

June 6, 1939.

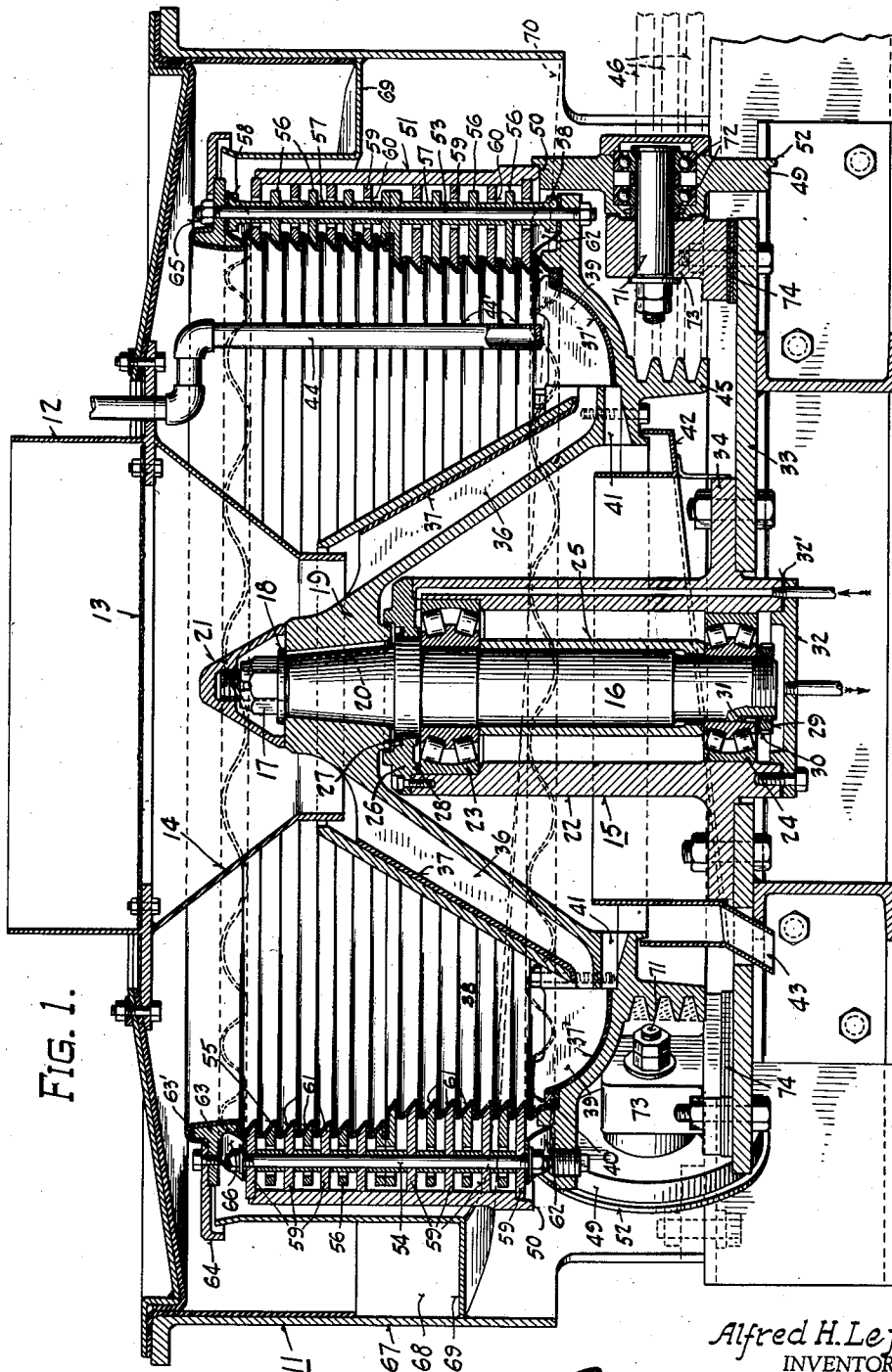
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2,161,476

ORE CONCENTRATOR

Filed Jan. 26, 1938

3 Sheets-Sheet 1



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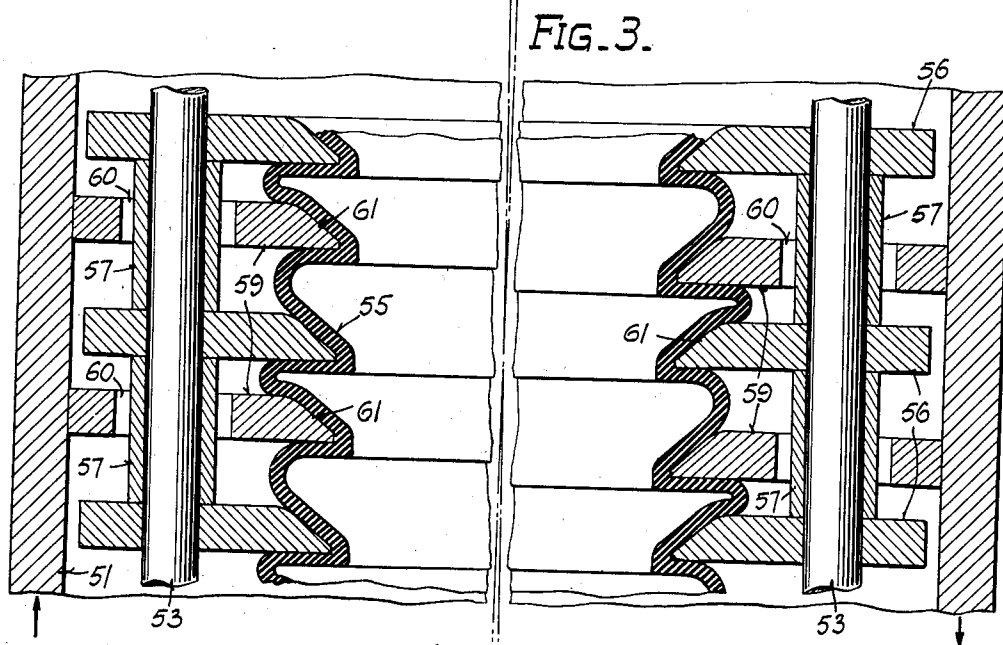
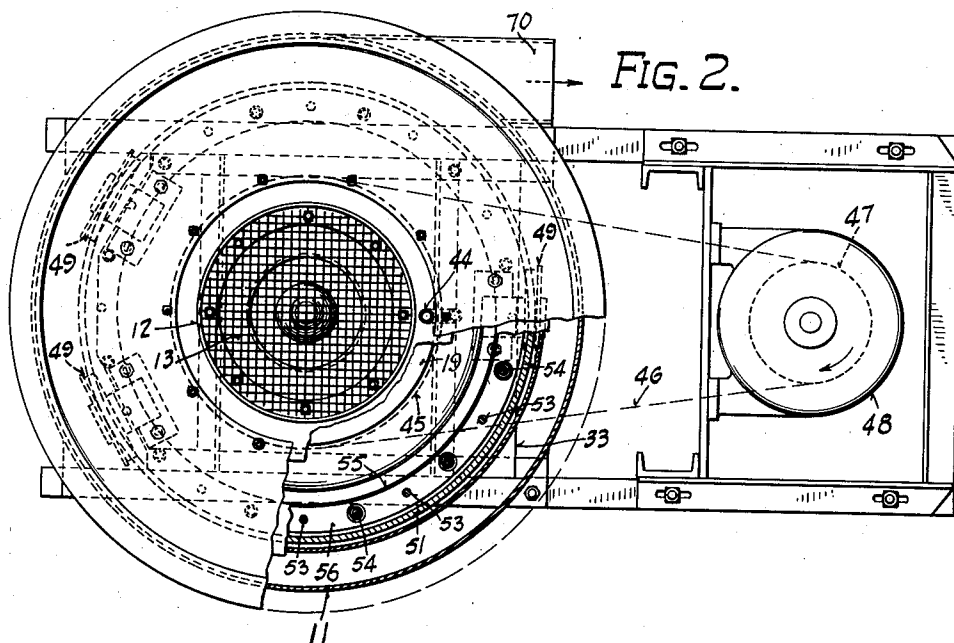
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2,161,476

ORE CONCENTRATOR

Filed Jan. 26, 1938

3 Sheets-Sheet 2



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ORE CONCENTRATOR

Filed Jan. 26, 1938

3 Sheets-Sheet 3

FIG. 4.

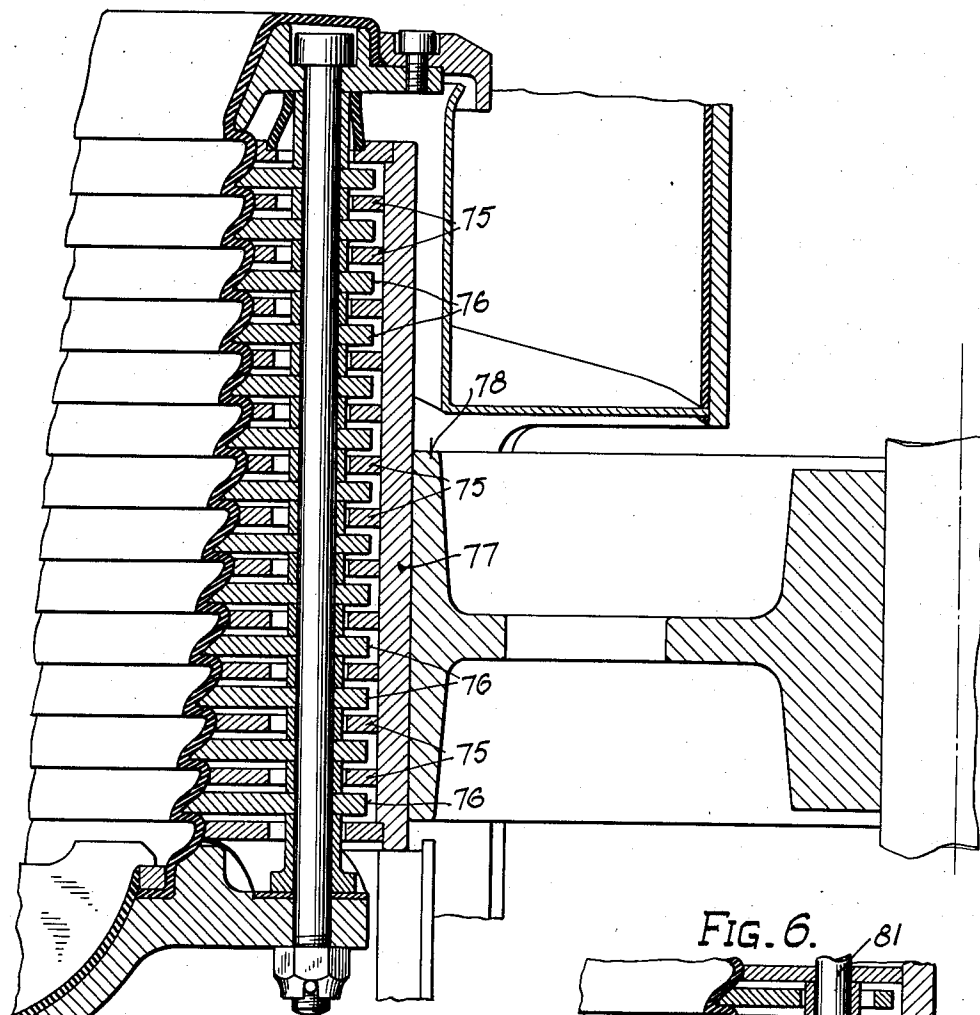


FIG. 5.

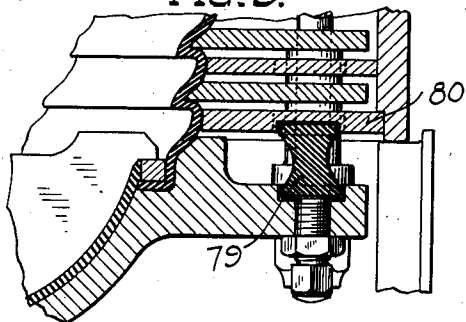
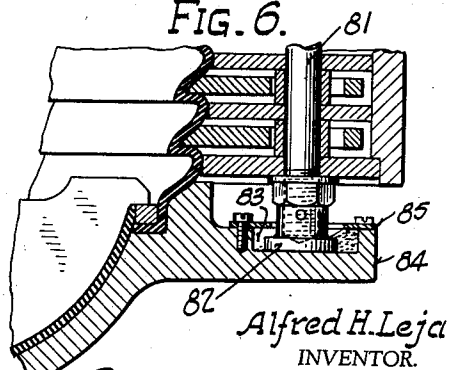


FIG. 6.



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2,161,476

ORE CONCENTRATOR

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Application January 26, 1938, Serial No. 186,930

10 Claims. (Cl. 233—3)

This invention relates to an improved concentrator for separating gold or other particles from ores, the particles being of heavier weight than the rest of the material comprising the ore pulp.

It is an object of the present invention to provide an ore classifier of the rotary bowl type which has riffles along the interior of the bowl that may be moved periodically to effectuate more complete concentration.

Another object is to provide an improved form of riffle which has greater capacity for concentrates and because of its design and composition will last longer in service without leakage or clogging.

Still another object is to provide a centrifugal concentrator which is provided with riffles that may be moved in such directions and at such intervals of time that the stratification of pulp in the separator may be most efficiently controlled to cause concentration of the metal particles between the riffles.

Other objects and accomplishments of the invention will be more fully explained in the following description of the preferred embodiment shown in the drawings. Referring to the drawings,

Figure 1 is a vertical longitudinal central section of the concentrator, the riffles being shown in neutral position;

Fig. 2 is a plan view showing the relation of parts, a portion of the concentrator being shown in section;

Fig. 3 is an enlarged detail sectional view of the riffles in one extreme position of movement, the central portion being broken away;

Fig. 4 is a modified form, in section, of the bowl shown in Fig. 1;

Fig. 5 shows an alternate form of supporting means for the bowl cylinder; and

Fig. 6 is still another modification of the support.

By application filed of even date herewith, separate claim is made to the method of concentrating ores, in the practice of which the present apparatus might be used.

The concentrator consists of a housing 11, enclosing a rotary bowl, the top of the housing having a central opening and an upwardly projecting hopper 12 into which the pulp is poured at the beginning of and during the concentration operation. Stretched across the opening in the hopper 12 is a screen 13, the opening registering with a funnel portion 14 extending into the bowl and discharging pulp thereto.

The bottom of the bowl is raised in the central portion and a stationary vertical support 15 extends upwardly beneath this portion of the bowl to provide a sleeve for the bowl axle 16. The bowl is mounted on the axle by means of nut 17 which engages washer 18 to hold down the bottom portion 19 of the bowl. The portion of the axle 16 which extends through the bottom 19 is conical and is slotted as at 20 for a locking key. Covering the end of the axle and screwed to a threaded extension thereof is a conical hub cap 21 which spreads the pulp around the bowl and protects the nut 17.

The support 15 consists of a vertical sleeve 22 which acts as journal for a pair of bearing cages 23 and 24 carrying suitable roller bearings spaced apart on the axle 16 by a spacer sleeve 25. The axle diameter is increased above the bearing cage 23 to provide a shoulder which bears upon the cage, the lateral surface of the extended portion being enclosed in a ring 26 bolted to the top end of the sleeve 22. Packing 27, disposed within the ring 26, protects this portion of the axle. The ring has an annular depending flange 28 which fits into the upper end of sleeve 22 to position said ring and to retain the outer portion of the cage 23.

The lower bearing cage 24 is retained by a nut 29 engaging a threaded portion at the end of the axle, and a lock washer 30 engages a detent 31 in the end of the axle to lock the nut in position. A plate 32 encloses the lower end of the axle and is bolted to the sleeve 22, a gasket 22' being provided to seal the bearing.

For lubrication of the bearings, oil is pumped through a channel in the wall of the sleeve 22 to the top bearing and allowed to flow down between the axle and sleeve to the lower bearing and out through a central opening in the plate 32. An oil pump may be attached to the system for recirculation of the oil.

The structure just described is supported on a base member 33 disposed beneath a horizontal flange 34 of the sleeve 22 and bolted thereto. The base member is part of a rectangular frame with longitudinal side rails and cross members disposed beneath the bowl and the motor, as shown in Fig. 2.

Returning now to the bowl, the bottom portion contains a number of passageways 36, provided with vanes for directing the pulp to the bottom of the riffle chamber, the upper openings of the passageways registering with the end of the funnel 14 in the top of the bowl. This bottom portion is also conical so that the pulp is

forced outwardly as well as downwardly to the bottom of the riffle chamber. To protect the metal defining these passages from the force of the outwardly thrown ore, a lining 37 of flexible material such as sand-blast rubber is applied to the outer walls of the passages.

The pulp which flows out of the lower end of the passageways 36 enters the bottom of the riffle chamber 38 and is forced outwardly and upwardly by centrifugal force to the top of the bowl. The bottom of the riffle chamber is also protected by a lining 37', a number of thin, vertical vanes 39 holding the same in place and also cooperating with the ring 40 to secure the lower ends of the riffle sections. There are a number of openings in the bottom of the bowl as at 41 through which the pulp may be flushed into a stationary circular trough 42 mounted on the flange 34. Trough 42 has an inclined bottom and a spout 43 at its lowest portion. When the bowl is rotated no pulp will flow through the openings 41 because of the centrifugal force, but when the riffles are filled and it is desired to clean out the bowl, rotation may be stopped and flushing fluid permitted to enter the riffle chamber through one or more pipes 44 and the concentrates collected beneath the spout 43. Pipe 44 may be provided with holes 44' facing the riffles, through which the flushing fluid may be sprayed.

In order to rotate the bowl, there is an extension 45 on the bottom portion of the bowl which serves as a pulley and has slots for a number of V shaped driving belts 46. These belts are driven by a pulley 47 mounted on the vertical shaft of a motor 48 positioned at one side of the bowl.

The bowl is supported by a number of rolls 49 mounted on the base, three such rolls being shown in the present embodiment, spaced around the outer periphery of the bowl. Each roll contacts the bottom portion 50 of the lateral wall 51 of the bowl, and is provided with a rim 52 outside the bowl, for retaining the side wall of the bowl.

Around the outer periphery of the bowl, but located within the wall 51 are a number of vertical studs 53 and 54. Stud 53 shown at the right side of the bowl in Fig. 1 is mounted directly on the bottom of the bowl and held rigidly by a nut engaging the threaded portion extending through the bottom wall of the bowl. In the drawings 24 studs are shown, the number selected depending upon the size of the bowl and the support necessary for the riffle surface. Stud 54 shown at the left side of the bowl is not rigidly mounted to the bottom of the bowl, but is free to move in an axial direction with respect thereto. Alternate studs on the bowl are similarly mounted in the manner of studs 53 and 54 respectively, in order that the desired vibration of the riffles may be obtained.

Located inside of the riffle chamber is the riffle sleeve 55, the contour of which has been carefully designed to afford the maximum receptive volume for ore concentrates under efficient operating conditions. The upper wall of each riffle groove in the sleeve 55 is horizontal and from the base of the pocket or groove the other wall normally depends inwardly at an angle of approximately 40°. This contour affords optimum riffle surface and also permits reenforcement by spaced metallic members or plates, which impart vibratory motion to the riffles.

It will be noted that the diameter of the riffle wall is smaller at the bottom of the bowl than at the top and to accomplish this the lower rows

of riffles are disposed further inwardly than the uppermost rows. The rows might be tapered in a uniform line as shown in Fig. 4, but that would necessitate the use of supporting plates or rings, each of which would be of different inside diameter. A single offset, as shown in Fig. 1, requires only two sizes of plates, and is less costly to construct.

Referring to studs 53, there are mounted thereon a series of horizontal annular plates 56 spaced apart by sleeves 57, the top and bottom plates being spaced from the top and bottom of the bowl respectively by sleeves which have enlarged end sections 58 for abutment against the top and bottom members of the bowl. Disposed between the plates 56 are a series of annular plates 59 mounted on the lateral wall 51 of the bowl, openings 60 being provided in plates 59 through which studs 53 extend. There must be enough clearance for the movement of the plates 59 relative to the studs to impart the full oscillatory-transverse vibration to which these plates may be subjected. Plates 56 and 59 are continuous about the bowl periphery in the form of rings, plates 56 being rigid with respect to the bottom of the bowl, and plates 59 being rigid with respect to the side of the bowl. Plates 56 and 59 are provided with chamfered inner edges 61 which conform to the desired shape of riffle sleeve. The inner ends of the plates contact the riffle sleeve and are to support the same as well as to control the contour of the riffles during vibrations.

The mounting on studs 54 is similar in all respects to that just described on studs 53, except that the plates 59 are rigidly fixed to studs 54, whereas relative to studs 53 axial and radial motion is permitted. Plates 56 will thus engage every other stud around the bowl, while plates 59 will engage alternate studs, not engaged by plates 56. In this manner the riffles will be supported by two relatively movable sets of plates which are mounted respectively on alternate studs.

Disposed beneath the bottom plate 59 on studs 54 and between the abutting surfaces of sleeve extension 58 and the bottom of the bowl and engaging studs 53 is an annular, formed spring-ring 62, the purpose of which is to resiliently carry the studs 54, which are not rigidly mounted on the bottom of the bowl. From the method of mounting described it will be seen that the lateral wall of the bowl may be moved in a vertical and horizontal direction while the bottom portion remains fixed in its central bearing support. The spring-ring 62 is of a conventional sinuous form and its annular design serves to maintain the floating studs 54 in proper circumferential position in relation to the bottom of the bowl.

Above the lateral wall 51 of the bowl is an annular member 63, to which the top of the rubber riffle sleeve 55 is attached. The member 63 has an upwardly projecting flange 63', over which the riffle sleeve is drawn, thus providing a higher wall for the riffle chamber. Attached to the top of member 63 and extending over the end of the bowl wall is a horizontal annular plate 64 over which the pulp flows from the bowl. Plate 64 is bolted to member 63 at a number of points, the section of the plate lying on the inside of the bolts engaging the ends of the riffle sleeve to hold down the same. Studs 53, which are rigidly mounted on the bottom of the bowl, are also rigidly attached to member 63, there being a nut 65 engaging the upper end of each stud 53

53 above the member 63. Studs 54 are not attached to member 63 and are free to move relative thereto, enough clearance being provided above the ends of such studs and below member 63 to permit such motion without interference. Connecting the top ends of all studs is a spring-ring 66, of similar design as spring-ring 62 which engages the lower ends of the studs. Both spring-rings cooperate to resiliently tie the adjustable member to the base member and maintain them in proper circumferential relation at the same time permitting relative axial and radial displacement.

The side wall 67 of the housing 11 is spaced outside the bowl wall to provide a trough 68 for overflowing pulp. In order to protect the metal from particles thrown from the centrifuge the top of the housing and the upper portion of the side wall is lined with a suitable lining such as sheets of sand-blast rubber. The bottom 69 of the trough 68 is inclined and the pulp is permitted to flow downward in a spiral trough to the outlet 70 which is tangential to the bowl. The housing is mounted on the base in any suitable manner, clearance being provided for the V-belt driving the centrifuge, and for easy access to the supporting rolls. It is preferable to make the housing detachable to permit access to the interior of the bowl for inspection or repairs.

Each roll 49 is mounted on a shaft 71, provided with suitable bearings 72. The shaft 71 is supported on a bracket 73 mounted on the frame by means of bolts. Any of the rolls may be elevated by inserting shims 74 between the base of the bracket and the frame 22, but the particular manner of accomplishing this result is immaterial insofar as the scope of this invention is concerned. For instance, the shaft of the rolls might be mounted in a sleeve eccentric therewith, the rotation of which would elevate the center of the rolls.

The elements in the apparatus have been described more or less in sequence according to the course followed by the pulp through the concentrator. The machine operates as follows:

When the pulp containing finely ground particles of different specific gravity but of fairly uniform size is poured into the rotating centrifugal concentrator the heavier particles in the fluid will be thrown into the riffle grooves, where they will become imbedded. Along with the particles desired to be classified, such as gold, will be particles of sand and the like which are not desired. In a bowl with non-vibratory riffles, particles will become packed in the riffle pockets and clog the same, thereby preventing further classification.

By the invention here disclosed, the walls of the riffle pockets may be contracted and expanded or the base of the groove may be moved inwardly to agitate particles deposited therein and permit improved concentration. Fig. 3 illustrates one extreme position of the riffle grooves. When the walls of the riffle are moved toward each other, there will be a pinching effect and a squeezing out of particles, with the heavier particles being retained at the apex of the riffle grooves. Simultaneous with this effect, there will be an expansion of the walls of the adjoining riffles, which expansion will automatically deflect the riffle base toward the bowl center, thereby loosening ore deposited in the groove and permitting more intensive agitation. The total volume of the riffle groove in the last po-

sition may be increased, but the depth is decreased, and as a result eddies are caused due to friction with the pulp stream. The pulp which is forced from the groove will be sheared off by the upward flow of fluid and forced into the next higher groove where centrifugal force will again operate to improve the concentration of heavier particles.

This desired agitation may be controlled in the following manner. By elevating two of the rolls and dropping the other roll, the plane defined by the contacting points on the three rolls will be inclined to the horizontal, thus imparting an axial, wobble vibration to the riffle sleeve. This inclination of the bowl cylinder will lift plates 59 mounted on the cylinder as they pass over the raised rolls, and then lower them to the other extreme position as they pass over the depressed roll. Meanwhile plates 56 remain in fixed elevation because of their rigid attachment to the bottom of the bowl by the studs 53. The axis of the studs 53 and 54 will not be parallel in this position, but slightly inclined to each other because of the inclination of the axis of the side wall of the bowl, which carries studs 54, relative to the axis of the bottom of the bowl which carries studs 53. The free mounting of alternate studs, such as studs 54, in the manner described, enables the apparatus to assume these changing positions at high speeds of rotation without unduly stressing the members.

The invention also permits what might be termed radial vibration of riffles, for with the riffle supporting plates mounted as shown, the axis of the bottom section of the bowl may be eccentric with respect to the axis of the side wall of the bowl, thus causing periodic oscillation of the riffles supported on plates rigidly attached to the side of the bowl, with respect to plates rigid relative to the bottom of the bowl. In Fig. 4 this form of mounting the plates is shown, there being added intermediate plates 75 with vertical, inner end faces abutting the apex of the riffle pocket. Radial motion of these plates, with respect to the plates 76 supporting the other portion of the riffles will periodically increase and decrease the riffle volume. With the apparatus shown in Fig. 1, axial vibration causes the base of the riffle to be drawn inwardly during an expansion stroke, which for most purposes is sufficient, but positive external pressure may be applied by the means disclosed in Fig. 4. To accomplish the relative motion of plates 75 and 76, the center of the plates 75 mounted on the side wall 77 of the bowl will be offset with respect to the center of the stationary riffles supported on plates 76 mounted on the bottom of the bowl. One or two idler rolls 78, contacting the outer surface of the side wall of the bowl at one side thereof will cause positive displacement of the wall with respect to the center of the bowl bottom. In all other respects the two apparatuses will be similar, provision being made for supply and discharge of the pulp and rotation of the bowl to effect centrifugal action.

In Fig. 5, a modification of the mounting of floating studs is shown. Instead of the formed spring-ring shown in Fig. 1, a flexible rubber support 79 is imbedded in the bottom member of the bowl. In this manner the bottom riffle supporting plate 80, which is rigidly attached to the wall of the bowl may be displaced vertically or laterally with respect to bowl bottom, and all

rifles supported by plates similarly mounted will partake of this movement.

In Fig. 6, a method of supporting the bowl cylinder is shown which replaces the rolls shown on Fig. 1. The end of the stud 81 is extended and has threaded thereon a shoe 82, preferably of bronze, the bottom portion of which rests on the bottom of a groove 83 in the member 84, which is the bottom of the bowl. The groove contains grease which is thrown outwardly by centrifugal force, but retained within the groove by a plate 85, covering the groove and attached to the member 84 by screws. There is an opening in the plate 85 for the shoe 82, of sufficient size to permit the necessary horizontal displacement.

The apparatus shown may be used for amalgamating purposes, by depositing an amount of mercury into the rifles, but when so used the inward acceleration caused by changes of the rifle volume must be carefully controlled to not exceed the centrifugal acceleration due to the rotation of the bowl or losses of amalgamation will occur. Due to the fact that the pulsating mercury level comes in contact with highly agitated ore of high specific gravity only, better amalgamation is possible.

The process of separation disclosed in this application is claimed in my copending application 186,931 filed January 26, 1938.

I claim:

1. A centrifugal ore concentrator which comprises a bowl, rifles disposed inside of the bowl and arranged transversely of the bowl axis, means for periodically varying the width of the grooves between rifles while in contact with the ore pulp being concentrated, and means for rotating the bowl.

2. A centrifugal concentrator which comprises a bowl, a series of rifles disposed around the inside wall of the bowl, and transverse to the bowl axis, means for periodically reciprocating alternate rifles in an axial direction in contact with the ore pulp being concentrated while the remaining rifles remain relatively stationary, and means for rotating the bowl to effect centrifugal concentration.

3. A centrifugal concentrator which comprises a bowl, a series of rifles disposed around the inside of the bowl and transverse to the bowl axis, means for narrowing the width of the grooves between alternate rifles to expel a portion of the ore deposited therein, means for widening the remaining grooves between the rifles simultaneous with the narrowing of the first named grooves to reclassify ore deposited therein and to collect ore expelled from the first named grooves, and means for rotating the bowl to effect concentration of ore within the grooves.

4. A centrifugal concentrator for concentrating ore particles which comprises a bowl, a series of rifles disposed around the inside wall of the bowl and transverse to the bowl axis, means for periodically reciprocating the rifles in an axial direction to widen and narrow the rifle grooves therebetween, means for periodically reciprocating the

bases of the rifle grooves in a radial direction, and means for rotating the bowl.

5. A centrifugal concentrator which comprises a bowl, a series of rifles disposed around the inside wall of the bowl and transverse to the bowl axis, said rifles defining a series of grooves therebetween, means for periodically flexing the walls of the rifle grooves in a radial direction, and means for rotating the bowl to effect centrifugal concentration within the grooves.

6. A centrifugal concentrator which comprises a bowl, a sleeve of flexible material forming the inner wall of the bowl and shaped to provide a series of rifles transverse to the bowl axis, and means for reciprocating the rifles axially and radially of the bowl in periodic intervals to impart a wobble motion to the rifle sleeve with respect to the plane of the bottom of the bowl perpendicular to the bowl axis.

7. A centrifugal concentrator of the rotary bowl type comprising a bowl, a flexible rifle sleeve forming the lateral walls of the bowl with rifles arranged transverse to the bowl axis, a cylindrical member disposed around the outside of the sleeve, a base member forming the bottom of the bowl, means connecting the cylindrical member and the base member permitting relative movement between the members in an axial and radial direction of the bowl, a series of annular plates alternately mounted on the cylindrical member and the base member respectively for supporting the rifle sleeve, and means for moving the cylindrical member with respect to the base member to impart periodic oscillations to the rifles during the concentration of the ore.

8. A centrifugal classifier of the rotary bowl type comprising a bowl, a sleeve of flexible material disposed on the inside of said bowl and defining a series of horizontal, parallel rifles, a series of annular members supporting said sleeve and controlling the contour of said rifles, and means for periodically vibrating said members to change the contour of the rifles during concentration of the ore.

9. A classifier of the rotary bowl type comprising a bowl, a cylindrical member forming the side walls of said bowl and providing a series of transverse rifles over which the material to be classified is passed, an independent member forming the bottom of said bowl, means connecting the aforesaid members and permitting relative movement therebetween, and means for rotating said cylindrical member about an axis either angularly or eccentrically disposed with respect to the axis of rotation of the bottom of said bowl.

10. A classifier comprising a sheet of flexible material, raised portions in said sheet forming a series of rifles disposed transversely to the direction of flow of material to be classified, said rifles having grooves therebetween said grooves being defined by rifle walls forming an acute angle with each other, and a series of members supporting the walls of said grooves and means for oscillating said members to change the contour of the rifles.

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