharged through the overflow 7; and all of the ore particles which are of greater specific gravity than the surface portion of the medium at this point and of less specific gravity than the bottom portion will be suspended in the medium below the upper portion thereof. That portion of the particles of intermediate specific gravity which is thus suspended within the gradient or controlled differential of the medium will be drawn by the air lifts thereinto and discharged from the tank together with some medium. The result of this is that all of the ore particles whose specific gravity is greater than that of the medium along the bottom of the tank are removed by the drag, while those whose specific gravity is less than that of the bottom are eliminated by the overflow of the air lifts from the tank. This produces a highly efficient and accurate separation of the particles into concentrates, tails and middlings.

By reason of the fact that the drags extend up an incline considerably above the surface of the medium in the tank, little or no medium in liquid form is discharged by the drags throughout the chute 4. The heavier particles thus discharged are wetted with the medium and carry more or less of the comminuted solids associated therewith. These particles are discharged through the chute 4 upon a suitable screen 10 (Fig. 4) and are sprayed with water from the spray 10'. The water and comminuted solids washed off the heavier particles pass through the screen into a suitable receiver 11, while the heavier particles thus washed clean are delivered from the screen. The lighter particles carried out of the tank at the overflow 7 are accompanied by a considerable amount of the medium and are discharged upon a screen 12. The medium flows through the screen into a receptacle 13, while the particles descend along the screen and are subjected to sprays 14 which wash the comminuted solids therefrom, the water and solids passing through the screen and into a receptacle 15, the washed particles being delivered from the screen 12.

The discharge from the air lifts 8' consists of a considerable body of medium carrying therein the ore particles withdrawn therewith and this medium, together with the particles, is delivered to a screen 16, the medium flowing through the screen into a receptacle 17, while the particles are advanced along the screen under a spray 18 where any of the comminuted solids of the medium adhering thereto are washed therefrom, and together with the spray water, are delivered into a receptacle 19. The medium which is thus delivered into the receptacles 13 and 17 may be and preferably is returned to the tank 1 together with medium from the tank 20 through the chute 6 by means of a pump or otherwise; or such portion of it as may be desired may be returned from receptacle 17 to the tank through conduits 30 (Fig. 2) having universally mounted delivery portions 31 preferably located at a point beyond the air lifts 8' and not too close thereto. The wash water from the sprays 10', 14 and 18 and which is received in the receptacle 11, 15 and 19 may be and preferably is conveyed to a suitable settling tank 20 for reconditioning and reuse. This tank 20 is of considerable size, and as the solids settle therein, the settling tends to more or less clarify the water at the surface of the tank and it may be delivered to the respective sprays by means of suitable pumps.

This matter of washing the particles to conserve the comminuted solids adhering thereto forms no part of the present invention, it being a process well known in the art.

It will, of course, be understood that the reconditioning of the medium may be effected by any suitable or well known means, and that, therefore, there is little or no waste of the comminuted solids employed in the medium.

In some cases the ores or other particles that are fed into the tank are washed before being introduced thereinto in order to free them from slimes and other objectionable particles. By reason of the large amount of ore or other particles thus washed and fed into the tank, the films of water surrounding each particle in the aggregate constitute a considerable amount of water, and this water being of less specific gravity than that of the medium itself would immediately rise to the surface of the medium in the tank. Means are provided in the form of suitable outlet or outlets for removing this water. This rising of water may even occur in the lower portion of the infeed ribbon, and in that case suitable outlet 22 (Fig. 2) or outlets are provided for eliminating such water.

In order to effect this delivery of the water from the tank before it is carried along to any extent on the surface of the medium, a baffle or plurality of baffles 23 (Fig. 2) extends across the tank, and to a limited extent below the surface of the medium. These baffles interrupt the flow of water along the surface of the medium and serve to more effectively remove this water through outlets 22'.

In that portion of the tank to the rear of the medium intake chute 6 the medium tends to be quiescent, with the result that some particles being elevated by drag flights 2' may tend to rise therein and escape the action of the flights. A baffle 24 extends across the tank and downwardly into the medium to approximately the path of the drag flights, and an inlet 25, preferably in the form of sprays, is provided for introducing water to the rear of this baffle, thereby decreasing the specific gravity of the medium to the rear of the baffle and insuring the settling of any of these particles to a point within the range of the baffle flights. An outlet 26 is provided for carrying off the water which will thus rise to the

surface of the medium immediately to the rear of the baffle 24.

Referring now to Fig. 6, there is therein shown a tank 1a of uniform depth for the greater portion of its length with its bottom to the rear of the intake of medium and ore materials extending upward along an incline at the rear end of the tank for the delivery of the heavier separated particles by a suitable drag. In Fig. 7 there is shown a tank 1b of uniform depth from end to end and a drag which delivers the heavier particles from the bottom of the rear end of the tank from which they may be delivered by an air lift or otherwise as desired.

It will be understood by those skilled in the art that the invention is not limited to the specific apparatus herein illustrated, but that various modifications thereof may be used for effecting the same result, and such modifications as fall within the terms of the appended claims are designed to be included therein. For the purpose of this description the point of overflow is to be regarded as the front end of the tank and the opposite end as the rear end thereof.

What is claimed is:

1. In an apparatus for separating ore particles having different specific gravities, the combination of a tank containing a liquid separating medium consisting of water and comminuted solids, means introducing said medium at uniform specific gravity adjacent one end of said tank and into the surface portion of the medium in the tank, overflow means adjacent the other end of the tank, means for feeding ore particles into the surface portion of the medium in the tank and intermediate the introduction of the medium and said overflow means, a baffle extending across the tank and projecting downward into the surface portion of the tank between the ore feed inlet and said overflow, and a liquid outlet between the baffle and ore feed and adjacent the surface of the medium in the tank.

2. In an apparatus for separating ore particles, a tank containing a separating medium composed of water and comminuted solids, means continuously introducing said medium at uniform specific gravity into the surface portion of the medium in the tank adjacent one end thereof, overflow means adjacent the opposite end of the tank, ore feeding means introducing the ore particles into the surface portion of the tank intermediate said medium inlet and said overflow, a baffle extending across and projecting above the surface portion of the tank, a liquid outlet between the baffle and ore feed and adjacent the surface of the medium in the tank, and an air lift between said baffle and said overflow means and removing portions of the medium intermediate the top and bottom portions thereof with associated ore particles from the tank.

3. In an apparatus for separating ore particles, a tank containing separating medium composed of water and comminuted solids, means continuously introducing said medium at uniform specific gravity into the surface portion of the medium in the tank at one end thereof, overflow means adjacent the opposite end of the tank, ore feeding means introducing the ore particles into the surface portion of the medium in the tank intermediate said medium inlet and said overflow, and an air lift the inlet to which is between said ore feed means and said overflow means and intermediate the top and bottom of the tank and removing portions of the medium with associated ore particles from the tank.

4. In a continuous process of separating ore particles, the steps of continuously introducing into a tank a separating medium consisting of water and comminuted solids and of uniform specific gravity, flowing the medium along the tank to a point of overflow, continuously introducing ore particles into the tank between said overflow point and the point of introduction of the medium, removing a portion of the medium with the ore particles suspended therein at a point intermediate the upper and lower zones of the medium through a common passage, separating the removed ore particles from such removed medium and returning removed medium to the tank at a point therein between the point of removal and the overflow point.

5. In a continuous process of separating ore particles, the steps of continuously introducing into a tank a separating medium consisting of water and comminuted solids and of uniform specific gravity, flowing the medium from the point of introduction along the tank to a point of overflow, introducing ore particles into the tank between said overflow point and the point of introduction of the medium, removing a portion of the medium together with the ore particles suspended therein at a point intermediate the upper and lower zones of the medium, separating the removed ore particles from such removed medium and returning removed medium to the tank at a point therein within the body of the flowing medium.

6. In an apparatus for separating ore particles wet with water in a tank containing a liquid separating medium, an ore feed conduit extending down to the surface of the medium in the tank, said feed conduit having a liquid outlet therefrom above the surface of the medium in the tank.

7. In an apparatus for separating ore particles wet with water, a tank containing a liquid separating medium, an ore feed conduit extending down below the surface of the medium in the tank, said feed conduit having a liquid outlet therefrom above the surface of the medium in the tank.

8. In a continuous process of separating ore particles, the steps of introducing into a tank a single separating medium of uniform specific gravity and composed of a liquid and comminuted solids, flowing this medium along the tank from the point of introduction, controlling the flow of the medium to produce and maintain therein a differential density the differential of which gradually and continuously increases as the medium moves from the point of introduction, controlling such increase in differential density, continuously introducing the ore particles into the medium, withdrawing a portion of the medium of intermediate specific gravity with the ore particles suspended therein from the tank and separating the withdrawn medium and ore particles after withdrawal.

9. In a continuous process of separating ore particles the steps of introducing the ore particles into a medium of uniform specific gravity and flowing the particles through a body of said medium while its specific gravity gradually and continuously increases from top to bottom and the differential between the top and bottom specific gravities continuously increases as the ore particels move farther and farther from the point of introduction, withdrawing a portion of the medium of intermediate specific gravity with the ore particles suspended therein from the tank

and separating the withdrawn medium and ore particles after withdrawal.

10. In a continuous process of separating ore particles into tails, middlings and concentrates, the steps of continuously introducing into a tank a separating medium of uniform specific gravity and comprising water and comminuted solids and having a specific gravity less than that of the desired concentrates and greater than the specific gravity of the desired tails, introducing the ore particles into said medium adjacent the point of introduction of said medium and flowing said medium along the tank toward a point of overflow, whereby said medium is converted into a medium of constantly increasing specific gravity from the top to the bottom thereof, controlling the rate of increase in the differential between the top and bottom gravities of the medium by controlling the rate of flow of the medium, and withdrawing medium of intermediate specific gravity and the middlings suspended therein from the tank through a common passage.

11. In an apparatus for separating ore particles, a tank containing separating medium composed of water and comminuted solids, means continuously introducing said medium at uniform specific gravity into the surface portion of the medium in the tank at one end thereof, overflow means adjacent the opposite end of the tank, whereby the medium is converted into one of constantly increasing differential between specific gravities of the top and bottom portions of the medium as it flows along the tank, ore feeding means introducing the ore particles into the surface portion of the tank intermediate said medium inlet and said overflow, and an airlift in the tank between the ore feed and said overflow and between the top and bottom of the medium, and means for adjusting the inlet to said airlift in the medium to points of different specific gravity thereof, whereby portions of the medium of a desired specific gravity and the ore particles associated therewith may be removed from the tank.

12. The continuous process of separating ore particles which consists in continuously introducing a separating medium of uniform specific gravity and consisting of water and comminuted solids into a tank adjacent one end thereof, flowing said medium along the tank and thereby converting it into a medium of increasing specific gravity from the top to the bottom, controlling the differential in specific gravity thus created, continuously overflowing the surface portion of the medium from the tank adjacent the other end thereof, continuously introducing the ore particles into the tank near the point of introduction of the medium, and removing from the tank a portion of the medium intermediate the top and bottom portions thereof together with ore particles suspended in said removed portion through a common passage intermediate the ore feed and said overflow.

13. The continuous process of separating ore particles which consists in continuously introducing a separating medium consisting of water and comminuted solids and of uniform specific gravity into a tank, continuously flowing said medium along the tank, continuously overflowing the surface portion of the medium from the tank, converting said medium into one of constantly increasing specific gravity, introducing the ore particles into the tank near the point of introduction of the medium, and removing medium intermediate the top and bottom zones thereof together with ore particles suspended in the removed medium through a common passage from the tank intermediate the ore feed and such overflow.

14. In an apparatus for continuously separating ore particles in a tank containing a liquid separating medium consisting of water and comminuted solids, means continuously introducing the medium into the tank near the rear end thereof, means continuously feeding the ore particles into the tank, means removing the heavier ore particles from the tank to the rear of the medium inlet, a baffle within the tank to the rear of said medium inlet and extending across the tank and from the surface of the medium in the tank to a point adjacent the means for removing the heavier ore particles, means reducing the specific gravity of the medium to the rear of said baffle, said means consisting of a water inlet to the tank below the surface of the medium and a liquid outlet adjacent the said surface, both the inlet and outlet being located to the rear of said baffle.

15. In a continuous process of separating ore particles, the steps of continuously introducing into a tank of horizontal extent a separating medium of uniform specific gravity and consisting of water and comminuted solids, so flowing said medium along the tank toward a point of overflow as to convert it into a medium of constantly increasing specific gravity from the top to the bottom and with constantly increasing differential between the specific gravities of the top and bottom as it flows along the tank, controlling the rate of increase of such differential, continuously introducing ore particles into said medium adjacent the point of introduction of the medium, separating said particles by the medium as it flows along the tank into "tails" "middlings" and "concentrates," withdrawing separated middling and medium of intermediate specific gravity supporting the same through a common passage, then separating the withdrawn medium and middlings.

16. In a continuous process of separating ore particles into "concentrates," "tails" and middlings," the steps of feeding a single separating medium comprising water and comminuted solids, and whose specific gravity exceed that of the tails but is less than that of the concentrates, into a tank of horizontal extent and flowing said medium through the tank from the point of introduction toward a point of overflow from the tank, whereby there is established a medium of constantly increasing specific gravity from the top to the bottom thereof, controlling the rate of increase in the differential between the top and bottom gravities of the medium as it advances from the inlet by withdrawing medium at a point between the inlet and the overflow, introducing the ore particles into the medium adjacent the point of introduction of the medium, whereby the tails float to the top and the concentrates sink to the bottom of the medium and the middlings are suspended in the medium, and removing suspended middlings from the tank, in company with the medium suspending the same through a common passage.

17. In a continuous process of separating ore particles into "concentrates," "tails" and "middlings," the steps of continuously feeding a single separating medium comprising water and comminuted solids, and whose specific gravity exceeds that of the tails but is less than that of the concentrates, into a tank of horizontal extent and flowing said medium through the tank from the

point of introduction toward a point of overflow from the tank, whereby there is established a medium of constantly increasing specific gravity from the top to the bottom thereof, controlling the rate of increase in the differential between the top and bottom gravities of the medium by modifying the rate of flow of the medium as it advances from the inlet, continuously introducing the ore particles into the medium adjacent the point of introduction of the medium, whereby the tails float to the top and the concentrates sink to the bottom of the medium and the middlings are suspended in the medium, and removing suspended middlings in company with the medium suspending the same from the tank.

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