

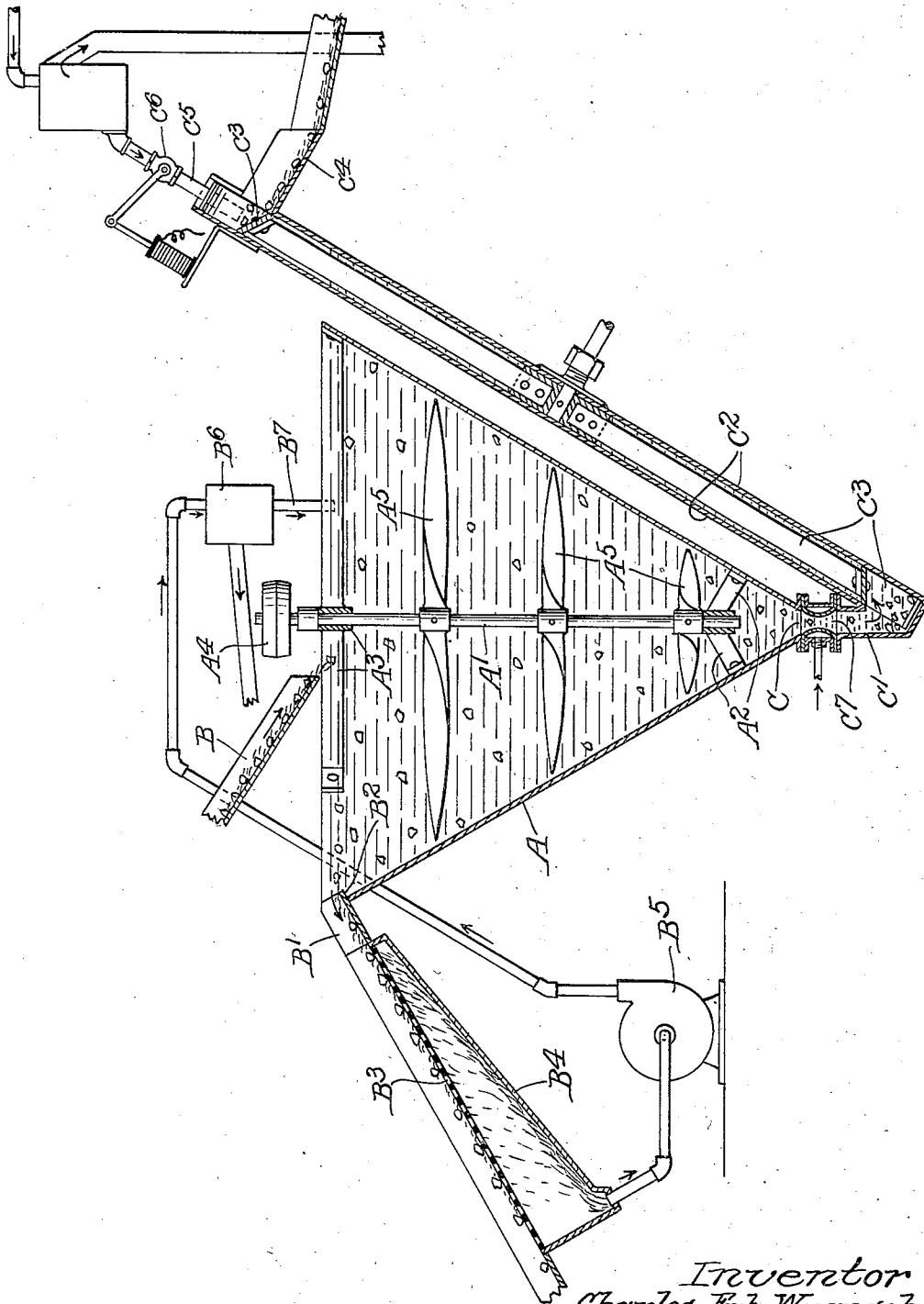
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APPARATUS FOR CLASSIFYING MATERIALS

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APPARATUS FOR CLASSIFYING MATERIALS

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My invention relates to improvements in gravity wet separating apparatus and has for one object to provide a new and improved form of apparatus for gravity separating, classifying or concentrating wherein and whereby fragmentary materials of different specific gravity may be gravitally separated, classified or concentrated with a minimum of expense in an apparatus of large capacity.

In general, it is well-known that if comminuted materials of varying specific gravities are floated in a fluid supporting medium whose specific gravity approximates the point at which the gravital concentration is to take place, the heavy particles will sink to the bottom and the light particles will float at the top and so the heavy and the light particles may be separately removed.

When this floating principle is made use of to concentrate materials and when large capacities are required, large masses of material are fed to the classifying tank at a high rate of speed and the concentrated materials are drawn off at a high rate of speed and the result is that heavy particles will be floated off with the light particles and light particles will be entrained down and carried away with the heavy particles and an accurate concentration especially of the specific gravities not widely different becomes exceedingly difficult. Moreover, because under these circumstances all the concentration must take place in a single horizontal plane, the space in which concentration takes place becomes relatively small and accuracy and capacity both suffer.

I propose to increase the volume of the zone within which concentration takes place and to cause gravital concentration not in a single horizontal plane but in a relatively extended volume of the floating medium. I accomplish this by providing a concentrating tank and maintaining in this concentrating tank a bath of liquid material whose specific gravity increases from the surface downwardly, maintaining such controlled increase of specific gravity at all times during operation. With this arrangement, I prefer to have the specific gravity of the medium at the surface slightly less than the specific gravity of the

lightest particles so that the danger of the light particles being entrained with the effluent at the surface before sufficient time has elapsed for concentration, is reduced to a minimum. The specific gravity of the differential density column increases downwardly until at some point at or near the bottom of the cone the specific gravity is greater than that of the lightest particle. It is evident, therefore, that the lightest particles cannot sink below this point and as more material is sent to the cone, that a bed of the lightest particles is built up from this point, which crowd each other upwardly, so that the excess volume of lighter particles is discharged at a suitable discharge point. The particles heavier than the medium, of course sink through the medium column and are immediately removed by a suitable discharge device, but the particles of intermediate gravity accumulate below the bed of lighter particles and by virtue of the weight of the supernatant bed of lighter particles are crowded downward to be discharged with the heavier particles.

In order that the light material may be drawn off from the top of the tank, it is of course essential that there be an outflow of the concentrating or separating medium so that there is of necessity a constant flow of this fluid medium from the tank at the top entraining with it the light particles. This overflow passes over a screen device which separates the lighter particles from the medium. The medium is returned to the top of the separatory cone near the center by a pump or other circulating device. The specific gravity of the return medium is substantially the same as it was when it overflowed from the cone, but the volume returned is somewhat less, and therefore this difference in volume and density is replaced by liquid fed into the bottom and because of this continuous flow of liquid to, through and from the tank, it is possible by manipulating the density of the inflow and if necessary combining it with diluents in proper proportion to maintain throughout the tank a continued controlled variation in specific gravity as above indicated, the specific gravity being a

maximum at the bottom and a minimum at the top. As the material to be concentrated is fed to the tank it is gently stirred horizontally, the stirring being only sufficient to prevent the floating particles from adhering one to another, to make it easy for the heavier particles to find their way downwardly, each particle sinking to a point at which the specific gravity of the liquid is equal to the specific gravity of the particle. The stirring also insures that conditions will be generally constant throughout each horizontal plane intersecting the vertical axis of the tank so as to minimize vertical eddy currents which otherwise might tend to interfere with the gradual change in specific gravity of the separating liquid from the top to bottom of the tank. The stirring of the material in the bath associated with the continual feeding in of material to be classified and the continual drawing off of the heavy material from the bottom and the light material from the top is assisted normally by a concentration of the material caused by the preferred conical shape of the tank so that in general there is a concentration intermediate between the top and bottom of the tank of the materials whose specific gravity is not widely different. This concentration is more or less continuous with the heavier particles being forced downwardly and the light particles being forced upwardly so that there is a continuous outflow of light particles at the top and heavy particles at the bottom.

35 Illustrating the operation of my device, if we are treating ore, the concentrate, the thing that we want to save is heavy, the refuse or tailings are light, the weight of the tailings is more or less constant and we set the apparatus to discharge all the rock or light particles from the top, all the pure ore or heavy particles from the bottom. There will be intermediate weight particles containing some ore which we will want to recover so the device is set so that those intermediate particles will come out at the bottom with the ore. On the other hand, if we are dealing with a product such as coal where the refuse is heavy, there will very likely be some coal or bone sufficiently rich in coal that we would want to save it. In that case the apparatus would be set, controlled and operated so that the heavy particles, the stone, would be discharged from the bottom, the light particles, the coal, would be discharged at the top, the intermediate particles, coal with a high percentage of ash, would be discharged from the top or the bottom depending upon the proportion of ash which it was safe to have included with the coal.

The heavier particles are drawn off from the bottom through any suitable form of conveyor to a point above the liquid level at which they are discharged, being preferably drawn upwardly along a path outside the

concentrating tank, the light particles flowing over the lip of the tank being discharged and the separating medium which is discharged with the heavy and with the light particles may be allowed to drain off and if necessary to be washed from them and is then fed to any suitable thickening tank where the medium is concentrated or thickened in its specific gravity before it is returned to the tank.

Preferably this separating medium comprises water with in suspension the slimes of the material being concentrated. These slimes must be so fine as to approach the colloidal in their action. In most cases it may be necessary to pulverize or grind up this material to obtain these slimes. Under many circumstances, however, there is sufficient of the fine material mixed with the coarse so that the material itself furnishes its own slimes but of course the liquid as it is drawn off from the material being concentrated is constantly screened or settled or otherwise separated so that its return to the concentrating tank carries only those slimes of sufficiently small size to form a suitable floating medium of controlled specific gravity, although of course under some circumstances a medium of some different character than this might be used and under some circumstances chemicals or chemical solutions having the desired specific gravity may be used, it being necessary in any event that the separating medium or liquid maintained in the bath must be susceptible of control so that its specific gravity may be controlled as above indicated. It must be a medium which is substantially permanent and constant in its character and does not readily separate out because if it is necessary to provide agitation to maintain the slimes distributed throughout the liquid to provide a medium of suitable specific gravity, such agitation will in many instances altogether destroy the concentrating effect by causing undue eddy currents, agitation and violence of flow which would make it impossible for the particles of but slightly different specific gravity to find their way in an orderly and satisfactory manner down to the level in the tank at which the concentration is to take place.

My invention is illustrated more or less diagrammatically in the accompanying drawing, wherein is shown a diagrammatic flow sheet of the apparatus which I propose to use.

Like parts are designated by like characters throughout the specification and drawing.

A is a concentrating cone, larger at the top than it is at the bottom. A¹ is a stirrer shaft mounted on brackets, A² at the bottom, A³ at the top of the cone and driven by any suitable source of power applied through

the pulley A⁴. This shaft carries a plurality of stirring blades A⁵ thereon. It is understood that this shaft travels at a low rate of speed and the shape of the vanes is such as to produce a very slight and very gentle horizontal stirring movement of the fluid in the cone and the particles suspended in it and tending also to exert an outward pressure on the material in the cone so as to force material floated in the cone especially toward the top outwardly toward the outer periphery thereof.

B is a chute adapted to feed the material to be classified to the cone at the top adjacent the center thereof. B¹ is a discharge chute at the top of the cone or tank having a lip or weir B² over which the light material as it is discharged from the tank flows with a certain amount of the separating fluid. B³ is a screen over which the material travels having a water box B⁴ beneath it associated with a centrifugal pump B⁵ which feeds the fluid as it drains off the lighter material back to a control and by-pass valve B⁶ and thence to the tank through the pipe B⁷.

C is the discharge throat of the cone or tank. In this case it is shown for convenience as exemplified by a pneumatically controlled flexible iris valve. Leading from this valve is a pipe C¹ which discharges to a concentrate boot C² in which is a scraper wheel C³ adapted to pick up the heavy material, lift it and discharge it through the chute C⁴ at a point above the common level of the liquid in the cone or tank A and the boot C². C⁵ is a pipe controlled by a valve C⁶ through which the flotation or liquid medium is fed to the boot C² whereby a current of medium passes down through the boot up through the pipe C¹ valve C to the tank so that the flow of the liquid is upward through the concentrating cone.

The means whereby the slimes or fines are mixed with this medium and the means whereby the particles too coarse to be satisfactory as part of the medium since they form no part of the present invention are not here shown and it will be understood that any suitable means are shown to insure that the solids in suspension in the fluid which give it its increased specific gravity are of such size and such volume generally in the order of colloids that they form an intimate mixture with the liquid itself such as to give the liquid an accurately controlled specific gravity constant throughout and controllable by intermixing so that the specific gravity of the liquid or separating medium in the concentrating tank may be controlled with a sufficient degree of accuracy such that as the solids pass downwardly through the medium and are gently stirred or propelled by the stirring device, those solids will pass downwardly through a medium of gradually increasing specific gravity.

The use and operation of my invention are as follows:

Starting with the concentrating tank containing the bath of separating or concentrating medium with the specific gravity of the medium a minimum at the top and a maximum at the bottom and with the stirrer in operation imparting to the bath a rotary motion, material be it coal or any other mineral or material to be concentrated is introduced to the tank at the center. All of this material being heavier in specific gravity than the medium of the bath at the top commences to sink because the specific gravities of the various particles vary among themselves; these particles will sink at varying rates of speed and they will continue to sink until the bath is substantially completely filled with a mass of loosely engaging floating stirred and moving particles, the heavy particles gravitating toward the bottom, the lighter particles sinking less rapidly and being suspended toward the top. The heaviest particles will pass on to the bottom of the tank, will be withdrawn by the concentrate conveyor whatever form it may take and be taken away without any substantial admixture of the light particles. The lighter particles as they are left by the heavier particles will tend to concentrate toward the top of the tank and as there is a rapid outflow of medium from the top of the tank and as the centrifugal action of the stirrer tends to propel the particles toward the outer periphery of the tank, these light particles will be entrained with the lighter specific gravity portion of the medium and carried over the lip of the tank.

Because no material to be separated is absolutely homogeneous in so far as its specific gravity is concerned and because separation is done entirely by gravity, a considerable area must be provided so that each particle will have a considerable path along which it may travel while it separates itself by gravity from the other particles, and because the specific gravity of the medium increases downwardly, each particle finds itself at the point at which it will no longer sink unless it belongs to that group whose specific gravity is greater than the medium, which group passes out of the tank altogether. Thus lighter particles which stop in their downward travel a greater or less distance below the surface of the floating medium will concentrate in the plane at which they cease to go down, will travel outwardly under the influence of the stirrer and will be entrained and discharged from the tank by the flow of light floating medium from the top of the tank.

This concentration cannot practically take place in the absence of a controlled gradual increase in density of the floating medium because if we undertake to provide a floating medium of constant density throughout, all

the particles heavier than the floating medium will try to sink to the bottom, all the particles lighter than the medium will tend or try to stay at the top and we will make our separation take place entirely in a single plane. Whether this can be done or not in the laboratory makes no difference, the point is that in order to get a sufficient capacity to make the device commercially useful, we must provide an arrangement wherein this gravitational separation may take place through a considerable range of movement of particles. This is especially true in both ores and coal even though the valuable product in one case is the light material and in the other case the heavy material. Consequently the separation would have to take place at the surface of the cone and if the separation does take place at the surface of the cone, then in order that sufficient fluid may run out from the cone to give capacity much of the material would be entrained and carried out before it has had time to be separated.

Owing to the fact that my apparatus is intended for large capacity, especially to handle and discharge large amounts of the lighter components being treated, provision must be made for the outflow from the top of the bath or tank of very large volumes of carrier medium. This medium comes of course from the top of the tank where the density of the medium is a minimum. As soon as such carrier or separating medium with the lighter separated materials have left the tank, the medium is screened out from the materials and immediately returned to the top of the tank, no further treatment of the medium being required other than its return to the tank or bath. A sufficient quantity of the denser portion of the medium is fed in from the bottom and the continuous inflow of this denser medium is controlled to maintain the density of the medium throughout the tank at the proper point. The sole purpose of the inflow of such dense medium at the bottom is to maintain proper density. As that dense medium travels upwardly it gradually diffuses with the less dense medium from above and this accomplishes and maintains the controlled variable density. Manifestly it would be impossible to feed in to the bottom of the tank sufficient volume of carrier medium to take care of the discharge of the bulky larger proportion of the material treated without setting up upward currents in the tank or bath which would interfere with the proper stratification of the material in suspension in the medium.

Because the major portion of the medium, perhaps ninety-five percent is returned directly to the tank without further treatment, only some five percent which goes off adhering to the classified material and which must be washed off the material needs to be treated or thickened before it is returned to

the bath, hence my apparatus and process does not have to be burdened with a large, expensive and cumbersome thickening apparatus, a thickener being needed only to take care of the remaining five percent which when thickened is returned at the bottom of the tank and furnishes the denser medium.

Because the specific gravity of the fluid medium varies from a maximum at the bottom of the column or tub to a minimum at the top and because there is a distinct difference in specific gravity decreasing as you go up the column and because we are dealing with particles having a wide range of specific gravity some greater than the maximum specific gravity of the fluid column, others less than the minimum specific gravity of the fluid column and others in the range between the maximum and minimum of the fluid column, we have three separate conditions to consider.

Those particles which are discharged into the tub and which are heavier than the maximum specific gravity of the fluid will, of course, go to the bottom of the column and be discharged. Those particles which are discharged into the tub whose specific gravities are less than the minimum will, of course, float to the top of the column and be discharged. Those particles, and these form the true middlings, whose specific gravities are less than the maximum and greater than the minimum, will be concentrated in the tub between the top and the bottom and will stay there until something happens to get them out. The thing that happens is that as material is fed into the tub, there will be a gradually increased concentration of such particles in the column until those particles which are just about at the separating point, either a little above or a little below the average density of the column will tend to be gradually forced, down if they are heavier than the average, and up if they are lighter than the average, so that the crowding action of the material in the tub will gradually force out the middlings if light from the top of the tub, if heavy from the bottom of the tub. This forcing action will not take place until a certain concentration of middlings in the column has taken place. There is a limit to the capacity of the column to contain middlings. As that limit is reached, middlings will continue as long as the middling product continues to be supplied to the tub and will continue at substantially the same rate as that at which middlings are fed to the tub, this, however, taking place only after the initial concentration of middlings has occurred.

This action is very different from the action that takes place when material is separated in a tub wherein the specific gravity is the same throughout or wherein there is a sharp line of cleavage between the specific gravities of two floating media because in

either of those two cases, everything that is too heavy sinks, everything that is too light floats off immediately, the separation takes place and must take place in a single horizontal plane and there is no possibility for the formation of or for the accurate treatment of a mass of true middlings and that being the case, there can be no crowding out partially above and partially below of the accurately separated middlings product.

Stirring when associated with a separating process such as mine is desirable only so far as it prevents adhesion of individual particles one to another in the mass. If the particles did not tend to adhere perhaps owing to surface tension of the liquid, stirring could be dispensed with and would be because it is undesirable in that it tends to slow down or interfere with the accurate concentration of the middlings and the accurate control of the variable density. The more violent the agitation, the more difficult it becomes to maintain an accurately controlled variation in density of the column and the more difficulty we have in controlling this variation in density the more inaccurate becomes the separation.

It will be understood that the major mass of material discharged from my concentrator is the light material, be it rock or coal, and that material is discharged from the top of the tub. There is discharged with it a rather large volume of the fluid medium most of which medium is immediately drained off and returned to the top of the tub. There is a tendency toward a dilution of the medium in the tub as a result of this circulation. This dilution is compensated for by supplying to the bottom of the tub a relatively small amount of the heaviest or most highly concentrated medium, which medium as it is gradually diluted tends to rise and tends to maintain the controlled gradually upwardly decreased specific gravity of the column.

Because we are dealing with fluid media comprising preferably water mixed with very fine slimes from the material being treated, there is always possibility that difficulty may arise in controlling the concentration of the heavy medium fed in or controlling the amount and because we are dealing with a column of fluid medium whose specific gravity varies throughout an appreciable range, the slight local or temporary changes in specific gravity of the medium being fed, in the concentration of the medium being fed, in the volume of the medium being fed, or in the volume of the medium being returned, will not ordinarily materially affect the general situation. The worst that can happen would be to change the median line between the maximum and the minimum concentration somewhere between the top and bottom of the column and will not tend to materially change the concentrating effect as would be the case if a change in specific gravity took

place in a tub where there was a sharp change in the specific gravity of the medium, and where the concentration took place in a single concentrating zone. Furthermore, if a sudden change should take place in the specific gravity of the medium entering in the bottom and is detected, an alteration at the top of the tub can easily be made to compensate for this change in bottom gravity.

The specific gravity of the liquid separating medium, is controlled, or caused to increase downwardly from the top to the bottom of the tank by supplying continuously to the bottom of the tank, medium of the maximum specific gravity and supplying to the top of the tank, medium of the minimum specific gravity while simultaneously drawing off from the tank, sufficient of the medium therein contained to compensate for the inflow above referred to.

The heavy medium is supplied through the pipe C⁵ to the concentrate boot C² whence it flows upwardly through the pipe C⁷ to the bottom of the tank, being controlled of course in amount by the valve C⁶. The light specific gravity medium is fed in preferably through the chute by which the raw material is fed. This is preferable because it results in coating the particles of raw material with an envelope of water because normally the diluent or fluid of lightest specific gravity is water. Since the particles are thus coated preliminarily before they enter the bath, adhesion of the solid element of the liquid separating medium is thereby minimized and waste prevented.

Under some circumstances it is sufficient to merely wet down the raw materials as they go in or before they are discharged to the chute. Under other circumstances a separate hose pipe may be provided which discharges into the chute or, if desired of course, could be discharged directly into the tank. Under other circumstances the diluent is provided by washing the gangue as it travels over the screen B³, under which circumstances the separating medium passing over the lip B² with the gangue, is diluted before it returns to the tank through the pipe B⁷.

It must be very definitely understood that this control of specific gravity of the liquid is not in any sense or under any circumstances a result of the settlement downward of particles in suspension, nor is it in any sense a result of agitation of the liquid because the preferable flotation or separating liquid medium comprises water and fine particles, so fine as to approach in their nature colloidal action and under these circumstances these particles do not have time to settle out during the operating cycle sufficiently to in any way effect change of the characteristic of the settling medium.

It will be understood that the process with which I am concerned cannot be carried out

with solids which require any agitation to preserve the fluidic properties, when in suspension of a liquid, because since I propose to make a separation of particles having a very narrow range of specific gravity variation, any such agitation would entirely prevent separation. What I propose to use on the other hand, are mixtures of finely divided solids with water, which materials when finely divided, form suspensions in water that approach solutions in their physical properties.

Thus the control of the specific gravity of the liquid in the tank results from feeding to the bottom of the tank, liquid of highest specific gravity and feeding to the top of the tank, liquid of lowest specific gravity, so that the upward diffusion of the heavy liquid and the downward diffusion of the light liquid, when the relative amounts are properly controlled, result in maintaining constantly during operation, throughout the tank, a fluid separating column whose specific gravity is a minimum at the top, a maximum at the bottom and decreases gradually from the top to the bottom without any zoning or sudden change in specific gravity.

I claim:

1. A gravity separator comprising a tank adapted to contain a liquid separating medium, means for supplying liquid of relatively high specific gravity to the bottom, and liquid of relatively low specific gravity to the top, of the tank, means for withdrawing from the tank a sufficient quantity of the medium to maintain the volume thereof substantially constant during operation and a means for feeding raw material to be separated to the tank, means for withdrawing that part of the raw material whose specific gravity is relatively high from the bottom and that part of the raw material whose specific gravity is relatively low from the top of the tank.

2. A gravity separator comprising a tank, means for continuously maintaining therein a liquid separating bath whose specific gravity increases gradually from the top downwardly, including means for continuously supplying liquid of relatively high specific gravity to the bottom and liquid of relatively low specific gravity to the top of the tank and means for discharging from the tank a sufficient quantity of the medium to maintain the volume thereof substantially constant during operation, and means for controlling the relative rates of inflow of the heavy and the light specific gravity liquids, means for feeding raw material to be separated to the tank, means for withdrawing that part of the raw material whose specific gravity is relatively high from the bottom and that part of the raw material whose specific gravity is relatively low from the top of the tank.

3. A gravity separator comprising a tank, means for continuously maintaining therein a liquid separating bath whose specific gravity increases gradually from the top downwardly, including means for continuously supplying liquid of relatively high specific gravity to the bottom adjacent the center of the tank and liquid of relatively low specific gravity to the top adjacent the center of the tank, means for gently stirring the liquid in the tank along horizontal lines, means for discharging from the tank adjacent the periphery thereof a sufficient quantity of the liquid to maintain the volume thereof substantially constant during operation and means for controlling the relative rates of inflow of the heavy and the light specific gravity liquids and means for feeding raw material to be separated to the tank, means for withdrawing that part of the raw material whose specific gravity is relatively high from the bottom and that part of the raw material whose specific gravity is relatively low from the top of the tank.

4. A gravity separator comprising a tank, means for continuously maintaining therein a liquid separating bath whose specific gravity increases gradually from the top downwardly including means for continuously withdrawing from and returning to the bottom of the tank some of the liquid of high specific gravity, means for continuously withdrawing from and returning to the top of the tank some of the liquid of low specific gravity and additional means for continuously supplying to the bottom of the tank, liquid of relatively high specific gravity and to the top thereof liquid of relatively low specific gravity, and means for discharging therefrom a sufficient quantity of the liquid to maintain the volume thereof substantially constant during operation, means for controlling the relative rates of inflow of the heavy and the light specific gravity liquids, means for feeding raw material to be separated to the tank, means for withdrawing that part of the raw material whose specific gravity is relatively low from the top of the tank.

5. A gravity separator comprising a tank, means for continuously maintaining therein a liquid separating bath whose specific gravity increases gradually from the top downwardly including means for continuously withdrawing from and returning to the bottom of the tank some of the liquid of high specific gravity, means for continuously withdrawing from and returning to the top of the tank some of the liquid of low specific gravity and additional means for continuously supplying to the bottom of the tank, liquid of relatively high specific gravity and to the top thereof liquid of relatively low specific gravity, and means for discharging therefrom a sufficient quantity of the liquid to maintain the volume thereof substantially

constant during operation, means for controlling the relative rates of inflow of the heavy and the light specific gravity liquids, means for feeding raw material to be separated to the tank, means for withdrawing that part of the raw material whose specific gravity is relatively low from the top of the tank, the means for withdrawing the liquid of high specific gravity being associated with the means for removing from the tank, the materials of high specific gravity and the means for withdrawing from the tank liquid of low specific gravity being associated with the means for removing from the tank the materials of low specific gravity.

Signed at Prescott, county of Yavapai and State of Arizona, this 18th day of July, 1932.

CHARLES ERB WUENSCH.